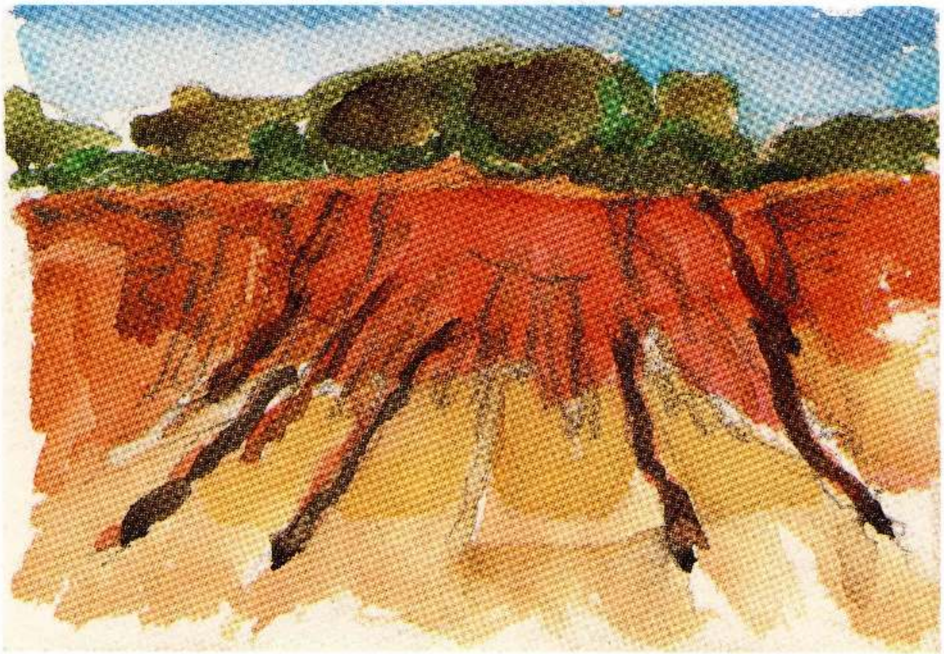
# THE PREHISTORY OF SRI LANKA

*PART I*




S. U. DERANIYAGALA

*Department of Archaeological Survey*
*Government of Sri Lanka*

**The Prehistory of Sri Lanka: an Ecological Perspective,** memoir volume 8 of the Archaeological Survey of Sri Lanka, is the first comprehensive, in-depth account to have been written on the subject. It is the definitive text on the prehistoric archaeology of the island. The systemic interaction of man and environment is viewed within a time-frame spanning over 130,000 years – probably 300,000 and possibly 500,000 – up to the beginning of the historical period at ca. 500 BC. This represents the very foundation of Sri Lankan culture, an aspect which has hitherto been enshrouded in myth, legend and archaeological nebulosity.

The range of topics covered is as wide as can be conceived. The focus is on dating. There has been such vagueness on this subject that it was not so much as known whether the Old Stone Age (Palaeolithic) is represented on the island or not. Both the cultural and environmental sequences are explicitly related to a chronological framework.

The interpretations are based on a very wide – so wide as to seem disparate – spectrum of data. The relevance of the different components of Sri Lanka's environment is assessed and those 'effective' elements which would have been of vital importance to a hunting and gathering mode of living isolated. The evolution of this 'effective environment' is considered in the light of postulated climatic shifts during the last half-million years in the Monsoon-dominated tropics and further afield. Novel hypotheses are presented as regards South Asian correlates of cold/warm climatic fluctuations in higher latitudes. The cultural traits considered are primarily the 'core' elements of technology, subsistence and settlement, with art, ornament, mortuary, ritual, and physical anthropology as secondary foci. The cultural record, stretched on a chronological framework comparable to that of the effective environment, is viewed against the latter, leading up to the formulation of hypotheses on man/ environment interaction patterns. These propositions are based on ethnographic analogy incorporating data on diverse South and Southeast Asian hunter-gatherer groups.

The stress being on chronology, amongst the salient points to emerge are (*a*) secure evidence of settlements in Sri Lanka by ca. 130,000 years ago, probably by 300,000 BC and possibly by 500,000 BC; (*b*) the manufacture of sophisticated 'geometric microlithic' stone tools by 27,000 BC; (*c*) the existence of a protohistoric Early Iron Age culture, breeding horses and practising iron production and paddy cultivation, as early as 900 BC; and (*d*) the discovery of writing in Brahmi script, the ancestor of all indigenous South Asian scripts, in contexts dated to ca. 500 BC, thereby increasing its known antiquity in South Asia by at least 200 years.

Technologically, the enigmatic absence in Sri Lanka of the Acheulean tradition of making stone tools in the Old a1

For His Excellency
Mr Hagen Prinzen
with best wishes
from Susan Devanayake
9 Apr. 99.

# THE PREHISTORY OF SRI LANKA

Red Latosol, Iranamadu Formation: Kudiramalai (*R.Y. Deraniyagala del. 1978; aquarelle x 1*)

# THE PREHISTORY OF SRI LANKA

## AN ECOLOGICAL PERSPECTIVE

MEMOIR VOLUME 8
PART I

DEPARTMENT OF ARCHAEOLOGICAL SURVEY

S. U. Deraniyagala
*Department of Archaeological Survey*
*Government of Sri Lanka*

Published by the Department of Archaeological Survey, Government of Sri Lanka.

Printed at the Department of Printing, Government of Sri Lanka.

ISBN 955 - 9159 - 00 - 3

To my Parents
and
the Tropical Sun

# *ABSTRACT*


## THE PREHISTORY OF SRI LANKA: AN ECOLOGICAL PERSPECTIVE

Sri Lanka, at ca. 8° north latitude, off the southern tip of India is characterised by a humid equatorial environment typified by rain-forests in the Wet Zone of the southwest and by their drier variants in the Dry Zone which encompasses the balance two-thirds of the island. Archaeological deposits have been dated radiometrically from ca. 74,000 BP onwards, with possible occurrences extending back into the Middle Pleistocene (?ca. 300,000 BP). Sedimentological data suggest increased atmospheric circulation, and hence increased seasonality of precipitation, during certain Pleistocene altithermals (e.g., at ca. 125,000 and 75,000 BP), particularly in the Dry Zone. It is postulated that altithermals witnessed increased aridity in the Dry Zone, with a concomitant increase in carrying capacity, and the converse has been proposed for glacial episodes when atmospheric circulation is considered to have been depressed. In the Wet Zone, these climatic oscillations are not thought to have registered markedly on prehistoric carrying capacity, the extant faunal and floral evidence not indicating an effective environment significantly different from that of the present throughout the last 28,000 ($^{14}C$) years.

While the effective environment has apparently been relatively constant since ca. 28,000 BP (at least in the Wet Zone), man's adaptation to it in terms of subsistence strategy and technology was also very consistent during this period, being devoid of marked evolutionary tendencies. Subsistence strategy comprised the non-specialised exploitation of a broad spectrum of plants and animals with an accent on small game. Technologically, the stone tool assemblages were predominantly microlithic, with excellent specimens of geometric microliths (lunates, triangles, trapezoidals) dating from ca. 28,000 ($^{14}C$, TL) BP onwards, up to possibly ca. 2,500 BP. There is evidence of a flake industry characterised by unretouched small tools at ca. 125,000 BP. Carrying capacities of Sri Lanka's biomes having presumably been low, as they are today, open-air settlements appear to have been small, with a modal extent suggesting occupation by no more than one or two nuclear families.

It can be concluded that relative homogeneity has been observed in the sub-systems of environment and culture during the last 28,000 years of the island's prehistory. This could constitute a model for equatorial Monsoonal environments in general. The indubitable presence of geometric microlithic assemblages in horizons dating back to ca. 28,000 BP offers a new perspective as to the emergence of microlithic technology in the Old World. Human remains dated to ca. 28,000 BP constitute the earliest evidence of anatomically modern man in South Asia. Finally, three assemblages of human skeletal material, dated radiometrically to ca. 16,000, 12,500 and 6,500 BP, display a degree of morphological similarity that suggests a strong genetic continuum over these ten millennia, with survivals in living Vadda ethnic groups in Sri Lanka.

## CONTENTS

# LIST OF ILLUSTRATIONS

**Maps**



**Figures**

# *PREFACE*

The present treatise, a slightly revised version of a doctoral dissertation submitted to the Department of Anthropology at Harvard University, constitutes the fourth stage of an overall strategy designed to elucidate the prehistory of Sri Lanka. It represents an attempt at pulling together diverse strands of information culled from a wide range of disciplines so as to present a perspective with an ecological base. Considering the rather rudimentary state of knowledge on this subject, in that not so much as a bare chronology has been formulated so far, I shall be restricting the scope of this work to providing no more than methodological pointers and a framework within which future research strategy can evolve.

The thrust of my work has been to generate data both in the field and from the literature to serve as a basis for inference. This treatise represents the basal, pioneering stage of such inference, and as such it is not an elegantly honed re-presentation of extant interpretative constructs. This latter procedure would constitute a secondary or tertiary level in the hierarchy of the progressive reworking of the data and their derivative hypotheses. Rather, the present work is a rough-hewn perspective, the basal level in the interpretational hierarchy, that has grown organically out of a very wide data base both directly and indirectly relevant to an investigation of the prehistory of Lanka with cultural ecology as its theoretical foundation.

Abstract theorising will be kept to a minimum, in favour of focusing on the more basic and relatively substantive problems of securing a general picture of Lanka's prehistory in its time/space and, specifically, environmental contexts. At present, the task of unravelling the intricacies of less tangible and more sophisticated questions, such as those relating to prehistoric social organisation, will be kept in reserve to be assayed at a higher level in the interpretational hierarchy.

My choice of Sri Lanka as the venue of investigation was in large measure dictated by the richness and diversity of the as yet untapped published data which are of relevance to a study of its prehistory. It is not often that an archaeologist is afforded an opportunity of breaking radically new ground in the research of an entire country, as opposed to one facet of archaeology in a particular area of that country. Recent theoretical advances in the discipline have for the first time provided the framework on which these seemingly unrelated data could be stretched to form a cohesive whole. A more practical inducement to my focusing on Sri Lanka comprises the numerous facilities for survey and excavation made available to me through the Sri Lankan Government's Department of Archaeological Survey in the context of the very numerous array of sites which have not drawn the prehistorian's attention. Finally, there is the not too rational desire to probe the past of one's own country and heritage; the element of personal involvement is hard to resist.

With regard to terminology, I shall be employing the term Lanka, a shortened form for Sri Lanka, which is current. Quotations will be used within the bounds of fair use wherever it is felt that a particular scholar's ideas and methods are best expressed in his own words. The system of citation follows that of the *American Anthropologist*; and, in order to avoid the cloying effect of repeating a single author's name or work, "idem" and "ibidem" will be used in the manner specified in the *Manual of Style* of the University of Chicago.

## *ACKNOWLEDGMENTS*

The primary impulse that channelled me into prehistory stemmed from my father, P.E.P. Deraniyagala, with his intuitive approach to the subject, full of the vitality and mystique of discovery, which he viewed more as an artist – a colourist at that – than as an academic. My own rather expansive approach to prehistory is due in no small measure to his influence: his candid opinion was that the study of stone implements as an isolated exercise is a perfectly suitable pastime for a dilettante or a narrow academic, but certainly not worthy of someone with more serious aspirations. Above all, he advocated the formulation of propositions and hypotheses without fear of their being demolished by fresh investigations. I have opted for the same strategy on the premise that controversy is more productive – and more decent – than a neutral calm.

My postgraduate studies at the Institute of Archaeology in London were supervised by Professor K. de B. Codrington, once again a man of rare intuition, but whose hallmark was incisiveness in the best English tradition. The ecological slant in my research had its origins in Professor Codrington's insistence that my orientation be towards geology with a superstructure of geography. He considered training in prehistory, with a geological background, a prerequisite for conducting any form of archaeological enquiry, even if it should be the historical period in all its baroque plumpness. Codrington's incisiveness was well exemplified at the Anuradhapura proto- and Early Historic excavations in 1969 directed by him and myself. He knew exactly when to stop expanding the scale of the project and considered any digging in excess of bare essentials an inexcusable manifestation of "greed" – a fine-honed application of the law of diminishing returns. This leash has undoubtedly had a salutory effect on the parsimony of my methodology.

Professor Codrington consistently required that I view Lankan culture-processes in the context of the broader South Asian backdrop. With this end in view, he arranged for me to study the very rich collections housed in various institutions in India, notably in the custody of Professors H.D. Sankalia and V.N. Misra of Deccan College, Poona, Drs B.B. Lal and B.K. Thapar of the Indian Archaeological Survey in Delhi, Professor R.N. Mehta of the Maharaja Sayajirao University in Baroda and Dr Vishnu-Mittre at the Birbal Sahni Institute of Palaeobotany in Lucknow – all of whom were exceedingly courteous in providing me with ready access and guidance to their material.

While the choice of strategy and tactics with regard to my research in Lanka was entirely mine, several colleagues provided essential assistance at various levels of specialisation. The basic orientation in the investigation of the Iranamadu and Reddish Brown Earth Formations came from Dr C.R. Panabokke, former Director of the Soil Survey of Sri Lanka, and from his successor in the latter institution, Dr K.A. de Alwis. Access provided by them to the detailed soil maps plotting the distribution of the Red-Yellow Latosols proved to be a great asset in the explorations conducted during Stage II of the research design. Dr de Alwis very considerately undertook the mechanical analyses of certain Latosols sampled during the surveys and excavations, while Dr D.B. Pattiarachchi, then Director of the Geological Survey, performed some of the identifications of rocks. Faunal identifications were effected by Dr P.E.P. Deraniyagala and Mr P.B. Karunaratne, former Curator in Entomology at the National Museums and now engaged in the faunal analyses of the material from Beli-lena Kitulgala and Batadomba-lena caves. Macro-floral identifications were assayed by Dr M.D. Kajale of the Deccan College and Dr F.R. Fosberg of the Smithsonian Institution, to whom I owe a debt of gratitude. Mr M.H. Sirisoma, now Deputy Commissioner of the Archaeological Survey Department of the Government of Sri Lanka, offered useful guidance with regard to historical sources and Dr R. Walburg of the Deutsche Bundesbank Geldmuseum in Frankfurt very kindly identified some of the Roman coins found in the Early and Middle Historic horizons of Kuchchaveli and Sigiriya respectively, which formed a basis for their chronological evaluation. Professor K.A.R. Kennedy of the Laboratory for Ecology and Systematics at Cornell University, U.S.A., has been most helpful in undertaking the physical anthropological aspect of the analyses, shedding new light on this thinly investigated field and thus providing a parallel research stream which may constantly be consulted and compared with the main archaeological interpretations.

The radiocarbon dating of the sites investigated as a part of this research programme has been conducted by courtesy of Professors D.P. Agrawal of the Physical Research Laboratory at Ahmedabad, Vishnu-Mittre of the Birbal Sahni Institute at Lucknow, R.R. Protsch of the Institute of Anthropology, Goethe University, Frankfurt, and Mr R. Knox of the British Museum. Thermoluminescence assays were effected by Dr A.K. Singhvi of the Physical Research Laboratory, Ahmedabad. I need scarcely stress that without the collaboration of these scholars the prehistoric chronology of Lanka would have continued to drift in a cloud of unknowing. Dr R. Gardner of the Geography Department, King's College, London, has communicated relevant and useful information pertaining to her radiocarbon dating of the South Indian *teris*. It is very important that the Indian data be at hand for comparative purposes.

The field work and the bulk of the subsequent processing were conducted under the auspices of the Archaeological Survey of Sri Lanka with the unstinting support of a succession of its Commissioners: Drs R.H. de Silva, W.S. Karunaratne and R. Silva. The facilities afforded by the Department have been all-encompassing and too numerous to list, apart from the fundamental assertion that the funding of the project in Lanka was borne entirely by the Archaeological Survey. Text Figures 1, 4 and 5 have been copied and reproduced by courtesy of Professor R.W. Fairbridge (1976) and his publishers, and Figures 2 and 3 by courtesy of the publishers of Dr R.F. Flint (1971). Messrs W.H. Wijepala (Assistant Commissioner), K.K.N. Dharmadasa (Inspector of Excavations), N. Perera (Technical Assistant), D.R.E. Hewathantri (Draughtsman) and M. Piyadasa (Excavator), all of the Department, have been of considerable assistance in executing the illustrations. Messrs Wijepala and Perera have directed the field operations at the crucial sites of Beli-lena Kitulgala and Fa Hien cave, and Batadomba-lena respectively, of which the salient results have been sketched in by me as addenda. It is expected that the three site reports being prepared by these two scholars will add a new dimension to prehistoric archaeology in Lanka.

Dr P.H.D.H. de Silva, former Director of National Museums, was most cooperative in permitting me to examine the very extensive prehistoric collections in his custody. This exercise enabled me to obtain my bearings before deciding on research strategy. Miss S. Galuschka of the West German Foreign Service provided the translation of the Sarasins' monumental works (written in a rather difficult German). Much important information would have been overlooked had this not been effected. Then there is P.B. Saranelis, former Collector and Assistant Taxidermist of the National Museums (who joined the Museum in 1918!). He has been responsible for several important finds in the various explorations that have been undertaken, particularly in Stage II of the research design, and at the age of 83 he continues to make significant discoveries with his unerring eye. The arduous typing of this manuscript was closely watched by my wife, Victoria Baroness von Plessen. Her exceptionally systematic mind caught many a flaw that dodged my notice and her patience with someone enmeshed in the toils of this work has been quite astonishing.

When the Anthropology Department at Harvard University admitted me into its programme of graduate studies, it was a natural complement to my initial training in England followed by fending for myself in Lanka. Harvard, with Professor H.L. Movius, Jr. as my chief supervisor, provided me with a wider theoretical and methodological base than I had previously been equipped with and my exposure to American anthropology-orientated archaeology served to fill out some of the sparser aspects of my methodological framework.

My travel to and from the United States was funded by a Fulbright Travel Grant. A series of grants dispensed by the Harvard Graduate School of Arts and Sciences (1973-1978) enabled me to maintain a full programme of graduate studies, supplemented by two summer grants from the Anthropology Department in 1976 and 1977 which supported a season of research at Cambridge University (by courtesy of Drs F.R. and B. Allchin and Mr B.H. Farmer of the Faculty of Oriental Studies and the Centre of South Asian Studies respectively) and field training in the Netherlands with Dr R. Newell and in France with Professors A. Leroi-Gourhan, H. de Lumley and J.-Ph. Rigaud.

I wish to be explicit as to my gratitude to the Department of Anthropology at Harvard, to Professor Movius in particular, for all that it has done to nurture my academic progress during my stay at Harvard. Without this input the present work would have been a conceptual impossibility.

# GLOSSARY AND LIST OF ABBREVIATIONS

| | |
|---|---|
| Balangoda Man | Lanka's Mesolithic human |
| BRW | Black and Red Ware |
| *Dotalu* | Sinhalese for the palm *Loxococcus rupicola* |
| Faunal carrying capacity | related to exploitable faunal biomass and human population density |
| Floral carrying capacity | related to exploitable plant biomass and human population density |
| Fm | geological formation |
| *Galge* | cave |
| -gl | below ground level |
| H Fm | Hungama Formation |
| I Fm | Iranamadu Formation |
| ITCZ | Inter-Tropical Convergence Zone |
| ITF | Inter-Tropical Front |
| *Kekuna* | Sinhalese for the nut-tree *Canarium zeylanicum* |
| *Kitul* | Sinhalese for the toddy palm *Caryota urens* |
| Lanka | Sri Lanka |
| *Lena* | cave, rock-shelter |
| +msl | above present mean sea level |
| my | million years |
| n | sample total |
| NBPW | Northern Black Polished Ware |
| *Palu* | Sinhalese for the fruit tree *Manilkara hexandra* |
| *Patana* | Sinhalese for grasslands |
| RBE Fm | Reddish Brown Earth Formation |
| +rl | above the river bed |
| RLW | Rouletted Ware |
| S. | Sinhalese, the Indo-Aryan language of the majority Sinhalese |
| SW | Southwest, in the context of the Monsoon |
| T. | Tamil, the Dravidian language of the minority Tamils |
| *Teri* | the southeast Indian counterpart of Lanka's Latosols |
| TL | thermoluminescence |
| Vadda | Lanka's aboriginal hunter-gatherers |
| *Veera* | Sinhalese for the fruit tree *Hemicyclia sepiaria* |
| *Vembu* | Tamil for dry doline |
| *Villu* | Tamil for wet doline |

# 1
# INTRODUCTION

## 1.1 THE COUNTRY

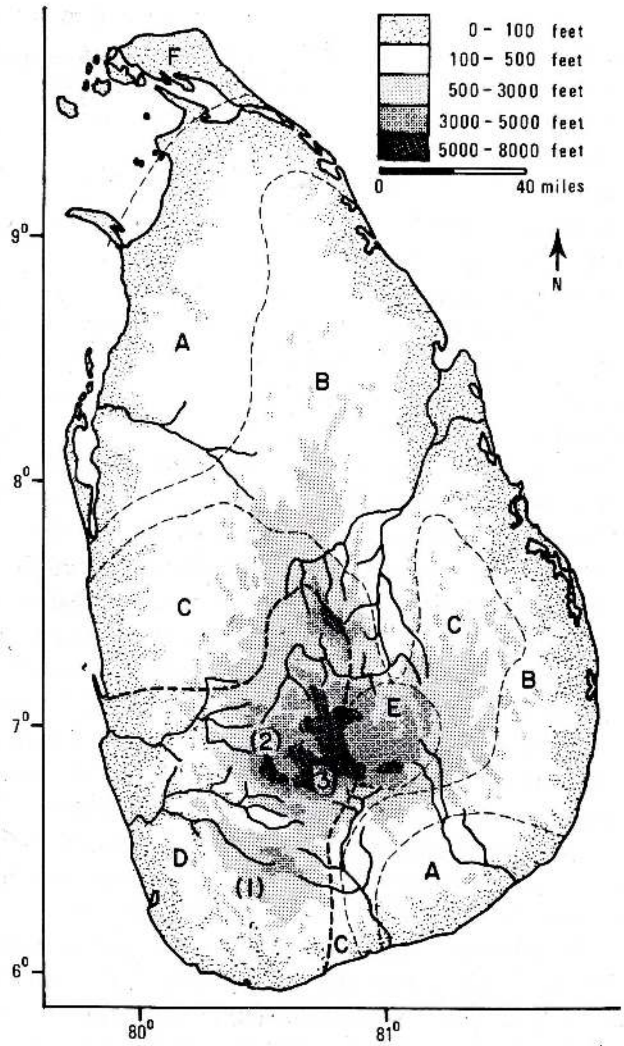
Sri Lanka, Ceylon prior to 1973, is an island in the Indian Ocean, situated some 48km off the southern tip of India at approximately 8° north of the equator. It is pear-shaped and the rough dimensions are 430km north to south by 225km east to west. The climate is dominated by the tropical Southwest Monsoonal system, with the annual precipitation ranging, according to locality, from ca. 635mm to well over 4,000mm. The average annual temperature varies from ca. 26°C in the lowlands to ca. 18°C in the highlands which reach a maximum elevation of slightly over 2,400m above sea level. The seasonal change in temperature is negligible, although rainfall is distinctly seasonal. The natural vegetation comprises tropical rain-forest and its variants. A detailed treatment of Lanka's environment is afforded in Appendix I.

It is scarcely an exaggeration when Allchin (1958:179) affirms that, for its size, Lanka has probably a more extensive literature relating to the Stone Age, particularly in its latter phase, than any other part of southern Asia. The initial probes took place in the '80s of the last century and a relatively sustained course of enquiry has been maintained ever since. Most of the island has been surveyed for its prehistoric artefacts and scarcely a nook or corner remains which can be termed *terra incognita*. The explorations have ranged from the warm arid wastes of the north to the almost temperate plains in the central highlands. However, no recent critical assessment of these studies is available. Hence, it is proposed to present the following account as a springboard for the formulation of my research strategy.

This review will be general in its scope; detailed aspects of the data will be treated in subsequent chapters under the appropriate sub-headings. With regard to procedure, since most of the important studies relating to the prehistory of Lanka were conducted in an era when methodological considerations were implicit rather than explicit, I shall not be taking it upon myself to level criticisms on this score unless these be of direct pertinence to a subject under discussion.

The following scheme of the island's ecozones is presented as an aid to visualising the regions covered (Map 1, adapted from Gaussen et al. 1968 and Mueller-Dombois 1968). It constitutes a summary of the systems delineated in Appendix I.

The country is divisible into Wet and Dry Zones respectively on the basis of its rainfall pattern. The Wet Zone (*Zone D*) is confined to the western and south-western parts of the island and comprises: *Zone D1*, lowlands at less than 900m (3,000ft) above sea level; *Zone D2*, uplands at 900-1,500m (5,000ft); and *Zone D3*, highlands at 1,500 - ca. 2,400m (8,000ft). The rest of the country is assignable to the Dry Zone which comprises: *Zone C*, intermediate-dry lowlands (< 900m) and *Zone E*, intermediate-dry uplands (900 - ca. 1,500m), both of which constitute an area of transition from the Wet Zone but which are predominantly Dry Zone in character; *Zone B*, dry lowlands (< 900m); *Zone A*, semi-arid lowlands at below 900m in the northwest and the southeast of the island, where the rainfall averages between 760 and 1,270mm (30-50ins) per annum; and *Zone F*, arid lowlands at below 900m in the north, where once again the annual rainfall averages around 1,000mm, but where prolonged droughts are characteristic.




**Map 1** Lanka's ecozones: *F* arid lowlands; *A* semi-arid lowlands; *B* dry lowlands; *C* intermediate dry lowlands; *E* intermediate dry uplands; *D* wet *1* lowlands, *2* uplands and *3* highlands at 0-3,000, 3,000-5,000 and above 5,000ft +msl respectively. (*Adapted from Gaussen et al. 1968; Mueller-Dombois 1968.*) Zones A-F coincide with vegetation Series A-E, ecozone F being within Series A.

## 1.2 HISTORY OF RESEARCH

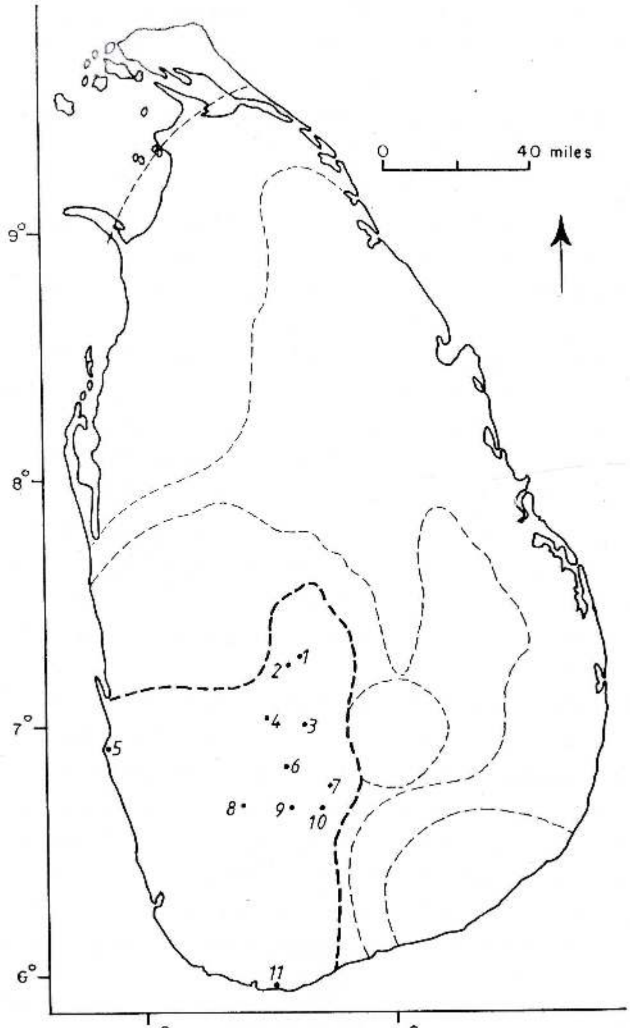
The initiators of prehistoric investigations in Lanka were E.E. Green and J. Pole (Pole 1913; Parker 1909:62). Commencing around the year 1885, surface collections of quartz and chert artefacts were secured by Pole from the vicinity of Maskeliya (v. Maps 2-7 for sites), and by Green from Peradeniya and Nawalapitiya (Sarasin 1926:81). These localities are situated in ecozone D2. However, the human authorship of these finds was held in doubt by scholars at the British Museum as well as by their colleagues in India (Sarasin and Sarasin 1908:19). It was at this juncture that the Sarasin brothers, two Swiss anthropologists, undertook a survey of the physical anthropology and ethnography of the Vaddas of Lanka, a relict population subsisting on hunting and gathering. The outcome of this project comprises the Sarasins' monumental publications of 1892 and 1893. Test excavations in the eastern ecozone B, in the hinterland, produced stone chips which could have been artefacts, but the investigators were doubtful as to their status (id. 1908:1). It was their work in the Toala caves of Sulawesi (Celebes) in 1903 which finally convinced the Sarasins that the material they had handled in Lanka perhaps represented artefacts after all (ibid.:3). This saw them back in Lanka in 1907, determined to make a frontal assault on the problem of the existence of Stone Age remains on the island (id. 1907).

The first probe was in a cave near Telulla in ecozone B of the south. The test pit did not extend below the topmost historical strata before it was abandoned (id. 1908:4). The Sarasins next proceeded to the caves at Galge further to the south in ecozone A (ibid.). These had been described by Davy (1821:419) as being situated close to a perennial supply of water, which prompted the Sarasins to investigate the locality. Three test trenches were excavated over a period of five days. Here, stratified beneath historical deposits, was a layer of quartz flakes associated with faunal remains; the first indubitable artefacts had been found (Sarasin and Sarasin 1908:7,8). The survey continued northwards into the caves of Buttala and Okkampitiya in ecozone B. Excavations at these sites produced no evidence of occupation by Stone Age man (idid.:9).

The Sarasins next moved on into the Vadda country and surveyed the area between Bibile and Nilgala in ecozone C of the eastern hinterland. The investigators were explicit in their reasons for this choice of location, in that they expected to find relics of prehistoric man in precisely those areas currently occupied by the Vadda hunter-gatherers (ibid.:1,9,10), on the assumption that the latter constituted the biological and cultural descendants of the former. A large cave on Yakunne-hela mountain near Nilgala did not yield any prehistoric artefacts. However, Gangodadeniya-galge (referred to as Nilgala cave) proved to be very rich in finds. The correct name for this latter site appears to be Mahawela-galge; my recent investigations revealed that Gangodadeniya-galge is devoid of prehistoric remains and it certainly is not the Nilgala cave described by the Sarasins. Several trenches had been excavated by them during the space of a week; it is significant that this was performed with attention to stratigraphy and that the investigators had the foresight to leave a part of the cave unexcavated for future research (ibid.:11). As at Galge, prehistoric artefacts of stone and bone, as well as faunal remains, were found stratified beneath a deposit of historical age (ibid.). The first discovery of Stone Age human skeletal remains is from Nilgala cave (ibid.:90) and the Sarasins, always sticklers for adequate sample size, consider this cave to have produced the first conclusive evidence for the erstwhile existence of a Stone Age in Lanka (ibid.:11,108).

Test excavations in Ballawala-boka (the spelling is confusing here) and Matigaha-ara caves in the Danigala chain of hills to the northeast of Nilgala produced remains of the historical period but none from the Stone Age (ibid.:13). Gongine cave at Ekiriyan-kumbura, although not excavated down to bed-rock, also proved to be devoid of prehistoric remains (ibid.:15). The area next surveyed comprised ecozone D2 around Kandy and the grassy *dry patana* hills of Bandarawela in ecozone E; surface collections of stone artefacts were secured (ibid.:17-9).

By now the Sarasins were adequately familiar with Lanka's lithic "idiom" as to be able to pronounce Pole's material from the region of Maskeliya and Nawalapitiya, as well as Green's collection from Pundalu-oya, in ecozone D2, indubitable artefacts; although the specimens collected by T. Farr (and submitted by




**Map 2** *1* Kandy; *2* Peradeniya; *3* Pundalu-oya; *4* Nawalapitiya; *5* Colombo; *6* Maskeliya; *7* Horton Plains; *8* Ratnapura; *9* Beli-galge Bambarabotuva; *10* Belihul-oya; *11* Matara.

Pole) from the Horton Plains in ecozone D3 occasioned some doubts as to their human authorship (ibid.:20). Further samples of artefacts were received by the Sarasins from Pole; these had been collected in ecozone A of the north-western coastal strip and Ambalantota in the south (ibid.).

The treatment afforded their data by the Sarasins in their final report (1908) is exemplary, considering that at that time prehistoric methodology, even in western Europe, was in its infancy. The Stone Age finds from Lanka were dated by correlating the stone artefacts typologically with the tentatively dated sequences of western Europe. It was observed that Lower and Middle Palaeolithic types were lacking in Lanka, as were the characteristic polished stone axes of the "Neolithic". Hence, the material from Lanka was assigned to a "Vadda facies" of the late Palaeolithic Magdalenian of Europe (id. 1907:189; 1908:44-5). A Mesolithic status was denied, due to the absence of roughly flaked, elliptical (?Maglemosian-type) stone axes (1908:42).

The faunal remains were analysed in considerable detail for the light they would shed on human subsistence activities; and the human skeletal remains, scanty as they were, were subjected to a close scrutiny. Perhaps the most significant aspect of the Sarasin methodology was their use of ethnographic analogy. Since prehistoric man had occupied the same caves and rock shelters as the present-day Vaddas, at least in some instances, it was assumed that the latter represent the biological and cultural descendants of the former (idid.:52). Hence, constant reference is made to Vadda culture traits as supplying clues to the interpretation of the prehistoric data. The Sarasins concluded as follows (id. 1907:190): "We, furthermore, may already venture to state that the second main period of the Stone Age, namely that characterised by the polished stone axe, is entirely wanting in the island of Ceylon, the Veddas having made the step directly from the Older Stone Age into the modern Iron Age, which was brought to them . . . by the Sinhalese, or perhaps by another people of the Indian sub-continent."

The Sarasin investigations led to a spate of interest in the prehistory of Lanka. Parsons, Chief Mineral Surveyor to the Government, published an account of the modes of occurrence of the two major raw materials employed by Stone Age man in Lanka, quartz and chert (1908). He also proceeded to excavate what is probably Beli-galge cave, on Dikmukalana tea estate, near Bambarabotuva, in ecozone D1 to the northeast of Ratnapura (Hartley 1911:197; Seligmann and Seligmann 1911:20-2). A noteworthy find is that of human skeletal remains, which were apparently deposited in the Colombo Museum.

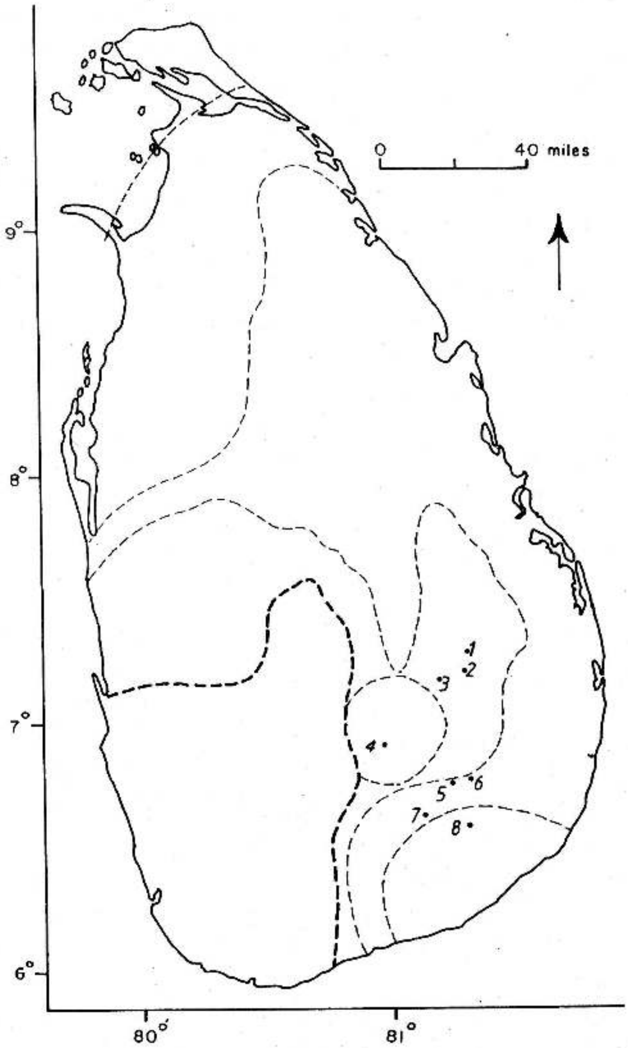
Parsons' excavation was succeeded by a more extensive one at the same site by Hartley (1911) in 1910. A large sample of faunal remains, particularly of molluscs, was secured. The artefacts were sampled selectively and Hartley (ibid.:200) observes that they were "cruder" than those found in the open-air sites of the uplands.

Parsons' and Hartley's excavations at Beli-galge are significant in having brought to light the first deposit of any depth to contain prehistoric remains, in contrast to the shallow stratigraphy encountered by the Sarasins and the Seligmanns (v. below) in the eastern and southern lowlands. It is singularly unfortunate that Hartley did not publish his findings in somewhat greater detail; there is more than a suggestion that the "crudity" of the stone artefacts left him unimpressed with the site as a whole.

It was around this time that Gardner found stone artefacts on a hill near Belihul-oya, in ecozone D2 to the east of Beli-galge (Parker 1909:64); and Lewis (1912) briefly investigated Urumutta cave, in the Matara District of ecozone D1. The finds in the latter instance comprised quartz artefacts, red ochre and faunal remains from not more than a few centimetres below the surface.

Parker, an hydraulic engineer, addressed himself to the unravelling of Vadda origins through a study of traditions found in the island's chronicles, notably the *Dipavamsa* and the *Mahavamsa*, as set down in the fourth and sixth centuries AD (Parker 1909). On the basis of these data, he tentatively outlined the distribution of the mythical "Yakkas" who are identified with the progenitors of the Vaddas at ca. 500 BC when the Indo-Aryan speaking Sinhalese first appear to have established settlements in Lanka (ibid.:19). Parker then follows the subsequent pattern of interaction between the Yakka/Vaddas and the Sinhalese, down to recent times.

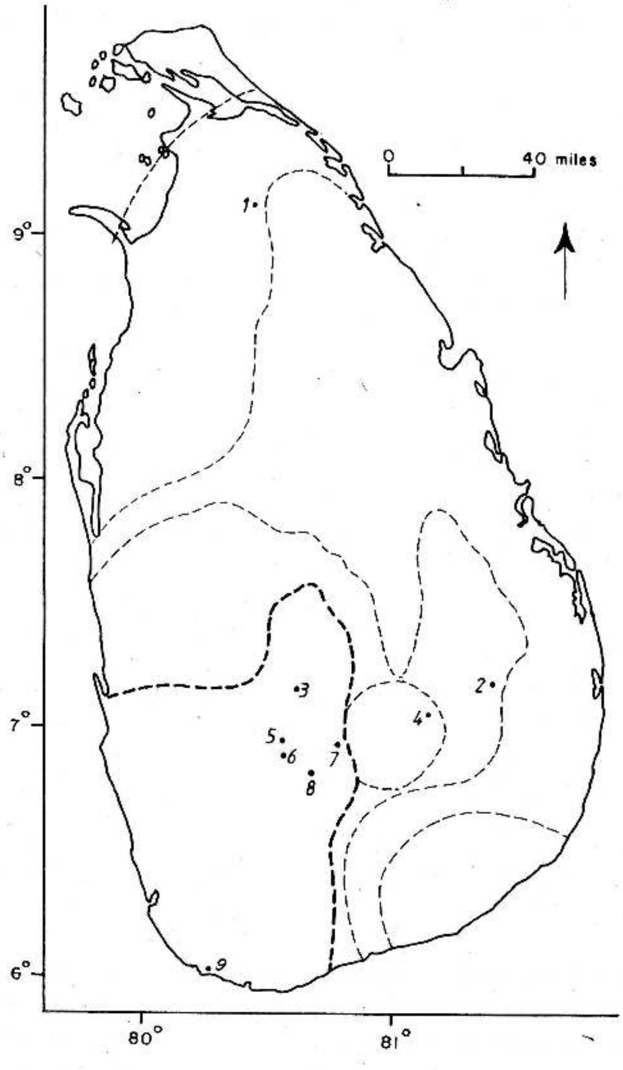
While it cannot be gainsaid that the textual data are rather meagre and blurred with legend, Parker's handling of the material cannot be contested seriously, apart from a few minor points – such as some of the identifications of localities mentioned in the chronicles. Hence, Parker's study provides information on an important aspect of the country's prehistory; namely, on the phase of change and adaptation when a Stone Age life-style was impinged upon by a technologically superior Iron Age civilisation. He also hypothesises on Vadda origins and their migration into Lanka, founding his arguments on certain aspects of Vadda ritual (ibid.:21,177-8).




**Map 3** *1* Danigala; *2* Nilgala; *3* Bibile; *4* Bandarawela; *5* Buttala; *6* Okkampitiya; *7* Telulla; *8* Galge.

In 1908 the Seligmanns undertook an ethnographic survey of the Vaddas in ecozone C of the eastern hinterland where the Sarasins had previously worked (Seligmann 1908; Seligmann and Seligmann 1908; id. 1911). This study resulted in the classic ethnography of the Vaddas (for comment v. Leach 1963:68). As a subsidiary course of investigation, the Seligmanns engaged in a few prehistoric probes. The two Bendiya-galge caves, near Henebedda, which at that time were being occupied by Vaddas, were partially excavated (Seligmann and Seligmann 1911:23). As in the case of the Galge and Nilgala caves, the lower Bendiya-galge cave revealed a historical layer preceded by a deposit containing stone artefacts. These latter were treated quantitatively by the Seligmanns, who thereby introduced a new analytical concept into Lanka's prehistoric studies. Mullegama-galge, a large habitable cave near Ambilinne, was tested; apart from the topmost deposit which was ascribable to the historical period, no prehistoric remains were found (id. 1908:163), a situation paralleling many of the Sarasin probes in the same general area (v. above). Stone artefacts were also collected from the surface of the hills at Bandarawela, which had previously been surveyed by the Sarasins (ibid.:157).

The Seligmanns assigned their lithic finds to a "Neolithic" phase, as opposed to the "Palaeolithic" favoured by the Sarasins (Seligmann 1908:115). Apart from this rather arid controversy on the cultural status of the artefacts, the concept of cultural symbiosis was invoked in considering the nature of the interaction between Lanka's Stone Age man and the Sinhalese (ibid.:116).




**Map 4** *1* Mankulam; *2* Henebedda; *3* Gampola; *4* Madulsima; *5* Dimbula; *6* Dick-oya; *7* Nuwara-eliya; *8* Bogavantalava; *9* Galle.

Pole (1907) had described some of the stone artefacts in his collection, although not with any clarity; and shortly before his death he finally published a rather fuller account (1913). The primary merit in these works lies in the information they provide on the provenance of the lithic finds, which includes

Mankulam in ecozone A of the north, Galle in ecozone D1 of the south, Dimbula, Dick-oya and Bogavantalava in D2, Madulsima in E, and Nuwara-eliya in D3 (ibid.:2,30). Pole suggests that in the Maskeliya area chert artefacts are of greater antiquity than those made on quartz, and he ventures to assign a chert specimen to the Madras Acheulean industry (ibid.:3,15). Hartley, however, declares that these so-called palaeoliths are more likely to be "Neolithic" choppers or cores, a more representative sample being required before this point could be settled (Hartley 1914:267). It is of interest to note that Hartley himself hoped to find palaeoliths in the gem-bearing gravels of Ratnapura District in ecozone D1 (Pole 1913:13). Meanwhile, R.B. Foote, the then authority on the Indian Stone Age, declared Pole's material sent to the Madras Museum to be artefactual and, together with Foote's own collection from Atgalle Hill near Gampola in ecozone D1, ventured to pronounce them "Neolithic" (Foote in Pole 1907:278; Foote 1914:250-1; id. 1916:166).

In many respects Pole's publication of 1913, based as it was on an artefact sample of well over 1,000 specimens (v. Seligmann 1908:115), left much to be desired. Hartley's review of this work is very much to the point (1914:265-8): "It is melancholy to reflect that the excellence of . . . [the] drawings renders the conviction so much the more inevitable that the majority of the stones figured are waste chips, not completed implements."

In 1913 Hartley focused attention on the typological affinities between the microliths, which he termed "pigmies", of Lanka and elsewhere in the world (1913; 1914*a*). Specifically, a "pigmy" comprised a small flake with its form altered by blunting retouch (id. 1914*a*:61); hence, it did not necessarily signify a geometric microlith, although he does state that the most common type is the backed lunate (id. 1913:123). He assigns these "pigmies" to a status typologically intermediate between that of the Palaeolithic and the Neolithic by correlation with the sequence of western Europe (id. 1914*a*:55); and he does not appear to have been aware of the term "Mesolithic", which he might otherwise have adopted. As for the "non-pigmies", Hartley places them typologically within the "Neolithic". The chronological relationship between the "pigmies" and the "Neolithic" artefacts is left vague. On the other hand, chronological implications are in evidence when he states that to judge by "size, design, and chipping, and comparing the workmanship with that of European specimens, it is plain that the immense majority [of artefacts] which have been found so far are Neolithic, and probably of no very remote date" (id. 1913:119). However, he does warn against dating by typology alone, and here, Hartley (1914*a*:55) strikes on the problem of diffusion versus independent evolution, to be echoed some thirty years later by Noone (1945:264).

He proceeds to indicate how closely microliths of crescentic, triangular and trapezoidal forms resemble each other from regions as far afield as Europe, Africa, India and Lanka, despite wide differences in the raw materials employed (Hartley 1914*a*:55).

Hartley reports finding backed microlithic lunates from surface sites in ecozones D1, D2 and D3 (id. 1913:122). However, Hartley's major survey was that of the hills around Bandarawela, already noted by the Sarasins and the Seligmanns. In the course of a few weeks he had apparently inspected almost every hill-top within several kilometres of Bandarawela. He found "plentiful Neolithic remains on the surface and occasional pigmies" at these sites (id. 1914*a*:57). It was, however, only on a single cluster of four hills that he discovered microliths in any profusion. In addition to collecting several hundred artefacts from the surface of these four hills, Hartley excavated on the richest of them, Church Hill, on which the present Anglican church stands, adjacent to the road leading to Welimada. This excavation produced a remarkably large sample of "worked" implements totalling 4,768 specimens. The "non-worked" artefacts were discarded. Hartley then proceeded to create the first formal lithic typology for Lanka's Stone Age (ibid.: 60-3), employing his total sample of excavated "worked" tools as well as the surface finds for this purpose. Finally, he presents quantitative information on the types occurring in his sample of 1,081 implements secured during the season of 1914 (ibid.: 66). Unfortunately, the typology is flawed by the overlapping of different categories and a stress on presumed function rather than on morphology. On the other hand, this is not to detract from what was a pioneering study; a quarter of a century was to elapse before anyone (Noone and Noone 1940) set about improving upon it. The illustrations are copious and of excellent quality.

Finally, Hartley was fully aware that stone artefacts represent but a single facet of the evidence on prehistoric man's activities. The open-air sites were acknowledged to be excessively susceptible to destructive weathering. He affirms that "the most important work to be done now is the excavation of caves, to which I hope to turn my attention before long" (1914*a*:66). However, until P.E.P. Deraniyagala undertook the excavation of caves in Sabaragamuva Province during the latter part of the 'thirties, Hartley's hopes were not to be fulfilled.

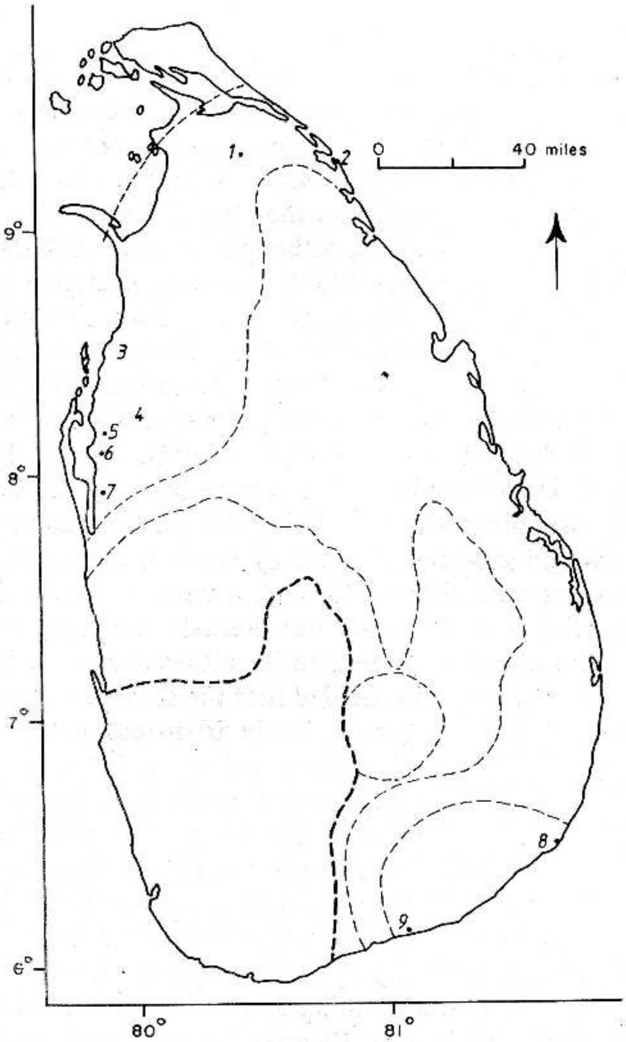
A major contribution to prehistoric studies in Lanka came from E.J. Wayland, Assistant Mineral Surveyor to the Government. He observed in ecozone A of the northwest, between the Kala-oya and Moderagam-ara rivers, a distinctive implementiferous geological formation (Wayland 1915). This comprised a basal gravel capped by a dark red loam and Wayland termed these the "Plateau Deposits" (id. 1919:101). The initial description was followed four years later by a much more detailed treatment (1919) and again in 1923 (Wayland in Wayland and Davies 1923:581-3). He surveyed the entire coastal sector, clockwise, from Uda Pottana in the south-eastern ecozone A to Mullaitivu in the north-eastern ecozone A, via ecozone D1. Although none of these prehistoric sites were excavated by Wayland, his treatment of the depositional environment of the Plateau Deposits constituted the first attempt at reconstructing the physical environment of Lanka's prehistoric man. He postulated a wet pluvial phase, correlating with a Pleistocene glaciation, followed by a dry aeolean phase during which the red loam was deposited (Wayland 1919:104-6,117,118; id. 1956:146).

With regard to the artefacts, Wayland divided the island's lithic assemblages into two "series" based on an apparent distinction in the size of the artefacts (1919:90). The assemblages with smaller artefacts, including microliths, constituted the "Hill Series" as represented by Hartley's material from Bandarawela. These he assigned to a cultural phase falling between the Palaeolithic and the Neolithic (ibid.:91). The assemblages in the basal gravels of the Plateau Deposits he assigns to the "Lowland Series". These latter artefacts are said to be larger than those assigned to the Hill Series and Wayland tentatively correlates them with the Middle Palaeolithic or Mousterian of western Europe on the basis of supposed typological similarities (id. 1919:94,98), as well as with the Middle Stone Age of sub-Saharan Africa, presumably on similar grounds (id. 1956:148). However, he does state that the overlying red loam, and certain redeposited gravels, contain an industry which is nearly identical with the Hill Series, in which "pigmies [microliths] of the finest workmanship" occur (id. 1919:97,107).

In addition to sub-dividing the lithic assemblages of Lanka on the basis of their typology and provenance, Wayland supplies useful data on the relative densities of artefact- and site-scatter in the areas surveyed. The sites are observed to be abundant and rich in the south and northwest, whereas those in the west, north and northeast are said to be few and meagre (ibid.: 107-110.)

It is perhaps not out of place to mention at this juncture that the term "Plateau Deposit" employed by Wayland has been superseded by "Iranamadu Formation" (abbr. I Fm) after the type-site for this deposit at the Iranamadu reservoir. These sediments do not necessarily occur on a plateau and hence Wayland's designation tends to be misleading. I have followed standard stratigraphic practice in assigning the basal gravels capped by the loams to a "formation" (v. Hedberg 1972:20-1; S.Deraniyagala 1976).

With regard to the Palaeolithic, apart from the so-called Lowland Series, Wayland reiterates Hartley's proposition that the gem pits of Sabaragamuva constitute a likely source of data on Palaeolithic man in Lanka (1919:124). He was the first to suggest that the remains of a Pleistocene mammalian fauna might be found in these alluvia (1916:274-5). His tentative proposition that a canine and a molar of an equid, found in old littoral sands at Colombo, are of Pleistocene age (1916; 1918) has since been discounted (Deraniyagala 1937:168; 1958:1,3). A useful adjunct to this latter study of Wayland is his schematic representation of the ?late Quaternary stratigraphy of the western coast. It remains a solitary piece of investigation which has not been followed up.




**Map 5** *1* Iranamadu; *2* Mullaitivu; *3* Modaragam-ara; *4* Kala-oya; *5* Vannati-villu; *6* Arnakallu; *7* Puttalam; *8* Uda Pottana; *9* Welipatan-vila.

Wayland sank a test pit into an implementiferous gravel "terrace" at Kosgalla Estate, near Ratnapura (1914). He is unequivocal in assigning the finds to the Palaeolithic. However, there is more than a shade of doubt cast on this assertion by the occurrence of microliths in association with the so-called palaeoliths, the site itself being apparently single-phase.

The above summary of Wayland's work brings out the salient features of his contribution to prehistoric studies in Lanka. The Sarasins provided information on subsistence patterns, Hartley on lithic types, and Wayland on the physical environment of Stone Age man, as well as, possibly, on the succession of industries on the island. Moreover, he filled a significant spatial lacuna in surveying a hitherto prehistorically uncharted segment of territory. Indeed, one might affirm that between Pole, the Sarasins and Wayland, most of Lanka had been surveyed; the one major area which remained relatively unexplored comprised the rain-forests of ecozone D1.

Wayland's description of the Lowland Series led F. Sarasin to believe that a Lower Palaeolithic status was being accorded to it, and 1924 saw him back in Lanka checking on Wayland's claims (Sarasin 1926; 1926*a*). He re-examined Wayland's sites in the I Fm of the northwest between Puttalam and the Kala-oya, and in the south at Welipatan-vila (id.1926:106-7). Two of Hartley's sites at Bandarawela were also sampled (ibid.:78). Finally, he inspected Wayland's collection of stone artefacts in the Colombo Museum.

The resultant publications by Sarasin (id. 1926; 1926*a*) provide the first comprehensive account of the history of prehistoric research in Lanka (particularly in Sarasin 1926). He also formed general conclusions beyond those formulated earlier (cf. Sarasin and Sarasin 1908) with reference to the advent and evolution of the Stone Age in Lanka. He reaffirms that the lithic remains are representative of the direct ancestors of the Vaddas, although he adds that the distribution of the artefacts indicates that the entire island had been occupied by the Vaddas at an earlier stage, contrary to their present territory which is limited to ecozones B and C of the eastern hinterland (Sarasin 1926:83-4). He reiterates that the arrival of the Sinhalese from India during the first millennium BC heralded the abrupt introduction of iron technology to Lanka, basing his views on archaeological (as opposed to textual) data (id. 1926*a*:6-7), thus confirming Parker's statements from the latter evidence. Under the impact of iron technology the Vaddas are thought to have "regressed" technologically from using a diversity of stone tool types to a single type of iron arrow- and axe-head obtained by barter from the Sinhalese (id. 1926:83). These generalisations were effected through a synthesis of the data secured by Pole, the Sarasins, Hartley and Wayland, and Sarasin produced the first overall view, although bare in the extreme, of prehistoric culture change in Lanka.

More specifically, Sarasin decided that the stone artefacts found in the Vadda country of ecozone C were typologically identical with the specimens from Bandarawela and elsewhere in ecozone D2 around Kandy and Maskeliya (id. 1926:100; 1926*a*:6). He further postulates that the artefacts collected from the I Fm at Welipatan-vila and at a site some 6km north of Vannati-villu in the northwest were no different in appearance from those secured in the caves and the uplands, the majority of the artefacts being small, namely less than 5cm in length (id. 1926:107). Conversely it is argued that the cave and upland assemblages include large, crude artefacts which exactly resemble Wayland's so-called "Lower Palaeolithic" category (ibid.:109). The major factor controlling artefact size is considered to be the type of raw material available (ibid.:100). Sarasin proceeds to state that the large chert "objects" occurring in the I Fm north of Vannati-villu do not represent artefacts. As an aside he adds that most of Wayland's "artefacts" in the Colombo Museum are not of human manufacture and that many of the so-called "tools" are in fact nuclei. The existence of Lower Acheulean, Mousterian or Aurignacian types is denied and the entire collection is labelled typologically non-descript (ibid.:100,102; id. 1926*a*:7). Wayland's paper (1919) is criticised, in that his statement – that the so-called Lower Palaeolithic tools always occur together with others which are being regarded as "Neolithic" – casts doubts on the status of the former (Sarasin 1926*a*:7). The final verdict is that "Wayland's Lower Palaeolithic" is non-existent, as is Pole's "Chellean handaxe" of chert from Maskeliya (v. Pole 1913). The latter is identified as just a large nucleus (Sarasin 1926:90,108). "In my opinion it has – up to now – not been possible to establish certain proof of a Lower Palaeolithic in Ceylon, which does not mean that in the future this might not be the case" (id. 1926*a*:7). "Only isolated examples of so-called Early/Lower Palaeolithic types are found instead of series of implements which could be referred as a whole to any one of the early Palaeolithic cultures, as should be the case had they really belonged to such a culture" (id. 1926*b*:567). This last statement constitutes an unqualified plea for a quantitative approach to lithic analysis.

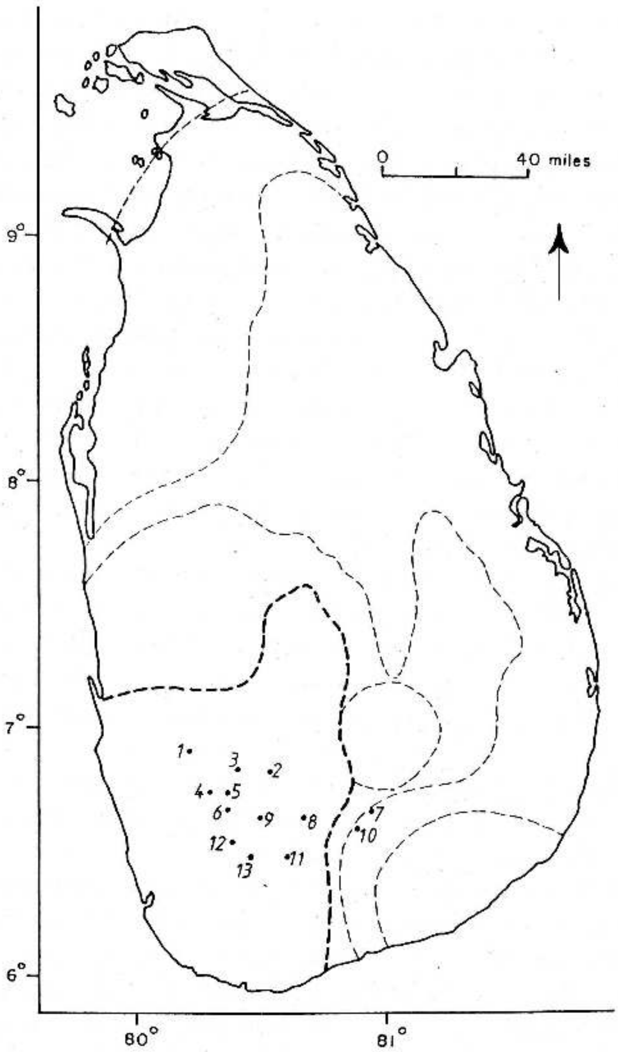
Sarasin proceeds to observe, with considerable acuity, that the Acheulean tradition had not been observed from south of Madura in southern India (a situation which prevails to this day), which would make it unreasonable to expect it to turn up in Lanka (id. 1926:110). It is hypothesised that Lanka's chert is most suitable for handaxe manufacture and that the lack of sedimentary quartzites need not have been responsible for the absence of the Acheulean in Lanka – (the Indian Acheulean is almost exclusively on quartzite). It is further reasoned that the island was probably not connected to the mainland during the period when the Acheulean Complex flourished around Madras (ibid.:112). In this, Sarasin was the first to view Lanka's Stone Age within the wider context of Indian prehistory. He affirms that the lithic industries of Lanka were probably partly contemporaneous with the Neolithic of peninsular India, but that the absence of polished stone celts, pottery and domesticates, and the presence of geometric microliths, indicate a very late Palaeolithic stage akin to the late Magdalenian or the Azilian of Europe (ibid.:82,94-5). Sarasin was in fact implicitly adopting a model of multilinear evolution in this last set of statements.

Sarasin displayed a considerable awareness of the hazards associated with placing too much trust on lithic typology (id.1926*a*:6): "It is a known fact that it is sometimes most difficult to classify Stone Age cultures from countries outside Europe into the same scheme as those from west and central Europe. Although the general forms of the tools are identical to the European ones, they often accord with neither type nor period. This difficulty we had in Ceylon." Fifteen years later the Noones (1940:19,20), with reference to their collection of artefacts from Bandarawela, said much the same thing, thus highlighting Sarasin's *avant garde* thinking.

It remains for me to add that some of the accusations by Sarasin against Wayland were founded on an inadequate reading of the latter's paper of 1919. Wayland did not unequivocally claim the existence of a Chellean in Lanka (v. his defense in Wayland 1926:193); he postulated Middle Palaeolithic or Mousterian, as well as Aurignacian, traits, with the possibility of an evolutionary sequence. Secondly, Sarasin missed the point that Wayland saw a stratigraphic distinction in the I Fm between the provenance of the microliths and that of the larger Lowland Series. The latter was considered to occur in the basal gravels, whereas the former were assigned to the overlying red loam and to the redeposited gravels. Hence, Sarasin's argument that both groups of artefacts occur in the I Fm does not in any way compromise Wayland.

It is probably not out of place here to mention that Wayland wrote an incisive paper on the theory of scientific method which dealt explicitly (among other topics) with the subject of "description" versus "explanation" (id. 1914*a*). Hence, not all prehistorians in Lanka, even in those days, have been mere collectors of curious stones; there was an awareness of the theoretical and methodological implications of the discipline of prehistory within the wider context of scientific enquiry.

The 'thirties saw the inception of a major new phase of prehistoric research in Lanka. The alluvial gem-bearing gravels in the area around Ratnapura came under the investigation of P.E.P. Deraniyagala, Assistant in Zoology at the Colombo Museum. The well-known historian Deraniyagala P.E. Pieris sent him the first fragments of a fossil vertebrate from a gem mine at Pelmadulla in 1930 (Deraniyagala 1958:1-4), and further specimens were collected from the same general area, resulting in the initial descriptions of this faunal series (id. 1936; 1937; 1937*a*; 1939). From 1939 up to 1963 Deraniyagala headed the Colombo Museum, which expanded into the Department of National Museums. During this period the data on the fossil fauna from the gem pits accumulated, and these were reported in a series of publications (notably, id. 1940; 1944; 1946; 1951; 1960; 1963; with syntheses in 1955; 1958).




**Map 6** *1* Getahetta; *2* Adam's Peak; *3* Batatota-lena; *4* Kuruwita; *5* Batadomba-lena; *6* Ratnapura; *7* Ukgal-kaltota; *8* Balangoda; *9* Pelmadulla; *10* Diyavinna; *11* Rakwana; *12* Kukulegama; *13* Kalawana.

These faunal remains were secured from alluvial gravels of indeterminate chrono-stratigraphic status which had been deposited in the strike valleys of the south-western sector of ecozone D1. These alluvia have, since at least the thirteenth century, been mined for their heavy mineral placer deposits which at times contain precious stones. The stratigraphic information that Deraniyagala offers is based on the Sinhalese classification and nomenclature as employed by miners and not on any standard descriptive procedure followed by stratigraphists. These "Ratnapura Beds" as they have finally come to be termed (for discussion of terminology v. Cooray 1967:144; *Ratnapura System*: Deraniyagala 1936; *Ratnapura Series*: id. 1939; 1957) are essentially a rather vague combination of bio- and litho-stratigraphic units.

The subject matter of Deraniyagala's publications on the Ratnapura Beds primarily comprises a description of their faunal contents, which he termed the "Ratnapura Fauna" (1944:25). The occurrence of palaeoloxodont elephants and the six-incisored hippopotamus *Hexaprotodon* in the Ratnapura Beds established a correlation with the Middle or Upper Pleistocene fauna found in alluvial deposits of peninsular India, notably on the Narmada river (v. de Terra and Paterson 1939), which in its turn partially correlates with the Upper Shivalik fauna of the Punjab (Deraniyagala 1954:114; v. also 1958; 1963:15; 1965:190; 1969). In addition to extinct Pleistocene genera and species, remains of forms which have become extinct during the historical period and others which continue to inhabit the island today constitute a part of the Ratnapura Fauna. This feature, together with the occasional discovery in the Ratnapura Beds of artefacts assignable to the historical period, caused the investigator to suspect that at least some of the fossiliferous gravels had undergone redeposition, resulting in a mixing of Pleistocene and more recent strata. The question of redeposition was partially resolved by a series of uranium assays conducted by K.P. Oakley of the British Museum on samples of the Ratnapura Fauna (id. 1958:103-4; 1960:68; 1963:5). These seemed to indicate that some of the beds had indeed suffered redeposition; on the other hand, a numerically larger sample requires to be assayed before any conclusive statements could be made. Two radiocarbon tests (Chowdhury 1965) conducted on samples of wood from two localities in the Ratnapura Beds provided the first incontrovertible evidence that these beds do, at least in part, comprise a Pleistocene component. Specimens of wood and pollen were despatched by Deraniyagala to the Birbal Sahni Institute in India for analysis, and environmental inferences were drawn from their identification (ibid.; Vishnu-Mittre and Roberts 1965).

As for artefacts, Deraniyagala reports finding a stone industry in the Ratnapura Beds, often in the same horizon as that which yields the Ratnapura Fauna (1937*b*:262; 1945; 1958:53-64; 1960*a*:95). Most of these finds were made after 1942. None of them resembled types characteristic of the Acheulean Complex of peninsular India, being typologically amorphous, with a chopper element which the investigator considered to be paralleled by the Soan industries of the Punjab. This stone industry has been assigned to the "Ratnapura Culture", while I have in my synthesis of 1971 referred to it as the "Ratnapura Industry" (id. 1940*a*:359-360; 1943:93; 1947:11; 1954:116; S.Deraniyagala 1971:15).

With regard to the age of the Ratnapura Industry, Deraniyagala states that due to possible redeposition undergone by the Ratnapura Beds, "some of the stone implements occurring together with these fossils [of extinct forms] might be younger than the fossils themselves" (1954:115). The absence of the Acheulean tradition in Lanka is ascribed to the non-existence of a land link with the Indian mainland when Acheulean man was in occupation of the latter (id. 1947:11; 1954:116), an opinion voiced by F. Sarasin two decades previously.

Another aspect of Lanka's past which Deraniyagala worked on was the nature of the discontinuous distribution of certain elements of its living vertebrate fauna in relation to India and south-eastern Asia in general, thereby expanding on the investigations initiated by Willey (1903). While these studies might be on the fringe of relevance to the Quaternary prehistory of Lanka, they opened up an independent source of information on past environments (v. Deraniyagala 1940*a*; 1944; 1944*a*; 1947; 1952; 1953; 1954:115; 1956; 1958; 1960*b*; 1965).

The segment of Deraniyagala's prehistoric research described above is significant: Hartley's and Wayland's proposal that the gem-bearing alluvia of Sabaragamuva be subjected to examination was finally realised. The result was the discovery of an entirely new extinct fauna for Lanka which could be correlated with its Indian counterparts. It established unequivocally the existence of the remains of a Pleistocene vertebrate fauna on the island. Harking back to Hartley's statement (1916) that despite intensive surveys of these same sedimentary beds by officers of the Mineral Survey nothing resembling the remains of a vertebrate fauna had been discovered, Deraniyagala's finds are instructive as to the extent to which discoveries constitute a function of survey technique.

During 1938-39 E.C. Worman, Jr., a postgraduate student at Harvard University, made collections of stone artefacts from the north-western coastal lowlands of ecozone A between the Kala-oya and Moderagam-ara rivers, namely, the I Fm deposits described by Wayland in 1915 and 1919. The collection is housed in the Peabody Museum, Harvard, and nothing has as yet been published on it. However, the notes attached to the finds refer to the specimens from the sandy loam as being "Mesolithic" and those from the basal gravels are assigned to the Middle Palaeolithic, with a possibility of their being Upper Palaeolithic. Worman also secured a sample from Bandarawela, which once again he assigns to the Mesolithic. As far as I am aware, this is the first occasion on which this term has been applied to an industry from Lanka, even though it is not in published form. The Noones (1940:19) were to follow suit one year later in a paper describing their finds from Bandarawela, with the proviso that they might just be assignable to the "Palaeolithic", although by 1945 H.V.V. Noone was firm in his commitment to the term Mesolithic (1945:264). Indeed, it is somewhat surprising that prehistorians had not employed this term at a much earlier date in Lanka, considering that its use in India had been inaugurated in the 1880's (Brown 1889:138-9; 1892:93; Sieveking 1960).

When Worman described the microlithic assemblages from Bandarawela as being Mesolithic he was probably employing typological criteria, namely, the presence of geometric forms, as the basis of his reasoning. Aspects of chronology or subsistence base could not have been taken into consideration since the requisite data were not available to him. Noone (1945:264) is explicit in his typological correlation with Europe where "similar types of implements are said to have been in use . . . as far back as 10,000 years ago (Mesolithic Age)". Deraniyagala (1945:134) assigned his finds from Neravana-galge cave, Kukulegama, to the Mesolithic, and subsequently refers to "Mesolithic man with his geometric pygmy implements" (1954:116).

Allchin (1958) followed Subbarao's lead (1956:12-15) in India in referring to the microlithic industrial complex of Lanka as the Late Stone Age. The present writer did likewise in his analysis of lithic artefacts from Bellan-bandi Palassa (1971*a*). However, in view of the reversion to the term "Mesolithic" in India (v. Misra 1962; 1965:57, 82-3; id. in Sankalia 1965:46), and since the Lankan assemblages fall well within the range of typological variability of their Indian counterparts, I myself sought to retain the nomenclature introduced by Worman, the Noones and Deraniyagala in re-assigning the term "Mesolithic" to the microlithic assemblages of Lanka (S.Deraniyagala and Kennedy 1972; S. Deraniyagala 1980:169), although in a strictly technological sense (as denoted by the presence of geometric microliths) and with no connotations as to chronology or subsistence strategy.

The Noones (1940) sampled the four open-air sites on hill-tops described by Hartley, at Bandarawela, over a period of three months. They found, as did Hartley, that most of the hill-tops in the area (when situated not too far above the valley bottoms) displayed vestiges of Stone Age occupation and that some of the sites had strongly demarcated areas of artefact scatter (ibid.: 1). The resulting collection comprised over 2,000 artefacts, and apparently some of these were "extracted" from beneath the surface of the ground (ibid.).

The primary contribution of the Noones to the study of Lanka's prehistory was in their intensive analysis of the lithic sample they had acquired from Bandarawela. Technology was taken seriously into account for the first time. A new typology was devised to replace, or rather to amplify, Hartley's scheme of 1914. Some sixty different types and varieties were distinguished. The basic methodology as stated by the authors (1940:4) indicates explicitly that morphological, as opposed to functional, criteria were being employed as the basis of the typology. This is a distinct improvement on Hartley's system. It denotes a thorough awareness that appearances can be deceptive as to function. Allchin (1958:190-1) presents an excellent critique of the Noone classificatory system. Hence, I need only point out the salient criticisms: (*a*) the lack of adequate illustration; (*b*) the omission of "size" as a variable requiring description; (*c*) the lack of quantitative data; and (*d*) the overlapping of categories due to inadequate definition of types and varieties. However, the system still remains a very useful tool for quick classificatory work.

Noones' analysis of the material from Bandarawela, when taken within the context of the work done by Wayland and the Sarasins, found them in agreement with the latter that, as far as the evidence went, there was no basis for postulating the existence of more than one Stone Age "culture" in Lanka (1940:20). This has persisted as one of the most vital issues in the study of Lanka's prehistory.

While the Noones were engaged in their analysis, it has already been mentioned that Deraniyagala had been finding stone artefacts in the Ratnapura Beds, to which the term Ratnapura Industry has been assigned. Another aspect of Deraniyagala's research, which in its most active phase was to continue down to 1963, was the exploration and testing of Mesolithic cave sites, primarily in Sabaragamuva Province (ecozone D1) – an area neglected by previous workers, apart from Parsons' and Hartley's excavations in Beli-galge near Bambarabotuva (Deraniyagala 1940*a*; 1943; 1945; 1953*a*; 1955*a*; 1956*a*; 1958*a*; 1960*a*; 1963*a*).

A series of caves along the escarpment between Diyavinna and Ukgal-kaltota in ecozone B to the southeast of Balangoda was tested. (id. 1940*a*:361ff). While the lithic sample was meagre, the associated faunal remains were abundant and, above all, described in detail with quantitative estimates (ibid.:365). This was the first significant set of data on prehistoric subsistence to have emerged since the Sarasins excavated Nilgala cave in 1907, Hartley's treatment of the Beli-galge data being cursory. Deraniyagala assigned the prehistoric finds to the "Balangoda Culture" (ibid.:371). Typologically he distinguishes the Balangoda Culture from the Ratnapura Industry by the presence of pitted hammer-stones and microlithic backed lunates in the former (id. 1958:64).

A second area to be surveyed was in the foothills of Sri Pada (Adam's Peak), around Kuruwita near Ratnapura (id.:1940*a*:367-8; 1941:F3). Here, two sites were investigated: Batadomba-lena cave and Batatota subterranean cavern. The excavation at Batadomba-lena yielded a large lithic sample in addition to a wealth of faunal remains, of especial interest being the fragmentary skeletal remains of a human, the first to have been found in a Mesolithic context since Parsons secured his specimen from Beli-galge during the first decade of the century. The Batadomba-lena human skeletal remains were despatched to B.S. Guha, a Harvard-trained Indian physical anthropologist, for comment; however, none was forthcoming due to the extremely fragmentary nature of the sample. Parsons' site, Beli-galge, was also excavated (id. 1943:110); the resulting finds were very similar, apparently, to those from Batadomba-lena.

It was at this stage that Deraniyagala re-opened the case of the relationship between the Vaddas and Lanka's Stone Age man, specifically Mesolithic man: "...that strange admixture of ancient and modern races, the supposedly autochthonous Vaddha of Ceylon, possibly carries some proportion of the blood of Balangoda Man [the author of the Balangoda Culture], but the two differ culturally" (ibid.:112). Deraniyagala also stressed the significance of Lanka for the study of Indian prehistory. He observed the tendency among Vaddas to throw-back to diverse physical types, which suggested to him the miscegenation of several "races" which sequentially entered the island-*cul de sac* off the tip of India (id. 1940*a*:354).

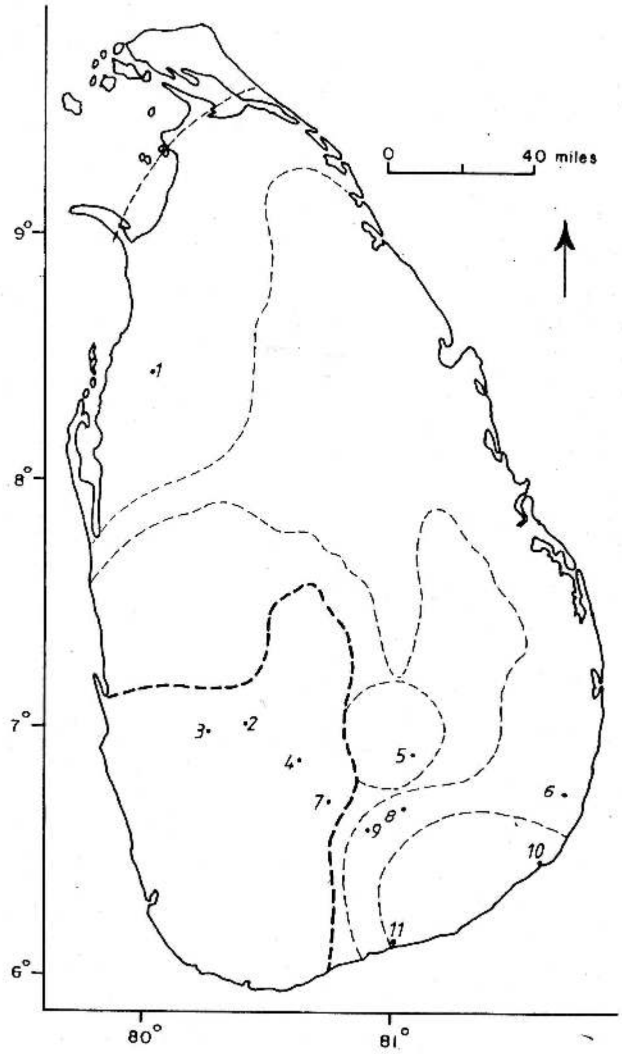
At about this time Noone was also speculating, in very general terms, on the relationship between the microlithic industries of Lanka, India, and further afield (1945:264). He postulates that the basic idea of manufacturing and using microlithic stone implements was introduced from the Indian mainland but that there seems to be little doubt that the high development reached in Lanka's examples was an indigenous accomplishment. He proceeds to suggest independent evolution in Lanka and Australia and, in this connection, the possibility is put forward that given similar requirements and resources man's reaction is sometimes expressed in the production, in unconnected areas, of a more or less similar type of artefact.

Between the years 1944 and 1963, Deraniyagala conducted numerous surface explorations as well as excavations of sites, particularly caves, in the lowland Wet Zone D1 (1945*b*; 1946*a*; 1953*a*:127; 1953*b*:E3; 1955*a*:300-3; 1955*b*:E16; 1959:E43; 1962:E15; 1963*d*:E36,37,44;1965:184-5). The finds were essentially similar to those from Batadomba-lena. In the semi-arid lowlands, the regions around Lenama in the south and Vilpattu in the northwest were explored (1948:F7; 1952*a*:E4; 1958*b*:E4; 1969*a*:89). Minihagal-kanda, one of Wayland's "Plateau Deposits" in the south, was sampled and the stratigraphy amplified (id. 1956*b*:1;1956*c*; 1958:63; 1961). Explorations in the dry and semi-arid lowlands of the south near Hungama revealed the presence of "Mesolithic" artefacts in association with two stone-lines which were capped by a mantle of earth (1963*c*:1,2) and general inferences were drawn with respect to their depositional environment.

The large cave at Ravanalla, in the intermediate-dry uplands to the east of Bandarawela, was extensively excavated over five seasons (id. 1950:E8; 1952*a*:F4; 1953*a*:127). A very large sample of stone artefacts and faunal remains was secured, as well as some bone tools. These, however, have not been described with any adequacy. A significant discovery (in 1945) from Ravanalla is the human frontal bone which provided the first firm intimation as to what Lanka's late Stone Age man might have looked like.

It was around 1954 that Alu-galge shelter, near Telulla, in ecozone B of the south, was excavated during two seasons (id. 1955*a*:295-300; 1955*b*:E4). The most significant find at this latter site comprised the fragmentary skeletal remains of a human. Faunal remains, as well as artefacts of stone and bone, resembling those from Ravanalla, were obtained.

1956 saw the initial season of excavation at the open-air midden site of Bellan-bandi Palassa, in the dry lowlands directly beneath the Kaltota escarpment with its series of caves described above. This site was excavated on a 2m by 2m grid over five short seasons, averaging a fortnight or less each from 1956 to 1961. The results, particularly those pertaining to physical anthropology, have been published in considerable detail, producing what is perhaps Lanka's best documented prehistoric site (id. 1956*a*:119; 1957*a*:8,9; 1957*b*:E4; 1958:66-82; 1958*a*; 1960*a*; 1963*a*; Kennedy 1965).




**Map 7** *1* Vilpattu; *2* Beli-lena Kitulgala; *3* Beli-lena Athula; *4* Norwood; *5* Ravanalla; *6* Lenama; *7* Balangoda; *8* Alu-galge Telulla; *9* Bellan-bandi Palassa; *10* Minihagal-kanda; *11* Hungama.

In 1956 Lanka's Mesolithic obtained its first radiocarbon dates, by courtesy of H. Shapiro of the American Museum of Natural History, when Isotopes Inc. assayed two samples of charcoal submitted by Deraniyagala from Bellan-bandi Palassa (id. 1958*a*:259). These dates are considered somewhat suspect, due to contamination from shellac consolidant as well as the strong possibility that their provenance is in the post-Mesolithic stratum at the site. A thermoluminescence date secured on fired rock-crystal which was found in direct association with one of the human skeletons is considered to be more reliable (Wintle and Oakley 1972). Nitrogen and uranium assays were conducted on human bones from this site, which yielded an age "to be reckoned in millennia" (Oakley in Deraniyagala 1960*a*:97,98; 1965:188) while being post-Pleistocene.

In contrast to the detailed treatment afforded the human skeletal material from Bellan-bandi Palassa, the other aspects of the data have been somewhat neglected by the excavator. Stratigraphy is dealt with but cursorily, the provenance of finds being indicated only in terms of depth below the surface. It is not quite clear whether pottery occurs in the Stone Age horizon or not; the accounts tend to be contradictory, although they incline towards its absence in this layer (Deraniyagala 1957*a*:8,9). The stone artefacts are sketchily described, despite the large quantity secured; they are assigned to the Mesolithic on the basis of the presence of geometric lunate-form microliths (id. 1956*a*:119). However, the bone artefacts and the faunal remains are dealt with in some detail approaching adequacy.

In a review of Lanka's prehistory it is easy to underestimate Deraniyagala's contribution: "Deraniyagala has worked much longer than anyone else and his finds are much more voluminous. The impact of his findings has, however, been poor. The *University of Ceylon History of Ceylon* seems to suggest that his work has made little contribution to the study. It is true that his presentation often lacks clarity. ... Yet it can hardly be denied that his work has amplified the very bald sequence suggested by Seligmann and Hartley" (Senaratne 1969:23). Indeed, the *University of Ceylon History of Ceylon* does suggest that scarcely anything is known about the island's prehistory and proceeds on this assumption to postulate a tentative sequence comprising a Lower Palaeolithic at ca. 50,000 BP with a pebble chopper element intruding (into an ?Acheulean) at some time or the other; a Middle Palaeolithic at ca. 25,000 BP; an Upper Palaeolithic, which is apparently scarcely separable typologically from the Middle Palaeolithic, at ca. 15,000 BP; a "degenerate" phase termed the Mesolithic at ca. 10,000 BP; a Neolithic at ca. 8,000 BP; and finally a "Microlithic" phase (*sic*) (Wijesekera 1959:74ff). There is no evidence whatsoever to support such a hypothesis and the *University History* is definitely in need of revision on this score.

There are obvious shortcomings in Deraniyagala's methodology, such as in the scant attention devoted to the artefactual finds. However, this is not to gainsay his strength as a field archaeologist with an almost uncanny ability to locate important sites, as is borne out by data recently retrieved from Beli-lena at Kitulgala and Batadomba-lena, two of his discoveries. He succeeded in this through his capacity to communicate with and inspire the local villagers as to the significance of prehistory – no mean achievement in a country where this discipline is viewed as something esoteric. It was these villagers, with their intimate knowledge of the surrounding countryside, who were largely responsible for initially locating the sites. Anyone who has conducted archaeological explorations in tropical forests would vouch for the fact that it is extremely easy to walk within a few metres of a large cave entrance and not notice its presence at all due to its being elevated on a cliff-side or due to surrounding vegetational cover. Hence, cooperation from the local inhabitants is an essential part of any survey strategy in Lanka. It is possibly the failure to appreciate this point to which one can ascribe the lack of success on the part of the officers of the Mineral Survey in discovering fossil faunal remains in the Ratnapura Beds at the turn of the century. Another feature in Deraniyagala's methodology deserving of note is the limited emphasis he placed on lithic analysis as a means to interpreting prehistoric culture. As a zoologist it was the faunal remains that he stressed, and in general he displayed a strong awareness of the necessity for viewing a site within the context of the overall ecosystem. It was this aspect of his work that has served to flesh out and complement the dry bones of "lithic" prehistory as exemplified in the works of Hartley and the Noones. It is also to Deraniyagala's credit that he referred his finds to specialists (whenever these were available), as in despatching the human skeletal material from Bellan-bandi Palassa to the British Museum for more detailed scrutiny than he himself could afford. Finally, he did fill in a major spatial lacuna in the prehistoric survey of Lanka in investigating the wet lowland ecozone. The result has been a proliferation of data, most of which await analysis, and which are readily accessible at the National Museums of Lanka. Many of his archaeological publications, in contrast to his zoological monographs, are in the nature of preliminary reports and a detailed study of the collections housed in the museums would yield rich rewards.

Meanwhile a solitary, but significant, "library *cum* museum" study of Lanka's Stone Age was made by B. Allchin (1958). Her excellent review of the Noones' methodology has already been cited; it is now opportune to consider her own contribution as a whole.

Allchin's paper constitutes the first major synthesis to have appeared since Sarasin's work of 1926. It is somewhat unfortunate that she does not appear to have had access to many of Deraniyagala's publications, thereby omitting a significant portion of the extant data: for instance, preliminary descriptions of the skeletal remains from Bellan-bandi Palassa had already appeared in print when Allchin (ibid.:200) wrote: "The almost total absence of human bones at many of the Late Stone Age sites suggests that the inhabitants have followed practices similar to those of the Veddas, who frequently leave the body lying in the cave covered only with leaves." A major focus in the paper is lithic typology, and Allchin having critically reviewed Noones' scheme constructs a new typology: "The following method of classification can be made to cover all stone tools found at a site, and divides them on a basis which integrates form and function as far as possible. This system of classification and the terms it employs have proved a satisfactory medium for comparing industries from different tropical and semi-tropical regions, whether these are adjacent regions such as Ceylon and South India, or widely separated like Australia and Southern Africa" (ibid.:191). The lithic analysis was based on the Hartley Collection housed in the Cambridge University Museum of Archaeology and Ethnology, comprising Hartley's finds from Bandarawela and elsewhere in the uplands and highlands. This material apparently includes surface collections made by one F.R.C. Reed in various parts of the island. Allchin, however, was unable to discover the exact provenances of the artefacts: "Owing to the somewhat haphazard nature of the collections, it is often impossible to discover from which site an object comes" (ibid.); and she proceeds to assign them all tentatively to Bandarawela. On the other hand, the accession registers at the museum do contain information purporting to refer to these artefacts, and if these can be trusted it should be possible to work back from Allchin's illustrations so as to secure a clearer comprehension of the actual distribution of the types assigned to "Bandarawela". For instance, the large pitted hammer-pebble illustrated by Allchin appears to have come from a site at Bogavantalava in the wet uplands, an ecozone (D2) quite distinct from that of Bandarawela (E). Similarly, none of the finely trimmed bifacial points, constituting perhaps the most distinctive type in Allchin's list, appear to have been found at Bandarawela: find spots include Norwood, Nawalapitiya and Balangoda in the wet lowlands and uplands – hence, I have termed these artefacts "Balangoda Points" (S. Deraniyagla 1980:179; 1985:16). It is unlikely that Hartley would have failed to illustrate this type had any specimens been found at Bandarawela, considering the abundance of his figures and the exquisite workmanship displayed on these tools (v. Hartley 1914*a*).

Allchin's classification comprises the following categories (1958:191-7):

A. Unworked Tools: utilised hammer-stones, anvil-stones, pitted hammer-stones

B. Flaked Tools:
   1. Edge-Tools

(*a*) Used flakes, with or without retouch
(*b*) Blades
(*c*) Scrapers, e.g., straight, hollow, and convex; end-, and side-; nosed, keeled, and semi-discoidal forms.
(*d*) Discoids
(*e*) Elouera, grading into the larger lunates
(*f*) Chopper/chopping tools, grading into the discoid group
(*g*) Burins (doubtful category)
(*h*) Transverse arrow-heads: wide lunates, grading into trapezoidal forms

2. Composite Points and Barbs [Geometric Microliths]
(*a*) Lunates
(*b*) Triangles
(*c*) Trapeziums
(*d*) Assymetrical points

3. Points
(*a*) Simple points
(*b*) Single-trimmed points with steep backing along one edge
(*c*) Double-trimmed points with steep backing along both lateral edges
(*d*) Unifacial points (absent)
(*e*) Bifacial points
(*f*) Borers

4. By-Products, e.g., nuclei

There are some marked shortcomings in Allchin's typology. The attributes considered are not defined adequately; for example, it is assumed that the distinction between a chopper and a scraper is obvious. The basis of the "integration of form and function" is not explicit: for instance, Type 1(*b*), blades, is primarily devised on morphological *cum* technological traits; 1(*d*), discoids, is entirely morphological, with no reference to function; 1(*h*), transverse arrow-heads, is functional, whereas its morphological traits are duplicated in the lunates of Type 2(*a*). Type 3(*b*), as illustrated in Figure 2(9), could as well be assigned to Type 2(*a*). The scalene triangles mentioned under Type 3(*b*) are not evident in the illustrations. Then, there are the rather redundant Types 1(*g*) and 3(*d*) which do not occur in the sample at all, their existence being in the realm of possibility. In overview, Allchin's scheme falls into the same error as Hartley's; there is too great an emphasis on functional criteria without adequate and explicit justification for employing these criteria. Hence, the deductions which Allchin makes, by employing Hartley's quantitative data for his different types for checking against her own typology (ibid.:197), are based on a rather insecure foundation. Besides, Allchin calculated her percentages from a total of 4,768 specimens, whereas, according to Hartley (1914*a*:66), the total should be 1,081, comprising the specimens secured during the second season of excavation in 1914.

There are, however, some very positive aspects to Allchin's study. The illustrations are of high quality, thereby partially redeeming an inadequacy in the Noone article. An important contribution is the use of the Seligmanns' Vadda ethnography (1911) as a source of analogy for interpreting the prehistoric record (Allchin 1958:197-200). While it is true that the Sarasins (1908) effected a similar study, they did not have the Seligmann work to draw upon and hence their scope is more limited. Finally, Allchin succeeded in making the first substantive comparison between Mesolithic stone tool types of India and Lanka, specifically between the *teri* industry of south-eastern India (Tinnevelly) and the Hartley Collection from Lanka (v. Zeuner and Allchin 1956). The correlation is summarised thus: "The stone industry which characterizes the Late Stone Age cultures of the greater part of the sub-continent [India] is based upon the same series of techniques with certain minor modifications and refinements. The only exception to this is a group of the Late Stone Age industries confined to Ceylon and the extreme south of India, which employ a different series of basic techniques in addition to those used further north" (Allchin and Allchin 1974:50).

In 1969 Senaratne published his account of the prehistory of Lanka. While its chief merit lies in its introduction of prehistory to the layman in Lanka, the synthesis and review of earlier work, although sketchy, is clear and to the point. However, as with the Allchin study of 1958, this work displays an inability to order the range of data published by Deraniyagala. With a view to righting this situation, I published an article (1971) synthesising the data secured primarily during the period post-dating the 'thirties and up to 1968. In addition to dealing with the Quaternary Ratnapura Beds and their fauna, this paper endeavoured to synthesise what was known about the subsistence base, mortuary and "ritualistic" practices, physical traits, environment, and chronology of Lanka's Mesolithic man. As such, the range of topics covered was much larger than in any previous synthesis.

Beli-lena Athula cave, near Avissawella in the wet lowlands, was excavated in 1969 by H.S. Gunaratne, Assistant in Geology at the National Museums (Gunaratne 1971). Approximately one-third of the surface area of the cave was excavated and the finds, inadequately described so far, comprised the usual wet lowland cave assemblage of Mesolithic quartz artefacts and faunal remains, which were confined to the topmost 60cm of the deposit (ibid:1). Of significance to the physical anthropologist is the discovery of the fragmentary remains of a human skull from within the Mesolithic deposit of the cave. Further, two samples of charcoal from this stratum have subsequently been radiocarbon dated in the late 'seventies.

From 1968 onwards, with the exception of the Beli-lena Athula excavation, most of the prehistoric research in Lanka has been conducted by the present writer under the auspices of the Archaeological Survey Department of the Government of Sri Lanka. However, before I introduce the reader to an account of my research on Lanka's prehistory it would be expedient to focus on some of the problems which had crystallised by 1968 from a review, as outlined above, of my predecessors' work.

## 1.3 PROBLEM FORMULATION

The sequence of archaeological investigation is four-tiered, the observations customarily escalating from perceived to inferred attributes (Clarke 1968:19; Sanders and Marino 1970:2,3): (*a*) chronology, the arrangement of cultural remains within a time framework; (*b*) the description of individual cultures at given points in time and space, thereby approximating to a palaeo-ethnography; (*c*) the comparison of cultures at different points in time and space, a palaeo-ethnology; and (*d*) the formulation of generalisations on culture dynamics through time and space. Some would place stage *b* on par with that of establishing a chronology, as far as priorities go: "The case studies provide interpretations of early human livelihoods and activity in relation to reconstructions of many facets of environment, including geography, topography, vegetation, fauna, climate, and seasonality. With the movement away from narrow historicism, we now recognize that such working models of life in the past have considerable interest and importance for evolutionary theory, even when the site is floating in chronology and its age is known only in rather vague terms. At the present stage of studies the scope and quality of the evidence is worth more than chronological precision" (Isaac 1975:882-3).

As of 1968, it was apparent that Lanka's prehistoric studies had not advanced beyond the first two stages and even in these several lacunae existed. The major ones comprised: (*a*) the absence of a chronological framework to which the cultural entities can even tentatively be referred; for instance, it was not at all certain if the island had been populated by humans during the Pleistocene; (*b*) the lack of a cohesive view as to what the palaeo-environment might have been; (*c*) our ignorance with regard to man/environment interaction, with particular reference to subsistence strategy; and (*d*) Lanka's prehistory had yet to be viewed within the wider context of South Asian and world prehistory. Inadequate use had been made of data from fields outside of archaeology in Lanka with a view to resolving archaeological problems. While it is true that material culture can only be properly studied if their former coupling within a socio-cultural system is taken into account (Clarke 1968:43), it is yet vital that the broader aspect of the coupling of culture with physical environment, namely the cultural ecosystem, be given adequate consideration. "It has emerged that off-site data must be considered as of equal importance to on-site data. The consideration of the relationship between these two categories of information is of the first importance" (Higgs and Jarman 1975:5). This situation needed rectification, and the present work will seek to do so, even though, considering the large volume of relevant but non-archaeological data available, only a fragment of the potential will have been tapped. Secondary lacunae existed in our knowledge of settlement patterns and technology. As outlined in the history of research, the analytical systems applied to the lithic finds, which by far constitute the bulk of the prehistoric cultural remains found on the island, required to be replaced by a more comprehensive and flexible scheme with fewer internal contradictions.

Of course, there were the less tangible aspects of Lanka's prehistoric culture, such as social organisation and religious beliefs, about which nothing was (and is) known. However, these problems do not require immediate assaying, in view of the priority assigned to the elucidation of the more basic issues such as those of chronology and palaeo-environment. Even with regard to these latter aspects, it suffices to concur with Clarke (1972:861) that considering the nature of archaeological data (v. below), it is only possible to assemble an idealised model at best, which, though unreal, provides a basis for prediction – and thus for testing the degree of its reality or unreality.

It was also evident that none of the past research on Lanka's prehistory had been conducted within an explicit theoretical and methodological framework. Much of it had been executed on a vague "hit or miss" basis. It is well to bear in mind the axiom that "what we see the data to be is what we are prepared to see" (Hole 1973:23), and, as Clarke pithily remarks (1968:22), the archaeologist must differentiate his discipline from that of entertainer on the one hand and the meaningless accumulation of data on the other: an explicit theoretical and methodological base is essential if one is to avoid inefficient utilisation of resources. I need scarcely elaborate on this point; the last two decades of archaeological theoretical discussions, particularly in the U.S.A., has unequivocally done justice to this concept. It suffices to mention that not least among the virtues of an explicit stance is that it facilitates the application of a wider range of strategic and tactical devices to a problem, in addition to lessening communication obstacles among workers. It is against this backdrop that the present work will seek to pull together a rather extensive and disjointed array of data; it is high time that these be organised and analysed with some degree of rigour. The following sub-heading outlines the theoretical framework which guided my strategy and tactics, and which to a considerable extent determined the structure of this treatise. The sub-discipline of archaeology will be presented within the overall perspective of cultural studies and general methodological aspects, as applying to the present work, will be discussed. It needs to be pointed out that much of what will be stated would be obvious to the professional archaeologist; but it would nonetheless be a "lighting of the way" within the Lankan context, to which the present work is primarily addressed.

## 1.4 THEORETICAL AND METHODOLOGICAL FRAMEWORK

Archaeology constitutes a sub-discipline within the overall field of cultural anthropology: it is an autonomous discipline comprising a method and a set of specialised techniques for gathering and interpreting cultural data. In general terms, cultural anthropology represents the comparative study of the statics and dynamics of culture, or learned human behaviour (Deetz 1967:6), in its formal, functional and developmental aspects (Taylor 1948:39) which could conveniently be treated under the six headings (or facets) of economy, technology, social organisation, religion, language and recreation (Sanders and Marino 1970). These elements overlap and interact and the sub-division of culture into its component sub-systems can merely be an arbitrary conceptualisation of different aspects of the same network (Clarke 1968:132). The paradigm which best accommodates this situation, where the role of "prime-mover" is subdued, is that of Systems Theory (v. Flannery 1968; Clarke 1968; Harris 1969; Rappaport 1971; Sherratt 1972; Sabloff et al. 1973; Doran and Hodson 1975; Renfrew 1977; and Hardesty 1977 for a treatment of the application of Systems Theory in the fields of cultural anthropology and archaeology).

It could be affirmed that Systems Theory focuses on comprehending variability and change, whereas a normative view aims at understanding homogeneity. Provided one interprets culture from a processual standpoint, as a problem of dynamics, it is to Systems Theory that one might most conveniently turn for an explanatory paradigm. The dynamic nature of cultural phenomena can better be fitted by systems models than by mono-causal concepts such as environmental or technological determinism. Basic is the idea that varying cultures can be adaptive to the same environment: cultures can be imposed upon nature as well as nature upon cultures.

All disciplines relating to the acquisition of knowledge operate according to the nature of the data which are pertinent to those disciplines. One may not ask a discipline to perform feats which would require the transgressing of the boundaries and limitations of the data base. The nature of archaeological data is distinctive and circumscribed and archaeology perforce has to define its goals in terms of the potentialities of its data (Trigger 1970:332; Hole 1973:22,29): it must be demonstrated that the empirical data at our disposal are suitable for making the interpretations we seek.

Archaeology and history purport to study culture within a temporal dimension (Taylor 1948:31; Sackett 1968:69) which is frequently long-term in nature. Hence, these diachronic analyses stand in contrast to the synchronic analyses inherent in social anthropology, another sub-discipline of cultural anthropology, where time is regarded as a fixed quantity (Tufte 1974:6,7). In general, the further back in time that one reaches the scantier the data base becomes and the result is that increasingly large segments of time require to be treated so as to maintain a constant density of data. Archaeology and history cannot tell what really happened in the totality of past time – to do so would take as long as the happenings themselves (Kroeber 1935:547-8), and archaeological data defy strict periodisation, with "synchronic" segments of the record being assumed to represent, as Michels (1973:9) states, a "meaningfully tolerable range of contemporaneity". The very terms "meaningful" and "tolerable" point to the relative scale of thinking which underlies them. "Few archaeological events . . . can be regarded as precisely contemporaneous. . . . While recognising the existence of short-term phenomena, a useful model for archaeological purposes will of necessity avoid the need for their consideration. Short-term models are in any case commonly based on data which are not available to archaeology, and there is little point in putting forward untestable hypotheses and explanations" (Higgs and Jarman 1975:5).

The variables responsible for distorting the vision of a total culture when viewed through archaeological data are (Doran and Hodson 1975:94): (*a*) partial and erratic reflection of culture by material remains; (*b*) partial and erratic survival of material remains through time; and (*c*) partial and erratic discovery of surviving material. It is thus apparent that archaeology is chronically saddled with a data base which is at best only moderately representative of the total culture it seeks to describe – and it could be a good deal worse. Such being the situation, it would be presumptuous to expect the discipline to display the accuracy in prediction evinced by the "hard" sciences; it is just not possible to achieve the same degree of experimental control in the social sciences (for an explicit treatment of "scientific" archaeology, espousing positivist philosophy, v. Binford 1962; 1972; Binford and Binford 1968; Fritz and Plog 1970; Watson et al. 1971; and for a critical treatment of their thesis v. Trigger 1970; Tuggle et al. 1972; Sabloff et al. 1973; Doran and Hodson 1975).

Considering the nature of archaeological data, as expounded above, it should not be surprising if several hypotheses could be stretched over the same data; which could lead (as it invariably does) to several schools of opinion on a single topic. While this might sound as if the entire discipline is compounded of frivolity and dilettantism for the entertainment of those with a penchant for airing baseless views, it is not necessarily the case that inadequate methodology is responsible for the occurrence of several answers to a single question; this diversity stems from the very nature of archaeological data, which are never capable of supporting but one interpretation. The latter rests upon complex probabilities and these probability propositions may not be conclusively refuted by producing contrary examples (Clarke 1968:12,17). As Hole (1973:30) affirms, the extreme point to which this line of reasoning can be carried is when faced with the problem of the fortuitous: how does one handle the possibility of accidental occurrences? However, let it be noted that the above is not an admission of total defeat, it is simply an overview of the nature of archaeological data. Methodology must be subjected to close scrutiny at every stage in the progression of an archaeological investigation, and even if it is not possible to eradicate the looseness of the structure of archaeological inference, it should still be possible to tighten it to the exclusion of some of the potential hypotheses, thereby making the corpus of propositions to be tested somewhat more manageable in its dimensions.

In the present work I shall seek to observe the interaction between prehistoric man and his environment in Lanka and this interaction will be considered from the viewpoint of Systems Theory in that no general assumptions will be made as to the identity of the prime-mover in the relationship. I would refer the reader to my earlier statements concerning the application of Systems Theory to cultural phenomena. To be more specific, my approach will be that of a "cultural palaeo-ecologist". However, Systems Theory will not be regarded as being applicable with any rigour to the discipline of archaeology; it will only serve as an overall theoretical framework, a paradigm. Cultural phenomena display too many stochastic traits for the direct application of Systems Theory to be a viable proposition (for further treatment of this topic v. Doran and Hodson 1975:315,339; Renfrew 1977:35).

Ecology may be defined as the science concerned with the relations between living organisms and their physical and biotic environments, which seeks to understand the lifeways of organisms by reference to their places or niches in the larger systems of which they are a part (Rappaport 1971:237). In short, it deals with the functional relationship between organisms and their environment (Geertz 1963:1). With regard to humans, the ecological approach seeks to specify the relations between human activities, biological transactions and physical processes by including them within a single analytical system, an ecosystem (ibid.:3). In this sub-discipline of "cultural ecology", the ecosystem subsumes both environment and culture. It is in its overall breadth that an ecologist's approach differs from that of an economist; the latter tends to focus entirely on the exchange relations within the species, namely the human-to-human interaction, and the environment is assigned a very subordinate position (Lee 1969:48). Similarly, environmental determinism, or its converse, cultural determinism, appear as narrow and simplistic segments of limited application within the broader and more sophisticated perspective of systemic interaction as specified by human ecology. Any separation of culture from the biophysical environment is arbitrary; culture as an adaptive system articulates with the environment (Struever 1971:192), and man is viewed, in cultural ecology, as just another variable in the ecosystem (Mangenot 1963:125), thereby divesting his study of at least some of the anthropocentrism which has cramped traditional cultural anthropology: "whereas cultural anthropology has generally taken as its starting point that which is uniquely human, an ecological perspective leads us to base our interpretations of human existence on that which is not uniquely human" (Rappaport 1971:244).

Ecology, as can be adduced from the above account, is a holistic science and hence is entirely compatible with archaeology, which, due to the nature of its data, is perforce another holistic discipline: there is no place for methodological individualism; the individual does not play a dominant role in their conceptual frameworks. However, it must be realised that cultural ecology *sensu stricto* provides only a large-scale model for archaeological interpretation; it constitutes a source of analogues. The ecologist is essentially concerned with the present and his data base is relatively unlimited for that very reason. The archaeologist, on the other hand, has to be content with a fraction of the data which would be considered adequate for a thoroughgoing "ecological" study of a past culture; with his highly selective and erratic data on past culture as well as on past environment, the archaeologist may not hope to launch out on an unreserved course of "ecological investigation". It is necessary to maintain an acute awareness of the data limitations which prohibit such presumption.

The most widely used tool of interpretation in archaeology is analogy, which is assaying any belief about non-observable past events, both cultural and environmental, by referral to observed contemporary situations. As Hole (1973:32) affirms, the frontiers of archaeological method and theory consist of studies of modern situations, which serve to elucidate what one might find archaeologically. Hence, models and hypotheses in archaeology can be derivatives of cultural ecology, via analogy.

Considering the strongly holistic nature of archaeology, it is to comparably holistic aspects of cultural ecology that one must turn for suitable analogues. Since cultural ecosystems comprise networks of interaction between man and environment, what are the holistic aspects of these two components that one might profitably consider applicable to data-starved archaeological situations? It is important to keep in mind that in the case of archaeology "the techniques which produce artefacts [are] easy to infer to, subsistence-economics fairly easy, social/political institutions considerably harder and religious institutions and spiritual life the hardest inferences of all" (Trigger 1970:322). Hence, it could be considered logical to progress from the relatively simple to the complex and the major focus in this treatise would be on exploitative technology and subsistence economics. Steward (1955:37) refers to this segment of culture as the "core". As summarised by Geertz (1963:7), the culture core includes such social, political and religious patterns as are empirically determined to be closely connected with the sub-systems of exploitative technology and subsistence economics. However, innumerable other features of culture may have greater potential variability because they are less securely linked to the core. These latter, or secondary, features are probably determined to a greater extent by purely cultural-historical factors, such as random innovations or diffusion, and they give the appearance of outward distinctiveness to cultures with similar cores. The implication is also present that it is to the culture core alone that ecological analysis is relevant and that core features occur in a limited number of total patterns representing responses to specific categories of environments by peoples at various levels of technological development.

It is true that this model smacks of technological determinism and hardly any allowance is made for genetic and demographic variables. However, considering the technological bias inherent in prehistoric data, Steward's model is admirably suited to the archaeological situation; although social anthropologists, with their rich data base, might with impunity accuse Steward of being simplistic (e.g., Vayda and Rappaport 1968:483-7).

Having dealt with the sub-system of culture in the cultural ecosystem, it is now necessary to consider the "environment" aspect of the system within the context of its application to archaeology. By definition of an ecosystem, the environmental component must be compatible with the cultural component, since otherwise the system would be out of balance – bearing in mind that an "ecosystem" is nothing but a tool for the analyst. Internal homogeneity has to be maintained in defining an ecosystem, whatever its scale might be: "The discrimination of the 'culture core', and the definition of the relevant environment, are directly reciprocal endeavours" (Geertz 1963:8). Hence, our attention is automatically focused on those aspects of the environment which are in regular or cyclical articulation with the culture core; this has been termed the "effective environment" (Binford 1972:431). The corollary is that the effective environment changes as the culture core sub-system itself develops (Sherratt 1972:481).

Since the present work is primarily concerned with a hunting and gathering economy, the core sub-system is assumed to be a constant, and where deviations occur from this assumption explicit reference will be made. It is also being assumed that, at the hunting and gathering level of exploitative technology, culture and the natural environment are just about equally manipulative of each other, with environment possibly having the upper hand – whereas with technological advance, culture tends to wrench the natural environment into an artificial form with which it articulates, and the feedback situation favours culture in such a case (Murton 1974:179).

In practical terms, the clue to what constitutes the culture core and its effective environment in a hunting and gathering economy, as envisaged in this work, lies in ethnographic studies. Indeed, detailed investigations of local groups in relation to their environment are a prerequisite to making ecological generalisations (Mason 1975:20). However, in the application of ethnographic analogy to archaeology it is essential that the ethnographic data refer to a society which is at a level of technological development similar to that estimated for the archaeological community under investigation, in addition to manipulating similar environments. It is only in such a case, where the living and extinct cultures feature similar technologies in a similar environment, that ethnographic parallels are particularly relevant (Gabel 1967:7). One should also be forewarned against employing analogues from relict groups surviving under external pressure from technologically more advanced groups, with a tendency to functioning at marginal efficiency (Vita-Finzi and Higgs 1970:5).

I have outlined above the conceptual framework which underlies the structure and planning of the research strategy which in turn underlie the substance of the present work, and, summing up, Butzer (1971:401-2) might be cited on the conducting of environmental or ecological analysis in its application to prehistory. Such a study, he states, is to be directed towards: (*a*) understanding the regional environment as it exists today; (*b*) understanding the regional food resource base as it might have affected prehistoric man, namely his effective environment, via ethnographic analogy; and (*c*) understanding the local setting of sites with respect to exploitable food resources, terrain, hydrography and other specific features. These latter include factors that would influence the selection of a site for settlement – such as natural shelter and features affecting human mobility.

The archaeological data in the present work will be set out against a backdrop of hunter-gatherer cultural ecology for Lanka, with emphasis on core traits and effective environments for the reasons adduced earlier. To reiterate: an ecological approach to the study of prehistory in Lanka is pertinent primarily because cultural ecology (or ecological anthropology) provides the widest perspective on culture processes, since culture is viewed as a mere sub-system within a larger ecosystem. The ecological approach is particularly appropriate for situations involving a hunting and gathering economy, whereas in more complex economies where human-to-human interaction assumes greater significance in determining cultural dynamics, this approach in its basic form of viewing man/environment interaction requires some modification. At the present juncture in the prehistoric studies of Lanka it would be rather short-sighted and premature to focus, as the Noones (1940) have done, on just a single facet of culture, such as stone tool technology, to the exclusion of the broader context within which it is nested. A general understanding of the pattern of prehistoric culture change through time and space is necessary before one might specialise on discrete topics; and such a comprehension is not within our grasp as yet for Lanka. The second reason for my choosing an ecological approach comprises the nature of the data available. A considerable body of environmental information has been published in non-archaeological contexts in Lanka. The present work will constitute the first occasion on which archaeology will have drawn significantly upon these sources, and as such will represent a major methodological departure from previous studies. Supplementing the environmental data would be the ethnographic material published by the Sarasins (1892; 1893) and the Seligmanns (1911). The Sarasins (1908) and Allchin (1958) have, to a certain extent, drawn inferences based on Vadda ethnography; but there is ample scope for a more intensive treatment. As explained above, ethnography constitutes one of the main procedural struts on which prehistoric studies operate, and hence the availability of ethnographic data has been an added factor contributing towards my choice of an ecological approach.

## 1.5 PRESENTATION

The present work is organised in accordance with the following general scheme (v. Redman 1974:7): (*a*) definition of overall aims; (*b*) assessment of the data required with respect to the stated goals; (*c*) evaluation of the choice of survey techniques, sampling units, and sampling procedure; (*d*) analysis of data; and (*e*) evaluation of research as part of an on-going multi-stage project. The definition of the overall aims has already been effected in the foregoing account.

The structure of this treatise requires elucidation since it will provide both an insight into the strategy and tactics employed by me in dealing with the problems outlined under sub-heading 1.3 as well as into the logic behind the sequence of chapters and their contents.

Appendix I will seek to create a series of environmental zones for Lanka.

Since this work purports to provide an ecological perspective, a detailed treatment of environment is an absolute prerequisite and it can in future be employed as a backdrop against which environmental and cultural changes will be observed through time and space.

Chapter 2 will formulate strategy and tactics for dealing with the archaeological problems current in Lanka's prehistoric studies. Sampling method will be considered, and the choice of specific tactics justified. Appendix III comprises a gazetteer of sites and excavation reports stemming from Stages II and III of the research design. Chapter 3 will consider the Quaternary chronology of Lanka, with specific reference to the alluvial and coastal deposits, caves and miscellaneous open-air habitation sites. Chronological information will be culled from stratigraphy, technology, radiometric dating and fauna. Chapter 4 deals with Lanka's Quaternary environment. Prehistoric deposits are assessed in terms of geomorphology and soils, and fauna and flora. Land connections with India and that very special weather phenomenon of South Asia, the Southwest Monsoon, will be treated under discrete sub-headings. Chapter 5 will concern the sub-system of culture, as manifested in the core traits of prehistoric technology, subsistence and settlement. The lithic systematics have been developed by me as a sequel to attribute analysis as pioneered by Movius (and the resultant classification is presented in detail in Appendix II). Miscellaneous items, such as mortuary practices, will also be subsumed in this chapter. Chapter 6 will consider ethnographic data relevant to Lanka's prehistory, with Appendix IV supplying information on the island's edible wild plants. Analogues for the interpretation of the prehistoric record will stem from the hunting and gathering societies surveyed, notably the Vaddas of Lanka.

Chapter 7 will formulate general conclusions based on the preceding accounts. In view of the axiom that no investigation, such as that of the present work, should conclude without projecting a set of problems to be resolved in future studies, thereby assuring continuity within the overall research strategy, I shall be formulating problems with just such an intent. Strategy and tactics for assaying these problems will be discussed at a pragmatic level. Addenda I-III at the end of this work brings up to date the radiometric evidence relating to the pre-, proto- and Early Historic periods of Lanka. They constitute the cornerstone of the chronology as formulated in Chapter 3, which in its turn represents the foundation and spine on which the environmental and cultural data of this treatise hang. Addendum IV seeks to update the data on Indian prehistory since some of what is presented in the main text requires revision in the light of recent advances in this field.

# 2
# SAMPLING

## 2.1 INTRODUCTION

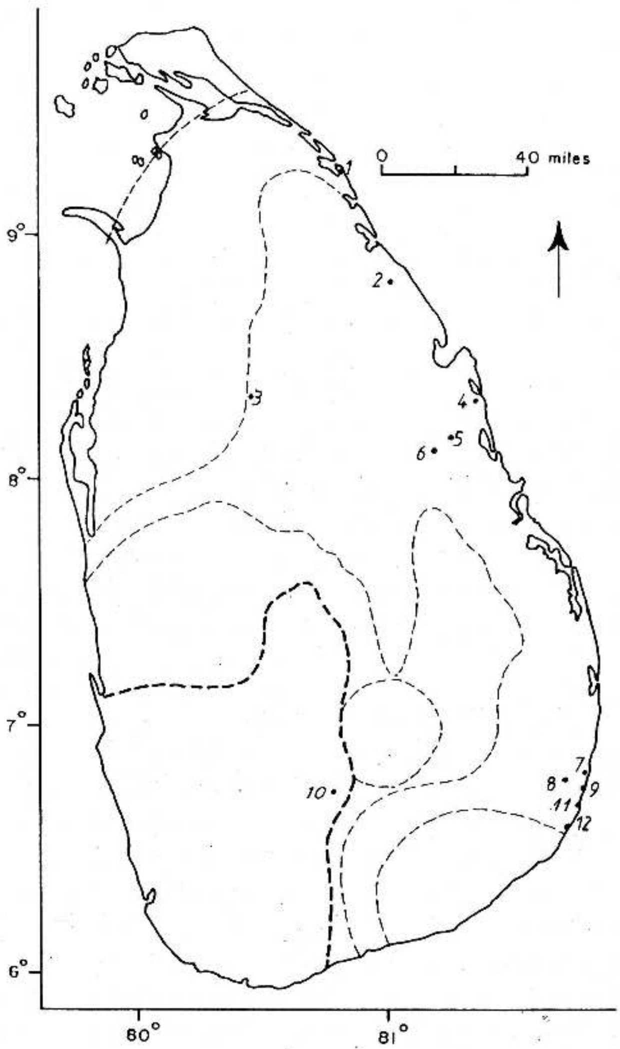
In response to the problems as formulated in Chapter 1.3, the theoretical framework, comprising a palaeo-ecological approach, has been delineated (Chap. 1.4); and in response to this theoretical framework I have, in Appendix I, outlined a set of classifications for Lanka's biotic and physical environments in relation to the requirements of a cultural ecology orientated study. In the present chapter, I shall narrow the methodological field down to the specifics of the strategy and tactics employed in assaying the archaeological problems set out in Chapter 1.3.

While, in problem formulation, it was convenient to list the desiderata in an orderly fashion, it would have been foolhardy to attempt to meet them at a single stroke. A multi-stage approach has been adopted, which permits maximum opportunity of revamping strategy and tactics as research proceeds.

## 2.2 STAGE I: SPOT SURVEY

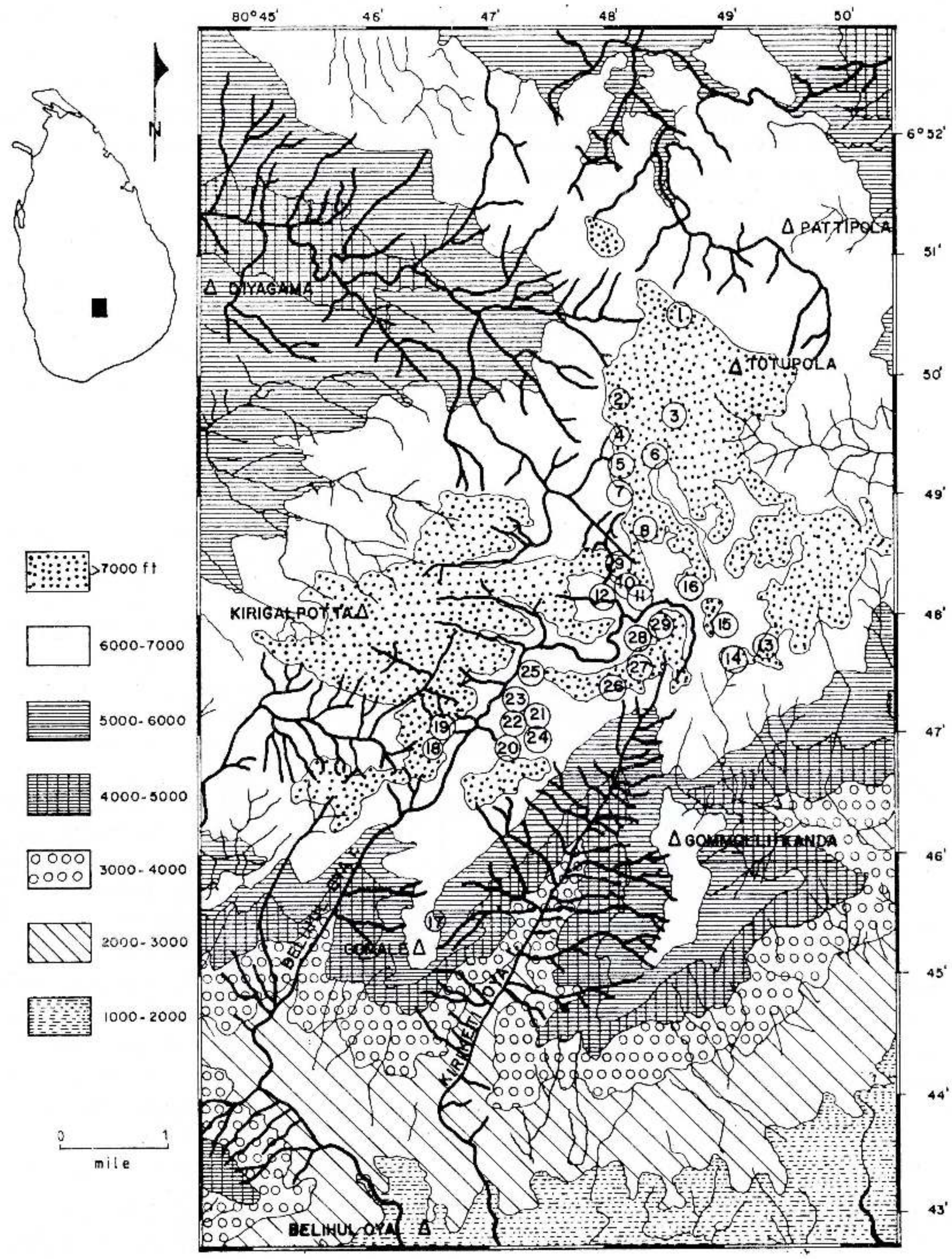
Stage I of the research design comprised a rather unconnected set of probes designed to provide the necessary orientation for more elaborate and cohesive projects. The large collection of stone artefacts from Bellan-bandi Palassa, which had been excavated by P.E.P. Deraniyagala, was analysed on the basis of a breakdown of their attributes (S.Deraniyagala 1971*a*) since these artefacts had not been adequately described by the excavator. This analysis provided the researcher with a fairly clear idea of the range of morphological variability one might expect within a Mesolithic stone artefact assemblage in Lanka. With regard to stratigraphy, it was deemed necessary to conduct a brief excavation at Bellan-bandi Palassa in order to check and amplify on Deraniyagala's published accounts, in addition to clarifying the issue of the presence of pottery in the Stone Age horizon of this site (S.Deraniyagala and Kennedy 1972).

In 1969 the citadel of the Early Historic capital at Anuradhapura was tested by the present writer in collaboration with K. de B. Codrington, Professor of Indian Archaeology at the Institute of Archaeology, London (S.Deraniyagala 1972). The selection of the site itself, which is termed Gedige, was based on P.E.P.Deraniyagala's and P.C. Sestieri's pioneering probes in the 'fifties (Deraniyagala 1958*c*; 1960*c*). The primary goal of this excavation was the delineation of the transition between the protohistoric and Early Historic phases. It was not known whether or not a pre-Iron Age horizon existed at Gedige and it was most gratifying when, towards the last stages of the excavation, the basal cultural layer at the site proved to be Mesolithic. This was the first occasion on which it was possible to establish a culture sequence comprising the Mesolithic, followed by a facies of the protohistoric Iron Age of India, and finally an Early Historic phase distinguished by the ceramic termed "Rouletted Ware". Sarasin's (1907) contention was corroborated, namely, that Lanka lacked both a Neolithic characterised by polished stone celts, as well as a Bronze Age. (For the 1984-5 season of excavation at Gedige and its radiocarbon chronology v. S.Deraniyagala 1986*a*.)




**Map 8** *1* Mullaitivu; *2* Nachchiyar Vellachchi Male; *3* Anuradhapura; *4* Sunkankulli; *5* Trikonamadu; *6* Kandakadu; *7* Kudumbigala; *8* Bambaragas-talava; *9* Okanda; *10* Horton Plains; *11* Itikala; *12* Kumana.

In the realm of regional surveys, it was noted that neither Wayland nor anyone else had explored the coastal sector between Mullaitivu in the northeast and Kumana in the southeast. This hiatus was filled by the present writer in collaboration with W.G. Solheim of the University of Hawaii (Solheim and S.Deraniyagala 1972). Solheim's main aim was to test the hypothesis, first enunciated by P.E.P.Deraniyagala (1957*a*:19), that the prehistoric Malays of the Extensionistic




Map 9 Sites on the Horton Plains (v. S.Deraniyagala 1972*a*)

Period had used Lanka as a stop-over on their sea voyages to Malagasy and Africa. The present writer complemented this programme by charting the Stone Age sites which were encountered in the course of the survey. The results were largely negative on both scores. Solheim received no indication from his data that the Malays had landed on Lanka's east coast; and, as for the Stone Age sites, the entire survey yielded a total of four – three of which were associated with the I Fm around Okanda and Kumana in the southeast. The testing of the impressive cave complexes of Nachchiyar Vellachchi Male, Sunkankulli and Itikala, and the surface survey of the Kudumbigala and Bambaragas-talava caves did not yield any Stone Age cultural material. This confirmed the observations of the Sarasins and the Seligmanns (in the Vadda country of the eastern hinterland), in that, due to some unknown factor, these eminently habitable caves do not contain remains of the Stone Age, whereas the nearby I Fm is dotted with open-air sites.

A second area which had remained relatively unexplored comprised the Horton Plains. It will be recalled that Pole, the Sarasins and Hartley have alluded to this inhospitably damp and cold region in tantalisingly vague terms; besides, there had been a long-standing controversy as to whether the grasslands of these plains were man-induced or natural (Mueller-Dombois and Perera 1971). The upshot was a survey of the Horton Plains in 1971, which brought to light some 25 Stone Age sites, of which the more diagnostic were assigned to the Mesolithic on the basis of lithic typology (S.Deraniyagala 1972*a*).

Finally, in addition to personally examining the Hartley Collection of stone artefacts from Lanka at the Cambridge University Museum of Archaeology and Ethnology (Chap.1.2), an exploration was conducted of the river terraces associated with the lower Mahaweli river, between Kandakadu and Trikonamadu, in the eastern dry lowlands (ecozone B). The results were negative, not a single prehistoric site having been found either on the present flood-plain or on the elevated terraces.

## 2.3 STAGE II: IRANAMADU FORMATION SURVEY

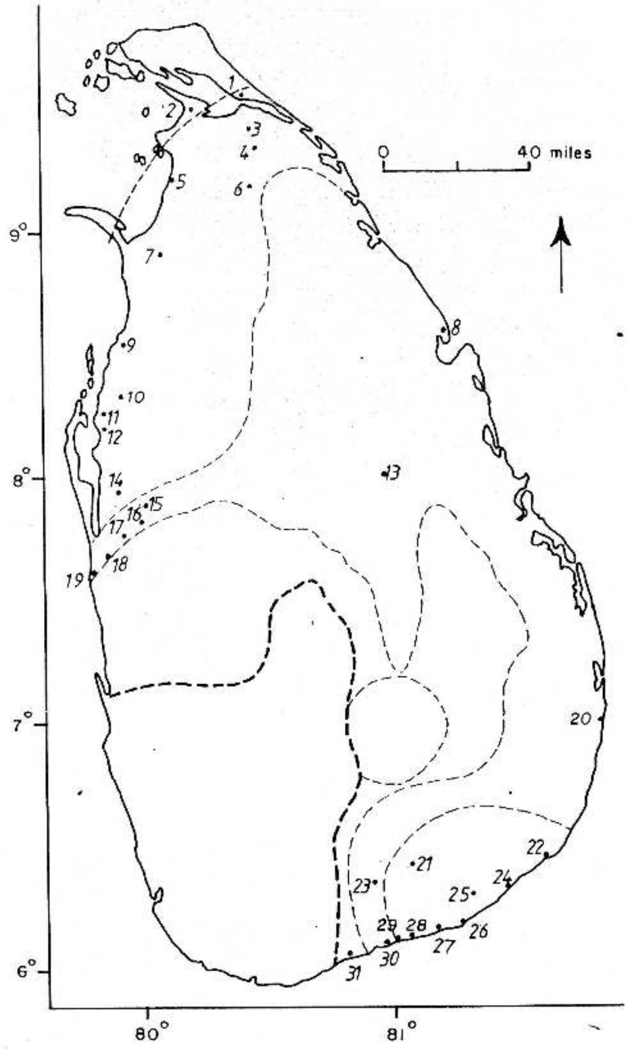
By 1971 the scene had crystallised and it was possible to home in on a specific research programme – although the spot surveys which continued, and which are still being conducted, can be considered a continuation of Stage I of the research design. The problems formulated in Chapter 1.3 led the present writer to focus specifically on the question of the existence of a Palaeolithic culture phase in Lanka. The intention was to direct enquiries in such a manner as to achieve the requisite broad chronological resolution between Palaeolithic and Mesolithic through stratigraphy, artefact typology and any other means within the archaeologist's repertoire. At the same time the ecological theoretical base which I had adopted required that a simultaneous point of focus be the prehistoric environments which would have been relevant to the cultural sub-systems under investigation. Accordingly, the sampling strategy was geared towards these targets.

As for the first goal, that of establishing a generalised chronology, it was necessary to secure data from localities where more than a single type of artefact assemblage was known to exist. The literature (v. Chap. 1.2) indicated that the only sites which might conceivably meet this requirement were those described by Wayland in the I Fm ("Plateau Deposits") (v. Wayland 1919:99; Allchin 1958:180; Senaratne 1969:34,37 for positive affirmation of the possible existence of a Palaeolithic phase in the I Fm). None of the material from the cave excavations, nor the open-air sites which were not associated with the I Fm, displayed any potential for yielding data outside of the Mesolithic. As for the Ratnapura Beds, they lacked adequate chrono-stratigraphic resolution. One exception could have been Wayland's

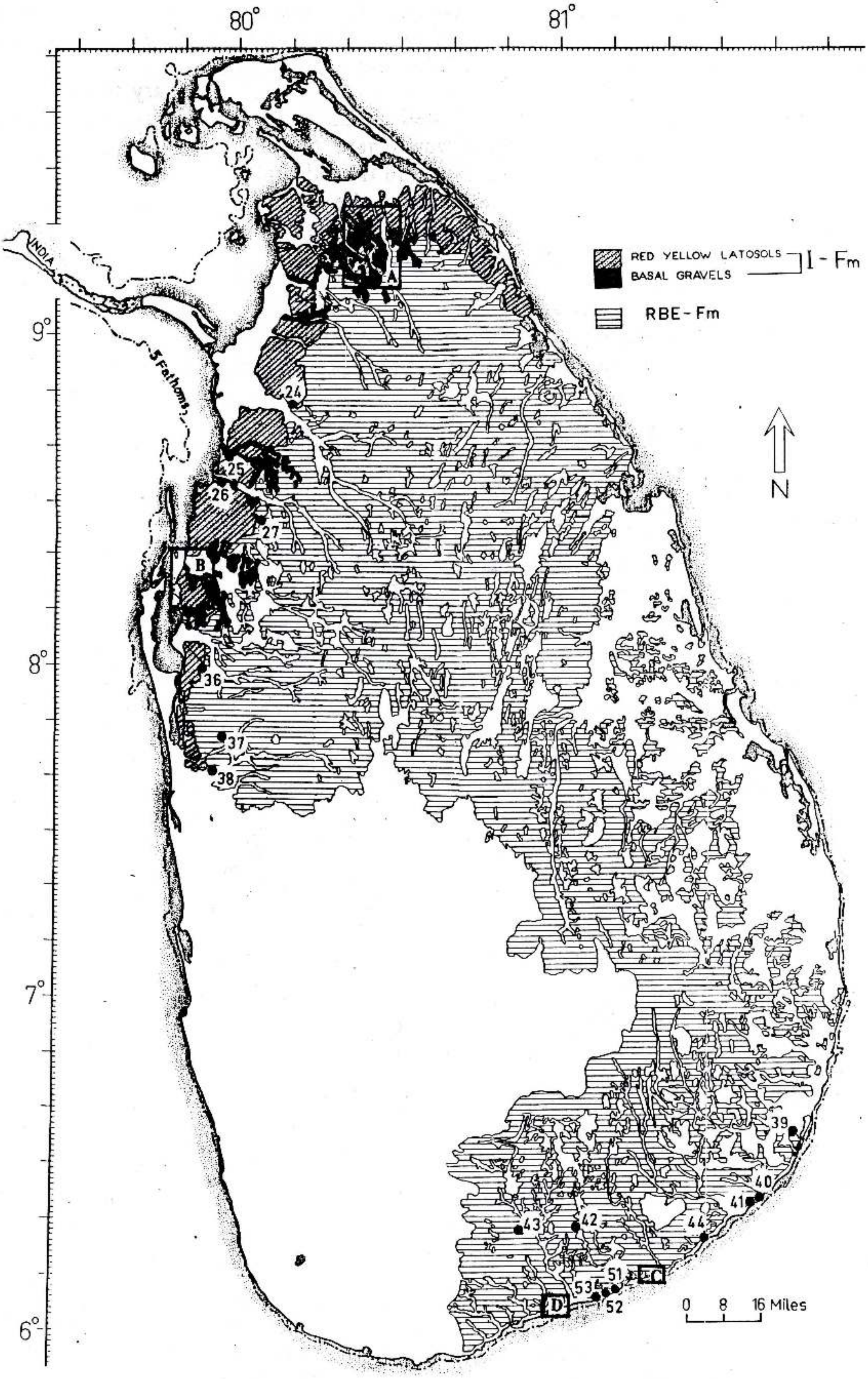
(1914) "Palaeolithic" site on Kosgala Estate, near Ratnapura. But the absence of a stratified sequence at this site and the presence of Mesolithic stone artefacts within the deposit, cast doubts over the Palaeolithic status of the site.

With regard to palaeo-environments, it was deemed necessary to link their study to that of the sites being investigated for their chronology, since (as per the framework of cultural ecology) there would have been no point in studying past environments which bore no direct relation to the cultural material being analysed. Once again, Wayland's I Fm sites constituted the only prehistoric localities which could be considered amenable to rudimentary geomorphological analysis, since cave sedimentology is still a nebulous field in the tropics and the expertise for pollen studies was not available.

Wayland defined the scope of his work on the I Fm thus: "Unfortunately the ... sites ... are hidden away in far jungles in places which are both costly and difficult to get at, and where too, the explorer must risk sickness and discomfort. It is

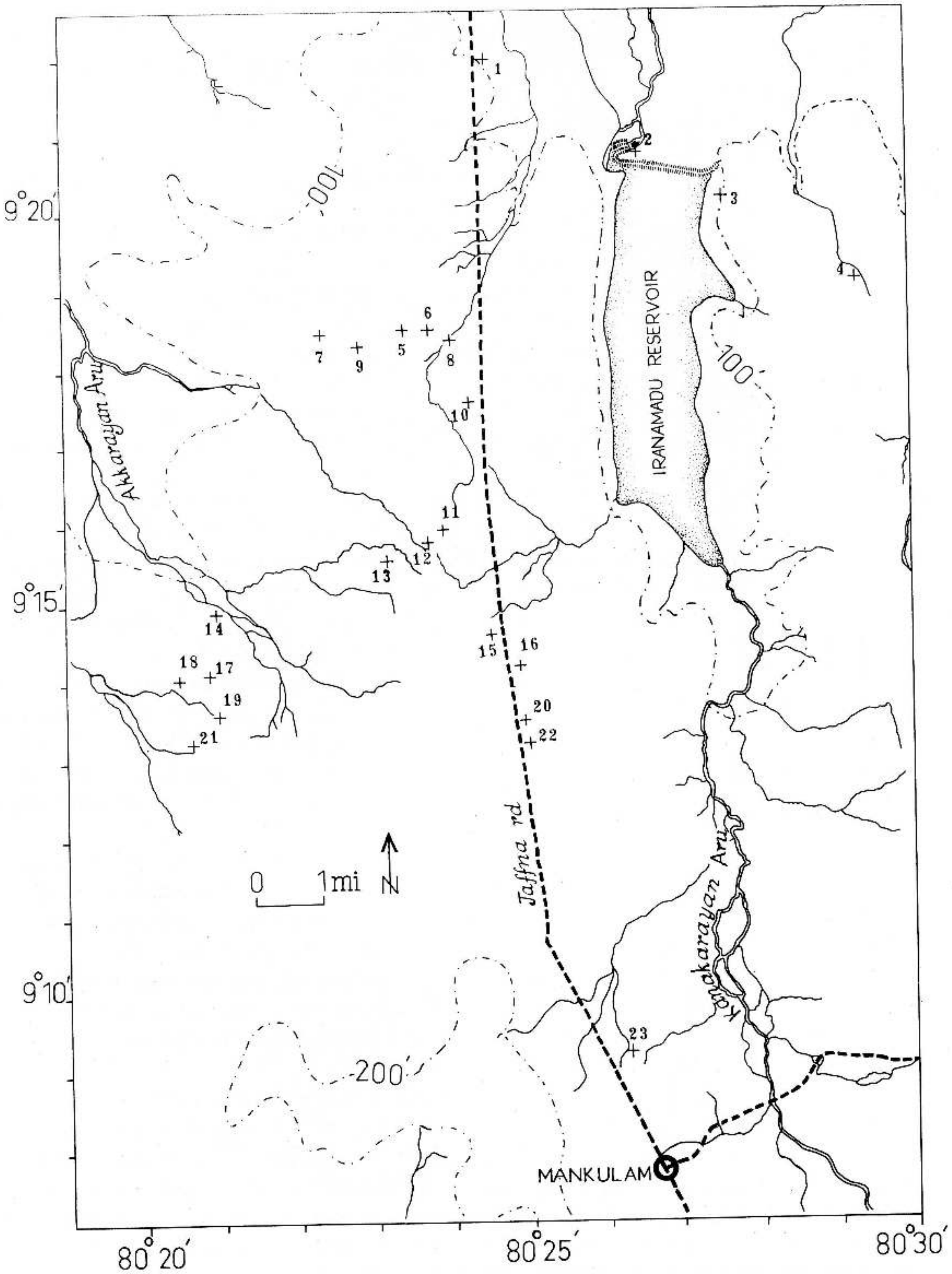



**Map 10** *1* Elephant Pass; *2* Poonakari; *3* Paranthan; *4* Iranamadu; *5* Vellan-kulam; *6* Mankulam; *7* Murunkan; *8* Trincomalee; *9* Marichchukaddi; *10* Pomparippu; *11* Vannati-villu; *12* Arnakallu; *13* Polonnaruva; *14* Palavi; *15* Anamaduva; *16* Andigama; *17* Pallama; *18* Bangadeniya; *19* Chilaw; *20* Pottuvil; *21* Angunakola-palassa; *22* Minihagal-kanda; *23* Embilipitiya; *24* Yala; *25* Tissamaharama; *26* Bundala; *27* Hambantota; *28* Ambalantota; *29* Hungama; *30* Ranna; *31* Tangalla.




**Map 11** Distribution of I Fm and RBE Fm (*by courtesy, Soil Survey, Sri Lanka*). The sites are numbered from north to south. See Maps 12-15 for insets A-D.

unlikely, therefore, that the work which I drop so unwillingly will at once be taken up by others" (1919:85). And again, "if there is any one . . . let him take up the work where I have dropped it; for there he will find himself on the edge of a vast and unexplored territory" (ibid.:124). Deraniyagala's and my own brief incursions into the subject (Deraniyagala 1961; Solheim and S.Deraniyagala 1972) had not added significantly to the information at our disposal. The challenge, Wayland's challenge,




**Map 12** Sites in the I Fm of northern Lanka (inset A in Map 11)

was irresistible, and Stage II focused almost exclusively on a surface survey of the I Fm – including those localities "hidden away in far jungles in places which are both costly and difficult to get at, and where too, the explorer must risk sickness and discomfort".

In order to test Wayland's hypothesis that more than a single industrial phase is present in association with the I Fm, it was necessary to secure a representative sample of artefacts from an extensive surface survey of the deposits. Such a sample was expected to provide a general view of the range of morphological variability present. It was indeed fortunate that the I Fm had been mapped recently by the Soil Survey of the Government of Sri Lanka, under the pedological category of Latosols and their associated basal gavels. Hence, it was possible to home in on these deposits by consulting the 2 inches to the mile (1:36,680) soil maps and an island-wide survey was conducted.

A total of over fifty sites was investigated, from Mullaitivu and Mankulam to Chilaw, and from Okanda to Ambalantota (Map 11). Contextual data were noted whenever samples were found *in situ*. Appendix III constitutes a gazette of the sites investigated during Stages II and III of the research design.

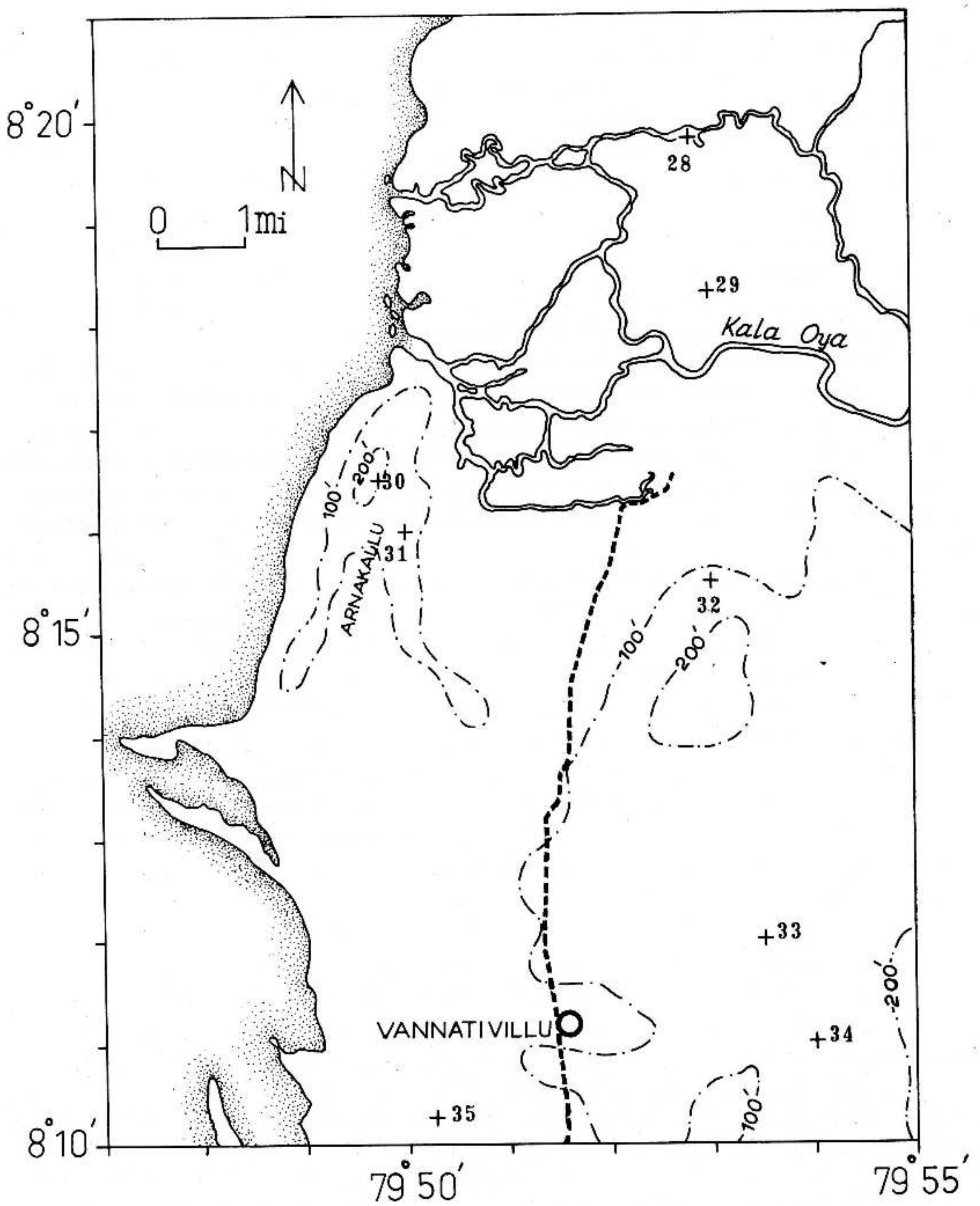
Mankulam was employed as the base for explorations in the northern sector of the I Fm (Map 12). The survey covered the following tracts: Mankulam – New Kokavil – Iranamadu – Elephant Pass; Mankulam – Iranamadu – Old Kokavil – Mutaliyarkulam – Tachchankulam – Olumadu; Mankulam – New Kokavil – Murikandy – Maradunkulam – Uyilankulam – Tunukkai – Vellankulam – Pallavarayankaddu – Poonakari – Paranthan – Puthukkudiyirippu – Oddusuddan – Nedunkeni – Puliyankulam.

Vilpattu National Park and Arnakallu constituted the bases for exploring the north-western sector of the I Fm (Map 13). The survey covered: the entirety of the Vilpattu National Park; Pomparippu – Mullikulam – Marichchukkaddi – Silavatturai – Murunkan – Madhu – Andankulam – Vellankulam; Arnakallu – Vannativillu – Ilavankulam – Puliyankulam; Arnakallu – Puttalam – Tabbova – Kalladi – Palavi – Madurankuli – Bangadeniya – Pallama – Andigama – Anamaduva.

Bundala and the Ruhunu National Park were the bases for the survey of the southern sector of the I Fm (Maps 14,15) covering: the entirety of the Ruhunu National Park, inclusive of Block II, excluding the Strict Natural Reserve; Yala – Minihagal-kanda – Okanda – Panama – Pottuvil; Bundala – Telulla – Tissamaharama – Hambantota – Ambalantota – Hungama – Ranna – Kahandamodera – Tangalla; Bundala – Angunakolapalassa – Embilipitiya.

It came as no surprise that the artefactual finds were all lithic, organic material being notably absent due to the porous nature of the sediments and the severe tropical leaching that these have undergone. The sampling procedure involved collecting selected artefacts from the I Fm, particularly specimens with retouch on them. Certain non-retouched items were selected for evincing specific technological traits or for the type of raw material used. On certain occasions, artefacts of very low analytical significance, such as waste chips, were sampled (in the absence of anything more specialised) simply to record the existence of a site.

Sophisticated sampling procedures, such as those inherent in the various types of probability sampling, were not resorted to. The limitations of such methods when applied to archaeology have been highlighted by Doran and Hodson (1975:96): "Whatever strategy for investigating ... [archaeological] populations may be followed, it will be impossible to claim that the available material is a statistically random sample" (also v. Read 1975). Further, since the selection of a suitable sampling fraction depends on prior knowledge or good guesses about the variability in a given artefact population (Cowgill 1975:263; Judge et al. 1975:89), and since this knowledge was not at hand at the commencement of Stage II, the size of the artefact sample from the various localities investigated was entirely dependent upon a subjective assessment of adequacy.




**Map 13** Sites in the I Fm of north-western Lanka (inset B in Map 11)

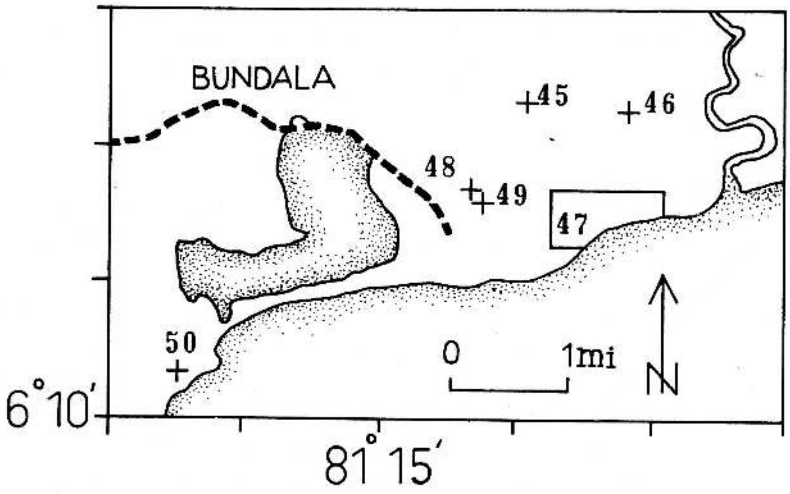
The artefact sample from Stage II being entirely lithic, it became necessary to concentrate on the methodology of stone tool analysis as the primary means of targeting on the goals of this research stage and, as it turned out, of Stage III as well. The systematics employed will be set out in Chapter 5.2.2.

## 2.4 STAGE III: EXCAVATIONS IN THE IRANAMADU AND REDDISH BROWN EARTH FORMATIONS.

The analysis of the lithic sample secured during Stage II produced the following counts. The material excavated from the $1m^2$ probe at Site 49a is excluded, since its sampling was non-selective and hence differed from the procedure employed for the rest of Stage II. Pigments and ecofacts are also excluded.

| *Category* | *Count* | % |
|---|---|---|
| Trimmed, excluding nuclei | 341 | 44.00 |
| Used, but not trimmed and excluding nuclei | 130 | 16.77 |
| Nuclei | 220 | 28.39 |
| Potential Tools (v. Chap.5.2.2) | 38 | 4.90 |
| Waste | 46 | 5.94 |
| Small (< 4.5cm) | 343 | 44.26 |
| Medium-sized (4.5-8cm) | 256 | 33.03 |
| Large (>8cm) | 176 | 22.71 |
| Total | 775* | 100.00 |

The occurrence of microlithic backed semi-lunates and bladelets of less than 2cm in length at certain sites in the I Fm indicated that at least some of the components were of late Upper Palaeolithic or Mesolithic status, by analogy with Europe, Africa and India. However, the frequency of occurrence of large and medium-sized scrapers and choppers did suggest that an earlier phase, perhaps a Middle Palaeolithic, was present, particularly since none of the Indian Mesolithic assemblages contains more than a vestige of these larger elements (v. Zeuner and Allchin 1956; Lal 1958; Sankalia 1965*a*; Misra 1969). Wayland seemed to have




**Map 14** I Fm-related sites in the south (inset C im Map 11).

surmised correctly: "Middle Palaeolithic types" as well as more recent forms appeared to occur in association with the I Fm. It thus became necessary, in Stage III of the research design, to excavate one or more sites in the I Fm to establish if the stratigraphy corroborated the existence of a sequence of Stone Age lithic industries ranging from the Palaeolithic to the Mesolithic.

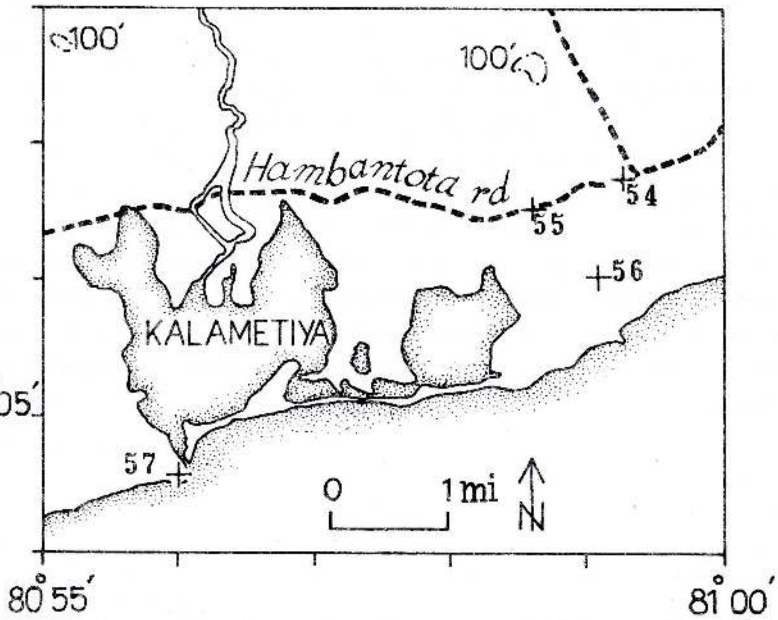
As for the environment of Lanka's prehistoric man, during Stage II of the project I gained access to a Ph.D. thesis submitted to the University of Alberta on the pedology of the Latosols of Lanka (de Alwis 1971). The Latosols have formed on the upper member of the I Fm, namely, on the sandy clay loams (Chap.3.3) and de Alwis states that the parent material of the Latosols are primarily of aeolean origin, as initially proposed by Wayland, and that the facies is most probably coastal. The latosolic weathering, which occurred subsequent to the deposition of the sands, could apparently not have taken place had the climate been significantly wetter than it is today. De Alwis' conclusions are backed up with a considerable array of physical and chemical analyses.

De Alwis, however, did not assay the problem of the genesis of the gravels which underlie the Latosols. It was these same gravels that baffled Wayland; the possibility of a marine origin, as suggested by their relation to the overlying coastal sands, complicated any attempt at climatic inference on the basis of morphology. The hope of a solution to this problem arose upon the discovery of Site 43. At this site, gravels underlay a Reddish Brown Earth, which is the major soil type replacing the Latosols on their landward aspect. The parent material of the loam on which the Reddish Brown Earths have formed, and which overlies the gravels, is considered to be of terrestrial, colluvial origin (Moormann and Panabokke 1961). Hence, it was possible to infer about the climate and conditions under which the associated basal gravels were deposited in a lag facies with greater confidence than was the case with gravels underlying the Latosols. The survey of Stage II further revealed that the gravels underlying the Reddish Brown Earths and the Latosols respectively could possibly comprise correlative stratigraphic horizons, with transitional stages between the two facies, as exemplified at Sites 54, 55 and 57. It was now possible to speculate that the environment which produced the basal gravels of the Reddish Brown Earths was similar to that which resulted in the deposition of the basal gravels of the I Fm. Should the artefactual contents of the two gravels be similar, it would then be possible to tie them in with greater confidence than with stratigraphic observations alone. The artefact sample from the basal level at Anuradhapura (S.Deraniyagala 1972) was indeed associated with the basal gravel of a Reddish Brown Earth, but it was too small a sample for comparative purposes. Hence, it became necessary to excavate Site 43, which was implementiferous, as well as a basal gravel of the I Fm; since the artefactual contents of the latter gravels (as opposed to their associations) were not known. These excavations were to be a part of Stage III of the research design.

Finally, the major hypothesis that the upper member of the I Fm represents coastal sediments created the corollary that they were deposited during a marine regression, or regressions, since they are found at considerable distances inland today. this would, in turn, have meant that the present landward boundary of the I Fm comprises earlier sediments than along the seaward aspect, the depositional sequence having been lateral as the sea regressed. It was thus conceivable that a succession of industries would occur from the inner boundary of the I Fm outwards, the innermost at the highest elevation above present sea level being the earliest. Should there be a Middle Palaeolithic associated with the I Fm it would be more likely to discover it at the inner, landward boundary of the depositional sequence(s), which would comprise the older sediments, than within the younger, seaward boundary. Hence, it was decided to excavate one or more sites on the inner boundary of the I Fm.

A glance at Zeuner's and Allchin's (1956) study of the Tinnevelly *teri* industry in the red consolidated dunes of coastal southern India indicated that the *teri* sediments and their artefactual associations represented the exact Indian counterparts of the I Fm in Lanka. In fact, Tinnevelly is situated at the same latitude as a series of sites in the I Fm of north-western Lanka (inset B on Map 11), the distance between the two sets of sites being a mere 150km. The descriptions by Zeuner and Allchin of the Indian basal gravels overlain by red sands tallied exactly with the appearance of the deposits in Lanka. However, although the Indian stone artefact assemblages were assigned by Zeuner and Allchin to the Mesolithic, they observed what were at least two marine peneplains at ca. 6m and 15m above sea level. It was surmised by them that the aeolean sands had accumulated upon these gravelly peneplains and they considered it possible that the artefacts from the 15m horizon to be more archaic than those from the 6m level, although the sample from the former level was extremely meagre.

There was no doubt in the minds of Zeuner and Allchin that the gravels and sands of the Tinnevelly *teris*, from ca. 30m+msl down to 6m+msl, represented coastal accumulations associated with one or more marine regressions. Here, in their opinion, was a series of Indian sites which could be correlated with eustatic sea levels of the Quaternary, on the assumption that tectonics had not affected the area. However, Zeuner and Allchin never followed up on their initial survey; and since their hypothesis was directly related to the problems enunciated for Lanka, it was naturally to be tested in Stage III. Among the sites investigated during Stage II were three sites at varying heights above sea level: Site 45 at 25m, 50 at 15m and 49 at 7m (Map 14). Excavations at these sites were expected to yield the necessary chronological information.




**Map 15** I Fm-related sites in the south (inset D in Map 11)

In view of the density of artefact scatter revealed in the erosion gullies associated with the sites selected for excavation, namely Sites 43, 45, 49 and 50, it was considered adequate to excavate an area of ca. 20m² at each one of the localities, so as to secure a sample of artefacts which would be representative of the main range of variability occurring within the populations. Two pits, 45a and 45b, each measuring 3m × 3.7m were excavated at Site 45, and one, 50a, measuring 3.7m × 6.1m at Site 50. The main concentration of artefacts in the Latosol at 49b, measuring 3.5m × 5.5m, was found to be relatively close to the surface and it was necessary to open another pit, 49c, measuring 1.8m × 1.8m, to confirm that this horizon of artefact concentration is in fact *in situ* and not a lag deposit. The method of excavation was stratigraphic, to the extent that the following units were sampled discretely of each other:

(*a*) Sandy clay loam, upper member of the I Fm (Latosol)
(*b*) Basal gravel of the I Fm
(*c*) Reddish Brown Earth loam, upper member of the Reddish Brown Earth Fm
(*d*) Basal gravel of the Reddish Brown Earth Fm

Within each one of these categories the excavations were conducted in artificial levels of 30cm each. This procedure was considered justified in view of two factors: (*a*) no more detailed stratigraphic treatment was required for the purpose of testing the hypotheses concerned; none of the hypotheses deal with the progression of industries or assemblage types *within* any of the four major stratigraphic units described above; (*b*) considering the limited funds available for this investigation, it was deemed necessary to avoid spending more than was essential for the testing of the hypotheses. The greater the micro-stratigraphic detail ensured, the greater the expense of excavation per unit volume. There was no need to be worried about destroying for "posterity" what could be thought of as irreplaceable micro-stratigraphic data. The area excavated in Stage III can conservatively be estimated, according to the data from Stage II, to represent no more than 0.1 per cent of the total area covered by similar sites on the island. Should it become necessary, at some future stage, to test hypotheses involving, for instance, the exposure of individual floor plans, there will be no dearth of sites to be sampled.

All of the excavated sediments were dry-sieved through a 6.4mm steel mesh. The sampling of the artefacts was very close to exhaustive, as revealed by frequent inspections of the spoil heaps after rain. The site data are set out in Appendix III.

As was expected, in keeping with the findings of Stage II, the excavations did not yield non-lithic artefactual material (excepting a single abraded piece of deer bone from 50a). Hence, once again as in Stage II, the analytical procedure to be followed devolved inevitably upon lithic typology – a procedure which can be considered adequate for reaching conclusions with regard to the Palaeolithic (as opposed to Mesolithic) status of any one of the assemblages sampled. A total of over 200,000 artefacts was analysed, in accordance with the system outlined in Chapter 5.2.2. Some of the quantitative results are as follows. Pigments, ecofacts and stone artefacts sampled selectively from the lag deposits on the surfaces of Sites 45a and 49b are excluded:

| *Category* | *Count* | *%* |
|---|---|---|
| Trimmed, excluding nuclei | 899 | 0.44 |
| Used, but not trimmed and excluding nuclei | 408 | 0.20 |
| Nuclei | 9,047 | 4.44 |
| Potential Tools | 2,713 | 1.33 |
| Waste | 190,544 | 93.58 |
| Small (<4.5cm) | 201,486 | 98.96 |
| Medium-sized (4.5-8cm) | 1,899 | 0.93 |
| Large (>8cm) | 226 | 0.11 |
| Total | 203,611 | 100.00 |

The low percentage (0.44%) of retouched and utilised (0.20%) tools secured in the excavations of Stage III is noteworthy. An interesting study on bias in sampling procedure can be made by comparing the percentages of artefact categories secured in Stages II and III. It is quite evident that the sampling in the surface survey was biased towards obtaining "Middle Palaeolithic" types, as suggested by the high proportion (55.74%) of medium-sized and large artefacts from Stage II compared to 1.04% in the excavated sample. Wayland's conceptions were obviously dominant when sampling in the shimmering heat of the *vembus*. With reference to the remarkably low percentages secured of retouched tools, I shall, in the sub-heading on lithic systematics (Chap.5.2.2), refer to the effect it has had on the quantitative base of the respective lithic types.

From Stages I through III, particularly in Stage III, the requirements of effective sampling procedure have been met: "To select the most productive sampling design for a project, the researcher must clearly outline both the project's goals and the data that must be collected to satisfy these goals. He must assess the adequacy of the proposed investigatory procedures for collection of the required data. In addition, decisions about the necessary precision and reliability of the results must be made before beginning data collection" (Redman 1974:3).

I have, in this chapter, delineated the methodology of sampling employed with reference to the study of Lanka's prehistoric past. The sequel to Stage III, namely Stage IV of the research design, is to consolidate and interpret all of the available data on Lanka's prehistory, within the methodological framework outlined in this work. The chapters which follow will, in fact, constitute this Stage IV, and they will comprise a synthesis of the data, including those derived from Stage III, and data from disciplines outside of strict archaeology will (for the first time) be extensively drawn upon for archaeological purposes in Lanka.

Meanwhile, certain new projects have been launched: the excavation of Beli-lena cave, Kitulgala, and Batadomba-lena cave at Kuruwita. The final reports are being prepared by the respective field directors. But the preliminary results are of startling significance and will be referred to under their respective subject headings (v. Addenda I-III).

# 3
# CHRONOLOGY

## 3.1 INTRODUCTION

The present chapter probes into the Quaternary chronology of Lanka. Note that I have refrained from attempting a division into Pleistocene and Holocene chronologies, since the technological and environmental data do not warrant such a procedure: the Upper Pleistocene and the Holocene constitute a continuum technologically and faunistically.

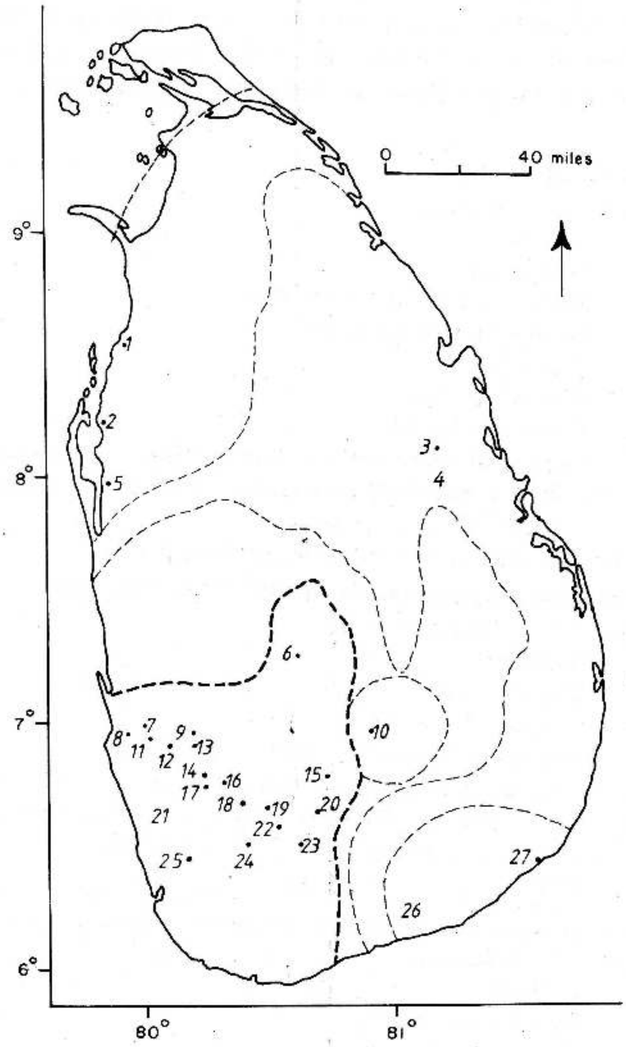
The alluvial deposits of Lanka, represented principally by the Ratnapura Beds, will be considered first, since they appear to contain traces of some of the earliest human habitations on the island, namely the Ratnapura Industry. The very insecure state of our knowledge concerning these deposits has necessitated the expedient of cross-dating by extensive comparisons, primarily faunistic, with India and further afield.

The data from caves and open-air sites, from the Upper Pleistocene onwards, are on a sounder footing than those from the alluvial deposits, although additional resolution from more radiocarbon dates is definitely required. The fossil dunes with prehistoric sites, which constitute the Iranamadu Formation are much less securely dated, the basis being eustatic geo-chronology coupled with a recently developed application of thermoluminescence dating. In both these sub-headings (Chap. 3.3 and 3.4) technology will be touched upon but briefly, to the extent that this subject has a bearing on chronology, since it will be dealt with in detail in Chapter 5.2.

## 3.2 RATNAPURA BEDS AND OTHER ALLUVIA

*3.2.1 Stratigraphy.* The Ratnapura Beds are alluvial sediments filling the valleys of the Ridge and Valley country (physiographic Sub-Zone 2 of App.I) in the south-western and south-central hinterland. The denudation of the less resistant rocks of this region has given rise to a very prominent series of parallel ridges of Charnockites and so-called metamorphic quartzites, often steep-sided, which follow the arcuate strike of the rocks. The strike valleys which separate these ridges are filled with alluvium, the Ratnapura Beds. Transverse valleys cut across the ridges along joint planes, forming a trellis pattern with the main strike valleys (Cooray 1967:67). The ridges become higher towards the south where they reach elevations of over 1,000m in the Rakwana hills. Rivers and streams are numerous and perennial in the Ridge and Valley country (for schematic section v. Wadia and Fernando 1945).

The Ratnapura Beds have been mined by traditional methods for their precious stones which are extracted by panning. They occur in the heavy mineral placer deposits within gravel (mainly quartz) horizons. The mining has until recently been restricted to the area encompassed by Getahetta, eastwards through Kuruwita, Ratnapura and Pelmadulla up to Balangoda, and southwards towards Badureliya, Kalawana and up into the Rakwana massif (Maps 16,17; Deraniyagala 1940*a*:357-9; 1943:98; Wadia 1941*a*:10; Cooray 1967:198).




**Map 16** *1* Kudiramalai; *2* Arnakallu; *3* Kandakadu; *4* Mahaweli r.; *5* Puttalam; *6* Peradeniya; *7* Biyagama; *8* Kelani r.; *9* Avissawella; *10* Welimada; *11* Malwana; *12* Hanwella; *13* Getahetta; *14* Eheliyagoda; *15* Horton Plains; *16* Kuruwita; *17* Ellawala; *18* Ratnapura; *19* Pelmadulla; *20* Balangoda; *21* Kalu r.; *22* Kahawatte; *23* Rakwana; *24* Kalawana; *25* Badureliya; *26* Valave r.; *27* Minihagal-kanda.

A series of faunal remains and artefacts have been found in the course of gem-mining. The former are termed the Ratnapura Fauna and the latter the Ratnapura Industry. As is to be expected, the distribution of these two categories is very nearly co-extensive with that of the gem mines.

The Ratnapura Beds are not found in a consistent stratigraphic sequence. They are primarily localised alluvial horizons laid down under varying conditions.

The artefact-bearing and fossiliferous "gem gravels" usually occur at the base of the sedimentary sequence, although as many as seven gravel horizons, each one grading into sands, silts and clays, have been observed within a single section. Most gravel horizons do not exceed ca. 1m in thickness (Deraniyagala 1944:22-4; 1958:15,31). The gems are considered to be derived from pegmatite veins in the Highland Series which constitutes the country-rock (for geology, v. App.I.2). Due to a general lack of public interest, the majority of the artefacts and faunal remains, even if they should have been identified as such, continue to be discarded by the miners.

The Ratnapura Beds range up to about 30m in thickness, as in the Kuruwita basin (Deraniyagala 1958:23). The modal thickness, however, appears to be around 7m (id. 1944:22-4), although massive accumulations from earth-slips can result in much greater thicknesses of sediment, as in the Rakwana region. Some typical sequences within the Ratnapura Beds, as described in gem-miners' terminology, are as follows:

(*a*) Mine at Balahapuva (id. 1960:5)

| *Thickness (m)* | *Stratum* |
|---|---|
| 0.00 | Surface |
| 2.00 | Black mud |
| 2.00 | Redeposited Red-Yellow Podsol |
| 1.00 | Sand with leaf fragments |
| 0.50 | Blue clay |
| 0.30 | Fine white sand |
| 0.15 | Compacted sand |
| 0.30 | Gem sand with fossils of *Homopithecus, Hexaprotodon, Rhinoceros kagavena, Elephas maximus, Axis axis, Cervus unicolor unicolor* (v. $eU_3O_8$ assay below). |
| | Bed-rock at 6.75m below surface (-gl) |

(*b*) Mine at Lindagava-kumbura, Muvagama (id. 1951:31; 1963:20)

| *Thickness (m)* | *Stratum* |
|---|---|
| 0.00 | Surface |
| 2.00 | Clayey loam |
| 3.50 | Greyish clay and sand |
| 0.15 | Fine black sand and gravel |
| 0.75 | Compact black clay and leaf remains |
| 0.15 | Black gem gravel with fossils of *Homopithecus, Hexaprotodon, Rhinoceros kagavena, Leo leo,* bovines. |
| | Bed-rock at 6.55m -gl |

(*c*) Mine at Thotapitiyage-watte, Manan-ela, Ellawala (id. 1963:9)

| *Thickness (m)* | *Stratum* |
|---|---|
| 0.00 | Surface |
| 1.00 | Brown surface loam |
| 1.00 | Yellowish clay |
| 0.30 | Blue-grey clay with some sand; water-table |
| 2.00 | Blue clay |
| 0.30 | Dark clay with vegetable remains, e.g., resin |
| 0.15 | Sand with leaf remains |
| 0.60 | Brownish yellow sand |
| 0.15 | Gem sand with mandible of *Hexaprotodon* |
| | Bed-rock at 5.50m -gl |

(*d*) Mine at Thotapitiyage-watte, Manan-ela, Ellawala (ibid.: 19)

| *Thickness (m)* | *Stratum* |
|---|---|
| 0.00 | Surface |
| 1.00 | Bluish clay |
| 0.30 | Dark brown clay with leaf fragments |

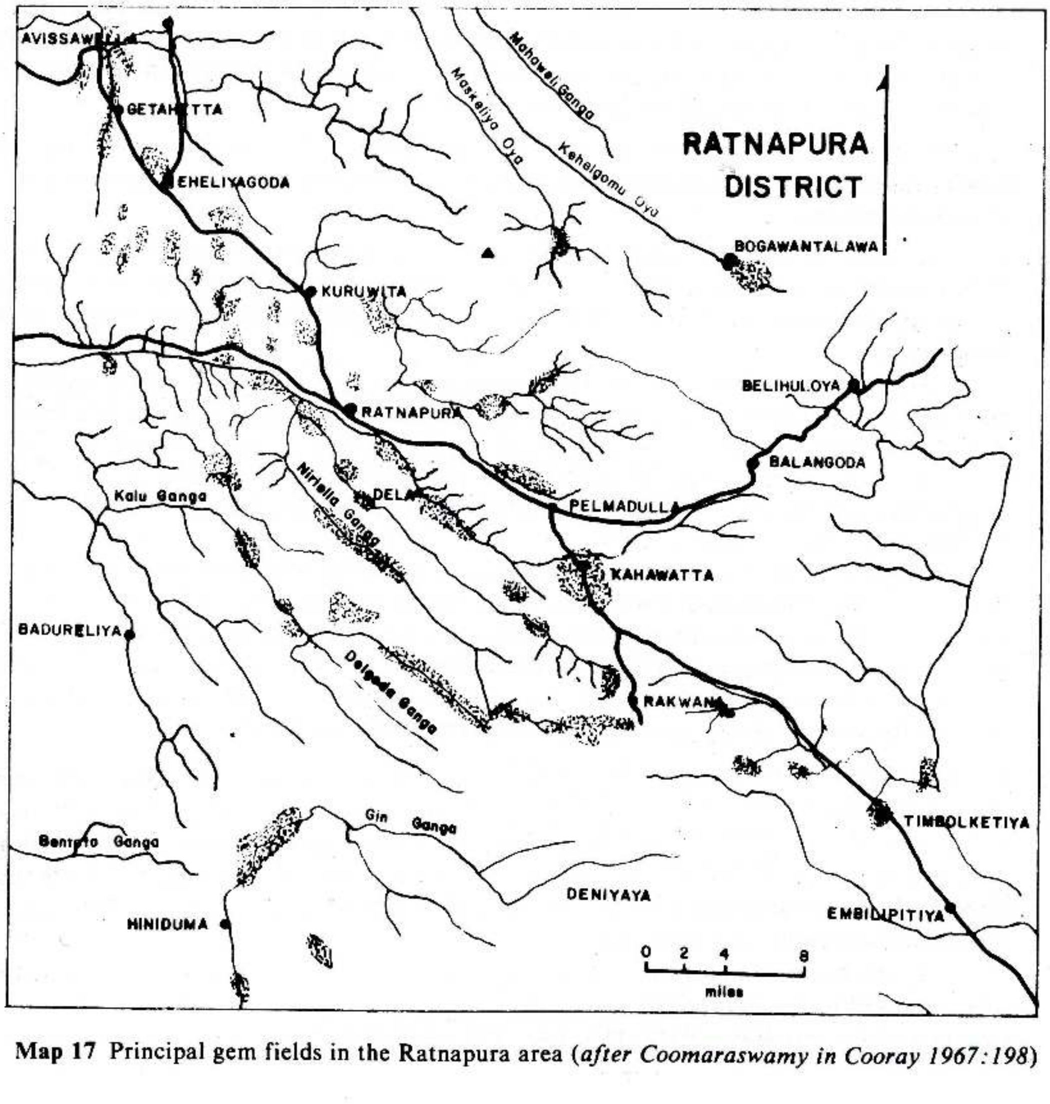
| | |
|---|---|
| 0.60 | Dark brown fine sand |
| 0.50 | Gem sand with *Bibos, Elephas maximus* |
| | Bed rock at 2.40 m -gl |

(*e*) Mine at Nuge-ovita, Demala Poruva, Karangoda (ibid.: 13)

| *Thickness (m)* | *Stratum* |
|---|---|
| 0.00 | Surface |
| 1.50 | Loam |
| 3.00 | Red-Yellow Podsol, loam |
| 2.00 | Clay |
| 1.30 | Clay with leaf fragments |
| 0.00 | Ferricrete |
| 1.00 | Gem gravel with tibia of *Hexaprotodon* |
| | Bed-rock at 9.40 m -gl |

(*f*) Mine at Kanukatiya, Karangoda (id. 1960: 8)

| *Thickness (m)* | *Stratum* |
|---|---|
| 0.00 | Surface |
| 1.00 | Loam |
| 0.50 | Coarse sand |




**Map 17** Principal gem fields in the Ratnapura area (*after Coomaraswamy in Cooray 1967: 198*)

| | |
|---|---|
| 0.30 | Blue clay |
| 1.00 | Blue clay with sand |
| 1.00 | Greenish clay |
| 0.30 | Sand |
| 0.15 | Ferricrete |
| | Gem gravel with *Rhinoceros* sp., *Hexaprotodon. Elephas maximus* (v. $eU_3O_8$ assay below). |
| | Bed-rock at 4.25m -gl |

There are a few deposits in Lanka, which could be considered potentially to be of Pleistocene age, but which are not among the Ratnapura Beds. There is no dating evidence whatsoever with regard to these deposits, but they do merit being placed on record as follows:

(*a*) The Moongil Aru Formation in the northwest, between Arnakallu and Puttalam (Hanreck and Sirimanne 1968:11-22). This deposit could be of Pliocene or Pleistocene age. It overlies the Miocene limestone, possibly unconformably. Its lithology is varied, comprising clays, lenticles of shale, coarse- and medium-grained sands and sandstones, and reef-type and sandy intercalations of limited extent. As with the Miocene strata, the deposit thins visibly towards the east, from a thickness of ca. 200m in the west. The upper boundary of the Moongil Aru Fm has not been adequately defined. The 10m of coarse to very coarse sand lying between the Miocene and Quaternary deposits in the region between Puttalam and Jaffna (Golani 1967:9) could correlate chrono-stratigraphically with the Moongil Aru Fm. No artefacts or macro-faunal remains have been observed in these sediments.

(*b*) The brown, marly sediments, possibly of a deltaic facies, occurring unconformably beneath the I Fm (App.I.3) and above the Miocene limestone at Minihagal-kanda, Yala. I have not been able to find any artefacts or macro-faunal remains in this deposit, although intensive investigations have yet to be carried out.

(*c*) The basal ferruginous grits, often violet to crimson in colour, underlying the implementiferous I Fm at Kudiramalai, Vilpattu. These grits have not yielded artefacts or faunal remains.

(*d*) Two fluviatile terraces are said to occur in the lower reaches of the Mahaweli river (C.R.Panabokke 1968:pers. comm.). $T_1$ at ca. 30m +rl is characterised by a reddish colour, and is observable near the Mahiyangana rest-house; and $T_2$ is said to exist above Manampitiya.

There is a ca. 10m +rl terrace clearly visible at Kandakadu, where extensive gravel sheets are found capped by silts. I am not aware as to what position this terrace takes in the Mahaweli sequence; perhaps, it correlates with $T_2$ and it is possible that a late Eem or early Würm date is assignable to this deposit if one assumes a eustatically determined sedimentation facies. Explorations in this area failed to produce any artefacts or faunal remains.

The soils on deposits of $T_1$ are frequently of the saline Solodised Solonetz category (Moormann and Panabokke 1961:30), which suggests a marine transgression due to eustatic and/or tectonic factors. If the former, this terrace, being close to the coast, may tentatively be dated to the Holstein interglacial of ca. 0.3 my BP. It is significant that the varieties of rice cultivated in this area, from the coast inland up to Kantalai, are selected for their tolerance to salt (P.Deraniyagala 1966:pers. comm.).

(*e*) The Kelani river valley is said to have two terraces above the present flood-plain (Coates 1913; Wadia 1941*a*:10). $T_1$, constituting the Malwana Formation (Map 6), is at ca. 16m +rl. Cooray (1967:155) affirms that it caps the ridge running beside the river, as at Ranala and Navagamuva villages on the south side and at Mapitigama, Welgama, Chittipatire and Wiyalananda on the north. Outliers are visible downstream at Biyagama, Waragoda and Talangama.

$T_2$ the Ranala Formation (ibid.), occurs at 6-8m +rl (ca. 10m +msl). It is said to consist of sediments similar to those of $T_1$, namely horizons of well-rounded quartz gravels within a lateritic matrix. The deposit reaches a thickness of ca. 4m. Its outcrops occur below Hanwella, near Ranala, and at several localities on either side of the river, some being situated away from the present course of the river.

These two terraces are adequately close to the coast to be considered thalasso-static in origin. Hence, $T_1$ can tentatively be dated to the Eem interglacial of ca. 125,000 BP and $T_2$ to the late Eem or an early interstadial in Würm. I am adopting here, for convenience, the general glacio-eustatic Pleistocene chronology as set out by Butzer (1971:43-4; also v. Flint 1971:342; Larsen 1975:46). It would be interesting to compare these terraces with the fluviatile terraces of Tamilnadu, India (Chap.3.4).

(*f*) Alluvial gravels at 15-20m +rl are said to occur at Avissawella (above the Sitavaka river), Peradeniya (narrow terrace strips of the Mahaweli, with rounded pebbles on hill summit (Seligmann and Seligmann 1911:20)), and Madampe Estate (on the Madampe-oya near the Hulanduwa-oya) in the Southern Province (Cooray 1967:156).

(*g*) Maha-oya valley, between Wattegama and Kurivella has a 30m +rl alluvium which has been terraced for paddy.

(*h*) A gravel terrace, 4m thick, resting on bed-rock at 17m above the Badulla-oya on the road to the Spring Valley Estate (Parsons 1908*a*; Cooray 1967:156).

(*i*) Four to five horizons of rounded pebbles at various heights above the Uma stream, Welimada (Deraniyagala 1963*a*:2).

(*j*) A fluviatile gravel at ca. 17m +rl capped by a colluvial silt at Locality 19 in the Horton Plains (Map 9; S.Deraniyagala 1972*a*:19). I did not find any artefacts in this deposit.

Although the ten localities mentioned above are potentially of Pleistocene Age, no significance can be attached to them until further dating evidence is forthcoming. They can, meanwhile, be listed as important areas for future research. The alluvial terrace gravels of the western coastal hinterland will be considered in Chapter 3.3.2

On the present evidence it is clear that the Ratnapura Beds are very significant for Pleistocene studies in Lanka. The typical sequence of these beds appears to comprise a basal gravel or sandy gravel grading upwards into sands, silts and clays, with ferricretes occurring at the approximate level of the current water-table. There is nothing unique or even characteristic about these Ratnapura Beds. A fair probability exists that some of the components have been derived from older sedimentary beds and there could have been several repetitions of this process. However, concerning the possibility of an inverted landscape prevailing today, where old valleys are now mountain crests and old mountains eroded into being valleys, the geology of the Ridge and Valley country is not conducive to such an event, the erosion pattern being governed by the relative resistance of the different stratigraphic horizons to weathering.

As to what effect tectonic movements would have had on the geomorphology of the Ratnapura Beds, very little can be surmised. It is often the case that the present stream channels flow at 6-10m above the gem gravels (Deraniyagala 1947:3), suggesting either that the land has subsided, forming alluvial basins, as in certain parts of peninsular India (Chap.3.3), or that the Holocene rise in sea level has resulted in a thalasso-static accumulation of sediments, or else that both processes had been in operation. Gem miners do hold a belief that the gem gravels slide along the bed-rock. If this should be the case, tectonic causes could be invoked.

One day, perhaps, a series of drill cores will plot out the sequence of knick points, representing Pleistocene glacial phases, receding along the main rivers into the Ridge and Valley country, thus facilitating correlations between eustatic levels and the Ratnapura Beds. However, borings along the Kelani and Kalu rivers, at ca. 1.5km inland from the coast, register bench depths of 10-20m below the present channel beds (id. 1958:12), which suggests that Würm knick points, commencing at ca. 100m -msl, have not been able to progress far through resistant Precambrian crystallines. An investigation of the ferricrete horizons in the Ratnapura Beds could be instructive with regard to water-table levels in the past, which in turn could have been thalasso-statically determined. However, this would assume that ferricrete survives as a fossil soil and that tropical leaching will not affect it significantly.

It has been affirmed (id. 1944:24; 1963*a*:2) that artefacts and faunal remains are usually found within or on the surface of the gravel or sand horizons of the gem pits and that they scarcely ever occur within the silts or clays. This could signify that the artefacts and fossils have been transported and that *in situ* archaeological deposits are lacking. However, considering the paucity of artefactual and fossil finds from the Ratnapura Beds, it is very likely that a closer scrutiny of the silt and clay members (which are not even examined by the gem miners) would yield *in situ* occupation sites. It is also possible that some of the unworn artefacts from the gem gravels do represent specimens which are *in situ* where prehistoric man would have left them.

*3.2.2 Technology.* A few artefacts have been found in the Ratnapura Beds, and these constitute the so-called Ratnapura Industry. In certain cases the objects termed artefacts are of questionable status. Some of the valid examples are included in Appendix II. Stratigraphic data on some purported artefacts from the Ratnapura Beds follow; further references may be secured from P.E.P. Deraniyagala's publications, (e.g., 1945).

(*a*) A flat discoidal chopper, ca. 14cm in diameter, Type 71 (Fig.10(4); v. App.II), was found in the gem gravel at ca. 6m -gl at Dehigaha-tenne, Kattange, 4km up the Ve river from Kahawatte (id.:1945:123,133-4; 1958:60).

(*b*) A purported artefact was found on the surface of a gem gravel at ca. 5.5m -gl at Bandara Bogavala, Dodampe. Three fossils of *Hexaprotodon* were found within the gem gravel, in indirect association with the artefact (id. 1958:60).

(*c*) A purported artefact was found in a gem pit at Gal-edanda Mandiya, Gonapitiya, in association with a fossil of *Hexaprotodon* (id. 1948:F19).

(*d*) A purported artefact was found in a gem gravel at ca. 2m -gl at Ambalandora (id. 1945:123).

(*e*) A medium-sized unifacial scraper of rock-crystal, with edge-trimming, was found in a gem sand at ca. 2.5m -gl at Bandara-watte, Eheliyagoda (ibid.:131,Fig.3c).

(*f*) A large convex chopper was found in a gem gravel at Narangwatte-ovita, near Pelmadulla (ibid.:132,Fig.4b).

(*g*) A water-worn so-called artefact of chert was found in a gem pit at Pahalewala, Gonapitiya, Kuruwita (id. 1958:131). A gem pit 2m away yielded a lion's canine at a similar depth. It can be assumed that this so-called artefact came from the same stratigraphic horizon as the fossil tooth.

(*h*) A pitted pebble (Type 109; v. App.II) is said to have been found in gem sands at ca. 9.5m -gl at Achariya-ovita, Ellawala (ibid.:77). *Paludomus* shells and a bovine tooth were found in association.

(*i*) A pitted pebble (Type 109) was found in a silt at 5.5m -gl and 1.5m above the gem gravel at Mativala-deniya, Pohorabava (id. 1946*a*:F4;1958:76). There is some likelihood that this artefact is much more recent than the gem gravel, although technically it is an inclusion within the Ratnapura Beds. *Elephas* and *Hexaprotodon* were found in the gem gravel.

Certain miscellaneous lithic finds which might be assignable to the Pleistocene are as follows:

(*a*) Water-worn artefacts were found in a gem gravel, overlain by 10m of silt at loci 20m from the Valave river at Hathkinda (id. 1957*a*:6).

(*b*) High level gravels on Kelani river, for example around Malwana and Ruwanwella, are said to have produced chopper artefacts on pebbles (Wayland 1956:150). These were surface finds and hence are chrono-stratigraphically indeterminate.

(*c*) Horton Plains, Locality 22 (S. Deraniyagala 1972*a*:20). A large waste flake of quartz was found in an unsorted gravel (of variable angularity) resting on bed-rock. The gravel was 0.5m thick and capped by ca. 2.5m of silt grading into clay. The present stream level should be at ca. 2m above the top of the gravel. However, gem mining has wrecked the stream morphology, making the reconstruction of the undisturbed bed-height difficult. The stream is currently either aggrading or in equilibrium. The gravel would have been deposited during a phase of immature drainage.

(*d*) Wayland (1914:117-8) mentions a considerable area, littered with artefacts, on Kosgala Estate, Ratnapura. The surface material comprised Mesolithic and suspected Palaeolithic elements. The latter are said to be represented by several large artefacts, including flakes of clear quartz and water-worn choppers. These occur along a quartz ridge (?vein *in situ*) at ca. 10m above the Kalu river. The alluvial (vs. colluvial) nature of this deposit has not been determined. A test pit yielded artefacts. My own efforts at locating this site have not been successful; however, I suspect a Mesolithic assemblage, with a chopper component, in a colluvial rubble. The presence of a Palaeolithic element is unlikely, although further investigation might prove the contrary.

(*e*) Small quartz flakes have been found in compacted sand overlain by 1m of leaf debris, overlain in turn by 13m of fluviatile sands, at Dambulvana on the Kalu river (Deraniyagala 1947:5). The implementiferous horizon is only exposed during extreme droughts when the river level drops. The present ground level at 14m +rl can possibly be correlated with a high sea level, which would mean that the artefacts antedate this event. The small size of the artefacts does not preclude them from being Palaeolithic: note the small tools from Vérteszöllös, Hungary, at ca. 0.4 my BP (Bordes 1968:89,92). This site deserves a detailed scrutiny.

(*f*) Pitted hammer-stones (v. App.II; Type 109) and nut-stones (Type 111) were found in a bed of ferricrete at Tun-modera, on the Vak-oya, which is situated almost at sea level (Deraniyagala 1965:185). The ferricrete is capped by ca. 6m of alluvial sands, silts and clays (id. 1965*b*). This suggests that the terrain here has been submerged by ca. 6m due to a rise in relative sea level through eustasy, tectonics, or both – although the 6m of alluviation could be the result of flash floods. Should the possibility of the latter two factors be discounted, which is scarcely justifiable, the surface of this deposit might be correlated with a 6m high sea level during Würm and the implentiferous ferricrete could be earlier. But this is unwarranted speculation.

The stone artefacts from Dambulvana, the Kelani river terrace, Hathkinda, the Horton Plains, and perhaps even the so-called palaeoliths from Kosgala Estate, can be assigned tentatively to the Ratnapura Industry, pending further data from these localities.

Summing up, the Ratnapura Industry, as known from a very small sample indeed, comprises a basic tool kit of core and flake tools, characterised by choppers and scrapers, made of quartz and chert. Typologically, all the artefacts discovered so far are useless as chronological indicators and as stylistic markers. Terming it a core-tool industry with choppers akin to those of the Early Soan of the West Punjab (id. 1937*b*:262; 1940*a*:359; 1942:124; 1943:93; 1954:116; 1961*a*:18) is meaningless. Chopper industries – such as the Oldowan of Tanzania (v. Leakey et al. 1971), Clactonian of Europe, Anyathian and Patjitanian of Burma and Java (Movius in de Terra, Movius and Colbert 1943) respectively, and the assemblages from Choukoutien Locality 1 – are found throughout much of the Old World simply by virtue of their being assemblages without any artefacts with form-trimming such as is found on Acheulean bifaces (for definition of edge- and form-trimming v. lithic systematics in Chap.5.2.2). Such artefacts are found from the Oldowan of East Africa (Shungura Fm, Koobi Fora, Olduvai Bed I), commencing ca. 3 my K/Ar BP, down to the Mesolithic at Bellan-bandi Palassa in Lanka (Leakey et al. 1971:1,280; Isaac 1969:5,13,15; 1971:12; 1972; Isaac, Leakey and Behrensmeyer 1971; Deraniyagala 1958*a*:246; S.Deraniyagala 1971*a*:Pls.17,18). As for patination, it is, as is well known, of no use as a method of relative dating; for instance, the bronze-coloured patina found on certain artefacts from the gem gravels has been found to be linked in some manner with the chemistry of overlying leaf beds (Deraniyagala 1958:54).

Contrary to Pole's (1913:15) proposition, there is no evidence of a technological evolution from the use of chert as a raw material to quartz. Both materials have been employed according to availability.

There has as yet been no indication that Acheulean bifaces have ever been manufactured in Lanka, unlike in peninsular India. There have indeed been a couple of false alarms. Pole's so-called handaxes from Maskeliya (ibid.:3,Pls.1,2) have been examined by me and found to be flake-producing nuclei with only the remotest resemblance to a handaxe form. Similarly, my own suggestion that three artefacts from the Ratnapura gem gravels appear to be Acheulean handaxes (S.Deraniyagala 1972*b*:5-7), cannot, on further examination, be substantiated, the resemblance being spurious. The problem of the absence of the Acheulean tradition south of the Kaveri river of South India and in Lanka will be discussed in a subsequent chapter.

The above discussion clearly indicates that the Ratnapura Industry has as yet failed to prove itself significant in space or time. Adding confusion to the non-distinctiveness of the industry itself are the occasional discoveries of certain artefacts of the historical period supposedly within the Ratnapura Beds. Such instances are: (*a*) potsherds from 10m -gl at Dikdandawa, Gonapitiya (Deraniyagala 1962:E15); (*b*) an amethyst bead found in association with *Hexaprotodon* and *Elephas maximus* at 5m -gl in a gem gravel at Talgaha-kumbura, Muvagama (id. 1960:8;); (*c*) a gold signet ring of ca. 5th century AD from the silt above the gem gravel at Kuttapitiya (id. 1958:26,27); (*d*) a punch-marked coin of the Early Historic period found just above the gem gravel at Bulugahapitiya (ibid.; for age v. Cunningham 1963:55; Sirisoma in S.Deraniyagala 1972:147). The provenance horizons of many of these items point to the silts overlying the gravels. I have seen several plough-tips of iron from the upper levels of gem pits, presumably discarded from the ploughing of rice fields on the alluvia in relatively recent times. However, the above data suffice to create a strong suspicion that all is not well with the Ratnapura Beds. They appear to belong to various ages, from the Pleistocene down to recent centuries, and redeposition also seems to have mixed up the old with the new.

It thus appears as if the "Ratnapura Industry" comprises an admixture of several lithic industrial phases, perhaps from the Middle or Upper Pleistocene up to ca. 2,800 BP when the protohistoric period superseded the Stone Age in Lanka (Chap. 5.4.2; Addendum II). It is frustrating, if amusing, to hark back to some of the pioneer prehistorians in Lanka: "In my opinion it has – up to now – not been possible to establish certain proof of a Lower Palaeolithic in Ceylon, which does not mean that in the future this might be the case" (Sarasin 1926*a*:107). And Senaratne (1969:27) states in his summary of prehistoric research, "the gem pit areas are a source with which investigations can begin, as also are the Plateau Deposits which Wayland identified".

The gem pits have been probed since the 'thirties. The conclusion after some fifty years of these efforts is that we still have not found a single artefact in the alluvial beds of Lanka which can unequivocally be termed Palaeolithic. It is to radiometric dating and the Ratnapura Fauna that we must turn for clues to the antiquity of the Ratnapura Beds and their artefactual contents.

*3.2.3 Radiometry.* The radiometric assaying of the alluvial deposits in Lanka has so far been minimal. The data thus secured can at best be described as being scanty. However, in the absence of any alternatives these data do merit consideration.

The following radiocarbon dates have been supplied by the Tata Institute of Fundamental Research, Bombay, and they pertain to the Ratnapura Beds (Kusumgar et al. 1963; Chowdhury 1965:189-91). Unless otherwise stated, the dates are given in years BP at $^{14}C$ half-life of 5,570 years:

(*a*) *Material*: seven specimens of wood of *Lagerstroemia speciosa* submitted as sample
*Provenance*: gem gravel at 8m -gl at Balahapuva, near Ratnapura
*Date*: 7,520 ±150 BP

(*b*) *Material*: five specimens of wood of *Mesua* sp. submitted
*Provenance*: gem gravel at 22m -gl at Pelmadulla. In association was an ulna of a rhinoceros (Deraniyagala 1970:pers. comm.).
*Date*: > 47,000 BP

The Balahapuva date is quite remarkable in that a gem gravel at 18m below the surface should be a mere 7,500 years old. Is this date reliable? If so, it indicates that even 18m of deposit in these alluvial beds need not signify great antiquity, and that localised aggradational environments can lead to considerable thicknesses of deposit over a relatively short span of time. Although Balahapuva is situated almost at sea level, it would be hazardous to attempt to relate the provenance of the wood samples to eustatic factors and the inland location of the site makes it much more likely that local geology and topography, and perhaps tectonics, were primarily responsible for the depth of alluvium overlying the samples.

The Pelmadulla date indicates clearly that a Pleistocene component does exist in the Ratnapura Beds and that, if redeposition is to be discounted, a rhinoceros was extant at the time. Considering that the radiocarbon dating techniques during the early 'sixties were in their infancy in India, certain reservations may have to be maintained concerning the reliability of both these dates. However, it is likely that the calendrical date for Pelmadulla was considerably in excess of 47,000 BP.

As a means of establishing a relative chronology, samples of fossil teeth from gem gravels were submitted by P.E.P. Deraniyagala to K.P. Oakley of the British Museum for uranium assays. The results are as follows:

(*a*) *Material*: enamel and dentine from teeth found in association
*Provenance*: gem gravel at 6m -gl at Bokiri-deniya, Kuruwita
$eU_3O_8$ *(ppm)*: *Hexaprotodon*, 20; *Elephas maximus*, 2; (Deraniyagala 1955*b*:E3; 1958:103).

(*b*) *Material*: enamel and dentine from teeth found in association
*Provenance*: gem gravel, Pahala Meepitivela, Getahetta
$eU_3O_8$ *(ppm)*: *Hexaprotodon*, 1 (dentine), 8 (enamel); *Rhinoceros kagavena*, 1 (dentine), 2 (enamel); (id. 1958:123,130).

(*c*) *Material*: dentine from teeth found in association
*Provenance*: gem gravel at 6m -gl at Balahapuva. Note that the *Homopithecus* incisor was also found in association (Chap.3.2.4.).
$eU_3O_8$ *(ppm)*: *Rhinoceros kagavena*, 3; *Hexaprotodon, 0; Elephas maximus, 0;* (id. 1951:31; 1960:6).

(*d*) *Material*: dentine from three teeth found in association
*Provenance*: gem gravel at 4m -gl at Kanukatiya, Karangoda
$eU_3O_8$ *(ppm)*: *Rhinoceros* sp., 179 ±2; *Elephas maximus*, 84 ±2; *Hexaprotodon*, 72 ±2; (id. 1960:8).

(*e*) *Material*: skeletal remains (?teeth) found in association
*Provenance*: gem pit, Ratnapura Beds

*$eU_3O_8$ (ppm)*: indications that the age of *Hexaprotodon* "has to be reckoned in millennia, whereas that of *Bibos* is in centuries" (id. 1963:5).

According to Kennedy (1964:8), anything over 15 ppm of $eU_3O_8$ could tentatively be considered Pleistocene in age (although it is clear that uranium adsorption is primarily dependant on the micro-environment of the finds). This could mean that assemblage (*d*) above is entirely assignable to the Pleistocene, with the rhinoceros perhaps considerably earlier than *E. maximus* and *Hexaprotodon*. The latter two appear to have been roughly contemporaneous. In assemblage (*a*) *Hexaprotodon* could be of Pleistocene age whereas *E. maximus* is post-Pleistocene. Assemblages (*b*) and (*c*) appear to be entirely Holocene in age, as is the gaur in assemblage (*e*). These interpretations are of course dependent on the validity of Kennedy's rule of thumb in tropical surroundings.

In general terms, the above data could be interpreted thus: one of the two species of rhinoceros, presumably *R. sinhaleyus* with its relatively primitive dentition, was the earliest Pleistocene form among the specimens assayed: next came *Elephas maximus* and *Hexaprotodon sinhaleyus*, ranging from the Pleistocene on to the Holocene; finally, there were *Rhinoceros kagavena, Bibos, Cervus unicolor* and *Axis axis*, all of the Holocene. The association of *Homopithecus* with the last group appears enigmatic. It would be interesting to assay the sediments associated with these fossils to ascertain whether the fauna is in fact contemporaneous with its matrix. As stated above, these interpretations are very tentative and require corroboration from other aspects of dating.

A very early human habitation to have been dated in Lanka is Batadomba-lena cave, Kuruwita, at $28{,}510 \pm^{2150}_{1710}$ $^{14}$C BP (½-life 5,730; PRL - 857). Large quantities of faunal remains were found within this deposit, and also in several other Mesolithic sites. However, no evidence of remains of either hippopotamus or rhinoceros has been forthcoming, although large mammals such as elephant and bovines are represented. Considering that the hippopotamus would have been easier to hunt than one of the large bovines, such as gaur or water buffalo, it can be concluded that it was not extant in Mesolithic times, namely that it had become extinct before the end of the Pleistocene and possibly prior to 28,500 BP. The same probably holds true of the rhinoceros, although it would have been a formidable animal to hunt. This casts further suspicions on the validity of the uranium assays as interpreted above. Besides, Oakley (in Deraniyagala 1951:29) affirms that "the ratio of extremes in the variation of uranium content in a single age group is often as much as two or even more.... There is quite commonly a misleadingly high uranium content in isolated specimens in any large assemblage", implying, for instance, that the rhinoceros in assemblage (*d*) need not have been earlier than the elephant or hippopotamus found in its association. This reduces the significance of intra-assemblage comparison of $eU_3O_8$ variation where just a few specimens are assayed, a large and representative assemblage being a prerequisite for interpretations of any consequence. To complicate matters further, the results from assemblage (*b*) indicate that dentine gives a different reading to that of enamel. Hence, in several cases where we are not informed as to which material the assays were conducted on in a given assemblage, a lack of clarity can ensue – particularly where different materials might have been assayed in a single assemblage. It is also noteworthy that enamel, due to its relative lack of absorption, should under normal conditions yield a lower reading of $eU_3O_8$ than dentine. The reverse is the case with assemblage (*b*).

It is worth noting that absolute dates for the Ratnapura Fauna should be obtainable from uranium-series assays ($^{230}$Th/$^{234}$U and $^{231}$Pa/$^{235}$U). The discovery of a probable tektite from a gem gravel near Karangoda (id. 1967*a*:99) opens up a potential source of potassium/argon dating for the Ratnapura Beds, as has been done in the case of the Trinil Fauna of Java. The object has been described as button-shaped, translucent and yellowish brown, with a thickness of ca. 1cm. A.V. Sankaran of the Atomic Energy Department of India states that its morphology suggests an extra-terrestrial origin (ibid.:100). Several tektites of confirmed identity from the Ratnapura Beds would be very welcome as a dating medium. Note that tektites have a very wide distribution in Southeast Asia, southern China and Australia.

It is now opportune to scrutinise the fauna of the Ratnapura Beds for any light it may shed on the problem of the antiquity of these deposits.

*3.2.4 Fauna.* A part of the faunal spectrum of Lanka's Pleistocene can be assessed from the Ratnapura Fauna (Deraniyagala 1944:25) which occurs as fossils in the gem gravels of the Ratnapura Beds. The single unifying aspect of this fauna is that its members are found within this rather nebulous stratigraphic entity. That Pleistocene forms do occur in the Ratnapura Fauna can be demonstrated (v. above). However, the discussion of the stratigraphy of the Ratnapura Beds does indicate that Holocene components can also be present at times. The Ratnapura Fauna comprises the following forms (id. 1958:42-146):

(*a*) The palaeoloxodont ridge-browed elephants *Elephas hysudricus* and *E. namadicus* (id. 1944:45-7). A few low-crowned "palaeoloxodont" teeth have been assigned to *E. hysudricus* (id. 1958:94), and *E. namadicus* has also been identified on the basis of teeth. However, in the absence of skulls with their characteristic ridge-brows, there is some doubt as to the accuracy of these identifications. Firstly, "the presence of vestigial enlargements on the frontal bone of *Elephas maximus* Linne and the similarity in their teeth suggest that *Palaeoloxodon* is a synonym for *Elephas*" (id. 1944:46). Secondly, "molars of the living *Elephas maximus* reveal a wide range of individual variation, some resembling those of such extinct Pleistocene elephants as *Hypselephas hysudricus* (F. et C.) and *Palaeoloxodon namadicus* (F. et C.). This renders the identifications here assigned to local races of these two extinct genera somewhat dubious, and it should be realised that the leaching of the softer elements produces differences in co-specific teeth which appear to be generic" (ibid.:45). Hence, "unfortunately the present identifications are based entirely upon dentition, and until skulls are available the determinations of the two races assigned to members of extinct genera should be regarded as tentative" (ibid.).

The living *E. maximus* of Lanka displays at times a loxodont sinus on abrasion of its molars (id.:1947; 1957*c*:190-2). It is therefore, for instance, entirely within the bounds of possibility that the molar of "*E. hysudricus*" found in association with a molar and tusk of *E. maximus* in a gem gravel at Nagoda (id. 1955:34), did in fact belong to the latter form. It is also possible that the various elephant teeth found in the Ratnapura Beds represent a complete evolutionary sequence, morphologically, from *E. hysudricus* through *E. namadicus* to *E. maximus*.

(*b*) *Elephas maximus sinhaleyus* differs from the living subspecies of Lanka only in minor features: the absence of a nutrient foramen in a femur and in the mandibular spout, again in a single individual, being shallower and wider than in the modern form. The spout is also said to display a distinctive groove (id. 1963:23). *E. m. sinhaleyus* apparently has a greater tendency than *E. m. maximus* to display traces of a loxodont sinus in its teeth, and for its lower molars to be brachydont (id. 1955:107).

The remains of *E. maximus* are common in the Ratnapura Beds, presumably due to the durability of its teeth. A single fossilised molar of this species was brought to me in 1980 from a gem gravel at ca. 2m -gl near Bibile in the Bintenne (physiographic Sub-Zone) 8 in App. I). It is likely, therefore, that the present tendency to mine for precious stones outside of the Ridge and Valley country will bring more faunal remains to light from these areas. The Pleistocene fauna of the Dry Zone might have differed significantly in its composition from that of the Wet Zone as typified by the Ratnapura Fauna.

The hirsuteness of the young of the living *E. maximus* of Lanka has been interpreted as being probably indicative of a relatively recent migration of this species from temperate climes (id. 1961*b*:246-8). So far, only Lanka has yielded fossils of *E. maximus* in any abundance.

(*c*) *Hexaprotodon sinhaleyus* is a six-incisored hippopotamus which is frequently found in the Ratnapura gem gravels. It is best known from the left half of a mandible from a gem pit at Ellawala (for provenance data v. Chap. 3.2.1; Deraniyagala 1963:8,15). The skull is short and square with a short mandibular symphysis. The first lower incisor is smaller than the third; the second lower incisor, which is the smallest, has been elevated by its neighbours so that the tooth line resembles an inverted "W".

On the basis of the above mandibular fragment, *H. sinhaleyus* has been considered almost identical with *H. palaeindicus* of the central Narmada, although the symphysial length is slightly less in the former (id. 1965:190). It is not unreasonable to suspect that some of the remains assigned to *H. sinhaleyus* correlate wih *H. namadicus*, also of the Narmada deposits. *H. sinhaleyus* differed significantly from *H. sivalensis* of the Punjab's Lower Pleistocene in possessing a considerably shorter mandibular symphysis (id. 1958:15).

(*d*) *Rhinoceros sinhaleyus* possessed a single horn, as adduced from its dentition, and low-crowned teeth. Its relatively short limbs were possibly an adaptation to swamp conditions (id. 1965*b*:291-2). The mandible has a curved lower edge, as in the modern African rhinoceros, and a strong gonial prominence, which occurs in the modern Indian form. It differs in its dental characteristics from *R. sivalensis* and has similarities to the living *R. unicornis* of India (id. 1958:116) which was once extant throughout peninsular India although today restricted to Assam and Nepal (Clutton-Brock 1965:10).

(*e*) *Rhinoceros kagavena* was also single-horned but possessed more specialised, higher crowned and larger teeth than *R. sinhaleyus*. This animal has rather tenuously been correlated with *R. sondaicus* of Southeast Asia, namely, Burma, Malay peninsula, Sumatra, Java and Borneo (Deraniyagala 1946:165; v. Clutton-Brock 1965:10). The relationship of Lanka's two rhinoceri to the ?Upper Pleistocene *R. karnulensis* of peninsular India (Murty 1975:135) requires to be established. The taxonomic status of the latter has yet to be clarified.

(*f*) *Homopithecus sinhaleyus* (Deraniyagala 1960; 1963*e*) is considered by its discoverer to be a hominoid akin to *Gigantopithecus* of the Shivaliks in India and of China. It is known from two teeth. The upper left first incisor, partially abraded and minus its root, was discovered at 6m -gl in a gem gravel at Balahapuva (id. 1960:3-6; for provenance v. Chap. 3.2.1). Associated with it were *Hexaprotodon sinhaleyus, R. kagavena* and *E. maximus* (for their $eU_3O_8$ v. Chap. 3.2.3) and also *Axis axis* and *Cervus unicolor* (id. 1951:30-1).

About 1km upstream from the Balahapuva site referred to above, a fragment of an upper left molar, of what appears definitely to be a hominid, was discovered at 5m -gl in a gem gravel at Lindagava-kumbura (ibid.:31; 1963:20; for provenance v. Chap. 3.2.1). The associated fauna comprised *Hexaprotodon, R. kagavena, Leo leo* and bovines.

The so-called brow-ridge of *Homo sinhaleyus* from Jahinge Angiliya Kumbura (id. 1960:2,3; 1963*e*:31) requires further examination before its faunal status can be established – despite P.E.P. Deraniyagala's and T. McCowan's identification.

(*g*) *Leo leo sinhaleyus* is known from two carnassials and a canine (id. 1963:19,20). That the animal was a lion and not a tiger has apparently been established conclusively (id. 1937*d*). In size, the teeth resemble those of the modern Indian lion; but they are more compressed bilaterally. It is noteworthy that no lion remains have been found in India's Pleistocene deposits, although a metacarpal from one of the Upper Pleistocene cave deposits in Kurnool has been suspected of belonging to a lion (Lydekker 18886:120-2). (For lion at Batadomba v. Addendum I.)

(*h*) *Cuon javanicus*, identical with the living red dog (dhole) of India, has been found with a rhinoceros tooth at 2.5m -gl in a gem gravel (id. 1958:84-5). This form, once again, is not known from the Indian Pleistocene. (A tooth suspected of being a red dog's or a very large otter has been found at Beli-lena Kitulgala (P.B.Karunaratne 1986:pers. comm.).)

(*i*) *Bibos gaurus sinhaleyus* was similar to, but smaller than, the living gaur of Mysore. The horn cores are relatively thicker, wider, flatter and shorter in the former which is known primarily from a calvarium discovered in a gem pit near Ellawala (id. 1963:16-9; for provenance v. Chap.3.2.1). This animal is said to have become extinct in Lanka during the nineteenth century (id. 1958:141,145-6).

(*j*) *Bubalus bubalis migona*, akin to the living water buffalo of Lanka

(*k*) *Bos* sp. (?sp. nov.). A fossilised last lower right molar of a *Bos* sp. was found in an alluvial gravel near Collure, between Biyagama and Waturupata on the Kelani river's flood-plain (lat. 6°56′25″ N by long. 79°58′30″ E) which is on the coastal plain near Malwana and hence removed from the Ridge and Valley country of the Ratnapura Beds. The specimen was found in association with well-rounded quartz pebbles at ca. 1m below the present water-table, together with some used hammer-pebbles. The age of the tooth cannot be estimated: there are the Malwana river terraces in the vicinity, possibly of Eem or early Würm age (Chap.3.2.1), from which it could have been derived; and then there is a Mesolithic site in the river silt a few hundred metres upstream from the find-spot. The hammer-pebbles are probably assignable to the latter phase.

The tooth was examined by P.B. Karunaratne of the National Museums Department, who (1978:pers. comm.) pronounced it to be significantly different from teeth belonging to either *Bubalus bubalis* (which are much bigger and relatively wider than the fossil tooth) or *Bibos* (which are much bigger, flatter and possess a different pattern of folds on the crown). However, bovine molars F-180 and F-181 from gem pits at Pelmadulla and Kamarangapitiya respectively were found to be similar to the Biyagama specimen. It also agreed well with fossil molars from F-170 which is a *Bos* mandible from a gem pit at Ellawala.

There is a possibility of a wild strain of *Bos*, ancestral perhaps to *B. indicus*, being domesticated in South Asia by prehistoric man. Could it be that *Bos zeylanicus* (?sp. nov.), now known from at least four teeth, was the animal concerned? There are numerous bovine fossils in the National Museums of Lanka meriting specialist scrutiny for the light they might shed on the vital question of bovine domestication in South Asia. *B. namadicus* is a notable absentee in Lanka, unless some of the larger limb bones can be assigned to it.

(*l*) *Muva sinhaleya* was apparently a small deer, known from a single antler. The distinctive traits are said to comprise the bezel being at least one and a half times as long as it is wide and the distance from the bezel to the fork of the brow-tine and beam being less than the bezel width (ibid.:137). The antler was found in a gem gravel at ca. 3m -gl at Gonapitiya, Kuruwita. It is possible that this form is coterminous with *Axis porcinus*. The latter has recently been identified from a fossilised antler from the Ratnapura Beds (P.B.Karunaratne 1988: pers. comm.).

(*m*) *Cervus unicolor unicolor*, known from antlers, teeth and limb bones. Identical with the living sambhur of Lanka (ibid.).

(*n*) *Axis axis ceylonensis*, identical with the living spotted deer of Lanka (ibid.)

(*o*) *Sus sinhaleyus* is known from only five teeth from different gem pits. They are smaller and lower crowned than in the living wild pig of Lanka, and the third molar is less complex. Gem miners at Potgul-kanda, near Ratnapura, are said to have found several skulls of wild pigs in a gem gravel, which were apparently unusually elongate and considerably smaller than in the living species (ibid.:124).

(*p*) *Hystrix sivalensis*, resembled the Shivalik porcupine, although smaller. It differed from the living form in Lanka, and it has been found associated with *Hexaprotodon* and *Bibos* (id. 1951:122; 1958:83).

(*q*) *Tatera sinhaleya*, a large gerbil rat found at 3.5m -gl in a gem gravel at Marlakkara-vila, Muvagama (id. 1960:13). Its teeth are larger, thicker bilaterally, more curved and with less prominent growth corrugations on the dentine than in the living gerbil rat of Lanka, *T. ceylonica*.

(*r*) *Crocodylus* sp. (*?porosus*). It is known from a single tooth, found with rhinoceros teeth, in a gem pit at Gonapitiya (id. 1940*a*:33; 1958:52). The estuarine form *C. porosus* is known to come up the Kalu river occasionally today, all the way to Ratnapura. The fossil tooth is more slender and recurved at the apex than the latter.

(*s*) *Geoemyda trijuga* is thought to have been somewhat larger than the living hard-shelled terrapin of Lanka, and its corselet ossification thicker (id. 1945*a*). It has been found with *Hexaprotodon* at 6m -gl at Horaliyadda, Kuruwita (id. 1953:5).

(*t*) *Trionyx punctata*, very akin to the living soft-shelled terrapin on Lanka. The former appears to have been larger and with fewer and more pronounced granular prominences upon its plastral ossifications (id. 1945*a*; 1958:50).

(*u*) *Paludomus* spp., gastropods of fluviatile habitat. These have been found in association with a rhinoceros fossil (id.1958:28).

(*v*) *Tanalia* spp., fluviatile mollusca (id.1947:6)

The above descriptions of the fauna in Lanka's Quaternary alluvial beds leaves the question of their age unanswered. In the absence of Pliocene faunal elements, it is clear that they can be assigned to the Quaternary. But are they Pleistocene or Holocene remains?

The stone artefacts found in the Ratnapura Beds certainly cannot answer this question, as discussed in Chapter 3.2.2. However, the fauna can be of assistance. The procedure to be followed in this respect is as follows:

(*a*) Investigate the relative chronology of the different faunal elements by examining the associations in different assemblages so that some form of seriation could be conceptualised.

(*b*) Cross-dating Lanka's fauna by comparing with more securely dated correlates in India and in the Oriental Faunal Zone in general.

The following account seeks to achieve this end. It should be noted that India's Pleistocene chronology has not been synthesised into a cohesive form by any of her numerous researchers as yet, the closest approximation to such a study being Sankalia's compilation (1974). As such, the treatment in the following sub-heading and the interpretation of India's multiple strands of data, as a means of securing chronological resolution for Lanka's Ratnapura Beds, could have wide-ranging significance for South Asian Quaternary research in general. The same holds true for the discussion of prehistoric environments in Chapter 4.5.

As mentioned above the relative chronology of the Ratnapura Beds can constitute an important feature in estimating the age of the Ratnapura Beds. This can best be achieved by examining and comparing the components of the various faunal assemblages found in the gem gravels. A selection of these follows:

I. *Hexaprotodon sinhaleyus*

(*a*) Direct associations

i. *Rhinoceros kagavena, Homopithecus, Elephas maximus, Axis axis, Cervus unicolor*; from a gem gravel at 6m -gl at Balahapuva, Ratnapura (id. 1960:5; v. $eU_3O_x$ above).

ii. *R. kagavena, Homopithecus, Leo leo*, bovines; from a gem gravel at 5m -gl at Lindagava-kumbura, Muvagama, Ratnapura (id. 1951:31; 1963:20).

iii. *R. kagavena*; from a gem pit at Pahala-Meepitivela, Getahetta (id. 1958:130; v. $eU_3O_x$ above).

iv. *Rhinoceros* sp., *Leo leo*; from a gem gravel at 6m -gl at Panvila, Edandevala, Kuruwita (ibid.:87).

v. *Rhinoceros* sp., *E. maximus*; from a gem pit at Moragalage-kumbura, Eheliyagoda (ibid.:105).

vi. *Rhinoceros* sp., *E. maximus*; from a gem gravel at 4m -gl, Kanukatiya, Demala-poruwa, Karangoda (id. 1960:8; 1958:105; v. $eU_3O_8$ above).
vii. *Leo leo*; from a gem gravel at Pahalevala, Gal-edanda Mandiya, Gonapitiya, Kuruwita (id. 1958:131).
viii. *Hystrix sivalensis, E. maximus, C. unicolor*; from a gem gravel at 6m -gl at Talgaha-kumbura, Muvagama (id. 1960:8).
ix. *Hystrix sivalensis, Bibos*; from a gem gravel at 2m -gl at Gorakagaha-deniya, Gonapitiya, Kuruwita (id. 1951:121; 1958:83).
x. *Bibos*; from a gem gravel of the Ratnapura Beds (id. 1963:5; v. $eU_3O_8$ above)
xi. *E. maximus*; from a gem gravel at 4m -gl at Talgaha-kumbura, Muvagama. Probably redeposited, as an amethyst bead was found in association (id. 1960:8).
xii. *E. maximus;* from a gem gravel at 6m -gl at Bokirideniya, Karangoda (id. (1958:103; v. $eU_3O_8$ above).
xiii. *E. ?namadicus*; from a gem pit at 10m -gl in the Ratnapura Beds (id. 1936:317)
xiv. *Geoemyda trijuga*; from a gem pit at 6m -gl at Horaliyadda, Kuruwita (id. 1958:49).

(*b*) Indirect associations

i. *E. ?namadicus* or *maximus*; from a gem gravel at 4.5m -gl at Jahinge Angiliya Kumbura, Radella, Karangoda (id. 1960:2-3; 1965:185).
ii. *Rhinoceros* sp., deer, bovine; from a gem gravel in a lateral tunnel of the main pit in which *Hexaprotodon* had been found; at 6m -gl, which is 1.3m above the *Hexaprotodon* level, Edandevala, Kuruwita (id. 1951:*a*:126).
iii. *Leo leo;* 2m away from *Hexaprotodon*; from a gem gravel at 6.5m -gl at Pahalevala, Gonapitiya (id. 1951:118). The two fossils were found at similar depths and their degree of fossilisation was the same (id. 1944:26-7).
iv. *Bibos, E. maximus*; at ca. 7m from the find-spot of *Hexaprotodon* mandible from a similar horizon; from a gem gravel at 2.5m -gl on the bank of the Manan-ela stream at Thotapitiyage-watte, Horakada-ovita, Pahalagama, Ellawala (id. 1963:6).
v. *E. maximus*; 45m away from *Hexaprotodon*; from a gem gravel at Pahalavela, Gonapitiya (id. 1951*a*:127; 1963:20).

II. *Rhinoceros sinhaleyus*

(*a*) Direct associations

i. *E. maximus*; from a gem pit at Narangwatte, Kamarangapitiya, Pelmadulla (id. 1958:117).
ii. *E. maximus*; from a gem pit at 4.3m -gl at Kuttapitiya, Pelmadulla (ibid.)
iii. *E. ?maximus*; from a gem pit at 7m -gl at Talgaha-kumbura, Muvagama (id. 1960:11).

III.. *Rhinoceros kagavena*

(*a*) Direct associations (for provenance data v. above).

i. *Hexaprotodon, Homopithecus, E. maximus, A. axis, C. unicolor*; from Balahapuva (v. $eU_3O_8$ above).
ii. *Hexaprotodon, Homopithecus, Leo leo, bovines*; from Lindagava-kumbura
iii. *Hexaprotodon*; from Pahala-Meepitivela (v. $eU_3O_8$ above)

IV. *Rhinoceros* sp.

(*a*) Direct associations (for provenance data v. above)

i. *Hexaprotodon, Leo leo*; from Panvila
ii. *Hexaprotodon, E. maximus*; from Kanukatiya (v. $eU_3O_8$ above)
iii. *Hexaprotodon, E. maximus*; from Moragalage-kumbura
iv. *Cuon javanicus*; from a gem gravel at 6.5m -gl at Ihala-Minuvandeniya, Gonapitiya, Kuruwita (id. 1958:84-5).
v. *E. maximus*; bovine; from a gem pit at Haldola, Badamuva, Karangoda (ibid.:105).
vi. *E. maximus*; from a gem pit at Raigam-ovita, Veraniyagoda (ibid.:104)

vii. *Crocodylus* sp.; from a gem pit at 4m -gl at Gonapitiya, Kuruwita (id. 1940*a*:353).

V. *Homopithecus sinhaleyus*

(*a*) Direct associations (for provenance data v. above)

i. *Hexaprotodon, R. kagavena, E. maximus, A. axis, C. unicolor*; from Balahapuva.

ii. *Hexaprotodon, R. kagavena, Leo leo*, bovines; from Lindagava-kumbura

VI. *Hystrix sivalensis*

(*a*) Direct associations (for provenance data v. above)

i. *Hexaprotodon, Bibos*; from Gorakagaha-deniya

ii. *Hexaprotodon, E. maximus, C. unicolor*; from Talgaha-kumbura

VII. *Leo leo*

(*a*) Direct associations (for provenance data v. above)

i. *Hexaprotodon*; from Pahalevela

ii. *Hexaprotodon, R. kagavena, Homopithecus*, bovines; from Lindagava-kumbura

iii. *Hexaprotodon, Rhinoceros* sp.; from Panvila

(*b*) Indirect associations (for provenance data v. above)

i. *Hexaprotodon, E. maximus*; from Pahalevala

VIII. *Cuon javanicus*

(*a*) Direct associations (for provenance data v. above)

i. *Rhinoceros* sp.; from Ihala-Minuvandeniya

IX. *Bibos gaurus*

(*a*) Direct associations (for provenance data v. above)

i. *Hexaprotodon, Hystrix sivalensis*; from Gorakagaha-deniya

ii. *Hexaprotodon*; from a gem gravel (v. $eU_3O_8$ above)

iii. *E. maximus*; from a gem gravel at Pahalagama, Ellawala (id. 1963:16-7)

(*b*) Indirect associations (for provenance data v. above)

i. *Hexaprotodon, E. maximus*; from Manan-ela

X. *Elephas maximus sinhaleyus*

(*a*) Direct associations (for provenance data v. above)

i. *Hexaprotodon, R. kagavena, Homopithecus, A. axis, C. unicolor*; from Balahapuva (v. $eU_3O_8$ above).

ii. *Hexaprotodon, Rhinoceros* sp.; from Moragalage-kumbura

iii. *Hexaprotodon, Rhinoceros* sp.; from Kanukatiya (v. $eU_3O_8$ above)

iv. *Hexaprotodon, Hystrix sivalensis, C. unicolor*; from Talgaha-kumbura

v. *Hexaprotodon*; from Bokirideniya (v. $eU_3O_8$ above)

vi. *Hexaprotodon*; from Jahinge Angiliya Kumbura

vii. *Hexaprotodon*; from Talgaha-kumbura; probably redeposited in sediment

viii. *R. sinhaleyus*; from Narang-watte

ix. *R. sinhaleyus*; from Kuttapitiya

x. *R. sinhaleyus*; from Talgaha-kumbura

xi. *Rhinoceros* sp., bovine; from Haldola, Karangoda

xii. *Rhinoceros* sp.; from Raigam-ovita

xiii. *Bibos*; from Pahalagama

xiv. Deer (*?Axis*); from a gem pit at Hulavala-kumbura, Edandewala, Kuruwita (id. 1958:104).

(*b*) Indirect associations (for provenance data v. above)

i. *Hexaprotodon, Leo leo*; from Pahalevala

ii. *Hexaprotodon, Bibos*; from Manan-ela

If any reliance can be placed on the assumption that the various faunal elements set out above are contemporaneous within each association, and that redeposition has not played a significant role, the above data suggest that:

(*a*) *Hexaprotodon, R. kagavena, Homopithecus, Hystrix sivalensis, Leo leo, Bibos,* several bovines (including perhaps *Bos namadicus*), *E. maximus*, *A. axis* and *C. unicolor* were approximately contemporaneous.

(*b*) *R. sinhaleyus*, although found with *E. maximus*, might not have overlapped with several of the other forms of the Ratnapura Fauna.

The absence of *Elephas hysudricus* or *namadicus*, except in the dubious identification at Jahinge Angiliya Kumbura and once more in a gem gravel (id. 1936:317; 1960:2-3; 1965:185), among the above faunal assemblages, and the very prominent presence of *E. maximus*, suggests that the palaeoloxodonts, if their remains have indeed been correctly identified in Lanka, were earlier than the components of the assemblages referred to above. *E. maximus* appears to have displaced them effectively. This is the only instance with regard to the Ratnapura Fauna where an "early" form of a certain genus might have been succeeded (perhaps evolved into) by a more "advanced" form. It is likely that further investigations will reveal a similar succession within *Hexaprotodon sinhaleyus*, from *H. namadicus* to *H. palaeindicus*.

Redeposition, as a source of stratigraphic interference, could upset all of the above hypotheses. Until the Ratnapura Beds are investigated from an explicitly chrono-stratigraphic standpoint, no further chronological resolution is likely to be achieved.

Meanwhile, it is very reasonable to maintain that Lanka's Pleistocene faunal immigrants had necessarily come from India, there being no other land mass in the vicinity during the Cainozoic. This would have occurred during periods of eustatic low sea levels or through land links established by tectonic factors. (It will be recalled that a 10m drop in today's sea level would create a land corridor between India and Lanka.) Hence, the two countries would have been linked together by a land connection on numerous occasions during the Pleistocene, 10m being a very small amount in terms of eustatic sea level oscillations. This would have enabled a series of faunal (and human) migrations into the island from the mainland.

The eustatic changes of sea levels have long been linked to the four-fold scheme of Günz, Mindel, Riss and Würm glaciations interspersed by Cromerian, Holstein and Eem interglacials. For convenience, this scheme (v. Butzer 1971:43-4; Cooke 1972:7) with its attendant rough chronology is adopted in this work for purposes of rapid chronological evaluation. However, it should continually be borne in mind that the four-fold glaciation model is currently being questioned. Flint (1971:9) affirms that the Alpine sequence of Günz, Mindel, Riss and Würm is poorly known in most respects and that its use as a general reference is misleading. It has also been emphasised that "distinct sequential interglacials [with their corresponding high sea levels] were, under conditions of less than optimal correlation criteria, being lumped into categories such as 'Eemian', 'Holstein', or 'Cromerian'" (Isaac 1975:876). This state of affairs precludes any possibility of constructing a reliable time scale for sea level changes prior to ca. 30,000 BP. However, from this latter date onwards, multi-disciplinary correlations of sea level changes have produced a set of working models which would suffice for estimating the chronology of the land connections between India and Lanka during the late "Würm" (remember, that I shall be continuing to employ the four-fold scheme in the absence of convenient substitute) and the Holocence (v. Fairbridge 1961; 1974; 1976; Butzer 1971; Flint 1971; Emery et al. 1971; Bloom 1971).

Assuming that tectonics and coastal sedimentary features such as sand spits and bars along what is now an aggrading north-western coast did not influence the sequence of connections with India significantly, it appears as if the last separation between India and Lanka would have occurred around 7,000 BP (v. Bloom 1971:368;

Emery et al. 1971:383; Flint 1971:326; Butzer 1971:225; Fairbridge 1974:1004; 1976:546). This was when the sea level would last have been equal to or more than 10m -present msl, which would have served to establish the land connection. Sea level data of, for example, Emery et al. (1971:383) suggest that the previous occasion on which the two countries separated from each other was at ca. 35,000 BP. Corroborative evidence exists in the dating of a 8m + msl coastal deposit in South India to ca. 38,000 $^{14}$C BP (SRR-1481). Moreover, the freshwater faunas of India and Lanka are very alike (Deraniyagala 1954:115) and there is very little distinction between the mammalian faunas. The last connection with India appears to have been so recent that certain birds and reptiles, which might have crossed over in this final stage, are restricted in their distribution to the Dry Zone of the northwest and north and have not as yet spread to the eastern and southern sectors of the Dry Zone despite identical environmental conditions (Wait 1914:24-9; Deraniyagala 1940*a*:356). This might be construed as supporting the view that the final connection was at ca. 7,000 BP. A more detailed treatment of sea level fluctuations will be afforded in Chapter 4.5.3.

Having propounded that, barring tectonic and coastal aggradational interference, peninsular Indian faunal elements could have crossed over to Lanka from ca. 30,000 to 7,000 BP, it becomes necessary to survey India's Pleistocene faunal chronology, with particular reference to those forms which have their counterparts in the Ratnapura Fauna.

Peninsular India's Pleistocene stratigraphy has been investigated rather intensively, as exemplified in de Terra and Paterson's work (1939). A composite picture of the fluviatile stratigraphy of the peninsula has crystallised, perhaps prematurely so. However, the succession for the central Narmada near Hoshangabad can be considered typical, and it has served as the model (rightly or wrongly) for much of the subsequent interpretations of peninsular Indian Pleistocene stratigraphy (de Terra and Paterson 1939:314-20; Khatri 1966:115-22; *IAR* 1963/64:14; Rajaguru and Hegde 1972:72).

The base of the sequence on the central Narmada comprises a laterite, devoid of fauna or artefacts, overlain unconformably by Gravel I, which is coarse, bouldery and often cemented. Acheulean artefacts and a Middle Pleistocene fauna are frequently encountered within this deposit. The gravel is capped by fluviatile Silt I, which is usually reddish in colour and sterile of artefacts and faunal remains except in a few instances where Acheulean artefacts in mint condition are claimed to have been found. Gravel I and Silt I constitute Aggradation Cycle I.

Gravel II comprises particles finer than in Gravel I. It is frequently composed of fine gravels (without cementing) and cross-bedded sands. This deposit lies disconformably above Aggradation I. It typically contains a Middle Palaeolithic flake industry, with a fauna akin to that of Gravel I. Gravel II is capped by Silt II which is usually buff coloured, and these two members constitute Aggradation Cycle II.

A third, less compacted and finer Gravel III, capped by Silt III, rests unconformably against the two earlier aggradations. At Hoshangabad this Aggradation III has not yielded any artefacts or faunal remains.

The Belan valley, Allahabad District, U.P., has a sequence which amplifies that of the central Narmada (G.R.Sharma's data in Mujumdar and Rajaguru 1970:97,100-2; Allchin 1973:46; Sankalia 1974:40-1,180-1,224,238). A basal laterite is overlain (?unconformably) by Gravel I with an Acheulean industry which is then capped by Silt I. Gravel II succeeds Aggradation I (?disconformably) and it contains a Middle Palaeolithic industry and an extinct fauna with *Elephas ?namadicus* and *Bos namadicus*. Silt II is of colluvial origin here and it has yielded a Middle

Palaeolithic industry (?*in situ*), although gravel intercalations in the upper horizons are said to contain Upper Palaeolithic elements. Gravel III has an Upper Palaeolithic, and Silt III displays a progression from Upper Palaeolithic in its lower levels to a "non-geometric microlithic" industry in the upper horizons. Aggradation IV is an aeolean Silt IV containing Mesolithic geometric microliths. There is said to be a Silt V with microliths and pottery. Here we have a sequence of four, or perhaps five, aggradation cycles, displaying diagnostic cultural markers, although the faunal remains are restricted to Gravel II and are dismally sparse.

The sequence of Aggradation I with an Acheulean industry, invariably in the gravel, followed by Gravel II with a Middle Palaeolithic, succeeded by Silt II, is found in several localities in peninsular India. Additional examples of these, as given below, indicate the ubiquitousness of this techno-stratigraphic sequence:

(*a*) Saurashtra:
  i. Rojadi, Bhadar valley (Sankalia 1974:98-101,187)
  ii. Somnath (ibid.)

(*b*) Madhya Pradesh:
  i. Chambal system, Malwa (ibid.:107,187; Khatri 1966)
  ii. Betwa system, east of Malwa (Sankalia 1974:107-9,182)
  iii. Upper Son (ibid.:113,182)

(*c*) Orissa:
  i. Baitarni system (ibid.:178)
  ii. Brahmani basin (Mohapatra 1962; Sankalia 1974:54)
  iii. Mayurbhanj District (Ghosh 1970)

(*d*) Maharashtra:
  i. Bhadane, Kan river (Sankalia 1974:75)
  ii. Ranka Nala (ibid.:75,155)
  iii. Bhandara District, with both Acheulean and Middle Palaeolithic industries being on chert (Joshi 1972:43).

(*e*) Karnataka:
  i. Taminhal, Malaprabha valley (id. 1955; Sankalia 1974:70-1,163)
  ii. Hunsgi Nala, Bhima-Krishna doab (Paddayya 1970:68; Sankalia 1974:219-20,246).

(*f*) Andhra:
  i. Tungabhadra river, Kurnool District (*IAR* 1959/60:11; Sankalia 1974:57,174)
  ii. Bhavanasi valley, Kurnool District (ibid.)
  iii. Musi river, Nalgonda District (Sankalia 1974:61,174)
  iv. Rallakalava river, Chittoor District (ibid.:63,176,209)

Situations anomalous to the two-fold aggradation scheme of Gravel I with an Acheulean and Gravel II with a Middle Palaeolithic have, however, been noted; for example:

(*a*) Bihar:
  i. Singhbhum District: Gravel II contains an Acheulean, whereas the Middle Palaeolithic occurs on its surface (Ghosh 1970; Sankalia 1974:46-7,180,223).

(*b*) West Bengal
  i. Midnapore District: Silt I contains a Middle Palaeolithic and Gravel II an Upper Palaeolithic (Sankalia 1974:51,178,180,224).

(*c*) Rajasthan
  i. Wagan river, Berach basin, Mewar: Gravels I and II contain a Middle Palaeolithic (Misra 1967:16; Sankalia 1974:194).

(*d*) Gujarat
  i. Sabarmati and Mahi (Zeuner 1950:7-30) and the Lower Narmada (Wainwright

1964; Hegde in Vishnu Mittre 1965:27-8); Gravel II and a Middle Palaeolithic are lacking. This situation prevails in most of northern and central Gujarat (Sankalia 1974:94-7,187).

(*e*) Madhya Pradesh

i. Maheshwar, Narmada river: Terrace 1 has two aggradation cycles of gravels capped by silt. Both contain Acheulean artefacts. Gravel III in $T_2$, on the other hand, contains a Middle Palaeolithic (ibid.:117-8).

ii. Mahadeo Pipariya, central Narmada, Supekar's excavation: Gravel I contains an admixture of Acheulean and "Middle Palaeolithic" elements. A series of gravels capped by silts occur within Aggradation I (ibid.:115).

(*f*) Maharashtra

i. Gonda, Kan river, Dhulia District: Gravel II contains an Upper Palaeolithic, whereas Bhadane, 2km away on the Kan, has a Middle Palaeolithic (ibid.:226).

ii. West Khandesh, Tapti river: Silt I with an Acheulean is succeeded by a gravel with an Upper Palaeolithic (ibid.:75).

iii. Chirki, Pravara river: Gravels I and II, both, contain a Middle Palaeolithic (Corvinus 1973:22-3; 1976:8-10).

(*g*) Tamilnadu (de Terra and Paterson 1939:327-30; Wainwright and Malik 1967) has a sequence of terrace deposits which cannot be directly related geomorphologically to the central Narmada/Belan aggradation scheme, although tentative correlations can indeed be attempted (v. below). This is not surprising, since Tamilnadu is situated within the rain-shadow of the Southwest Monsoonal airstreams crossing the Western Ghats. Hence, this region can be considered climatically anomalous with the rest of peninsular India, with the possible exception of coastal Andhra which has a similar climate. Tamilnadu receives its rains during the Northeast Monsoon in winter, whereas the remainder of the peninsula gets the majority of its rain during the Southwest Monsoon in summer. In this respect, Tamilnadu resembles the Dry Zone of Lanka (v. App.I.4).

The anomalies noted above are based on the Acheulean/Middle Palaeolithic dichotomy: the wrong industry appears to occur in the wrong aggradation. However, many of these apparent anomalies can be explained by the very nature of fluviatile geomorphology, where local depositional conditions could vitally affect the presence, absence or the final configuration of a deposit or sedimentary sequence: a single aggradation cycle could comprise several gravel-sand-silt-clay sub-cycles; an entire aggradation cycle, sub-cycle or sedimentary bed could be missing in a given locality, due to erosion, or what constitutes a gravel upstream (e.g., Gravel II, central Narmada) can grade into sands and silts downstream (e.g., lower Narmada). There can also be tectonic interference in the depositional environment. The morphology of the Tapti, Narmada, Godavari and Pravara rivers is known to have been affected by tectonic factors (Zeuner 1950:22,32; Corvinus 1976:8-10; Shkurkin 1976:7): the sediments in the central Tapti are said to be folded and tilted (Sali 1970:211-4), and, as with the Narmada, it flows in a rift valley. The presence of waterfalls along the Godavari and Pravara rivers, the Pravara's Aggradation II occurring within an extensive basin-like area, and its entrenched meanders, have been interpreted as further indications of tectonic interference (Rajaguru and Hegde 1972:74; Corvinus 1976:8). These tectonically affected regions can have immense thicknesses of sediment which correlate litho-stratigraphically with small-scale deposits in tectonically unaffected areas.

As for the Acheulean/Middle Palaeolithic differentiation, it has been executed primarily on the predominance of flakes and crypto-crystalline raw materials in the latter, as against core bifaces and quartzites in the former (v. Sankalia 1974:33,146,148). It is known that any Lower Palaeolithic assemblage, be it Koobi Fora in East Africa or a typical Acheulean assemblage in peninsular India, can have a significant component of flake-tools. It is often the case that there is a sampling bias towards focusing only on core-tools and bifaces in Acheulean assemblages, thus omitting the flake elements. Due to the relative scarcity of core-tools in Middle Palaeolithic assemblages in India, the flake-tools assume dominance in the samples. However, the mere fact that an artefact is a flake-tool need not disqualify it from being a part of an Acheulean assemblage. In other words, there is no one-to-one correlation between a core-tool being Lower Palaeolithic and a flake-tool being Middle Palaeolithic. This brings us to the question of sample size: a representative sample is essential before it is possible to so much as attempt to assign an assemblage on typological grounds alone to one of the three phases of the Palaeolithic; Lower, Middle or Upper.

With regard to raw material, many of peninsular India's deposits of Gravel II are richer in crypto-crystalline rocks than in Gravel I (ibid.:149). It is thus obvious that there will be many more artefacts on crypto-crystallines in Gravel II than in Gravel I. Hence, an Acheulean industry, should it occur in Gravel II, could have flake-tools on crypto-crystalline rocks, which can easily be mistaken for a Middle Palaeolithic assemblage. For instance, the so-called Middle Palaeolithic at Mahadeo Pipariya has been identified as such primarily on the grounds of its raw material being a crypto-crystalline. There is, however, nothing to prevent its being a part of the Acheulean assemblage with which it is asociated in Gravel I. Similarly, the rolled flakes of chalcedony, identified as Middle Palaeolithic, from Dhamner on the Krishna river, Satara District, could well have belonged to an Upper Palaeolithic or Mesolithic phase. The associated radiocarbon date (PRL-143) of 10,130± 250 BP on shell (Agrawal et al. 1977:235) favours the latter identification. Note also that several assemblages on quartzite have been assigned to the Middle Palaeolithic; for example, from Hyderabad in Nalgonda District, the Ghataprabha valley in the Bijapur District of Karnataka (Sankalia 1974:166) and in Saurashtra, Kutch and Madras (Soundara Rajan in Sankalia 1965:43). Presumably these identifications were based on the flake- versus core-tool dichotomy.

It is clear that the central Narmada/Belan composite sequence cannot be employed indiscriminately as the model for the study of peninsular India's Pleistocene stratigraphy without involving many more case studies. However, its usefulness as a stop-gap model, a launching point for discrete investigations, while being aware of its potential limitations, is an established fact. Hence, in the following treatment of peninsular India's Pleistocene fauna, which will be employed for dating the Ratnapura fauna, the central Narmada/Belan scheme can be assumed to be a fixed point of reference.

As indicated above, *Hexaprotodon palaeindicus* and possibly *Rhinoceros unicornis* and *Elephas namadicus* would have had their counterparts in *H. sinhaleyus*, *R. sinhaleyus* and *E. ?namadicus* of the Ratnapura Beds. *Bos namadicus* too might be represented among the bovines of the Ratnapura Fauna. These Indian forms occur in Aggradation I and/or II of peninsular India, as components of what may coveniently be termed the "Narmada Fauna" after the type-locality on the Narmada. Hence, any radiometric dating information on Aggradations I and II would be relevant to the dating of their faunal contents, which in turn could be used for cross-dating the Ratnapura Fauna. No radiometric assays have been conducted directly on Aggradation I; however, an Acheulean industry, such as designates Aggradation I, has been dated to over 200,000 BP in a dune in Rajasthan (TL, uranium series; V.N.Misra 1985:pers. comm.), and in northern Pakistan an Acheulean assemblage *in situ* has dates of 700,000-400,000 BP (magnetic polarity, fission track dating of context; Rendell and Dennell 1985). It can, hence, be assumed that Aggradation I could range from 700,000 to 200,000 BP (v. Addendum IV).

A few radiocarbon dates are available for Aggradations II and III:

(*a*) *Locality*: buried channel of Mula river, Maharashtra (Misra 1967:17; Agrawal and Kusumgar 1974:41).
*Deposit*: correlate of Gravel II; the stratigraphy of this locality is complicated by signs of faulting, thereby reducing the significance of the dates.
*Material*: wood, found in association with *Bos namadicus*, *Elephas ?namadicus* and "Middle Palaeolithic" flake.
*Dates (1/2-life 5,730 years)*: 31,980 $\pm\,^{5715}_{3340}$ BP (TF-345); > 41,000 BP (TF-217)

(*b*) *Locality*: Narmada, Mahi and Sabarmati rivers (Hegde and Surtsur 1973; Hegde 1975; Sankalia 1976:7).
*Deposit*: Silt II
*Material*: caliche
*Date*: ca. 20,000 BP

(*c*) *Locality*: peninsular India (Agrawal et al. 1975:5)
*Deposit*: "old alluvium" with "Middle Palaeolithic"; therefore, possibly Aggradation II
*Dates*: twelve dates, 20,000 to 40,000 BP

(*d*) *Locality*: Rati Karar, Narmada river (ibid.; Agrawal and Kusumgar 1974:43)
*Deposit*: Aggradation II, with Middle Palaeolithic and fauna
*Date*: 33,700 $\pm\,^{1820}_{1625}$ BP (TF-967)

(*e*) *Locality*: Deoghat, Belan river, U.P. (Mujumdar and Rajaguru 1970:97; Agrawal and Kusumgar 1974:220; Agrawal and Kusumgar 1975; Agrawal et al. 1977:235).
*Deposit*: Gravel III with an Upper Palaeolithic
*Material*: shell
*Dates*: 19,160 ± 330 BP (TF-1245); 25,070 $\pm\,^{810}_{730}$ BP (PRL-86)

The above data suggest a lower date in excess of 40,000 $^{14}$C BP for Gravel II, whereas the upper date, on the Belan evidence, is equal to or in excess of 25,000 $^{14}$C BP. The twelve radiocarbon dates for the "old alluvia" with "Middle Palaeolithic" industries might contain a few referring to Aggradation III in instances where the Upper Palaeolithic flake elements have been misidentified as typical Middle Palaeolithic flake-tools (v. above for discussion of typological index fossils and the associated pitfalls). It should be borne in mind that the materials on which the dating has been conducted are not very suited for the purpose, the majority being freshwater shells, the rest being bone or oolite grains.

The dating of the upper boundary of the Indian Middle Palaeolithic of Aggradation II correlates rather well with that of the European Mousterian which has been intensively studied:

(*a*) The earliest Mousterian in Europe is from the Riss glaciation (ca. 250,000 BP) from along the Atlantic coast, for instance Torre in Pietra, Italy (Coles and Higgs 1969:214,217) and Rigabe in the Provence (Bordes 1961*a*:807; 1968:98).

(*b*) The Mousterian was fully developed in western and central Europe during the Eem interglacial (ca. 125,000 BP) (id. 1961*a*:803; Coles and Higgs 1969:214,217).

(*c*) The majority of the French Mousterian assemblages fall within Würm I and II, which is equivalent to Würm I of central Europe and commences ca. 90,000 BP (Bordes 1968;98; 1972:7; Mellars 1970:137).

(*d*) The Mousterian fades out in France during the interstadial of Würm II/III, which has been correlated with the Hengelo interstadial with a date of 39,000-36,000 $^{14}$C BP (Mellars 1970:140).

The upper boundary of the European Mousterian can hence be placed at ca. 36,000 BP, which is very close to the Indian dates for its Mousterioid Middle Palaeolithic. One could hypothesise that the European lower boundary of ca. 200,000

BP is similarly applicable for the boundary between Acheulean and Middle Palaeolithic, and hence Aggradations I and II, in peninsular India. Note that the early Mousterioid industries of Morocco, the Evolved Acheulean, have also been assigned to ca. 200,000 BP, and that the Evolved and Final Acheulean assemblages of Africa, for instance the one associated with Saldanha Man (Clark 1959; Bordes 1968:125), have been correlated with the French Mousterian of the Acheulean Tradition stylistically and dated independently to 200,000-100,000 BP. The above dates imply a general lower boundary of ca. 200,000 BP for Mousterioid industries in Europe and Africa, which can be extended hypothetically to India. These cross-data suggest a hypothetical dating of 200,000-35,000 BP for India's Aggradation II.

With regard to the relative chronology of the Narmada Fauna, the following data on faunal associations are pertinent:

(*a*) *Locality*: Belan valley, U.P. (G.R.Sharma's data in Sankalia 1974:38-40, 180-1,224,238)
*Deposit*: Gravel II
*Fauna*: *Bos namadicus*, *Elephas* sp. and Middle Palaeolithic

(*b*) *Locality*: Bihar (Sankalia 1974:47)
*Deposit*: Gravel I
*Fauna*: *Bos* sp., *Equus* sp.

(*c*) *Locality*: Sisunia, Gandeshwari river, Bankura District, West Bengal (ibid.:51-2)
*Deposit*: sandy sediments overlying an Acheulean industry; ?Gravel II
*Fauna*: *Bos namadicus*, *Equus namadicus*, *Bubalus palaeindicus* and Middle Palaeolithic

(*d*) *Locality*: Narsinghpur to Hoshangabad, central Narmada river, M.P. (de Terra and Paterson 1939:317-9; Khatri 1966:130; Sankalia 1974:142).
*Deposit*: Gravel II. De Terra and Paterson (1939:317-9) consider it very likely that the fossils occur on the erosion surface of Aggradation I and that they date from prior to the deposition of Gravel II.
*Fauna*: *Elephas namadicus*, *Hexaprotodon namadicus*, *Hexaprotodon palaeindicus*, *Equus namadicus*, *Bos namadicus*, *Ursus namadicus*, *Bubalus palaeindicus*, *Rhinoceros unicornis*, *Sus*, etc. and Middle Palaeolithic.

(*e*) *Locality*: central Narmada (ibid:322)
*Deposit*: Gravel I
*Fauna*: *Hexaprotodon namadicus*, *Bos* sp. and Acheulean

(*f*) *Locality*: Locality 4, Hoshangabad, central Narmada (ibid.:316)
*Deposit*: Gravel I
*Fauna*: *Hexaprotodon namadicus*, *Bos* sp.

(*g*) *Locality*: Hoshangabad, central Narmada (ibid.; Deraniyagala 1944:46; Sankalia 1974:115).
*Deposit*: Gravel I
*Fauna*: *Elephas hysudricus*, *E. namadicus*, *Hexaprotodon namadicus*, *Bos namadicus* and Acheulean.

(*h*) *Locality*: Locality 8, Narsinghpur, central Narmada (de Terra and Paterson 1939:317-9)
*Deposit*: Gravel II
*Fauna*: *Elephas namadicus*, *Hexaprotodon*, *Bos namadicus*, *Bubalus* and Middle Palaeolithic.

(*i*) *Locality*: Locality 9, Narsinghpur, central Narmada (ibid.)
*Deposit*: Gravel II
*Fauna*: *Elephas namadicus*, *Bos namadicus* and Middle Palaeolithic

(*j*) *Locality*: Marble Rocks, Handia, central Narmada (Khatri 1966:132)
*Deposit*: Gravel I or II?
*Fauna*: *Bibos*

(*k*) *Locality*: Marble Rocks, Handia, central Narmada (ibid.:122-4)
*Deposit*: post-Aggradation II; ?recent
*Fauna*: *Elephas maximus*

(*l*) *Locality*:Nandur Madhmeshwar, Nasik, upper Godavari river, west-central Maharashtra (Sankalia 1974:81-2,142).
*Deposit*: Gravel I
*Fauna*: *Elephas namadicus, Hexaprotodon* and, in indirect association, Acheulean

(*m*) *Locality*: Locality 1, Nevasa, upper Godavari (ibid.:82)
*Deposit*: alluvial gravel (?Gravel I)
*Fauna*: *Bos namadicus* and Acheulean

(*n*) *Locality*: Chirki, Nevasa (ibid.:84-8)
*Deposit*: Gravel I
*Fauna*: *Elephas* sp., *Bos* sp. and Acheulean

(*o*) *Locality*: Mula river, Poona, Maharashtra (Misra 1967:17; Sankalia 1974:75,146; Agrawal et al. 1975:5).
*Deposit*: Gravel II (v. radiocarbon dating above)
*Fauna*: *Elephas* sp., *Bos namadicus* and "Middle Palaeolithic" flake

(*p*) *Localities*: Godavari, Pravara and Bhima rivers (Sankalia 1974:199)
*Deposit*: old alluvia
*Fauna*: *Elephas namadicus, Bos namadicus, Bubalus* sp. and Middle Palaeolithic

(q) *Locality*: Nittur, Tungabhadra river, Bellary, east-central Karnataka (ibid.:72-4)
*Deposit*: alluvial gravel
*Fauna*: *Bos namadicus* and ?Lower Palaeolithic

(*r*) *Locality*: Muchchatla Chintamanu Gavi cave, Betamcherla, Kurnool District, western Andhra Pradesh (ibid.:215-7; Murty 1975).
*Deposit*: cave strata
*Fauna*: *Bos* sp., *Equus asinus, ?Rhinoceros* sp., antelope, *Gazella, Bubalus* (all extinct in the area today) and Upper Palaeolithic.

(*s*) *Locality*: Billa Surgam Cave, Betamcherla, Kurnool (Lydekker 1886; Sankalia 1974:209; Murty 1975).
*Deposit*: cave strata
*Fauna*: *Rhinoceros unicornis* and "Upper Palaeolithic" bone tool industry. Note that *R. unicornis* might have survived into comparatively recent times on peninsular India: there is the scapula from Mesolithic Langhnaj (Zeuner 1963:21) and the bronze rhinoceros from a Malwa Culture site of ca. 2,300 BC at Daimabad, Maharashtra (Dhavalikar 1975:15,Pl.45). There is an opinion that the Kurnool rhinoceros should be assigned to a new species, *R. karnulensis* (v. Murty 1975:135), although this needs to be confirmed.

The above data indicate that peninsular India's Pleistocene faunal assemblages are typified by *Elephas hysudricus, Elephas namadicus, Hexaprotodon namadicus* and *Bos namadicus* in Aggradation I, at ca.700,000-200,000 BP. Apart from *E. hysudricus*, all of these forms occur in Aggradation II (v. Misra 1967:17), although there is a suspicion that some of the specimens assigned to Gravel II on the central Narmada have been derived from Aggradation I. The forms making their initial appearance with Gravel II are *Hexaprotodon palaeindicus, Bubalus palaeindicus, Ursus namadicus, Equus namadicus* and *Rhinoceros unicornis*. However, considering the evidence from the Shivaliks (v. below), it is very likely that *Bubalus palaeindicus* and *Equus namadicus* do occur in Gravel I. Neither *Stegodon* nor *Leptobos* have been conclusively identified from either aggradation (Khatri 1966:130).

It is thus apparent that it is the fauna of Gravel II which corresponds closest to that of the Ratnapura Beds, namely in *Hexaprotodon palaeindicus* and *Rhinoceros unicornis*. However, *Bubalus palaeindicus* is more archaic than *B. bubalis* of the Ratnapura Fauna, and *Elephas maximus* has not been found in Gravel II (although some of the *Elephas* sp. finds might be assignable to this form), thereby suggesting an age younger than that of Gravel II for the Ratnapura Fauna. Alternatively, one could also affirm that some members of the Ratnapura Fauna, such as *Hexaprotodon sinhaleyus*, are as old as the fauna of Gravel II, whereas others such as *Bubalus bubalis* are younger. This brings us back to the upper boundary of Aggradation II: the radiocarbon dates indicate this to be at ca. 25,000 BP, which would place the younger elements of the Ratnapura Fauna at less than 25,000 BP. Note, however, that the rhinoceros at Pelmadulla was dated to over 47,000 $^{14}$C BP (Chap.3.2.3), thus definitely indicating that some of the Ratnapura Beds contain elements coeval with Aggradation II at 200,000-25,000 BP and others perhaps coeval with Aggradation I. It is, hence, relevant to attempt to bring greater precision to the approximate age range postulated for Aggradation I; one method of doing so is through technological cross-dating.

The Acheulean Complex of India, as exemplified in Aggradation I, correlates stylistically and technologically with the Upper Acheulean of East Africa. Note that the sub-divisions of the African Acheulean (Leakey 1953) have been reduced to two: Lower (formerly Abbevillean) and Upper Acheulean (Isaac 1969; 1973; Clark 1970:81). Handaxes and cleavers (bifaces) being the only formal tool types of the Acheulean (Clark 1975:610), the Lower Acheulean is characterised by the bold flaking on its bifaces, often resulting in zig-zag edges and relatively thick cross-sections. The Upper Acheulean displays finer craftsmanship, reflected in the extensive use of step-flaking, and the cross-sections were thus made thinner and more regular and the edges much less zig-zag. Despite claims to the contrary (e.g., Todd 1939; Khatri 1966:115-8,122; Ghosh 1970), there is no conclusive evidence of a Lower Acheulean (or an Oldowan) in India, particularly as Abbevillean-looking bifaces and Oldowan-like choppers are a frequent component of any Upper Acheulean assemblage, as at Olorgesailie and in Mayurbhanj District, India (Isaac 1973*a*; Sankalia 1974:54).

While bearing in mind Isaac's (1972) warning that the viewing of artefacts as culture-historic markers, rather than as functional parts of operative systems, is hazardous in the extreme, the Upper Acheulean handaxe techno-traits constitute a useful chronological marker for Africa. The Lower Acheulean of Olduvai upper-middle Bed II has a date of 1.4 K/Ar my, and Peninj on the Kenya/Tanzania border has two dates of 1.4-1.6 and 1.52 K/Ar my BP for a horizon just preceding its Lower Acheulean level (Clark 1970:78; Isaac 1972). Olduvai Bed IV, with its clearly Upper Acheulean assemblages, has been dated to 0.7 my by the Brunhes-Matuyama magnetic reversal, which is now accepted as the beginning of the "Middle Pleistocene" (Isaac 1975*a*:500; Maglio 1975:436). This latter date is corroborated by the 0.4-0.5 K/Ar my date for the Upper Acheulean at Olorgesailie (Isaac 1967:96; 1972; 1972*a*:180). The horizon underlying the Upper Acheulean at Kariandusi in Kenya has been dated to 0.991 K/Ar my (id. 1972) and in North Africa it is associated with the 30m beach of supposedly Holstein interglacial (ca. 0.3 my) age. These data could be construed to fix the lower limit of the Upper Acheulean in East Africa at ca. 0.7 my BP. The upper boundary for Africa and Europe, when "Middle Palaeolithic" industries superseded the Upper Acheulean, appears in general to have been at ca. 200,000-150,000 BP (v. Leakey 1975:477). The dating of the Upper Acheulean in Africa to 0.7-0.2 my BP can in turn be hypothetically transposed to Gravel I of peninsular India, although a more recent lower date is entirely feasible. This cross-dating of Gravel I via the African data by their techno-traits is in agreement with its cross-dating with Acheulean sites in Rajasthan and northern Pakistan (v. above).

There is yet another venue available for attempting to date India's Acheulean Complex, and thence Aggradation I: it is by correlating Indian thalasso-static fluviatile aggradations with Pleistocene sea levels. A basic assumption in this exercise would be that terrace elevations have not in any manner been influenced by tectonic or isostatic factors. The effects of glacial isostasy can be ruled out in peninsular India. Tectonics, on the other hand, do continue to affect the western coast of India, such as on the Sabarmati and the lower Narmada in Gujarat (v. Zeuner 1950:22,32; Allchin and Allchin 1968:1; Shrivastava 1968; Allchin and Hegde 1969; Joshi 1970:60; Ahmad 1972:128,183; Rajaguru and Hegde 1972:72-4; Spate and Learmonth 1972:23,643–5; Agrawal and Kusumgar 1974:51). However, the Tamilnadu coast is relatively stable tectonically and its thalasso-static fluviatile aggradations can be assayed with some confidence.

Several marine peneplains are said to occur along the Tamilnadu coastal belt: at 250m, 150m and 80m +msl, against the Alicoor Hills (de Terra and Paterson 1939:327). There is no mention of any artefacts associated with these peneplains. However, four marine peneplains at 73m, 45m (with Acheulean artefacts on its surface), 30m (with Acheulean on surface) and 17m (with Middle Palaeolithic on surface) have been observed, apparently, by K.R. Banerjee (1969; Sankalia 1974:69). In this latter series of peneplains, the occurrence of the artefacts upon the ground surface, as opposed to within sediments coeval with the cutting of the peneplains, greatly reduces the chronological significance of the finds. However, if one adopts the four-fold glacio-eustatic model on a tentative basis, the 45m peneplain can be correlated with the Cromerian interglacial, the 30m with the Holstein and the 17m with the Eem interglacial. There is a slight possibility that the stone tool industries, perhaps only some of them, are coeval with the peneplains, which would date the Acheulean assemblages from the Cromerian at ca. 0.7 my BP down to the Holstein interglacial at ca. 0.3 my BP. The Middle Palaeolithic would appear to have taken precedence by Eem at ca. 125,000 BP. These dates are in full agreement with the European and African dates for the Acheulean and Middle Palaeolithic Complexes.

The rest of the evidence from Tamilnadu stems from the valley of the Kortalayar river, just north of Madras, on the eastern extremity of Chittoor:

(*a*) Vadamadurai terraces (Krishnaswami 1938:88,90; 1938*a*; de Terra and Paterson 1939:327,30; Sankalia 1974:66,7):

$T_D$ rests on a primary laterite, and it comprises a basal gravel with an Acheulean industry. Although there is said to be a heavily patinated Lower Acheulean and a relatively fresh Upper Acheulean in this deposit, this statement needs verification. (Banerjee in his excavation of $T_D$ observed a rolled Acheulean in a basal conglomerate, overlain by a lateritic gravel and then a lateritic silt, with fresh Acheulean assemblages in both.) The gravel in $T_D$ is capped by a silt, with Upper Acheulean tools stained red in its lower horizons and unstained specimens in the upper levels. Once again, further investigations are required before it is possible to discern any typological evolution within the silt. The top of the silt is at ca. 30m +rl, which could date it to the Holstein interglacial, which is in keeping with dating by techno-traits. It is tempting to correlate $T_D$ with Aggradation I of the rest of the peninsula, which in turn would date the latter to the Holstein interglacial.

$T_1$ has been cut into $T_D$ at 19m +rl (Eem), but no coeval deposits have been observed

$T_2$ at 6m +rl comprises a basal gravel capped by a silt; but it is sterile of artefacts

$T_3$ at 2.5m +rl constitutes the present flood-plain

(*b*) Poondi (de Terra and Paterson 1939; Wainwright and Malik 1967): the terrace sequence resembles that of Vadamadurai but is more complete:

$T_1$, correlating with Vadamadurai $T_D$, comprises a thick lateritic basal gravel, devoid of artefacts, capped by a lateritic crust with a red-stained Acheulean, which in turn is overlain by a thin deposit of non-lateritised gravel containing white-patinated, unworn Acheulean artefacts. The surface of $T_1$, at 30m + rl, can be correlated with the Holstein interglacial.

The next geomorphic phase (?Riss) witnessed down-cutting and the lateritisation of the bed-rock underlying $T_2$.

$T_2$, termed Lorry Terrace, comprises a basal gravel with white-patinated Acheulean artefacts, overlain by a colluvial laterite. Despite claims that the Acheulean is stylistically more "evolved" than in $T_1$, the artefacts could have been derived from the latter, as is the case with the lateritic lumps which apparently have been redeposited in $T_2$ from $T_1$. The surface of $T_2$ is at 16m +rl, which correlates with Vadamadurai $T_1$, and is probably datable to the Eem interglacial. Should the artefacts be *in situ* they might be assignable to a transitional industry between the Acheulean and the Middle Palaeolithic; further typological investigations are required concerning this matter.

$T_3$, at 7.5m + rl, correlates possibly with Vadamadurai $T_2$ and is assignable either to late Eem or one of the Würm interstadials. It comprises a basal gravel with an "evolved" Acheulean characterised by advanced handaxes, cleavers and a strong Levallois component. This industry might turn out to be an early transitional phase into the Middle Palaeolithic. The basal gravel is capped by a silt which also contains a Middle Palaeolithic.

$T_4$ deposits are unconformous against $T_3$ and they comprise thick gravels, once again with an "evolved" Acheulean which is probably a Middle Palaeolithic. The surface of $T_4$ is at 5m +rl, which could place it in one of the Würm interstadials.

$T_5$, at 2.5m +rl, is said to comprise 1.5m of gravel deposit with a Middle Palaeolithic industry in it, and hence it probably does not correspond to Vadamadurai $T_3$, despite the similarity of elevation. Whether the $T_5$ industry is indeed Middle Palaeolithic and not Mesolithic needs verification by adequate sampling.

The Middle Palaeolithic excavated from Gudiyam 3, just north of Madras, included so-called late Acheulean elements (*IAR* 1962/63; 1963/64; Sankalia 1974:68,178). Moreover, excavations in the Attirampakkam Terrace, opposite Poondi, which appears to correlate with Vadamadurai $T_2$ and Poondi $T_3$, revealed a decomposing bed-rock with an Acheulean industry on its surface, followed by a detrital laterite with a Middle Palaeolithic which included several (almost Micoquian) handaxes with an "S" twist on flat, elongated flakes (de Terra and Paterson 1939:329; *IAR* 1964/65; Sankalia 1970:154; 1974:67).

The presence of bifaces in Tamilnadu's Middle Palaeolithic is not anomalous. Note, for instance, the small handaxes found in the Middle Palaeolithic of the Luni river, Marwar, Rajasthan, and in the Karimnagar District of Andhra (Sankalia 1974:176,188-94). Further support can be adduced from Europe for the contention that Tamilnadu's Middle Palaeolithic could conceptually include strong Acheulean survivals, which in turn suggests a technological and chronological continuum from the Acheulean to the Middle Palaeolithic, as in the Poondi terraces.

The Mousterian Complex of France, akin to the "Mousterioid" Middle Palaeolithic of India, has also been defined primarily on typological traits (v. Bordes 1961) although it does appear to fall within a specific time-span. The unifacial treatment of tools on flakes from discoidal cores is characteristic (Binford and Binford 1966:238; Bordes 1968:243; Clark 1969:43) although discoidal cores themselves are also known from the Lower Palaeolithic, for example, the medium-sized and large specimens from Kukana, Mayurbhanj, Orissa in the Peabody Museum, Harvard. Bifaces do, however, exist in the Middle Palaeolithic of Europe, although displaying more step-flaking than is the case with the Acheulean

(Leakey 1953:60). For instance, there is the Mousterian of Acheulean Tradition (A) of France (AMTA), with its strong biface component (Bordes 1966:80ff; 1968:102,105; 1972:54; Bordes and de Sonneville-Bordes 1970:63,72; Mellars 1970:141). On the other hand, there are the Quina, Ferrassie and Typical Mousterian assemblage-types where this element is almost lacking (Bordes 1961*a*:805; 1966:82; 1968:101-2; 1972:53; Bordes and de Sonneville-Bordes 1970:61-3; Mellars 1970:141,150), which is also the case in West Asia and which in India would have their counterparts in the assemblages without handaxes. Then there are the Micoquian assemblages with characteristic handaxes such as cordiforms with thick butts (Bordes 1968:106). (The AMTA has been assigned an age of Würm I, or even earlier, down to late Würm II (Bordes 1961*a*:804; 1968:102; 1973:217; Mellars 1970:147). The Micoquian was partly contemporaneous with the AMTA (Bordes 1966:85).

There were, apparently, other abundant and characteristic Middle Palaeolithic handaxe industries in western Europe and North Africa at or shortly before the beginning of Würm at ca. 90,000 BP: for instance, Le Tillet in northern France (id.: 1954:398-400,440-1; Mellars 1970:147-8) and the "Evolved Acheulean" of north-western Africa (Biberson 1961:331-98; Mellars 1970:149).

The data from Tamilnadu point towards the hypothesis that India has a chronological continuum from its Acheulean to the Middle Palaeolithic which could mean that some of the Middle Palaeolithic assemblages in peninsular Aggradation II might be very early indeed and that some of the so-called Acheulean assemblages in Gravel II might be Middle Palaeolithic with handaxe survivals. Considering that the Lower to Middle Palaeolithic evolution in Tamilnadu appears to have followed a pattern similar to that of Europe and North Africa, one could postulate a correlative date for the commencement of the Middle Palaeolithic in India, at ca. 200,000-150,000 BP. Cross-dating by comparing two similar evolutionary patterns carries far more conviction than the correlation of isolated techno-stylistic traits. This, in turn, could signify that Aggradation II of the peninsula, with its Middle Palaeolithic, can date from as early as ca. 200,000 BP, thus tentatively defining this elusive lower boundary – which is in approximate agreement with the hypothetical geo-chronological dating of the Middle Palaeolithic on Tamilnadu's marine peneplain at 17m +msl.

Synthesising the above data from coastal Tamilnadu, the following points emerge with reference to peninsular India:

(*a*) The earliest evidence of the appearance of the Upper Acheulean techno-complex could be during the Cromerian interglacial of ca. 0.7 my BP.

(*b*) The Acheulean and the Middle Palaeolithic form a technological and perhaps chronological continuum.

(*c*) The Middle Palaeolithic first appears in the Eem interglacial, although the possibility of evidence from Riss deposits cannot be ruled out.

(*d*) The Middle Palaeolithic continues into Würm interstadials

It has to be stressed, however, that Pleistocene sea levels as chronological indicators constitute a subject rife with controversy (Bloom 1971:370,372,376; Flint 1971:318,320,330,342,382; Butzer 1971:25,225-6; 1975:49-50; 1975*a*:861-2; Larsen 1975:46-7). As the same sea level could be achieved by several transit episodes, firmer geomorphologial dating evidence is required.

Various workers have recently emphasised that it is very difficult to distinguish glacio-eustatic sea level changes. One could quote a number of factors that could change the sea level: capacity of the ocean basins can change by tectonic activity, or by deposition of sediments; 1 °C change of temperature of sea water will cause 2 metre change in sea-level; crustal deformation or land isostasy; shifts in the earth's axis of rotation, etc. It is, therefore, an insuperable task to disentangle the purely glacio-eustatic changes of sea-level from the effects of the other factors.

Not only the causes, even the data on eustatic effects, viz. changes in sea-level in different parts of the world, are a matter of serious polemics [Agrawal and Kusumgar 1974:49].

The multiplicity of sea levels at a few convergent points of elevation... renders altimetric correlations next to useless. So, for example, on Mallorca there were at least seven strands in +1.5-4 metres, at least four at +8-15 metres, and at least two at +30 metres. What, under these circumstances, does a "4 metres sea level" mean? [Butzer 1975:48].

Clear markers of sea level maxima, such as wave-cut notches in cliffs, have not as yet been recorded from India. Should the thalasso-static fluviatile terraces of Tamilnadu be referrable to wave-cut notches, the correlations with sea level maxima during interglacials and interstadials would reach a higher degree of acceptability. Meanwhile, the above attempts at dating the terraces can only be considered tentative.

It is now appropriate to enquire whether data from further afield, namely from the western Himalayas, have anything to offer by way of chronological enlightenment with regard to the peninsular aggradation cycles. De Terra and Paterson (1939) traversed ca. 500km in a northeast-southwest direction from ca. 4,000m +msl in the south-western Himalayas down to ca. 300m +msl in the Punjab plain, via the Kashmir valley, Pir Panjal range and the Himalayan foothills respectively. Stratigraphic correlation was effected by them for glacial activity in the Himalayas, glacial outwash and lake sediments in Kashmir, and fluviatile terraces of the upper Indus in the Shivalik foothills and in the Potwar plain of the western Punjab (v. ibid.:facing p. 224).

The late Tertiary and Quaternary sedimentary sequence of the Potwar plain (which is bisected by the Soan river at ca. 650m +msl) is as follows:

*Tatrot Zone*: The Dhok Pathan Zone, faunistically Pliocene, is succeeded unconformably by the Tatrot Zone (ibid.:260-1) with its typically Lower Pleistocene (Villafranchian) fauna. *Hexaprotodon sivalensis* makes its first appearance in the Tatrot (Deraniyagala 1958:103; Sahni and Khan 1964:63), other noteworthy forms being *Gigantopithecus*, *Stegodon insignis-ganesa* and *Elephas planifrons* (Sahni and Khan 1964:63,67). Sedimentologically, Tatrot has been correlated with outwash and morainic deposits of the first Himalayan glaciation by de Terra and Paterson, although Sahni and Khan place it in the Upper Pliocene (in the Sutlej and Ghaggar valleys of the East Punjab) due to the absence of *Equus* and *Bubalus* and the occurrence of *Hipparion* and *Proamphibos*. Note, however, that *Gigantopithecus blacki* of the southern Chinese Liuch'eng Fauna has been assigned to the second (Poyang) glaciation of China (Chang 1977:26,30) which has been lithologically correlated with the Tatrot of the Shivaliks. Note also that Villafranchian faunas have been dated to 1.7 and 1.9 my BP in North America and Europe respectively (Isaac 1972).

*Pinjor Zone*: The next zone, Pinjor (de Terra and Paterson 1939:261-4), has been correlated sedimentologically with the Lower Karewa lake beds of Kashmir. Since the latter underlie outwash deposits of the second Himalayan glaciation, they (and the Pinjor) have been assigned a first interglacial age (Vishnu-Mittre et al. 1962:92-5; Sankalia 1974:35). The Pinjor fauna is very akin to that of the Tatrot, although more abundant: *Stegodon insignis-ganesa*, *Elephas planifrons*, *Hexaprotodon sivalensis* and *Camelus sivalensis* continue from Tatrot. However, *Equus sivalensis*, *Rhinoceros sivalensis*, *Rhinoceros palaeindicus*, *Bubalus platyceros* and *Elephas hysudricus* appear for the first time in the Pinjor (Sahni and Khan 1964:68; Hooijer 1975:39). *E. hysudricus* is also recorded from the Lower Karewas (de Terra and Paterson 1939:facing p. 224). Primates have not been found in the Pinjor (Sahni and Khan 1964:69,72). The upper boundary for the Pinjor has tentatively been drawn at 0.7 my BP (Brunhes-Matuyama magnetic reversal) on the basis of its Villafranchian fauna (Maglio 1975:448).

*Boulder Conglomerate*: Four Pleistocene glaciations have been postulated for the Himalayas by de Terra and Paterson. The second of these was apparently the most extensive. It saw the deposition of the massive Boulder Conglomerate (1939:264-5) unconformably over the folded Tatrot and Pinjor beds. Sahni and Khan (1964:63) term this the Upper Boulder Conglomerate, the Lower Boulder Conglomerate being conformous with the Pinjor.

The Boulder Conglomerate has been correlated with moraines of the second Himalayan glaciation and with the Karewa Gravels in Kashmir. Some of the fluviatile fans of the Boulder Conglomerate exceed 500 m in thickness, and these merge with outwash trains of the second glaciation in the Salt Range and in the Potwar. The fauna associated with this deposit has been termed "Middle Pleistocene" and it comprises (de Terra and Paterson 1939:266) ***Elephas namadicus, Hexaprotodon*** sp., ***Equus namadicus, Bos*** sp., ***Bubalus palaeindicus*** and ***Camelus. Elephas hysudricus*** is said to have been found in the Boulder Conglomerate. *E. planifrons* had been displaced completely and *E. namadicus* is thought to have intruded from Africa (Maglio 1975:450). ***Rhinoceros sivalensis*** is also said to have persisted (ibid.).

The fauna of the Boulder Conglomerate appears to correlate somewhat with that of Aggradations I and II of the Indian peninsula. Despite the presence of *Equus namadicus* and *Bubalus palaeindicus* which would correlate the Boulder Conglomerate with Gravel II (v. above), the stone artefacts which have been observed to occur in the upper horizons of the Boulder Conglomerate in the Indus and Soan valleys, and also in the Liddar valley in Kashmir (de Terra and Paterson 1939:269; Sankalia 1974:33) comprise large flakes of a non-descript appearance, which are apparently earlier than the Acheulean tools found in $T_1$ of this region (de Terra and Paterson 1939:304-5; Movius 1949:376-9). It has already been noted that an Acheulean occurs in Gravel I of the peninsula, and it was probably an Upper Acheulean at that. Although a larger sample of artefacts could reveal the presence of Acheulean handaxes and cleavers in the Boulder Conglomerate, this so-called Pre-Soan industry can for the present be considered pre-Acheulean in India. Tentatively, therefore, Gravel I of the peninsula can be considered younger than the Boulder Conglomerate of the Potwar. The absence of ***Bubalus palaeindicus*** and ***Equus namadicus*** in Gravel I can be attributed to sampling vagaries. However, the Boulder Conglomerate is significant in that it is the only stratigraphic unit in the Himalayas displaying faunistic links with the peninsular aggradations – and thence with the Ratnapura Fauna.

$T_D$:The next geomorphic phase saw the dissection of the Boulder Conglomerate, thereby forming $T_D$.

$T_1$: The material derived from the formation of $T_D$ was deposited as channel sediments making up $T_1$ of the sequence (de Terra and Paterson 1939:269-71). This terrace is said to correlate with the Upper Karewas of Kashmir and is dated to the second interglacial, the longest in the Himalayas, which saw extensive degradation. $T_1$ was sterile of fauna. However, it did contain a chopper industry, the Early Soan, as noted in the Indus and Soan valleys (ibid.: 295,302,305,311-2; Movius 1949:377).

There are indications that an Acheulean component does exist among the Early Soan choppers and flakes (de Terra and Paterson 1939:303,308,310,320); for instance, at a locality southeast of Rawalpindi, at Site 21 and at MS-163 on the Grand Trunk Road (ibid.: 294-5,320; Movius 1949:381; Sankalia 1974:22,145,149). This would mean a technological correlation between $T_1$ and Gravel I of the peninsula which could signify a date coeval with the second Himalayan interglacial for the latter. Since the thalasso-static fluviatile aggradations of Tamilnadu have been shown to contain an Acheulean during a postulated Holstein interglacial, de Terra and Paterson's assigning of the Potwar $T_1$ to the second interglacial, which in turn can hypothetically be correlated with the Holstein of Europe, appears to be corroborated. This is the only evidence there is which could serve to tie up the Himalayan glacial sequence with that of the Alps (through eustatic sea levels) and I am not aware of this having been pointed out so far. The correlation proposed above is between

Indus and Soan $T_1$ with Vadamadurai $T_D$ and Poondi $T_1$. This crucial hypothesis is urgently in need of testing as it will supply a vital key to Indian Palaeolithic studies.

The absence of an Acheulean in the Boulder Conglomerate of the second glaciation and its presence in $T_1$ therefore suggests a lower age boundary equating to the Holstein interglacial at ca. 0.3 my BP for peninsular India's Aggradation I.

*$T_2$*: Terrace 2 of Potwar has been correlated with moraines of the third glaciation in Kashmir (de Terra and Paterson 1939:271-6). If one accepts the above correlation of $T_1$ with the Holstein interglacial, $T_2$ could correlate with Riss at ca. 0.2 my BP. This latter terrace comprises a basal Potwar Gravel, overlain by up to 120m thickness of silts of periglacial origin. The latter is termed the Potwar Loess.

The Basal Gravel has apparently yielded a ?*Camelus* sp. (ibid.:273). It also contains the Late Soan A (ibid.:308), a Middle Palaeolithic industry, with a predominance of flakes, a Levallois component and core-tools resembling small handaxes, as at Chauntra (ibid.:310,319; Movius 1949:383,Fig.29; Sankalia 1974:19). The Chauntra handaxes apparently could have originated during a period intermediate between the deposition of $T_1$ and $T_2$ (de Terra and Paterson 1939:289,290,295,304). Ganeshpur in the Liddar valley of Kashmir has also produced a single "Middle Palaeolithic" artefact in a glacial scree assigned to the third glaciation (Sankalia 1974:133,144). These data appear to place the beginnings of the Middle Palaeolithic in the Himalayas squarely within the Riss glaciation, thus corroborating the lower boundary date hypothesised for the peninsular Aggradation II and its Middle Palaeolithic.

The Potwar Loess has yielded a loess fauna of *Equus, Camelus, Bos* and canines (de Terra and Paterson 1939:273). This does not admit of correlation, either negative or positive, with the Narmada fauna of Gravel II in the peninsula. This non-correspondence is directly attributable to the differing environments: the periglacial Potwar versus tropical peninsular India. The associated lithic industry, the Late Soan B, has a greater proportion of Levallois elements and blade-like flakes than in the preceding Late Soan A (ibid.:310; Movius 1949:383; Sankalia 1974:19).

A few "true blades" are also claimed to have been found in the Potwar Loess, which, if of Riss age, would make the appearance of blade technology very early indeed in India. The earliest evidence of blades in France is in the BMTA of Pech de l'Aze, an industry dated to 36,000 BP at La Rochette (7) (Bordes 1968:105; 1972:91; Mellars 1970:165). However, the "blades" in the Late Soan B deserve closer scrutiny before they can be accepted unequivocally as products of blade technology.

*$T_3$*: The third interglacial in the Himalayas is thought to have cut $T_2$ and the considerable eroded material, which included the Potwar Loess, redeposited as the sediments within $T_3$ (de Terra and Paterson 1939:230,276). Neither faunal nor artefactual remains have been found *in situ* within this terrace, although some of the less water-worn specimens assigned to the Late Soan, found in $T_3$, could in fact be coeval with the deposit (ibid.:295). This interglacial could correlate with Eem.

*$T_4$*: The sediments in $T_4$ were deposited during the fourth Himalayan glaciation. These deposits have been correlated with moraines in Kashmir. They comprise gravels overlain by sands, silts and loessic loams. Although no faunal remains were found within them, the Evolved Soan does occur (ibid.; Movius 1949:383). These artefacts are smaller and more blade-like than in the Late Soan B (Sankalia 1974:20). It is probable that this industry correlates chrono-stratigraphically with the Upper Palaeolithic of Gravel III in the peninsula. A detailed morphological comparison between the Evolved Soan and the peninsular Upper Palaeolithic is necessary before concluding on this correlation.

*$T_5$*: Holocene loessic silts are said to cover much of the Potwar terraces and these silts contain pottery and charcoal. $T_5$ on the Soan is considered recent and it constitutes the present flood-plain.

It is clear from the above account that de Terra and Paterson (1939:222) saw a definite four-fold glacial sequence in the Himalayas. To what extent were they influenced by the Alpine model? On the other hand, my observation concerning the dating of the

Acheulean in $T_1$ of the Soan and the Indus to the Holstein interglacial, by correlation with Vadamadurai and Poondi, does appear to suggest a correlation between the Himalayan and Alpine four-fold glacial schemes. This correlation hinges on the identification of Acheulean handaxes in the Potwar. Do these really exist in $T_1$, or are the resemblances to handaxes merely spurious? Pending further intensive typological studies on the Potwar "handaxes", we cannot but accept their identification as true handaxes of the Acheulean tradition. The result of this acceptance would be the continued use of de Terra and Paterson's four-fold Himalayan/?Alpine glacial scheme as a working model on which the data are to be stretched until it becomes patently obvious that the model needs revision.

A few anomalous glimmerings are already showing through which could eventually lead to such a revision of the de Terra and Paterson scheme. The Potwar's $T_D$, $T_2$ and $T_3$ display signs of post-depositional tilting according to de Terra and Paterson. Such tectonic instablity could easily have given rise to localised conditions of fluviatile aggradation which could cross-cut the overall aggradation and degradation pattern.

Investigations by Lal (1955:59-92) have brought to light sequences of four and five aggradational terraces along the tributaries of the Sutlej, in foothill-country of Himachal Pradesh comparable to the Pir Panjal. These terraces have once again been correlated with glacial deposits along the Himalayan foothills. However, according to Rozycki and Chmilewski (University of Warsaw), numerous variables, such as the Southwest Monsoon and tectonics, have affected the aggradation pattern of these terraces (Joshi 1968; 1970:54,55,57; Rajaguru and Hegde 1972:71; Agrawal and Kusumgar 1974:39-40). A chopper industry, akin to the Early Soan, was observed within $T_1$, $T_2$ and $T_3$ at Guler, which thus indicates a techno-stratigraphic sequence, and hence probably a chrono-stratigraphic sequence, which is different from that described for the Potwar by de Terra and Paterson. No Acheulean handaxes were found, nor was there a Late Soan, although small artefacts of chert were often found associated with what are otherwise typically Early Soan assemblages on quartzite. This highlights the problem concerning the identification of the Acheulean in the Punjab and the risks of employing size or raw material as dating criteria for artefacts.

Porter's work in Swat Kohistan (1970), West Pakistan, has yielded evidence of only three glaciations (v. also Rajaguru and Hegde 1972:80; Agrawal and Kusumgar 1974:36-7); and Bengal, while displaying traces of four major Pleistocene terraces, appears to have been affected by the subsidence of the flood-plain and uplift of the Lakmai hills (Morgan and McIntire 1956; Vishnu-Mittre 1974). However, despite any doubts that might arise concerning the validity and general applicability of the four-fold Himalayan scheme, there is no gainsaying the enormous breadth and scope of de Terra and Paterson's work on the Shivalik deposits. It will, hence, be yet a while before we can direct any major criticisms at their conclusions and, until then, it would be eminently reasonable to accept their scheme as a working construct.

Synthesising the above data from the Potwar, the following points emerge:

(*a*) The earliest evidence of the appearance of the Acheulean techno-complex in the region is probably during the Holstein interglacial of ca. 0.3 my BP. This ties in well with the Acheulean in the 30m terraces of Vadamadurai and Poondi but leaves the Cromerian horizon for Tamilnadu without a correlate. The Holstein date is hypothetically transferable to peninsular Aggradation I.

(*b*) The Middle Palaeolithic first appears during the Riss glaciation at ca. 0.2 my BP, which agrees well with European and African parallels and corroborates the hypothetical lower boundary of the material from Tamilnadu.

(c) The Middle Palaeolithic, which continues into the Eem and (?early) Würm, had a final Middle Palaeolithic. Should this industry be assigned to an Upper

Palaeolithic, it could correlate with the industry in peninsular Gravel III at over 25,000 BP. The dating of the Punjab Middle Palaeolithic from Riss to early Würm is hypothetically transferable to peninsular Aggradation II.

(*d*) The Boulder Conglomerate correlates very closely with Aggradation I, with particular reference to the presence of both *Elephas hysudricus* and *Elephas namadicus*. The *Hexaprotodon* and *Bos* spp. in the Boulder Conglomerate might refer to *H. namadicus* and *B. namadicus* as found in Aggradation I.

(*e*) *Rhinoceros sivalensis* of the Boulder Conglomerate was more archaic than *R. unicornis* of Aggradation II, hence the Boulder Conglomerate is likely to be earlier than Aggradation II.

(*f*) *Gigantopithecus* of the Tatrot would date *Homopithecus* of the Ratnapura Fauna to the first glaciation. Of course, the identity of the latter needs further verification.

(*g*) *Elephas hysudricus* and *E. namadicus*, once again if correctly identified in Lanka, could date these elements in the Ratnapura Beds to the first interglacial and the second glaciation of the Himalayas respectively.

Since typological correlations between the Ratnapura Industry and Pleistocene industries of other countries are not feasible due to the absence of distinctive stylistic traits in the former, associated faunal correlations have, as indicated above, assumed considerable significance. In this respect it is the Oriental Faunal Zone which is of prime importance, particularly since the boundaries of this zone have remained remarkably stable during the Quaternary. The countries which come to mind with reference to the Oriental Faunal Zone are Pakistan, India, Burma and Southeast Asia up to the Wallace Line east of Borneo. Having surveyed the Indian scene, the next step outwards in the Oriental Faunal Zone is Burma. The standard reference for the geo-chronology of this region is by de Terra, Movius and Colbert (1943). (For revised chronology of India v. Addendum IV.)

The area explored by de Terra et al. comprises the main Irrawaddy valley in central Burma, latitudinally akin to Gujarat and Madhya Pradesh in India. The Tibeto-Burmese border had been glaciated during the Pleistocene and it is surmised that the alluvial deposits along the Irrawaddy would be related to glacial activity. However, it should be borne in mind that the Irrawaddy valley occurs within the rain-shadow of the Arakaṇ Yoma range and that the Southwest Monsoon would have had a katabatic drying effect on this area, unlike in the Himalayas where the contrary would have been the case. In this respect, an aspect of climatology which has not been remarked upon by de Terra in India or Burma, the Irrawaddy valley resembles the coastal plain of Tamilnadu, which is also in the Southwest Monsoonal rain-shadow. The relevant sequence on the Irrawaddy is as follows (de Terra, Movius and Colbert 1943:331):

(*a*) The Upper Irrawaddian Beds are faunistically Villafranchian (ibid.:288,293,397ff), and they correlate with the Pinjor of the Himalayas. Noteworthy faunal elements include *Hipparion, Boselaphus, Stegodon insignis, Elephas hysudricus, Rhinoceros sivalensis, Hexaprotodon sivalensis* and *Bibos* cf. *sondaicus*. The only prominent Far Eastern element in this fauna is *Equus yunnanensis*.

(*b*) The Upper Irrawaddian Beds are overlain unconformably by a thick lateritic gravel containing a chopper industry (ibid.:341ff), the Early Anyathian 1. No faunal remains have been found. This gravel has been correlated with the Boulder Conglomerate of the Potwar.

(*c*) The next phase is erosional, as represented by a lateritic crust containing the Early Anyathian 2. Once again, no faunal remains.

(*d*) The fourth phase is aggradational, and correlated with $T_2$ of the Potwar. It contains Early Anyathian 3 and remains of *Elephas hysudricus*.

(*e*) The fifth phase is said to be erosional and thus assumed to correlate with $T_3$ of the Potwar. Its terrace deposits contain the Late Anyathian 1, which is also a chopper industry, but distinguished from the Early Anyathian by the smaller size of its artefacts and the larger proportion of flake-tools. No faunal remains were found in association.

(*f*) The next terrace deposit is considered aggradational and correlated with $T_4$ of the Potwar. It contains the Late Anyathian 2, but no faunal remains were found.

(*g*) The final terrace is correlated with $T_5$ of the Potwar and assigned to the Holocene. No faunal inclusions have been observed.

Technologically, the Anyathian has nothing to offer which can be used for chronological correlation with the Indian sequence. That the Early Anyathian 3 is Lower Palaeolithic appears to be borne out by the presence of *E. hysudricus*. One can also hazard a guess that the Late Anyathian represents a Middle Palaeolithic industry, due to its smaller size and higher proportion of flakes compared to the Early Anyathian.

Faunistically, while there is a clear correlation between the Villafranchian faunas of India and the Irrawaddy valley, the presence of *E. hysudricus* in $T_2$ of the Irrawaddy is the only other item of significance. It is impossible to hypothesise whether *E. hysudricus* survived longer in Burma than in India (behind the protective screen of the Arakan Yoma), or whether this deposit correlates chrono-stratigraphically with the Boulder Conglomerate of the Potwar. The correlation chart (Movius 1949:346) certainly does not correlate the Irrawaddy's $T_2$ with India's Boulder Conglomerate; but then, considering the two radically different depositional environments due to the climatic factor which I have mentioned above, it would be best to view de Terra's correlation between the Potwar and the Irrawaddy alluvial deposits with some reservations. It would appear essential that the fluviatile deposits along the Irrawaddy be correlated with the glacial deposits in the Tibeto-Burmese border, which in turn can possibly be correlated with the Himalayan glaciations and thence with the Potwar terraces.

The occurrence of *Stegodon orientalis* and *Elephas namadicus* in the Mogok Fauna (not associated with any lithic industry) from the karstic fissures of the Shan Plateau (de Terra, Movius and Colbert 1943:324) suggests that certain faunal elements, *Stegodon* in this case, might have survived longer in Burma than in India (where *Stegodon* became extinct before the appearance of *E. namadicus*). This in turn suggests that *E. hysudricus* might also have survived for a longer period in Burma than in India. If this should be the case, perhaps de Terra's correlation between Irrawaddy $T_2$ and Potwar $T_2$ might be valid after all, and a glimmer of a suspicion arises as to whether the so-called *E. hysudricus* from the Ratnapura Beds might not represent a similar case of survival. Militating against this latter hypothesis is the easy accessibility of Lanka from India, with no obstacles to cross such as the Arakan Yoma; which would mean that Lanka's faunal chronology closely paralleled that of India.

Moving eastwards from Burma, Thailand has not produced any data relevant to the Pleistocene chronology of India. Northern Malaya has yielded a tooth of *Elephas namadicus* associated very indirectly with a Tampanian chopper assemblage on the Perak river (ibid.:333,376-7; Movius 1949:403). This, once again, is of little significance for our purposes. Sumatra and Vietnam have also not produced anything of chrono-stratigraphic relevance, except perhaps that *Elephas planifrons* has survived much longer than in India in the Long Son Fauna of Vietnam where it was found associated with *E. namadicus* (Hooijer 1975:38). But then, Vietnam is already outside the Oriental Faunal Zone.

Java, on the other hand, has produced abundant data on its Lower and Middle Pleistocene (v. de Terra, Movius and Colbert 1943; Movius 1949:347):

(*a*) The Putjang Beds, containing the Djetis Fauna, is widely distributed on the island. They have two dates of ca. 1.9 K/Ar my BP from Sangiran (Hooijer 1975:39; Verstappen 1975:22). Faunal elements (von Koenigswald in de Terra, Movius and Colbert 1943:443; Hooijer 1975:38) include a primitive *Stegodon*, *Elephas planifrons*, *Bubalus* sp., *Cervus* sp., *Muntiacus* sp., *Hippopotamus antiquus* (less specialised than *H. namadicus*), *Rhinoceros sondaicus*, *Felis* cf. *tigris*, *Felis pardus*, *Canis* sp., *Meganthropus*, *Homo modjokertensis* and *Homo robustus*.

The potassium/argon dates for the Putjang Beds appear to be indirectly corroborated by East African K/Ar dates. Olduvai Upper Bed II has produced Hominid 9 which W. Howells of Harvard (1973 :pers. comm.; v. also Clark 1970:77) considered morphologically very akin to some of the Djetis hominids. The middle and upper horizons of Bed II have been dated to 1.7 and 1.4 K/Ar my BP respectively (Isaac 1969; 1972); whereas Bed IV with an Upper Acheulean has a palaeomagnetic date of 0.7 my BP (Isaac 1975*a*:500). Hence, on the basis of the correlation between the East African and Javanese hominids, the Putjang dates of ca. 1.9 my are acceptable. Note, however, that hominid morphology can be very misleading as a chronological index: for instance, Skull 1470 from Koobi Fora near Lake Rudolf, Kenya, has a date of 2.8 K/Ar my BP, but is yet, perhaps, assignable to *Homo erectus* (Leakey 1973; Pilbeam 1975:839). It could also be objected that Africa does not belong to the Oriental Faunal Zone and that correlations between early hominids across such zones are not chronologically valid. While there can be considerable truth in this statement, hominid precocity in seeking to expand territorial boundaries, even during the Lower Pleistocene, could be assumed to have cross-cut otherwise relatively rigid zonal boundaries.

(*b*) The Putjang are succeeded by the Djombang (723,000 K/Ar BP) and Kabuh (595,000 K/Ar BP) Beds (Verstappen 1975:22). These constitute the lower and upper stratigraphic horizons respectively of the Trinil Fauna. Further potassium/argon dates for these beds comprise 903,000-795,000 BP (4 samples), 730,000-610,000 BP (upper boundary of Kabuh). A basalt above the Kabuh has a date of ca. 500,000 K/Ar BP. The Trinil Fauna can hence be dated to ca. 1-0.5 K/Ar my BP.

The Trinil Fauna forms a continuum with the Djetis, although southern Chinese intrusions are more noticeable in the former. Important new arrivals in Trinil are (von Koenigswald in de Terra, Movius and Colbert 1943:448-9) an advanced *Stegodon*, *Elephas namadicus*, *Hexaprotodon namadicus*, *Bubalus bubalis palaeokerabau*, *Axis* sp., *Muntiacus* cf. *muntjak* and (mostly in the middle horizons) *Homo erectus*. *Elephas planifrons* and *Meganthropus* are not found any more. Other forms in the Trinil Fauna include *Bibos sondaicus palaeojavanicus*, *Rhinoceros sondaicus*, *Felis tigris*, *Felis pardus* and a *Canis* sp. *Elephas hysudrindicus* in the Trinil is considered to be derived from *E. hysudricus* (Hooijer 1975:39). If correct, this hypothesis would place the lower dates of *E. hysudricus* at a pre-Trinil stage.

The potassium/argon dating of the Trinil Fauna at ca. 1-0.5 my BP has been corroborated by the dating of *Homo erectus* in the Middle Breccia of Choukoutien Locality 1 to 0.5-0.21 my (uranium/thorium) and 0.3 my (amino acid) (W.Howells 1973:pers. comm.). Morphologically Peking Man is considered to be somewhat more evolved than *H. erectus* of Trinil, and hence the Javanese and Chinese dates are in sequential agreement. The Trinil flora suggests a cold (?Mindel) phase.

A flake industry has been found with the Kabuh Beds at Sangiran.

(*c*) The Kabuh Beds are succeeded by an unconformity and then the Notopuro Beds (Movius 1949:334). These comprise the Sangiran Gravel and also Terraces 1-3 on the Solo river. The potassium/argon date of ca. 500,000 BP for a basalt above the Kabuh might be transferable to the Notopuro Beds; but no secure dates are available for the latter, particularly in view of the unconformity succeeding the Kabuh. The cold climate crane *Grus grus* suggests a glacial phase of the Pleistocene which might correlate with Riss.

The Ngandong Fauna is associated with the Notopuro Beds (von Koenigswald in de Terra, Movius and Colbert 1943:453). Among the faunal elements are a specialised *Stegodon, Elephas namadicus, Hexaprotodon namadicus, Rhinoceros sondaicus, Bubalus bubalis palaeokerabau, Cervus, Axis, Muntiacus muntjak, Felis tigris, Felis pardus, Bibos sondaicus palaeojavanicus* and *Cuon crassidens. Homo soloensis* was found in $T_2$ of the Solo river and is considered a part of the Ngandong Fauna. Several of the Trinil forms disappear and there are few new arrivals.

The Sangiran (or Ngandong) flake industry is assigned to Solo Man (ibid.:354-5; Glover 1973:54-5). It is a crude, flake industry on chalcedony, jasper and agate, a noteworthy category being bolas-stones. Bone tools have also been observed: an antler pick and a spine of a ray which appears to have been mistaken for a bilaterally barbed harpoon.

The Patjitanian stone tool industry of Java (ibid.:352-64) is associated with three terraces on the Baksoka river. It does not relate to any of the faunas described above, due to the lack of associated faunal remains. Stylistically it is non-distinctive – predominantly unretouched flakes, large and small. The Patjitanian remains undated and is of little chronological significance.

The stylistic non-distinctiveness of south-eastern and eastern Asian Palaeolithic chopper industries is best exemplified in China (v. Movius 1949:391,394,397; Chang 1977:22-7,46-7,53-6; Choukoutien material in the Peabody Museum, Harvard): Hsi Hou Tou of the first (Poyang/Taku) interglacial, followed by Lantien KWL and then Lantien CCW, Ko Ho and Choukoutien 13 of the final second (Taku) glaciation (?ca. 0.4 my), followed by Choukoutien 1 of ca. 0.3 my BP where small (<4.5cm) flakes of quartz occur in the same assemblages as very large choppers of quartzite and other materials. The artefacts from these sites are typologically so amorphous that, if devoid of independently dated associations, they can be assigned to any phase of the Palaeolithic, or indeed post-Pleistocene, evolutionary sequence of stone tool industries. They are useless as chronological indicators; and the same applies to the Patjitanian, the Early Anyathian and the Early Soan industries.

In relating the Javanese faunal data to India, the Djetis appears to correlate somewhat with the Pinjor fauna, as typified by the final presence of *Elephas planifrons* and a hippopotamus more primitive than *H. namadicus.* However, the age of ca. 1.9 K/Ar my BP for the Putjang Beds exceeds all estimated dates for the Pinjor Zone which is correlated with the first Himalayan interglacial.

The Trinil Fauna, on the other hand, approximates closely to that of the Boulder Conglomerate and peninsular Aggradations I and II, noteworthy faunal correlates being *Elephas namadicus* and *Hexaprotodon namadicus*, neither of which occur in the Djetis Fauna. Two Trinil forms are, however, more evolved than in the Narmada Fauna: *Elephas hysudrindicus* (vs. *E. hysudricus*) and possibly *Bubalus bubalis palaeokerabau* (vs. *B. palaeindicus*). Considering the very early age of the Kabuh Beds, 1.0-0.5 my BP, a satisfactory explanation has not been forthcoming as yet with regard to this situation. Meanwhile, assuming that, due to easy access across the Sunda Shelf (maximum present depth: 40m -msl) from the mainland to Java, the chronological lag between the Javanese and Indian faunas was not too significant in terms of early Middle Pleistocene time-spans, the potassium/argon dating of 1.0-0.5 my BP for the Kabuh Beds would appear to apply to the Boulder Conglomerate and peninsular Gravel I.

However, the geo-chronological evidence from India supports a more recent (Holstein interglacial) age for Gravel I. Hence, one has to turn to the Javanese Ngandong Fauna. The age boundaries of this fauna, which has Indian correlates in *Elephas namadicus* and *Hexaprotodon namadicus*, can fall at any date after

500,000 K/Ar BP, extending possibly well into the Upper Pleistocene. At a general level, the Notopuro Beds, with their cold-climate (?Riss) Ngandong Fauna can be considered to correlate faunistically and chronologically with Aggradation II of peninsular India and, in their early horizons, possibly with Aggradation I as well.

From among the Javanese Pleistocene faunas, it is noteworthy that *Bubalus bubalis palaeokerabau* (Trinil, Ngandong) has its species counterpart in the Ratnapura Fauna, although the latter is not the wide-horned variety. Similarly, *Rhinoceros sondaicus* (Djetis, Trinil, Ngandong) has been tentatively correlated with *R. kagavena.* None of these forms have been recorded from India's Pleistocene faunas, as is also the case with *Cuon* (Trinil, Ngandong). This raises the question as to what became of the forms found in Java and Lanka as far as India is concerned. The answer appears to be that they will be discovered one day in the Narmada Fauna and that their absence so far is due to inadequate sampling and taxonomic procedures. Meanwhile one can hypothesise that the ca. 1 my BP lower date for *Bubalus bubalis* is applicable to the same species in Lanka. *R. sondaicus* has a lower date of ca. 2 my BP in Java, which can be transferred to *R. kagavena* if the taxonomic correlation between the two forms is acceptable. *Bibos sondaicus,* considering specific differences, can only give an indirect lower boundary of Villafranchian age from the Upper Irrawaddian evidence at ca. 1 my BP; and the same applies to *Cuon* at $\leqslant$ 0.5 my BP in the Ngandong Fauna.

*Felis tigris* occurs from the Trinil onwards in Java. However, its earliest record in India is at ca. 4,500 BP on seals of the Indus Civilisation. When did the tiger enter India, and, despite its ubiquitous distribution on the sub-continent, including the Aravallis where it is known to have co-existed with the lion during the nineteenth century (Misra 1967:5), why is it that, unlike the lion, no traces of it have been found in Lanka? One explanation is that these traces are still waiting to be discovered; the other is that it arrived in India after 7,000 BP when the mainland was severed from Lanka by the post-glacial rise in sea level. If the latter hypothesis is correct, the tiger's arrival in India can be dated to 7,000-4,500 BP. It would be interesting to enquire if the hamadryad *Dendraspis hannah* and the flying lizard *Draco,* which have also failed to cross over to Lanka despite a congenial environment on the island, entered India together with the tiger (v. Deraniyagala 1940*a*:356). But what could have been the factor responsible for acting as a barrier to the tiger's movement between Java and India during the Middle Pleistocene? Zoogeography is still beset with apparently insoluble riddles. (For lion at ca. 13,000 BP, Addendum I.)

Borneo's Niah Cave (Solheim 1969:36; Glover 1973:56) has produced evidence of the antiquity of that mysterious animal *Elephas maximus* whose fossil remains are so scarce outside of the Ratnapura Beds. Excavations conducted down to 4m below the surface at this site brought to light a faunal assemblage, inclusive of *E. maximus,* whose components did not alter appreciably throughout the deposit. A radiocarbon date of 41,600±1,000 BP exists for a sample found at 3m -gl and, although the site has been excavated metrically, it can be assumed that this date is applicable to *E. maximus* at Niah Cave and elsewhere in the Oriental Faunal Zone. This could signify that ca. 30,000 $^{14}$C BP for *E. namadicus* in Gravel II of peninsular India, which (barring overlap) presumably precedes *E. maximus* on the sub-continent, is too recent a date due to technical errors in the dating procedure.

Concerning Pleistocene mammalian distributions, conspicuous survivals such as *Archidiskodon* and *Stegodon* with the Tjabenge flake industry of the Walanae river terrace in Sulawesi, and *Stegodon* with "palaeoliths" in Flores (Glover 1973:55), can be attributed to isolation by deep intervening straits which were not bridged during glacial phases. *Stegodon orientalis* is known from the early Middle Pleistocene (?ca. 0.5 my BP) of Lantien in northern China in association with the hominids and in the Middle Pleistocene Wan Hsien Fauna of southern China. It continues into the Upper Pleistocene of southern China, as at Ch'ienhsi and Yungshan Cave with artefacts and Liuchiang and Lungtung Cave with *Homo sapiens* (Chang 1977:27,54,56). South China, however, is adequately distant from South Asia for it to have its own discrete pattern of Pleistocene faunal extinctions. In the absence of major natural obstacles, such as deep seas, mammalian dispersal through the Oriental Faunal Zone can be considered to have been rapid. Indeed, *Elephas namadicus* seems to have appeared in northern China (Lantien CCW), which is at a considerable distance from the boundary of the Oriental Faunal Zone, during the Taku glaciation and in the succeeding interglacials (ibid.:156) – thus approximating the date of its first appearance in Java and indicating rapid dispersal. Hence, *E. maximus* at Niah Cave could have been coeval with *E. maximus* in Lanka at ⩾40,000 BP. Concerning Pleistocene faunal evolution and dispersal, the following summing up is of direct relevance in the overall interpretation of the above discussions:

> In the tropics in general, and Africa in particular, stable mammal faunal configuration had been achieved by the end of the Pliocene and faunistic change since then has been comparatively slight. By contrast, the faunas of temperate Europe and Asia have undergone drastic change involving reduction in diversity and marked modification to many characteristic provincial forms. The difference shows particularly clearly in the micro-mammals. . . . Geophysical dating now shows that the faunas designated as early Middle Pleistocene by biostratigraphers in East Africa are actually almost three-quarters of a million years older than early Middle Pleistocene (Biharian) faunas in Europe. The relative and absolute ages of faunas in separate biogeographic provinces which have not been adequately calibrated by geophysics are still very uncertain [Isaac 1975:879-80].

## 3.3 IRANAMADU AND REDDISH BROWN EARTH FORMATIONS

*3.3.1 Introduction.* The significance of the Iranamadu and Reddish Brown Earth Formations (abbr. I Fm, RBE Fm) in relation to the strategy and tactics of the overall research design has been delineated in Chapter 2.3-4. Note that Wayland's (1919:101-3) term "Plateau Deposit" for the I Fm has been discontinued since stratigraphic practice requires a formation (for terminology v. Weller 1960:421-33; Hedberg 1972:20-1) to be designated after a type-locality, which in this case is Site 2 near the Iranamadu reservoir (Map 12). Besides, these deposits need not necessarily constitute plateaux and hence Wayland's designation can be physiographically misleading. As for the term "Red Earth Formation" employed by Cooray (1967:149-50), it refers only to the upper member of the I Fm comprising Red Latosols and does not take into account the Yellow Latosols, or the basal gravels, which, for the purposes of this work, form an integral part of a single formation – and Cooray's designation is hence considered inadequate. So much for nomenclature, the I Fm and the RBE Fm will be described below.

*3.3.2 Distribution.* The I Fm occurs within ecozone A of Lanka's Dry Zone. It is very extensive and forms an arcuate belt in the coastal lowlands (at below ca. 80m +msl) of the northwest and north (physiographic Sub-Zone 4; v. App.I.3.2) from around Pallama to Pulmoddai (Map 11). This belt has a maximum radial distance of ca. 32km from the sea. Occasional outliers occur along the southern and south-eastern coast (physiographic Sub-Zone 7) from the vicinity of Ambalantota up to Muhudu Vihare in Pottuvil (Solheim and S.Deraniyagala 1972:28,36) and Komari (v. Panabokke 1971). Climatically, the I Fm occurs in those areas receiving ca. 1,450-950mm of rain per annum, which represent the drier parts of climatic Sub-Zone 1 (App.I.4.8). The southern sites to the east of the Kumbukkan-oya river appear to be somewhat anomalous in that they occur in ecozone B. However, closer scrutiny of the climate at these localities might well reveal that the rainfall pattern is similar to that of the I Fm regions on the rest of the island.

The soils associated with the I Fm are Red-Yellow Latosols (App.I.5) and the vegetation is assignable to Series A (App.I.6.1). Visually it is the Latosols, with their highly distinctive appearance, and which are restricted in their range of distribution to that of the I Fm, that provide an immediate clue as to the existence of these deposits. Hence, it will be observed that the pedological term "Latosol" will frequently be loosely employed as being coterminous with "sandy clay loam of the I Fm" or "sands of the I Fm". This procedure is justified as a measure of convenience since the Red-Yellow Latosols are only known to have formed on the I Fm's sands.

The topography of the I Fm is flat (or it comprises gently undulating ridges) with feeble surface drainage features which are confined to the lower slopes (de Alwis 1971:10) where seasonal streams have degraded (Herath, Pattiarachchi and Fernando 1961:6) into the gravelly lower stratigraphic member to form distinctive, shallow ravines (Tamil: *vembu*) which often appear to terminate in dry dolines. These *vembus* are almost devoid of vegetation and are littered with quartz and iron-stone gravels, ferricrete and artefacts.

The RBE Fm is co-extensive with the Reddish Brown Earth soil category (App.I.5), although further investigations might reveal that this geomorphic unit has a wider distribution. The landward aspect of the I Fm gives place laterally to the RBE Fm which is found primarily in physiographic Sub-Zone 9 at elevations below ca. 300m +msl. The topography of the RBE Fm tends to be much more irregular than that of the I Fm, with hills and deep ravines conforming to the contours of the basement crystallines. The RBE Fm occurs in climatic Sub-Zones 1 and 2 with an annual rainfall of ca. 1,800-950mm. The associated soils are, as mentioned above, Reddish Brown Earths and the vegetation is of Series A, B and occasionally C.

Further information on the distribution of the I Fm and RBE Fm may be obtained from the two inches to the mile soil maps prepared by the Soil Survey of Sri Lanka.

Certain sediments which are apparently transitional geomorphologically between the I Fm and the RBE Fm occur in southern Lanka (eg. Sites 54,55,57 of Map 15). These have been assigned to the Hungama Formation (abbr. H Fm; v. S.Deraniyagala 1976:22). Similar deposits probably occur in the north but have yet to be recorded.

Lanka's Quaternary deposits cannot be considered in isolation from those of southern India in view of the close proximity of the two countries. The I Fm appears to be represented in India by the *teri* sands of the south. The descriptions of the latter tally almost exactly with that of Lanka's I Fm (v. Foote 1916:50; Pate 1917:16,24; Aiyappan 1945:145-7; Spate and Learmonth 1972:772-3; Ahmad 1972:175). The *teris* are known to occur from the southern tip of India at Cape Comorin up to Pondicherry on the south-eastern coast. They do not appear to be present as far north as Vishakapatnam in northern Andhra Pradesh or Orissa (v. Mohapatra 1962:148).

As for the RBE Fm, I have not been able to locate its Indian counterpart in the literature. One candidate is the colluvial red loam of the Kamban valley, to the northwest of the *teri* zone in Tinnevelly District, at ca. 300m +msl and with an underlying stone-line (Spate and Learmonth 1972:775).

*3.3.3 Stratigraphy and Geomorphology.* Appendix I.2 provides a description of the geological antecedents of the I Fm. Since these do not assume any significance in the following account, a repetition of their description will be avoided here.

The I Fm comprises a basal member of ferruginous quartz gravels (Stratum II in the section drawings of the excavations at Sites 49 and 50, v. Figs.52,53). This is overlain by a member consisting of sandy clay loam (Stratum III of Sites 49 and 50). Since the I Fm is known to directly overlie the basement gneisses and the Jurassic sedimentaries, as well as Tertiary rocks in various localities (Wayland 1919:102; Cooray 1967:150), it would appear as if there is an unconformity between the Moongil Aru (v. App.I.2) and Iranamadu Formations – although this need not necessarily be so.

The basal gravels of the I Fm are of widespread occurrence. They comprise sub-angular to well-rounded particles (predominantly of quartz) ranging up to 10cm or more in size, in unsorted association, together with iron-stone nodules which tend occasionally to conglomerate into ferricrete. Localised horizons comprising stone-lines with boulders measuring over 30cm in diameter have been observed, as at Sites 45 and 49 (Figs.50,52). The gravel particles occur within a dominant matrix of sandy and argillaceous material (v. mechanical analysis of samples from Site 50a in App.III). The clayey component appears to be a product of chemical break-down of the less resistant minerals. The basal gravel stratum rarely exceeds ca. 1m in thickness, although occurrences of over 2.5m are known from certain localities such as Site 40. These gravels occasionally pass laterally into placers of weathered sand and, as in the case of Kudiramalai in Vilpattu, into ferruginous grits (Wayland 1956:148-9; Katz 1975:93). (The latter, ca. 5m thick in places, might on further investigation prove to be at least partially correlative with the Moongil Aru Fm (v. Wayland's Kudiramalai Series) and certainly deserves further study (1919:102).)

There is a definite stratigraphic break between the basal gravels and the overlying member of sandy loam. The latter is generally less than 10m in thickness and is often devoid of apparent stratification or bedding (Cooray 1967:151). It is known to display a uniformity in particle size throughout its vertical profile (e.g., down to 3m-gl in de Alwis' series, 1971:57-8,201-2), although an increase in the percentage of the very coarse sand fraction has been noted at times (ibid:56). This latter horizon might be assignable to a distinct depositional facies.

The pedology of the sandy clay loams is very distinctive. The A horizon is usually absent, apart from a vestige under forest cover (Panabokke 1967:73). The B horizon represents a zone of very intense chemical weathering, reaching depths of over 15m without a trace of micro-horizons. This soil has been designated a "Red-Yellow Latosol" (Moormann and Panabokke 1961:21-2). Only the more resistant minerals such as quartz and ilmenite have survived in their original form, the rest having been reduced to argillaceous iron oxide and well-crystallised kaolinite (ibid.:23; Cooray 1967:151; de Alwis 1971:96,153). There is a near-absence of feldspars and ferro-magnesian silicates (de Alwis 1971:137). The silt grade occurs only as a trace (ibid.:56), suggesting its absence in the parent material.

The Latosols in the upper regions of the local drainage topography are coloured a dark red (Munsell: 10R 3/4, 2.5YR 3/6 (dry)) due to the presence of comminuted haematite (ibid.:94,139). The lower reaches, as at Site 45, grade from a yellowish red colour into a yellowish brown, which is due to an increase in goethite (Herath, Pattiarachchi and Fernando 1961:11; Panabokke 1967:74; Cooray 1967:151; Dahanayake and Jayawardana (1979:439). The red and yellow Latosols, being geomorphologically identical, have been termed Red-Yellow Latosols (Moormann and Panabokke 1961:22; Panabokke 1967:74). Where recent sands overlie the Red Latosols, there is a tendency for the former to acquire a reddish colour due to capillary permeation of iron oxide derived from the underlying stratum. The Latosols pass into a soil stratum of ferruginous mottles on reaching the zone of water-table fluctuation, as at Site 50a.

Further data on the stratigraphy of the I Fm may be obtained from a perusal of the excavation reports of Sites 45, 49 and 50 in Appendix III (also v. Wayland

1919:102-3; Cooray 1967:149-52; de Alwis 1971:7,26; de Alwis and Panabokke 1972:33,75-6).

As for the genesis of the basal gravel member of the I Fm, the most plausible hypothesis is that it was deposited in a fluvial, coastal environment. The sharp contact between the lower boundary of the basal gravel member and the underlying strata suggests a terrestrial depositional environment. This proposition is corroborated by the absence in the I Fm's basal gravels of "well-rounded, rather flat, and homogeneous" pebbles, which are said to be characteristic of a littoral facies (Butzer 1971:221). That the gravel deposits are coastal is clearly indicated by the arcuate form of their pattern of distribution in the north. The similarity between this configuration and that of the Miocene Jaffna Limestones with their arcuate inner boundaries in the north and intrusive tongues in the south, as at Site 40 and Arugam Bay (Deraniyagala 1940:376; Cooray 1967:Fig.84), leaves little room for doubt that the basal gravels of the I Fm do indeed constitute a coastal deposit. Corroborative evidence is to be found in the co-extensiveness of the gravels with the overlying shore *cum* shore-dune sediments which constitute the Latosols (v. below). (The soil maps suggest that the Latosols do not extend as far inland as the basal gravels; however, they do, although as vestigial outliers which have survived surface denudation.)

The basal gravels of the I Fm appear to be the product of floods debouching onto the coastal plain. Their very extensive spread, particularly in northern Lanka, indicates this feature. The poorer gravels are said to be further from today's water courses (Wayland 1919:119) thus confirming their fluviatile affiliations. Another factor which could have caused widespread deposition of gravels is the lateral shifting of fluviatile courses due to changes in sea level. For instance, aerial photographs suggest that Agara-ara near Site 40 in Yala was the ancient estuary of the present Menik-ganga river, and that the deposition of the basal gravels of Site 40 (Minihagal-kanda) might in some way be linked with the Agara-ara. The lack of lateral grading in particle size, except in rare instances, and the fact that the gravel deposits undulate with the underlying landscape, indicate deposition close to the shoreline.

As for a possible marine component in the basal gravels of the I Fm, longshore currents of any magnitude, such as could be associated with the powerful Southwest Monsoon, are absent in the north and northwest (Ahmad 1972:142) where the I Fm is best represented, and an evaluation of the tidal currents in the Gulf of Mannar (Nyrop et al. 1971:10) does not suggest that these would have significantly affected the depositional configuration of the basal gravels. (For a detailed analysis of hydrographic conditions in the Gulf of Mannar and the results of a three-year survey of the entire littoral of Lanka, v. Herdman 1903-6; Malpas 1926; Arudpragasam 1974:70.) However, longshore currents could certainly have affected the deposits in the south of the island, since the Monsoonal currents, which reverse themselves annually with the Southwest and Northeast Monsoons (Ahmad 1972:142), are very prominent in this region. It is also not likely that wave action has contributed any material directly to the basal gravels by attrition of the north and northwest, since the country-rock comprises soft limestone. The basal gravels of the I Fm are predominantly of quartz with occasional occurrences of chert and gneiss pebbles. All these materials would have originated in the hinterland, inland of the band of Miocene limestone, with the possible exception of some of the chert (e.g., at Site 40). It is noteworthy that the chert occurring in Jaffna Limestone, frequently found heaped for road construction between Mannar and Poonakari, is of a soft consistence and quite unlike the very dense material that is often found in the I Fm. Moreover, due to the shelter afforded by the Indian land-mass and the consequent lack of fetch, there is scarcely any wave action in evidence today along the north-western coast, as in the Gulf of Mannar. The limestone cliffs along this coast, as at Kudiramalai, appear to be the product of solution of these rocks rather than of direct wave action. Once again, the southern sites do not conform to this pattern and it is likely that strong wave action has indeed contributed to the formation of the basal gravels in this region.

Very pronounced among the components of the basal gravels are the iron-stone gravels. It is known that in well-drained sediments, such as alluvial gravels, segregation of iron in the form of concretions and mottles occurs in the zone of water-table fluctuation and this is thought to occur at an early stage of the weathering cycle (Papadakis 1974:1027). Hence, the formation of iron-stone nodules in the I Fm's basal gravels can be inferred to have happened when the zone of water-table fluctuation was at the level of these gravels. Considering that the present water-table is frequently over 15m below the level of the gravels, it is possible to postulate that the iron-stone gravels were formed during a phase of high sea level which corresponded with the elevation of the gravels – thus establishing pedologically that the gravels represent contemporaneous sea levels.

The above discussion indicates fairly convincingly that the basal gravels of the I Fm are essentially of fluviatile origin and that they have been deposited in a coastal environment. Direct marine action on the sedimentation process would have been negligible in the north and northwest, and more pronounced in the south.

It is thus possible to hypothesise that the basal gravels existing today had been deposited during marine regressions in those areas (e.g., the southern localities) where the scouring action of a transgressing sea would have removed any gravels there might have been prior to the transgression. This would signify that in any given locality in these areas the basal gravels represent only a single regression, as each transgression would have scoured away gravels from previous regressions. The assumption here is that the pattern of wave action along Lanka's coasts had been similar to that of the present when these regressions and transgressions took place, the corollary being that the Monsoon systems responsible for this pattern of wave action and the associated longshore currents had not been significantly different from that of today. The complexities of the Monsoon system will be discussed in Chapter 4.4, but there are indications (Chap.4.5) that the basic Monsoonal pattern throughout the Quaternary was similar to that of the present and that only the relative intensities would have oscillated.

As for the north-western localities, physically sheltered from Monsoonal vagaries, the basal gravels could have been deposited during both trangressive and regressive phases. Any given deposit could hence represent more than one such cycle – assuming that the tidal currents during transgressions were insufficient to scour away any gravels that might have been existing from a previous cycle.

The sandy clay loams of the I Fm, which overlie the basal gravels, can be shown to be highly weathered sands of a shore (beach) and/or shoreline-dune facies (for terminology v. Worcester 1948:376-7; Flint 1971:245; Zenkovich 1974:727,777). The arcuate form of the landward boundary of the Latosols in the north tallies well with the configuration of the Miocene marine sediments, which suggest a marine *cum* coastal depositional environment for the former. Indeed, the rough co-extensiveness of the loams with the Miocene limestones even in the south and southeast, where they are found in isolated occurrences, is worthy of note. The incidence of the Latosols in undiminished thicknesses over karstic Miocene limestone where streams tend to disappear underground (de Alwis 1971:145) is also indicative of a shore *cum* coastal depositional environment.

With regard to the bedding of the I Fm's sandy clay loams, de Alwis (ibid.:135-6) was unable to trace any vestiges of it, even with the assistance of

X-radiography and mineralogical studies. He affirms that placers of heavy minerals suggestive of fluviatile sorting are notably lacking (ibid.:65). These factors, together with the usual absence of any traces of buried soils in the profiles, seem to indicate a rapid accumulation of sediments, as could well have been the case in a shore *cum* coastal deposit (ibid.:65,145). That a dune facies definitely occurs in certain deposits is demonstrated in exposures of Latosols at Gurugoda (S.Deraniyagala in Solheim and S.Deraniyagala 1972:30), the estuary of the Kirindi-oya (near Bundala), and at Kudiramalai. In these localities, contrary to de Alwis' findings, laminae characteristic of dune foresets and backsets have been brought into relief by the blasting action from currently moving shoreline dunes. Near-identical laminae were observed by me in the associated recent dunes, as clearly brought out by the dark ilmenite component.

Sedimentologically, too, the I Fm's loams are considered to have formed through the weathering of shore *cum* coastal sands. The original sandy texture of the parent material of the Latosols is indicated by the relative absence of surface erosional features, which indicates the high permeability of the sediments (ibid.:135-6). The lithological uniformity of the parent material in each profile is suggestive of a shore *cum* coastal deposit. Moreover, dune sediments are known to be deficient in silt and clay components. The mean percentages of the silt fraction in the Latosols of Arnakallu (3%), Iranamadu Reservoir (6%) and Site 50a Stratum III (8%) suggest that these sediments are aeoleanites (for mechanical analyses v. App.III). The same holds true of the three widely separated areas comprising the Vilpattu, Gambura and Mullaitivu Series, assayed by de Alwis (ibid.:Fig.2,56-8,200). I have estimated the mean percentages of the silt fraction for the B horizons of these three series (the A horizon being suspect due to possible colluvial admixture): Vilpattu, 3%; Gambura, 4%; Mullaitivu, 4%.

The high proportion of clay in the sandy clay loams of the I Fm, ranging from 17 to 44 per cent, can be ascribed to the chemical decomposition of feldspars and ferro-magnesian silicates in the parent sands (ibid.:65; Wayland 1919:105). Differences in the relative quantities of these minerals in the parent materials account for the variation in clay and iron oxide contents in Latosols from various localities (de Alwis 1971:146). A certain amount of clay illuviation is apparent in the lower horizons (>9m -gl) of the Latosols at Arnakallu and, indeed, in the lower levels of the basal gravels of Site 50a.

There is uniformity of particle size throughout the respective profiles (down to ca. 3m -gl) examined by de Alwis (ibid.:132,135-6), as firmly established by X-radiography, which suggests an aeolean facies. These findings are corroborated by the particle size analysis of specimens from Arnakallu (0-10m -gl), Iranamadu (0-2.5m -gl), Site 49c (0-4m -gl) and Site 50a (0-3.5m -gl) (App.III).

The uniformity of particle size distribution through individual profiles of the I Fm's sandy clay loams does indeed suggest a strong aeolean component; but are the dunes of coastal or continental facies? In general, continental dunes are said to comprise 20-90 per cent of predominantly quartz sands, measuring 0.06-0.20mm (Butzer 1971:196). In peninsular India, the desert dune sands of central Gujarat and western Rajasthan have a median of 0.10-0.15mm and 0.15mm respectively (Goudie et al. 1973:247-8). The Punjab, which is further from conditions prevalent in Lanka, has a median of 0.125mm (ibid.; Verstappen 1968). As for shore sands (non-aeolean), these are said to stabilise at ca. 0.3mm after losing ca. 5 per cent in weight annually through attrition (Zenkovich 1974:779). The particle size analysis of sands by de Alwis (1971:57-8) does not indicate clearly the frequency of occurrence of the 0.3mm grade. However, the presence of coarse sands (>0.5mm) in admixture with medium (0.25-0.50mm) and fine (0.10-0.25mm) sands suggests that these deposits are not continental but that they comprise shoreline dunes. Typical coastal aeoleanites are said to have ca. 70 per cent of 0.2-2.0mm sands (ca. 40 per cent in interior facies) with 5-15 per cent in silt and clay (Butzer 1971:224) which are adequately close to de Alwis' figures (1971:57-8). Wayland (1919:105) affirms that the majority of the particles in his samples were 0.4-1.6mm, which, once again, would rule out a continental facies.

At Kalmunai in the extreme north, shoreline dunes merge with inland parabolic dunes (up to 30m high) aligned with the effective Southwest Monsoonal wind direction. These latter dunes of apparently continental facies can be regarded as extensions of coastal dunes. The natural vegetation series, which probably would have stabilised the shoreline dunes, has been drastically reduced by human agencies, thereby creating a situation where dunes drift into the hinterland. A similar occurrence seems to prevail in the dune fields on the eastern aspect of the Jaffna peninsula (v. Wayland and Davies 1923). (In northeast India between Midnapur and the Godavari coastal dunes are active up to a distance of 12km from the coastline (Ahmad 1972:173).)

An illustration of the fact that the sands of the I Fm are shore *cum* coastal (vs. continental) sediments can perhaps be seen in the environs of Mantai (Matota) in the northwest. Here, Mannar Island limits wave fetch and beach sands appear to be scarce along the coast of the mainland (i.e., Lanka). The Latosols representing the ancient sands occur much further inland around Madu Road. This seems to signify that once the waves lacked the fetch to deposit shore sands due to the coastline approaching Mannar with the sea regressing, no other aeolean sands (of non-shore derivation) were being deposited on the exposed continental shelf, which could have weathered into Red-Yellow Latosols. In other words, the sands in the Latosols of this region are exclusively shore derivatives, and the same can be hypothesised for the rest of the sandy clay loams of the I Fm.

The Indian *teris*, the correlates of Lanka's I Fm, provide further evidence as to the non-continental nature of these deposits. The *teris* extend inland along the southeast coast of India up to an elevation of ca. 60m + msl (Spate and Learmonth 1972:772). Since the present dune movements are controlled by the Southwest Monsoon, certain poorly consolidated *teris* have been observed to drift eastwards annually (ibid.). If such be the case, what constitutes the parent material of the *teri* sands? They certainly cannot be shore sands blown for any considerable distance inland (westwards) from the shoreline since the dynamics of the Southwest Monsoon do not permit this – and, pending evidence to the contrary, there is little reason to doubt that the Southwest Monsoon has not been the dominant and effective wind component in southern India throughout the Quaternary, the Northeast Monsoon being very weak in comparison (v. App.I.4). Hence, it could be concluded that the *teri* sands are strictly shore or coastal deposits which have not been displaced inland by wind activity to any significant extent; namely, the *teris* do not comprise continental aeoleanites.

There is one school of thought which maintains that the *teri* sands of southern India originated in the red soils of the hinterland (Cardamom Hills in the case of Tinnevelly) to the west, and that they had been blown across to the eastern seaboard by Southwest Monsoonal winds (Pate 1917:26; Aiyappan 1945:145; Ahmad 1972:175). This view is scarcely tenable since many of the *teris* comprise beach ridges in stepped series, from the hinterland towards the coast, with remnants of ancient lagoons occurring between these ridges (Sarma 1976:185). What these authors refer to is probably the Monsoonal shifting of surface sands derived from red soils which have been exposed to denudation as a result of human interference with the natural vegetation cover. The so-called moving *teris* are probably assignable to this category.

It is significant that the I Fm invariably occurs along currently prograding coastal tracts – which is further confirmation that it comprises shore *cum* coastal (vs. continental) sediments. The gently shelving shoreline of the prograding northwest as well as of the southeast (up to Batticaloa: v. Cooray 1967:76; Katz and Comaner 1975:100) is highly sensitive to movements of sediments along the coast through the action of tides, currents and waves, and this results in the formation of sand-spits and barrier bars enclosing lagoons (Wadia 1941*a*:17). These sandy marine alluvia tend to be reworked by wind action into shoreline dunes. There is strong corroboration of the view that the north-western coast has been prograding coevally with and since the deposition of the I Fm sands: five of Vilpattu's *villu* dolines in Latosol country are saline, including Kokkare-villu which is ca. 9km inland from the sea (Deraniyagala 1956*c*), and the soils immediately to the landward aspect of the present shoreline dunes remain saline (Eisenberg and Lockhart 1972:5). The south-eastern lagoons, some of which have been adapted for use as salterns, are similarly indicative of coastal advance in this region.

Perhaps the main reason for the north-western and south-eastern coasts to prograde is that they are parallel to the dominant southwest-northeast wind patterns. The longshore currents which alternate with the Monsoons tend to deposit their load along these coasts which are, due to the wind direction, scarcely affected by wave attrition (Ahmad 1972:142). It is noteworthy that Lanka's tides, with their exceedingly low range of less than 1m, do not suffice to scour away these spits and bars (Nyrop et al. 1971:10). On the Indian aspect, Ahmad (1972:74,76) mentions the 1.5km-wide backshore facing the Palk Strait and the Gulf of Mannar, which once again indicates coastal progradation. Butzer (1971:219) states that "when gradients are extremely gentle [as in north-western Lanka] a coastal type develops with wave action barely affecting the immediate shoreline. Instead, waves break, erode [the sea bed] and deposit off-shore, forming submarine or off-shore sand bars. . . . These are separated from dry land by a shallow-water zone, a lagoon, or a tidal marsh". Off-shore bars move progressively towards the coastline, due to erosion of its seaward aspect, until finally driven up against the coastline itself (Ahmad 1972:85-7).

Cooray (1967:15-2) has observed the strong resemblance between the elongate Latosol ridges in the northwest, particularly with regard to their shape in cross-section, and the currently forming barrier bars and spits at the northern end of the Kalpitiya peninsula and to the north of Chilaw. (For illustration of currently prograding coast with ancient ridges and runnels, and recent barrier spit, in the Negombo area v. ibid.:Fig.29 after Herath.) Such Latosol (I Fm) ridges are said to occur in the northwest at Kollan-kanatta, Palugaha-turai, the region east of Puttalam, between Kalladi and Palavi, between Kiriyankali and Mundel, near Karaitivu, and betweeen Maha-oya and Chilaw (ibid.:152; Katz 1975:85-6; Katz and Comaner 1975:86). The occurrence of silted-up portions of ancient lagoons abutting against the western flanks of these ridges has been construed by Cooray (ibid.) as pointing unequivocally to a shore facies as regards the deposition of the Latosol ridges. Spits formed by longshore drift are very likely to have constituted another sub-facies of marine alluvia which could have led to the formation of the I Fm's sandy ridges. It is interesting to note that those areas of the north-western coast that are devoid of currently forming off-shore barrier bars are also lacking in Latosol ridges – which constitutes strong corroboration of Cooray's hypothesis. However, the latter does concede (1965:114) that not all Latosols in the northwest are offshore facies, and that some almost certainly comprise shoreline dunes: the positive correlation between the ranges of distribution between the Latosols on the one hand

and the areas where coastal dunes are accumulating conspicuously today, namely, in the northwest, northeast and south (id. 1967:164), is of more than passing interest as indicative of an aeolean depositional facies for the Latosol sands. It is obvious that localised movement, sorting and deposition of backshore sediments through wind action would have been constantly in operation until stabilised by vegetation.

An added factor to be taken into consideration is that certain Latosol ridges, as at Orukem-pola in Yala (Katz and Comaner 1975:100) and Arnakallu, appear to reflect the trend of the underlying country-rock. Some of the south-eastern ridges comprising basal gravels of the I Fm, as at Site 47, and perhaps Amaduwa and Uda Pottana in Yala (ibid.), could also represent ancient storm ridges (berms) in the backshore, although these too could be reflecting the underlying topography of the crystalline basement. As for the Indian *teris*, some of the ridges are considered to be related to original eminences resulting from the denudation of coastal Tertiaries and older sedimentaries which have arrested in-blowing sands (Ahmad 1972:175), as was probably the case with Arnakallu and Site 40 in Lanka. However, it is very likely that some (perhaps many) of the *teri* ridges represent ancient barriers which have attached themselves to the mainland: for instance, the succession of *teri* ridges at increasing elevations in the Tinnevelly area (Sarma 1976:185) with Black Cotton Soils (*regur*) overlying gneissic bed-rock in the intervening depressions, as in northern Tinnevelly District (Spate and Learmonth 1972:780). (These latter soils are probably the correlates of Lanka's Grumusols.) The inter-ridge depressions are clearly depicted on Pate's (1917) map showing irrigation reservoirs (tanks) in linear arrangements. There is, however, a certain element of doubt as to whether the *teri* ridges comprise marine alluvia or shoreline dunes. Ahmad (1972:175) mentions that an outer ridge of recent dunes frequently separates the Tinnevelly *teris* from the shoreline. By analogy, it can be hypothesised that the *teri* ridges themselves represent ancient linear dunes. Similarly, Lanka's south-eastern coast is marked by ridge-like linear shoreline dunes (8-13m high), parallel to the wind direction of southwest-northeast. The same applies to the north-western coast (Katz 1975:86). It should be noted that these ridges do not comprise marine alluvia. Hence, it is debatable as to the degree to which the Latosol ridges represent marine alluvia as opposed to ancient linear dunes of shoreline facies.

In terms of particle sizes, the fine sand (0.15-0.25mm) percentages of de Alwis' (1971:57-8) Latosol profiles tend to increase progressively from the base upwards, whereas there is at times a pronounced increase of the very coarse (1-2mm) fraction in the basal levels of the profiles. The former phenomenon can be attributed to increasing distance of the source of aeolean sands, due to the recession of the shoreline. In Vilpattu, with its undisturbed vegetation cover, dune sands are found as far inland as ca. 2km from the coastline (Katz 1975:86). Presumably these sands would be finer than those closer to the shore. The coarse sand horizons at the lower levels of the Latosol profiles are conceivably of a shore facies which grades upwards fairly abruptly into the aeolean component. This coarse sand predominance in the lower levels can also be explained by invoking relative immunity of the lower levels of the profiles from chemical weathering which would break down the feldspars and ferro-magnesian silicate sands into clays. An instance of such relatively unweathered sand is recorded from Stratum III(13) of Site 49c (App.III).

The vexed question of deciding whether a given deposit of I Fm sands represents a marine alluvium or an aeoleanite (v. Butzer 1971:219), or a combination of the two, can only be resolved after intensive study at each locale, since the facies could change from one to the other over very short distances laterally. Besides, the relative widths of beach terrace and fore-dunes can be highly variable in Lanka, as in Yala (Katz and Comaner 1975:100). The frosting of quartz grains, observed in the

I Fm's sands in Lanka and in the *teri* sands of South India, has been considered to be diagnostic of aeolean deposition (Wayland 1919:104-5; S.P.Gupta in Joshi 1965:256; Spate and Learmonth 1972:772). However, recent studies seem to indicate that the minute pitting results primarily from chemical corrosion of the surface of the grains, mechanical impact being of secondary importance (Butzer 1971:176). The occurrence of mica in the coarse sand fraction, as well as the presence of a wide range of angularity in the quartz particles of some of the Latosols (Perera 1965:65; de Alwis 1971:65,123-4) indicate that certain deposits are of a shore (vs. aeolean) facies. However, that a dune facies definitely is present in certain other deposits is demonstrated by the absence of mica (Wayland 1919:104). Summing up, in the present state of our knowledge concerning the genesis of the sandy clay loams of the I Fm, it can only be affirmed that they represent either backshore deposits or coastline dunes.

Having postulated that the parent material on which the Latosols of the I Fm have formed comprise varying combinations of shore and dune sands, one could cite Butzer (1971:224) who states that well-developed aeoleanites, as in the case of the I Fm, usually pertain to marine regressions: "once regression ceases or a renewed rise in sea level occurs, no new sands are exposed to deflation, and consequently sedimentation stops". As for the Latosols, the high degree of variability in the rounding of the quartz grains, with the majority not being well-rounded (de Alwis 1971:65,76), and the presence of a considerable percentage of sands exceeding 0.3mm in size, suggest a rapidly advancing coastline, such as would have occurred during a eustatic marine regression which did not leave adequate time for the shore sands to stabilise at ca. 0.3 mm. The sharp contact between the basal gravels and the overlying Latosol sands also indicates a relatively rapid depositional succession, with a coastal alluvial facies being replaced by a dune-shore facies. It is noteworthy that, so far, there has been a lack of evidence as to the existence of a buried soil (representing a lengthy period of subaerial weathering) on the basal gravels (ibid.:146), which could, once again, point to a rapid sedimentation cycle.

The continental shelf in the Palk Strait has a very shallow gradient of 0° 1-2′ (Ahmad 1972:13), and on the Indian aspect the shelf in the Gulf of Mannar is some 30km wide. Hence, any slight drop in sea level would have exposed large tracts of shore sands for deflation and subsequent stabilisation as shoreline dunes. While dune cordons can form in front of a trangressive sea (Butzer 1975:34), they would only survive at around the level of the sea level maximum and the aeoleanites situated at lower levels would necessarily relate to a sea in regression. It is, hence, possible to hypothesise, in general terms, that the aeolean components of the I Fm are chrono-stratigraphically the equivalents of phases of glacial advance. It is necessary, however, to be aware that a single aeoleanite, as instanced in Israel (Bar-Yosef 1975:579) and at Site 50, can represent several marine regressions, the most recent episode being uppermost among the sediments in a given locality.

This leads on to the aspects of redeposition and lag deposits in aeolean sediments. Deflation and redeposition of stabilised but unconsolidated shoreline dunes can be a common phenomenon, given either an increase in effective wind strength and/or a depletion of the vegetation cover. It is noteworthy that subsidence of the water-table in the zone of the I Fm's distribution could have taken place due to fluviatile intrenchment during phases of low sea level. This could have resulted in a thinning out of the vegetation cover (v. Flint 1975:249). The resultant exposed surfaces of already stabilised dunes from an earlier marine regression can then be prone to deflation, leading up to redeposition further afield. Particle size analysis could shed light on whether a single section of an aeoleanite can represent more than one phase of dune formation.

It is to be noted that lag deposits inevitably accompany the process of deflation and caution is required in interpreting horizons of artefact concentration, such as in Stratum III of Site 49, which might or might not represent intensified human activity as opposed to a lag deposit – although the particle size analysis in the case of Site 49 suggests only a single cycle of deposition.

It is in connection with lag deposits that the *vembus* associated with the I Fm should be described. These are expanses of basal gravels exposed as a result of erosion by seasonal streams, as in the case of the *vembu* near Kokmotai bungalow in Vilpattu; or else they represent dry dolines in karstic terrain. The alignment of the dry dolines (as with the wet *villu* dolines, e.g., in Vilpattu) appears to conform to the predominant joint directions in the underlying country-rock, which is often Miocene limestone, where these joints are zones of weakness and preferential loci for solution and collapse (Katz 1975:88). The joint patterns in the limestone itself appear to be determined by the structures in the basement crystallines (ibid.:Fig.6). Fringing the *vembus* are Latosol cliffs, as excellently exemplified at Site 40. These cliffs tend to recede with stream erosion and sub-aerial weathering, resulting in lag deposits resting on the progressively exposed basal gravels. Hence, any cultural finds secured from the surface of a *vembu* would be chronologically suspect. A further element of confusion enters the picture when it is realised that Stone Age man seems to have exploited the *vembu* gravels as convenient sources of quartz and chert pebbles for implement manufacture. This naturally would have led to factory sites with an admixture of artefacts representing numerous cultural periods.

There is another component of the Latosols which deserves scrutiny: the colluvia. It is well known that in aeolean deposits, with their indistinct bedding, it takes very close examination to distinguish between colluvial and *in situ* sediments (Flint 1971:252). This certainly is the case with the Latosols. However, artefact inclusions and particle size analyses can be of assistance in determining whether a given deposit is colluvial or not. For instance, the wide range of variation of particle size percentages between the various levels of Stratum V of Site 50a, and (to a lesser extent) in 45b III, corroborates the artefactual evidence that these strata are colluvial (App.III).

Termite activity has been noted to be prevalent in implementiferous Latosols, as at Site 49b. At this site traces of such activity were observed throughout the Latosol section of ca. 2m. Two old nests, with their characteristic semi-cemented consistency, and several ash-coloured honeycomb-structured nurseries, were encountered together with their foraging tunnels leading up to the ground surface. Live specimens of the termite responsible for these were seen occasionally and they have been identified, tentatively, as the fungus-growing macro-termite *Macrotermus estherae* (P.B.Karunaratne 1972:pers. comm.). It is a dry-habitat species which does not construct mounds upon the surface of the ground and which forages nocturnally in large armies in a harvester pattern.

The disturbance to the archaeological stratigraphy inflicted by these termites is apparently limited to the utilisation of small quantities of earth for the construction of their nests and nurseries, and to the material removed in constructing the networks of foraging tunnels. Since both the nests and nurseries as well as the tunnels are of very limited dimensions, the effect of termite activity upon the archaeological stratigraphy at Site 49b is unlikely to have been significantly disruptive. This supposition is supported by the uniformly near-horizontal conformation of the boundaries of the artefact-rich horizons, without intrusions into the enclosing horizons. The degrees of activity noted at Sites 45a,b and 50a were of a much lower intensity than at 49b.

On the other hand, termite hillocks assignable to forms other than *M.*

*estherae* have been observed by me to occur on the Latosols. It is difficult to evaluate the effect these would have had on the archaeological stratigraphy of any associated sites. De Alwis (1971:20,29-32,150) notes that passages and nests occur at over 3.5m below the surface, but that they are most frequent at 1.00 to 1.25m -gl. The particle size analysis of sediments from a termite mound in a Latosol of the Mullaitivu Series (ibid.:57) has indicated that termites discriminate against coarse sand in favour of fine sand (0.25-0.10mm:46%). It can, however be assumed that at depths below ca. 1.25m -gl their effectiveness in sorting the sediments would be negligible and that the basal gravels, in view of their coarse particle size, would be quite unaffected. Since dunes, as represented by the Latosols, and backshore deposits are constructed rapidly, and since termite activity would not have commenced until the sediments had stabilised and had vegetation growing on them, it is possible to have reliance on the lack of post-depositional disturbance of the archaeological stratigraphy of Latosol horizons below ca. 1.25m -gl. This, however, would not be the case if a single section in a Latosol represents several episodes of dune building. Such instances will require to be studied and evaluated individually as to the reliability of their internal stratigraphy. De Alwis' demonstration that termite mounds are strongly selective towards the fine sand fraction can be of considerable assistance in determining the extent of displacement caused by termite activity in a given horizon. The particle size analyses of the Latosols from the sites enumerated in Appendix III, and of those assayed by de Alwis, do not suggest that termite activity could constitute a significant factor to be considered in any evaluation of the I Fm's archaeo-stratigraphy. (Eisenberg and Lockhart (1972:79-80) touch on termite habitats and density in Vilpattu; scrub vegetation supports a higher density than forest.)

I have, in the above discussion, merely touched upon a variable which is of vital importance in the analysis and interpretation of archaeological stratigraphy in the tropics. Termite activity is not restricted to open-air sites; it is known to occur in cave sediments as well, for instance at Batadomba-lena, wherever woody parts of vegetation, such as roots of trees are to be found. This is a subject which has been ignored by most archaeologists dealing with tropical stratigraphy, and it certainly merits intensive investigation.

That stone artefacts occur within both members of the I Fm has been indisputably demonstrated in the exploration and excavation reports set out in Appendix III. This situation is paralleled in the *teris* of South India (Foote 1916:50; Aiyappan 1945:145-6; Gordon 1958:17). It should be noted that artefacts associated with the basal gravels are not only those representing a lag deposit derived from the overlying Latosols; they are also present within the gravels. For instance, their occurrence below the level of the boulder-line in the basal gravel of Site 45a leaves no doubt as to the contemporaneity of the artefacts with the deposition of the gravels. This is corroborated by the signs of water-wear that are frequently observable on artefacts from the basal gravels, as in Stratum II of Site 49b, which indicate the coevality of the artefacts with the gravels.

Horizons rich in the remains of lagoon molluscs are occasionally encountered in the Latosols; for instance, Stratum IV of Site 50a (App.III), Site 30 and Site 56. It is proposed here that these represent ancient middens, contrary to my preliminary conclusion (1976) that they are *in situ* in the Latosols. The latter proposition is not tenable considering that deposits of molluscs have yet to be found which can unequivocally be assigned to a horizon within, as opposed to upon, an undisturbed Latosol. Stratum IV at Site 50a occurs on the surface of the aeolean sediments and is sealed by a colluvial Latosol. It is noteworthy that where molluscan horizons occur in a Latosol, nodules of caliche, deriving from the shells, frequently fleck the underlying horizons through recrystallisation, as in Stratum III of Site 50a.

The soils termed Grumusols (App.I.5), which are "imperfectly to poorly drained, dark grey brown to black, moderately shallow" and clayey (de Alwis and Panabokke 1972:38), are considered by de Alwis (1971:11) to represent lagoonal and marsh sediments. Grumusols are commonest in the northwest and north, where in certain localities (e.g., around Tunukkai) they occur on the landward aspect of the Latosol ridges (Panabokke 1971). Some of these deposits may represent ancient lagoons and marshes at the then prevailing sea levels. The marshes could have formed by silting up of lagoons and along the sides of estuaries in sheltered areas (v. Ahmad 1972:30). The dark brown deposit at Henagahapugala which has been radiocarbon dated (v. below) could be considered a Grumusol, although the relatively recent age assigned by the assay creates doubts as to the coevality of the dating material with the associated Grumusol. As mentioned earlier, the *regur* Black Cotton soils of South India, for instance around Tinnevelly (Spate and Learmonth 1972:780), appear to be the counterparts of Lanka's Grumusols. They are distinct from the *regurs* of the Deccan, which have developed on the trap rock which characterises the region. The parent materials of the South Indian *regurs* appear to be akin to those of Lanka's Grumusols.

On the landward aspect, the I Fm gives place laterally to the Reddish Brown Earth soil type (Map 11). Geomorphologically the latter comprises a basal ferruginous gravel member, which is very similar to that of the I Fm with respect to texture and particle angularity, overlain by an upper member comprising less than 1.5m of reddish brown clayey loam of colluvial origin, which has probably been at least partially resorted by earthworm activity. This soil usually occurs upon basement crystallines which have themselves been incorporated within the B horizon of the soil profile (Moormann and Panabokke 1961:8-10,47; de Alwis and Panabokke 1972:69). The gravel member overlain by the clayey loam has been termed the Reddish Brown Earth Formation (RBE Fm; S.Deraniyagala 1976:16). The underlying basement, even though transformed into a Reddish Brown Earth, belongs to a different geological formation (vs. a pedological unit). The RBE Fm has been categorised under three variants, in three different parts of the Dry Zone, on the basis of the relative prominence of their respective basal gravels (de Alwis and Panabokke 1972:19-21).

The basal gravel bed of the RBE Fm is generally not as thick as that of the I Fm: it frequently occurs as a mere stone-line. Occasionally there is more than one stone-line in a single stratigraphic section (for tropical stone-lines v. Butzer 1971:203). The particles in the basal gravels often tend to be a relatively unsorted mixture, ranging from well-rounded to angular forms. At Gedige, Anuradhapura, out of a total of 1,827 quartz gravel particles, 4 were well-rounded, 25 sub-angular and 1,798 angular, suggesting immature depositional conditions (S.Deraniyagala 1972:55). That these conditions were fluviatile is indicated by the near-horizontal conformation of the upper boundary of the gravel stratum at Gedige (ibid.:57). The iron-stone concretions in the basal gravels of the RBE Fm appear to originate in a B soil-horizon within the zone of water-table fluctuations, although at times they could also constitute a secondary deposit (ibid.). (For details of the stratigraphy of the RBE Fm v. the excavation reports of Gedige (ibid.:55-7) and of Site 43a in App.III.)

The deposition of the RBE Fm would probably have conformed to the following pattern: the landscape recedes under erosion, and the eroded sediments are deposited in a lateral order of coarse to fine particles relative to the erosion face. Such a pattern would result in the coarser material being overlain by finer sediments once the distance from the erosion face and the topography of the place determine that the finer sediments should be deposited at a given locus.

Ideally, such a pattern would give rise to a graded vertical profile. However, subsequent colluvial movement of the finer sediments would result in a basal coarse stratum of the initial "primary" colluvium being overlain by a relatively homogeneous loam which could be considered a "secondary" or "post-secondary" colluvium. Archaeological corroboration of this proposition lies in the occurrence of pottery assignable to the Christian era in the loams of the RBE Fm, for instance in Stratum III of Site 43a, whereas the basal gravels only contain prehistoric artefacts. Note that the latter have been observed within the gravels. The stone artefacts found in the gravels at Gedige (ibid.:64) include specimens with water-wear, suggesting coevality with the deposition of the gravels. Stone artefacts were also found within the gravels of the RBE Fm along one of the irrigation canals at Polonnaruva (Map 10; Deraniyagala 1946:field notes), and Todd is known to have found them in the gravels on the rifle range to the southeast of Trincomalee town (Allchin 1958:188). This latter site has wrongly been assigned to the I Fm by Allchin (1980:62-3): on the north-eastern coast, Latosols do not occur as far south as Trincomalee.

The degree of down-cutting by the fluviatile system associated with Site 43a (App.III), creating an inverted landscape, suggests a considerable antiquity for the deposition of the gravels at this site, despite the occurrence of geometric microliths within the deposit. The Malvatu-oya river, which is associated with the basal gravel at Gedige (S.Deraniyagala 1972:57) appears to have degraded by ca. 8m since the deposition of the gravels. As mentioned earlier, the wide range of angularity on the gravel particles suggest an immature fluviatile regime. Whether the down-cutting was caused by tectonic uplift, receding knick points, or a combination of both factors, has yet to be determined. The river is known to rise by as much as ca. 10m when in spate, but since the gravels in Stratum I have the appearance of a channel deposit it is unlikely that floods were responsible for these high level gravel deposits.

It is tempting to correlate the basal gravels of the I Fm with those of the RBE Fm: as I have tentatively done in my preliminary analysis of the stratigraphy (1976:16). However, the artefactual evidence, as revealed by subsequent study, has not succeeded in either confirming or refuting this proposition. On the other hand, certain sediments are apparently transitional geomorphologically (and pedologically) between the I Fm and RBE Fm. They comprise a basal gravel member which is similar to that of the RBE Fm in that it consists of a stone-line with an average thickness of less than 1m, overlain by a pinkish yellow sandy clay loam which is texturally similar to the loams of the I Fm although rarely exceeding 1m in thickness. These deposits are located in the south in the vicinity of Hungama and Ambalantota and they have been termed the Hungama Formation (H Fm; ibid.:22; also v. Deraniyagala 1963*c*:1-2).

With regard to the mode of origin of the latter formation, it appears as if the gravels of the stone-line were deposited under terrestrial, colluvial conditions, as was the case with the gravels of the RBE Fm. The upper member, namely the loam, comprises sands which had mostly been blown in from a beach which was sufficiently close, relative to the wind direction and intensity, for a deposit of restricted thickness to have been laid down. The apparent range of particle size in the sand fraction of the loam suggests that local colluvial material has supplemented the aeolean sediments.

Apart from attempting to compare by artefactual content, geomorphic correlation between the basal gravels of the I Fm and the RBE Fm can usefully be assayed via the H Fm which appears to bridge the two formations in certain localities. The basal gravels of the RBE Fm also appear to merge with those of the I Fm in north-western Lanka (v. de Alwis and Panabokke 1972:21). Until further investigations relating to these aspects have been undertaken, the question of the geomorphological correlation between the basal gravels of the I Fm and RBE Fm must remain in abeyance. Similarly, the relationship between the alluvial "terrace gravels" in western Lanka (Seneviratne et al. 1964:22; Cooray 1963:27-8; 1965:114; 1967:152-8) and the basal gravels of the I Fm has yet to be established. It is noteworthy that Reddish Brown Earth soils seem to have developed on some of these terraces (v. Cooray 1967:Fig.54). Since Seneviratne et al. (1964:23) have suggested that these terrace gravels do correlate with the basal gravels of the I Fm, they merit scrutiny – despite their being, apparently, non-implementiferous.

Several deposits of possibly thalasso-static, fluviatile terraces at 3-8m +rl have been observed between Chilaw and Puttalam in the west coast's hinterland (Cooray 1965:114). These include the following:

(*a*) Erunwala, at the 5th milepost on the Bangadeniya-Anamaduva road (id. 1963:27; 1967:152-3): The surface of this gravel is at ca. 5m +rl. The fluviatile bench is at ca. 1m -rl. A section examined by me revealed a sandy deposit of over 3m thickness, with gravel lenses, which is capped by ca. 2m of silt. The base of the terrace was not visible. The bed of the present stream is at ca. 5m below the top of the silt and 3m below the top of the gravel. It is not known whether there is a stratigraphic break between the gravels and the silt. The gravels could represent a 3m terrace correlating with one of the Peron mid-Holocene eustatic maxima, and the silt could be of any age subsequent to that. It is also possible that the 3m +rl gravels represent a sea level that was higher than the 2-3m mid-Holocene levels and that they are of Pleistocene age.

(*b*) Muttibandi-wila (the exact location is Yatakalana): a gravel terrace ca. 3m thick, with its surface at ca. 11m +rl (id. 1967:153). It is possibly datable to the late Eem or an early Würm interstadial.

(*c*) Andanakatuwa, on the road to Attangane (ibid.): a gravel terrace at ca. 6m +rl, possibly assignable to a Würm interstadial.

(*d*) Bambakuliya (ibid., after D.N.Wadia): a gravel terrace at ca. 10m +rl on the Maha-oya, possibly of late Eem or early Würm interstadial age. A close scrutiny of the stratigraphy shown by Cooray (1967:Fig.53) suggests a sequence that needs checking. Stratum I is gneissic bed-rock and Stratum II comprises laterite. As to whether the latter is a laterite in the real sense of the term (v. Chap.4.2.2) or simply a horizon of water-table fluctuation with the accompanying mottling requires to be verified. I suspect that it is the latter, since this region is outside the known range of distribution for laterites in Lanka. (Note that the gravel terraces at Yatakalana and Erunwala (v. above) are mottled, presumably due to fluctuations of the water-table.) The second question is whether Stratum II is primary or detrital. Stratum III comprises the gravelly terrace, reaching a height of ca. 10m +rl, and finally IVa and IVb consist of recent alluvia. What is somewhat puzzling is that the section-drawing suggests that IVa is earlier than III, whereas IVb is subsequent. It requires checking to determine whether this is an error in draughtsmanship or in Wadia's interpretation of the sequence.

The terrace gravels of western Lanka appear to have been deposited when the sea level ranged between 10 and 5m above that of the present. This can (simplistically) be construed as referring to the late Eem or one of the Würm interstadials. However, without dating by radiometry, not much reliance can be placed on these estimates. Of course, it scarcely needs stating that the stratigraphic correlation between the terrace gravels and the basal gravels of the I Fm and RBE Fm has to be established on a firmer footing than is apparent as yet, and that until this is effected the age of the terrace gravels bears little relevance to the Quaternary prehistory of Lanka, except perhaps from the point of view of dating the pedogenic process of the Reddish Brown Earths which are known to occur on these terraces.

*3.3.4 Radiometry and Eustasy.* Two radiocarbon dates are available for the Red Latosol member of the I Fm. In both cases the assays were conducted on lagoon molluscs: *Arca granosa* at Site 30 and *Meretrix casta* at Site 50a. The provenance of the former was just above the basal gravel at ca. 1m -gl (Deraniyagala 1969*a*:89; 1969*b*:552). The date arrived at is 2,820±80 BP (UM-1534; R.Gardner 1979:pers. comm.), which when adjusted on the calibration of Pearson and Stuiver (1986) approximates to. 2,947BP (997BC The shell was tested for contamination and found to be pure aragonite, thus making the date relatively reliable. (An oxygen isotope analysis ($^{18}O/^{16}O$) yielded a result of -2.46 which could be of use for palaeo-environmental studies (R.Gardner 1979:pers. comm.).)

The radiocarbon date for the shelly Stratum IV excavated at Site 50a (App.III) is 4,500±170 BP (PRL-107; Agrawal et al. 1976:91), which when calibrated after Pearson et al. (1986) approximates to 5,260 BP (3,310 BC). The excavation of Stratum IV did not yield any ceramic material, only stone tools, and hence it is reasonable to conclude that this stratum represents a pre-ceramic midden on the surface of the Latosol. Note that geometric microliths were found in Stratum III underlying the midden (App.III).

A third radiocarbon date was secured for the dark loam resembling a Grumusol at Site 57 at Henagahapugala (ibid.). The deposit lay at ca. 17m +msl and the dating once again was conducted on shells of *Meretrix casta* found at 1.0-1.25m -gl. The age of the sample came out at 2,960±160 BP (PRL-108; Agrawal and Kusumgar 1975:93), which when calibrated after Pearson and Stuiver (1986) would approximate to 3,190 BP (1,240 BC). This layer was devoid of artefacts, despite the occurrence of stone tools in the horizon immediately succeeding it. The layer beneath the shell horizon was not probed. This date could signify that stone tools were in use in Lanka until at least as recently as 1,240 BC.

The above dates do not assist us in the dating of the I Fm sands, since they refer to post-depositional phases. Even the sample from Site 30 seems to refer to a surface colluvium of the Latosol overlying the basal gravel. Similarly, the shells at Site 57 appear to constitute a midden resting upon a Grumusol relating to a 17m high sea level. What is significant is that the date for Site 50a indicates that the deposit which underlies the midden, presumably a shoreline dune, had stabilised by ca. 3,310 BC. It is noteworthy that the possibilities of contamination of PRL-107 and 108 from older carbonates are very limited, due to the absence of limestones in the country-rock. However, the bed-rock at Site 30, where UM-1534 was sampled, does comprise Miocene limestone. It is also necessary to be aware that lagoon molluscs are notoriously unreliable as radiocarbon dating material, and it is well known that shells from coastal deposits tend to yield dates that are far too young and that different species are prone to produce dates that differ by a factor of two or more from a single stratigraphic horizon (Polach and Golson 1966:28; Emery et al. 1971:388). In conclusion, it can be affirmed that the radiocarbon dating of the deposits associated with the I Fm referred to above provides no more than clues as to the terminal dates for the stabilisation of the coastal dunes at Sites 30 and 50, and for the use of stone artefacts in Lanka as evidenced at Site 57. Much depends on the reliability of the dates themselves, considering that the dating media are lagoon shells.

A recent development is the ability to date dune sands by thermoluminescence, on the basis of the bleaching of the sands (Singhvi 1982; Singhvi et al. 1982; Singhvi and Wagner i.p.). Two samples of Latosol sands from Site 49 Stratum III, and two from Site 50 Stratum III, both sets secured from close proximity to the excavated Sites 49c and 50a (now back-filled), were despatched to A.K. Singhvi and D. Sengupta at the Physical Research Laboratory, Ahmedabad, for assaying. The dates secured for 49 III (Singhvi et al. 1986; also v. Singhvi et al. 1985) are 22,600 TL BP (1.1m -gl) and 28,260 TL BP (1.7m -gl), of which the latter is more reliable in terms of sampling in the field. It will be observed that both dates are in excellent agreement with (*a*) R. Gardner's radiocarbon dates for the *teris* overlying the 8m beach in south-eastern India (v. below) and (*b*) the radiocarbon date of ca. 28,500 BP for the basal stratum of Batadomba-lena cave, which yielded artefacts that were typologically very akin to those from Site 49b,c III (Chap.3.4.1).

50 III at 1.8m -gl produced a date of 28,480 TL BP, which correlates well with the TL age of 49 III, suggesting that both sets of sediments, namely 49 III and 50 III (1.8m -gl), are coeval. On the other hand, the lower sample from 50 III at 4m -gl yielded two dates of 74,200 and 64,380 TL BP, and it is noteworthy that there are indications of a palaeo-sol associated with this horizon, which could represent a stratigraphic hiatus intervening between the two sample provenances in 50 III. It would appear that the lower horizon at ca. 4m -gl correlates with a final Eem or early Würm regression, which may speculatively be correlated with the end of the Amersfoort episode, followed by a period of soil formation, to be superimposed upon by coastal dunes during the Paudorf interstadial. It cannot as yet be established that the 74,000-64,000 BP horizon was represented in the levels sampled in the archaeological horizons of 50a III, although it is probable that the lower levels of 50a III do indeed correlate with this depositional phase. It is of the utmost importance that Site 50a be re-sampled with a view to its TL chronology.

As for the *teris* of South India (i.e., from Kanyakumari to Rameswaram), the counterparts of Lanka's I Fm, lagoon deposits at ca. 8m +msl correlating with a marine terrace at a similar elevation have been dated to $38{,}100 \pm ^{1260}_{1100}$ $^{14}C$ BP (SRR-1481; lagoon shells; Gardner 1981; 1983), which could perhaps correlate with a high sea level of an interstadial of early Würm (with due allowance for imprecision stemming from lagoon shells as the dating medium). It can be hypothesised that this date of $>38{,}000$ $^{14}C$ BP is applicable to the basal gravel at Site 49, which is at a similar elevation above the present mean sea level – although it is more likely to be Late Monastirian at ca. 75,000 BP.

The aeoleanite overlying the 8m terrace in south-eastern India represents ancient coastal dunes which seem to correlate with the latosolic sands of Site 49b,c III. This Indian aeoleanite has two radiocarbon dates of 21,000±400 BP (BM-1670) and 25,450±750 BP (BM-1671) on aragonite of land snails (id. 1981:467). The shells in all three samples mentioned above have been checked for contamination using X-ray diffraction and thin sections and the dates are considered to be reliable, as corroborated by the delta $^{13}C$ values for SR-1481. Hence, as per the Indian evidence, the fossil dune sands at Site 49 can tentatively be cross-dated to ca. 25,500-21,000 $^{14}C$ BP, which, once again giving due allowance to the imprecision inherent in the shell dating material, might be construed as referring to the Paudorf interstadial at 33,000-25,000 BP. It scarcely needs to be emphasised that the Indian dates agree exceptionally well with the thermoluminescence dating of the Latosol at Sites 49 and 50 III (1.8m -gl) at ca. 28,000 BP.

There are several other radiocarbon dates available for lagoon deposits in the *teri* region. For instance, a 2-3m +msl deposit has been dated to ca. 4,500 BP, which apparently is in agreement with dates secured for raised reefs (v. Sarma 1976:184) at Rameswaram by Stoddart and Gopinadhapillai (R.Gardner 1979:pers. comm.). Corroborative dating of 2-3m terraces is available from various parts of the Pacific, the Younger Peron beach at 3m being 4,900-3,600 BP (Fairbridge 1976:533,548), the Andaman and Nicobar Islands (Ahmad 1972:185), and in Maharashtra and Saurashtra of western India (Agrawal, Avasia and Guzder 1973:15). The base of the Latosol cliffs at Site 40 appears to have been peneplained by a high sea level, possibly at 3m of the Younger or Older Peron episodes. It would be worthwhile examining this site in some detail for traces of earlier high sea levels – there could be a 30m (?Holstein) level – with associated thalassostatic, ?implementiferous basal gravels of the I Fm.

Finally, the excavations at Mantai, directed by J. Carswell, M.E. Prickett and myself, produced three radiocarbon dates on charcoal for a succession of cultural deposits immediately preceding an inter-tidal zone representing a coastline that now stands at ca. 1m +msl: 3,520±45, 3,550±70 and 3,790±70 BP, which when calibrated after Pearson and Stuiver (1986) provide dates of ca. 3,832, 3,847 and 4,170 cal BP respectively (BM-2340 to -2342; courtesy, R.Knox, British Museum). The +1m shoreline may be estimated at ca. 3,800 cal BP. A date of 2,990+220 BP (shell; LJ-207) secured from a coral reef at ca. 0.6-1m +msl at Hikkaduwa in south-western Lanka (Shepard 1963:5; 1964) is noteworthy. (For further data on Younger Peron beaches in Lanka v. Addendum I.)

Reverting to India, there are the fourteen samples of shell, *in situ* coral, and limestone, from Kanyakumari and Tinnevelly Districts, submitted by Sarma (1976:187-90; Agrawal et al. 1977:233-4) for radiocarbon dating. The twelve dates, mostly on lagoon shells, from Tinnevelly District are certainly from the *teri* region and these dates can be considered to relate directly to sea levels associated with at least some of the deposits. I have contrived to plot Sarma's dates on an age versus elevation ±msl basis and the resultant scatter is not too illuminating as regards fluctuations of sea level in the south-eastern Indian region. Perhaps the only point of significance to emerge from this exercise is that four of the dates (on shell) of ca. 6,000-3,000 BP cluster at an elevation of ca. 6m +msl, which is in agreement with the age of the 2-3m terrace as established for many other parts of the world (v. above). It is noteworthy that Upper Pleistocene deposits are present in Sarma's series.

It is very clear that the dating material in all fourteen of Sarma's samples had been far from ideal. It also appears as if they have been secured from exposed surfaces. Hence, little reliance can be placed on these dates. Several radiocarbon dates have also been obtained for Quaternary marine sediments along the west coast of India, for instance in Gujarat and Saurashtra (Agrawal, Avasia and Guzder 1973:8,13; Agrawal et al. 1977:232,234-6). In view of the tectonic instability of this region (v. below), these dates are of limited significance.

No radiocarbon dates are available in direct application to the RBE Fm (but v. Addendum I). However, the implementiferous basal gravels of the RBE Fm which constituted Anuradhapura I is sealed by Stratum II, a ploughed horizon of the protohistoric Iron Age (S.Deraniyagala 1972). This latter horizon has recently been dated to ca. 2,800 $^{14}C$ cal BP and the overlying Stratum IIIa, also of the protohistoric Iron Age, has a range of ca. 2,800-2,500 cal BP (charcoal; Addendum II). Hence it can be postulated that the basal gravels of the RBE Fm at the Anuradhapura Gedige excavation site is older than 2,800 cal BP.

Many more radiocarbon dates are required before even a rudimentary picture of the chrononogy of Lanka's I Fm and RBE Fm can emerge. It is unfortunate that relevant dating material is very scarce, although flotation sampling could yet produce the requisite charcoal. The following locations, associated directly or indirectly with the I Fm, and RBE Fm, are suitable for radiocarbon assaying:

(*a*) Lagoon molluscs within the Red Latosol at Site 56 (Welipatan-vila). The (?colluvial) Latosol cover over the shells is so thin as to make any samples from this site suspect as regards contamination. It is possible that these shells represent post-I Fm middens.

(*b*) Wayland (1919:114) mentions shell deposits at ca. 17m +msl around Ranna, near Site 57.

(*c*) Lagoon molluscs in clay beds at 4-6m +msl along the rims of the Hambantota lagoons (Cooray 1967:169).

(*d*) Marine shells are said to underlie the basal gravels (?H Fm) between Kiula and Ambalantota, at ca. 5km inland from the sea, at the 136½ mile culvert (Deraniyagala

1942:2). The stratigraphy as to the provenance of the shelly horizon needs checking, since this is the only instance in Lanka where it is claimed that molluscs occur beneath the gravels.

(*e*) Beds of lagoon shells at 5m + msl at Hatagala, 4km to the west of Ambalantota and ca. 1.5km inland from the sea (Cooray 1967:169). Apparently there are several such "mounds" (?middens) between Hatagala and the shoreline (ibid.).

(*f*) Lagoon molluscs (e.g., *Placenta placenta*) at 2-3m -msl at Attaduwa and Nadugala, north of Matara (ibid.:170).

(*g*) Katz (1975:85-6,94, Pl.1) describes shell beds within a Red Latosol, visible in coastal cliffs ca. 1.5km south of Pookulam in Vilpattu. Contrary to his supposition that these molluscs are *in situ* within an undisturbed Latosol, my own examination of these beds indicates that they represent a pearl fishery (*Pinctada vulgaris*) site assignable to the proto or Early Historic periods, as suggested by the Black and Red Ware ceramic and, as in Site 50a, the colluvial nature of the Latosol overlying the shell stratum.

(*h*) The deposit of oyster shells, apparently *in situ*, at ca. 3m +msl on the bank of the Lunu-ala at Ilavankulam which is in Latosol country (Deraniyagala 1956c; Cooray 1967:166).

(*i*) Oyster shell middens, with stone artefacts, along the Mandakal-aru, near Poonakari, in the extreme north. Their dating would indicate when the contemporary sea levels were lower than the bases of the middens, since the habitations had perforce to be above sea – in this case, lagoon-level.

(*j*) Certain parts of the Jaffna lagoon are said to have deposits of conch shells (*Turbinella pyrum*) (Deraniyagala 1956c).

(*k*) Adam's Bridge, between India and Lanka, is thought to be a coral reef which has been killed by uplift and/or emergence and consolidated into coral rock (Spate and Learmonth 1972:773). These corals are datable.

(*l*) The two phases of coral building represented in the quarries at Akurala in south-western Lanka (Deraniyagala 1958:12).

(*m*) Galle Face in Colombo comprises a ridge of reddish coastal sands abutting against the Beira Lake. This ridge should be datable by assaying the sediments in the Beira Lake, which comprise (Wadia 1941*a*:14-5): bed-rock at ca. 9m -msl; sand, 2.5m; clay with carbonised wood, 3m; sandy clay with marine shells, 1m; peaty earth, 1m; silt with marine shells.

(*n*) The "vegetable earth" at ca. 1.5-2.5m +msl along the west coast in the vicinity of Colombo (Wayland 1916:geological section) can be assayed for dating a 2m beach. Wayland (ibid.:267) claims that there are vestiges of elevated beach-rock along the west coast. The dating of these deposits would shed light on the age of the inter-tidal zones that they represent (v. J.A.Steers in Helfrich and Townsley 1963:54).

In conclusion, "it need not be emphasised here that $^{14}$C dating of Pleistocene beaches has been disastrous, creating untold high beaches at 30,000-40,000 BP that owe their age only to minimal contamination of molluscan shell" (Butzer 1975:49). Extreme caution is required in the interpretation of radiocarbon dates secured on shell with respect to coastal terraces; and this point cannot be stressed too strongly. Since TL dating is applicable to aeoleanites, it would be eminently desirable to assay the Latosols found at high elevations in the northern hinterland, as at Iranamadu. Some of these might turn out to be as early as the Cromerian interglacial, which is within the time-span datable by thermoluminescence. Another possible venue of investigation is oxygen isotope analysis of the shelly strata, as at Site 30, which one could attempt to fit into a generally accepted temperature curve calibrated chronologically for the Pleistocene (Flint 1971:728,730; Shackleton 1975:4,18).

Concerning the chrono-stratigraphy of the I Fm, it is very necessary to be aware that, as mentioned in Chapter 3.3.3., the Latosol sands overlying the basal gravels need not even remotely be coeval with the latter, since, for instance, dunes can be blown on to much older land surfaces, and there can be superimposition of dune building phases as appears to have been the case at Site 50, punctuated by unconformities reflecting deflation. Hence, the basal gravels require to be dated totally independently of the Latosols. In the absence of datable organic remains in the gravels, thermoluminescence on burnt rock and eustatic altimetry present possibly the only alternate (even though imprecise) means of dating these deposits. Note Butzer's (1975*a*:861-2) observation, however: "On a worldwide basis, glacio-eustatic sea levels offer a relative stratigraphic tool for distinguishing glacial and interglacial alternations, but they are seldom suitable for specific time-stratigraphic purposes. Even on a regional basis, bio- or time-stratigraphic concepts such as Tyrrhenian or Monasterian offer no assistance in correlation and are often no more than a source of confusion." Hence, it is only possible to conclude that the basal gravels of the I Fm represent interglacial or interstadial episodes, but no precision can be achieved as regards their chronological status. The imprecise picture can, however, justifiably be presented.

A glance at Appendix III would indicate that the basal gravels of the I Fm range from ca. 80m +msl downwards. The range in India for the *teris* is ca. 65-30m (Spate and Learmonth 1972:722); although the elevations of the *teri* sands, as opposed to the basal gravels, is no index of antiquity – recent dunes have been observed at 55m +msl in Tinnevelly District (Ahmad 1972:76-7) and Manappad Point, south of Tiruchendur, has them at 30m (Pate 1917:27). (In Lanka, currently forming dunes in Kalmunai reach ca. 30m +msl, while those on the Kalpitiya peninsula comprise two sets, the inner being ca. 7m high and 1-5km wide, the outer 1-2m high and ca. 1km wide (Cooray 1967:165). It is possible that the strength of these dune-building winds has been augmented by human interference with the natural vegetation cover.) A stem and leaf graphic display (v. Doran and Hodson 1975:123) of the various elevations of the basal gravels in Lanka was prepared by me. It was found to indicate that most of the northern sites cluster at ca. 50m +msl, whereas the southern ones are bimodal at ca. 10m and 15m respectively. It is perhaps relevant to note that the *teri* region in Tinnevelly District, India, has a terrace indicating a high sea level of ca. 14m +msl, and there is apparently a similar terrace on Pamban Island (Spate and Learmonth 1972:773). The 20m terrace that Gardner (1981:467) refers to in south-eastern India is probably the same. Then there is a further group of sites, in both the north and south of Lanka, which occur at ca. 30m +msl.

Taken at their face value, the 10m gravels can be correlated with the late Eem or one of the Würm interstadials; note, radiocarbon age of the 8m terrace in South India (v. above). The 15m terrace can correlate with the Eem, 30m with the Holstein and 50m with a pre-Holstein high sea level (for rough approximations of interglacial sea levels v. Fairbridge 1961). Deviations about the mean sea level heights can be expected due to eustatic pulsations as postulated by Fairbridge (1976:546). The hypotheses enunciated above merit testing; the peneplanation of the soft Jaffna Limestone by successive phases of high sea level during the Quaternary could conceivably supply clues in this regard. Of course, it scarcely needs stressing that pre-Eem high sea levels are very much a matter of conjecture as to their precise elevations (Butzer 1971:226). It is interesting that Sarma (1976:183) mentions four peneplains of marine origin at Cape Comorin in South India, at 3, 6, 15 and 30m +msl respectively. It would be worth checking on this claim as to whether these peneplains are present in reality or whether they constitute a preconceived scheme imposed on a continuum of elevations. There are also said to be two peneplains at 76 and 183m +msl in Kerala (Spate and Learmonth 1972:673). The 11m-thick bed of lignite at Bahuri, Pondicherry, at ca. 80m +msl (Ahmad 1972:192) deserves isotopic assaying, despite its age being probably in excess of the range of radiocarbon dating.

There appear to be indications that south-eastern India and northern Lanka are undergoing tectonic uplift. Chapter 4.2.1 considers the matter of tectonic stability in Lanka. Of particular relevance to the tectonics associated with the I Fm is the evidence for localised uplift at Kudiramalai in Vilpattu, Arnakallu (Site 30), Minihagal-kanda (Site 40) and Welipatan-vila (Site 56). It is noteworthy that a sample of translucent chert from Site 40 has been identified by S.E. Ellis of the British Museum as being of hydrothermal origin associated with laccolithic intrusions (Deraniyagala 1961*d*:624). The rapid passage of water near the mouth of the Kirindi-oya river in the I Fm region of the south, within 1.5km of Site 45, suggests an immature river profile resulting from recent uplift. Similarly, the Kumbukkan-oya, to the east of Site 40, has a relatively straight course near its estuary, suggesting recent rejuvenation, although the possible influence of the joint pattern in the underlying bed-rock cannot be disregarded. Furthermore, the apparent difference in average maximum elevation above present sea level of the basal gravels of the I Fm in the case of the deposits in the north and south of the island respectively suggests that neo-tectonics have affected these two regions differentially. The pattern of distribution of the Miocene limestone in the north, with its marked westerly eccentricity, is further suggestive of regional uplift, as corroborated by the gentle westward dip of its bedding (Cooray 1967:244). As for the RBE Fm, I have already referred to the possibility of tectonic uplift as evidenced in the elevated basal gravels of Site 43a (28m +rl) and Anuradhapura (8m +rl) (Chap. 3.3.3).

The *teri* region of South India is said to be undergoing uplift (Aiyappan 1945:153; Sarma 1976:183,186). No resolution is available as to the relative parts played by glacio-eustasy and tectonics in the formation of the elevated coastal terraces which constitute the *teris*, although the basal gravels of the high level *teris* are said to have less sand and more clay than in the low-level ones, suggesting a longer period of weathering (and hence a greater antiquity) for the former (S.P.Gupta in Joshi 1965:256). The approximately straight shoreline south of the Mahanadi river, and the absence of rocky islands in this tract, has been interpreted as indicative of emergence (Ahmad 1972:36,99), as have the entrenched meanders in the Kaveri (Rajaguru and Hegde 1972:74), although most of the other rivers in the Tinnevelly District are not known to have entrenched themselves (Pate 1917:23-4). That the coast off Tinnevelly District is prograding is beyond doubt; for instance, several former islands are not attached to the Tuticorin coast (Spate and Learmonth 1972:773) and Early Historic ports such as Korkai are situated inland today (in this case, ca. 6km) (Pate 1917:434; Sarma 1976:184-5). On the other hand, the process of uplift appears to be pulsating, since there are submerged forests at the western end of Valimukam Bay in Tinnevelly District (Vishnu-Mittre 1965:17; for old strandlines v. Ahmad 1972:182). The associated peat deposits, if dated radiometrically, should shed further light on this aspect of coastal geo-chronology. In the northwest of Lanka, off the southern tip of Karativu Island, forests which were apparently alive in 1890 are now said to be submerged (Deraniyagala 1937*c*), thus, once again, indicating a pulsating pattern of general uplift.

The eastern coast of India, north of the Krishna river, is considered to be undergoing submergence (for Indian shoreline classification v. Ahmad 1972:126, 151). It is clear that the *teri* region cannot be investigated in isolation: "many individual studies pertain to short coastal segments, through which the influence of broad warping may not be recognisable. Even on long coasts the possibility of warping along axes parallel with a coast is not ruled out" (Flint 1971:342). In this connection the west coast of India is interesting. The pattern of drainage in south-western India is markedly eccentric eastwards from the source in the Western Ghats; and westwards, "entrenched meanders or straight defile-like valleys of small streams and their parallel courses point to youth and uplift of land" (Ahmad 1972:119). It has been hypothesised that the hydrology of the Western Ghats indicates a post-Miocene date for the macro-scale faulting of India's west coast, despite the possibility of its being associated with the Himalayan orogeny during the Miocene (Spate and Learmonth 1972:643): the uplift in the southwest "might be connected with the punching up of the Nilgiri, Anamalai-Palani, and Ceylon horsts, if that indeed be their origin" (ibid). It has been further hypothesised that the land west of the Ghats has been faulted into the Arabian Sea and that the eastern part has undergone "possible uplift assisted by prograding or a low shoreline of emergence" (ibid.:20,642-3). Spate and Learmonth (ibid.:21) observe that since the Deccan lavas are horizontal in their bedding and since the west-flowing rivers over the Western Ghats are immature in profile and have not captured any of the mature east-flowing rivers, the eccentric peninsular drainage pattern was more probably caused by a subsidence of the land mass to the west under the Arabian Sea rather than the eastward tilting of the peninsula. The fact that ports of the historical period are now situated inland in Kerala has been ascribed to the normal prograding of the coast rather than a change in relative sea levels (ibid.:673). Whereas the coast south of Goa is thought to be emerging, despite a contrary opinion that it is submerging (Ahmad 1972:43,126-8), the west coast north of Goa is apparently submerging (Spate and Learmonth 1972:24,44,643). And then again, Kutch is apparently emerging: a miliolite deposit at 211m +msl has been dated to ca. 25,000 $^{14}$C BP (Agrawal et. al. 1977:235). An illustration of Indian shoreline classification has been provided by Ahmad (1972: Figs. 31-2) and the escarpment of the Western Ghats is illustrated by Spate and Learmonth (1972:Fig.25.1).

It is important to note that the pattern of Lanka's drainage is radial. This suggests a structural discontinuity between India and Lanka, which could only be a fault-plane. If such be the case, one could expect tectonic movements in the I Fm region of Lanka and India. On the other hand, if, as Spate and Learmonth (1972:21) suggest, there is no eastward tilting of the peninsula, there need not be a fault-plane between the two countries.

Finally, there is the vital aspect of plate tectonics. The submarine Laccadive-Chagos ridge, ca. 300 km off the west coast of India (*Readers' Digest World Atlas* (1966:118)), leads down to the Mid-Indian Ridge and up to the tectonically unstable, terrestrial Kirthar and Sulaiman Ranges, and onto the notoriously unstable Hindu Kush and western Himalayas. One wonders whether plate tectonics associated with this ridge are not elevating parts of the west coast of India, while driving the Indian Precambrian shield under the Himalayas. "The demonstration of sea-floor spreading and the geomagnetic data supporting the concept of the displacement of continents. . .raise doubts as to whether any coast is in fact stable. If the crust is acting as a series of moving conveyor belts, it would be prudent to avoid correlation of strandline remnants by altitude on any coast. . . ." (Flint 1971:320). Further, plate motion associated with shifts of the terrestrial poles apparently result in elevation anomalies in the crust (Fairbridge 1976:550). This constitutes another variable which could differentially affect the relative elevations of land and sea in various parts of the earth.

The above discussion indicates, rather strongly, that the South Indian shield is not as tectonically stable as has generally been assumed and that, in default of faunal criteria or isotopic dating, altimetric correlations of the coasts with accepted glacio-eustatic models are not convincing. Hence, as regards the geo-chronology of the I Fm, many more radiometric dates are required before it becomes possible to visualise the sequence represented by the different shorelines. The evidence for tectonic instability in the South Indian region is still very much in the realm of hypothesis and it requires to be established on a sounder geological basis.

*3.3.5 Pedology.* As for the dating of the Latosols pedologically, "soil development has practically reached a steady state so that inferences regarding age cannot be drawn from the degree of this development" (de Alwis 1971:151). The ancient Sinhalese chronicles do indicate, however, that the Red Latosols were in existence in Lanka at ca. 2,500 BP (*Mahavamsa*:54; *Dipavamsa*:162). Reference to Lanka as "Tambapanni" in inscriptions of the Indian Emperor Asoka (268-232 BC), by Onesicritos (the admiral of Alexander the Great), and by Eratosthenes (Nicholas 1959:16) appears to allude to the "copper coloured" Red Latosols of Lanka. In India, the Red Latosol cliffs south of Quilon in Tinnevelly are referred to in the *Periplus of Erythraei Maris* of ca. 80 AD (Pate 1917:229). Hence, these Latosols can be inferred to be at least 2,000-2,500 years old, on the basis of historical sources.

There is an apparent association between burial pottery of the protohistoric Megalithic Complex of peninsular India (?800-500 BC in Lanka; v. S.Deraniyagala 1986*a*) with Red Latosols at Site 50 and possibly at Site 3 (App.III). The same applies to the *teris* of Tinnevelly (Zeuner and Allchin 1956:9,13). This association between burial sites and Red Latosols, if indeed there is a postive correlation, suggests that these loci were selected for their distinctive red colour – perhaps for a supposedly magical property of restoring the blush of life to the dead. It could thus be inferred that latosolic weathering had already taken place upon the sands of the I Fm by ca. 3,000-2,800 BP and that the sands themselves had been deposited at a much earlier date. In Lanka, Latosols of aeolean (as opposed to colluvial) facies have not been found containing pottery, which is known to have its inception at ca. 2,800 BP on the island, and ceramics of ca. 1,800 BP are found in coastal sands, in the Latosol region, which have not yet been weathered into Latosols (e.g., Panama-modera-gala, v. S.Deraniyagala in Solheim and S.Deraniyagala 1972). This signifies that it has taken at least 1,800-2,800 years for latosolic pedogenesis to have taken place in Lanka on the sands of the I Fm, considering that accelerated pedogenesis has not occurred on the I Fm (Chap. 4.2.3). Hence, for protohistoric man to have selected for Red Latosols in his burial ritual, pedogenesis at those localities would have commenced at least 1,800-2,800 years before his advent, which would date the deposition of the sands of the I Fm to at least 4,000 BP. This hypothesis concerning the association between the Red Latosols and protohistoric burial sites deserves testing as a means of dating the Latosols. On the present evidence it appears as if the Red Latosols of Lanka have taken more than 2,000 years to develop; perhaps considerably longer, in view of the almost total lack of pedogenesis evinced at Panama-modera-gala. The pedological data suggest that the sands of the I Fm are at least 4,000 years old.

*3.3.6 Techonology.* That stone artefacts occur within the basal gravels and the overlying sandy clay loams of the I Fm, and within the basal gravels of the RBE Fm, has been amply demonstrated in the results of the excavations at Sites 45, 49 and 50, Anuradhapura (Gedige) and Site 43 respectively (App.III). Among these artefacts, the categories which can be considered chronological indicators are small flakes with blunting retouch, bladelets and bladelet-nuclei, microlithic semi-lunates, geometric microliths (including backed lunates) and Balangoda Points (for lithic categories v. App.II; for the detailed treatment of stone artefacts and their chronological implications v. Chap.5.2). As outlined in Chapter 5.2, blade technology can be considered to have a lower age boundary of ca. 40,000 BP (Movius 1960:Fig. 1) by analogy with reliably dated European industries; microlithic semi-lunates, akin to microlithic versions of Chatelperron backed knives, can also be assigned a similar age, although they might exceed 40,000 BP according to the evidence from Zaire (v. van Noten 1977). Small flakes with blunting retouch occur in the European Mousterian, and hence do not provide the chronological resolution that the other categories afford. They first appear in France (on a significant scale) in the Mousterian of the Acheulean Tradition (A), which is thought to have its beginnings late in the Eem interglacial (?ca. 100,000 BP) (Bordes 1961*a*:804; 1966:80ff; 1968:102,105; 1972:54; 1973:217; Bordes and de Sonneville-Bordes 1970:69). It would be interesting to see if the African dates for this category of stone tools are earlier than ca. 100,000 BP. As for geometric microliths, despite their first appearing in Europe around 12,000 BP, the securely dated assemblages from Beli-lena Kitulgala and Batadomba-lena (Chap. 3.4.1.) indicate that they can be as early as ca. 28,500 BP in Lanka (Figs.54-9). Corroborative evidence of very early dates for geometric microliths in the tropics lies in the radiocarbon dates of ca. 29,000 BP at Matupi Cave in Zaire, and the claim of dates in excess of 43,500 $^{14}$C BP for Gombe Point, also in Zaire (van Noten 1977:35-40). However, pending the publication of the final reports on the Zaire material, I shall be assuming that the date of ca. 28,500 BP from Batadomba-lena represents the lower boundary of the age of geometric microliths in Lanka. With regard to Balangoda Points, a specimen was found in Stratum 7b of Batadomba-lena, which has been assigned a date of ca. 22,000 $^{14}$C BP (charcoal; PRL-920; BS-784). The technological data relevant to the age of the I Fm and RBE Fm can be summarised as follows (App. III).

The presence of geometric microliths and Balangoda Points in the sandy clay loam of Site 49b,c, and of geometric microliths in the sandy clay loam of Site 50a, would date these deposits to $\leqslant$ 28,500 BP. Their absence in the basal gravels of these two sites is noteworthy. In the case of Site 49b,c, the artefacts found in the basal gravels were frequently observed to be conspicuously water-worn and should geometric microliths have been present their diagnostic traits are likely to have been erased. However, as for Site 50a, the artefacts in the basal gravels were found in relatively fresh condition and the absence of geometric microliths in this stratum suggests a date antecedent to 28,500 BP. The presence of small, backed flakes (which first appear in Europe probably around 100,000 BP) within the uppermost basal gravels of Site 50a could fix an Eem lower age boundary (i.e., its maximum age) for this deposit, which, at ca. 15m +msl, probably in any case correlates with an Eem high sea level – as appears to be corroborated by the TL dates of ca. 74,000-64,000 BP for 50 III (4m -gl) (Chap.3.3.4). It is further noteworthy that blade technology is not represented in the basal gravels of Site 50a, which suggests a date earlier than 40,000 BP for this stratum. It is also apparently absent in the basal gravels of Site 49 where, however, caution is required in drawing inferences due to the artefacts being water-worn. This latter deposit is possibly datable to the Late Monastirian (ibid). The occurrence of large artefacts, with certain stylistic traits akin to those of the Acheulean tradition, in the *vembus* (e.g., Type 70 at Site 40) raises the possibility of some of the basal gravels of the I Fm being assignable to pre-Eem high sea levels.

The uppermost levels of the basal gravels of Site 45 do contain geometric microliths, thus dating this deposit to $\leqslant$28,500 BP. This is certainly unexpected in an apparently coastal sediment at 25m +msl (?Holstein interglacial), and one suspects that Mesolithic man had exploited the raw material in exposures of these gravels at $\leqslant$ 28,500 BP subsequent to the deposition of the gravels. The artefacts from the uppermost level at Site 45 could also comprise a lag deposit derived from overlying dunes which have been deflated or eroded away; this aspect of the I Fm's stratigraphy has already been dealt with in Chapter 3.3.3. The artefacts incorporated within the middle and lower levels of the basal gravels at Site 45 are likely to be of considerable antiquity, possibly dating back to the Holstein interglacial if one discounts the possibility of a very rapid rate of post-depositional tectonic uplift of these sediments. Another possibility is that the entire gravel member at Site 45 comprises a colluvium or a lag deposit, containing artefacts which are much younger than the primary gravel from which the colluvium was derived. The almost mint condition of the artefacts supports this hypothesis. An in-depth study of the geomorphology of this site is required before these nuances can be resolved; and, until then, it is necessary to desist from drawing chronological conclusions about Site 45.

The discovery of Protohistoric (A) Black and Red Ware (BRW) in colluvial Stratum V overlying the I Fm sands (Stratum III) at Site 50a (App.III) makes the latter pre-2,800 BP (for age of this BRW v. below). This dating is corroborated by the radiocarbon date of ca. 5,260 cal BP for Stratum IV of Site 50a. The ceramics from the test excavation at Panama-modera-gala (S.Deraniyagala in Solheim and S.Deraniyagala 1972) have also indicated that Lanka's Latosols are earlier than ca. 1,800 BP; which, when taken in conjunction with the apparent association between Red Latosols and protohistoric mortuary practices, has been indicative of an age in excess of 4,000 years for the sands of the I Fm (Chap.3.3.4). The above data on technology date the sandy clay loams of the I Fm to ≤ 28,500 - ≥ 4,000 BP

With regard to the RBE Fm, the presence of geometric microliths in the basal gravels of Site 43a and in Anuradhapura I dates these gravels to ≤ 28,500 BP. The Balangoda Points found in the gravel at Site 43 confirm this conclusion. The ploughed clayey Stratum II overlying the RBE Fm's basal gravel (Stratum I) at Anuradhapura has been radiocarbon dated to ca. 2,800 cal BP (charcoal; Addendum II) and it had previously been interpreted by me (1972:57) as suggestive of human interference with the natural drainage of this area at the dawn of the Iron Age when irrigated agriculture was introduced to Lanka, which, according to the chronicles *Mahavamsa* and *Dipavamsa*, would have been at over 2,400 BP. (A diverting of the river associated with Anuradhapura, the Malvatu-oya, is known to have been effected at ca. 2,200 BP (Nicholas and Paranavitana 1961:30,58).) Hence, technologically (and radiometrically) the RBE Fm's basal gravels in Anuradhapura I can be assigned an age of ≤ 28,500 - ≥2,800 BP – (v. Addendum III).

A "degenerate" Black and Red Ware was found associated with pottery post-dating 200 AD in the loam overlying the basal gravel at Site 43a (App.III). This brings up the question of the upper boundary of BRW in Lanka. Excavations conducted in 1983 at the historical port of Kuchchaveli in the northeast produced a coin of the Roman Emperor Marcian (Constantinople, 457 AD; identified by R.Walburg) from a stratum post-dating the BRW horizon at the site. This upper age boundary of <450 AD for BRW in Lanka has been corroborated by the discovery of over twenty Roman and Indo-Roman coins from the main structural phase at the historical fortress of Sigiriya. These coins have been assigned to the fourth and earlier part of the fifth centuries AD (Walburg 1983:pers. comm.), and it is noteworthy that despite the retrieval of very large quantities of pottery by the excavator (S.Dias Bandaranayake) of Sigiriya, no specimens of BRW have been forthcoming. It can hence be assumed that BRW was not in vogue after the end of the third century AD in Lanka (which, incidentally, coincides with the end of the Mahavamsa dynastic succession in the island) and that the "degenerate" BRW in the layer overlying the basal gravel at Site 43a effectively dates the latter to >1,700 BP. In conclusion, the technological evidence dates the basal gravels of the RBE Fm to ≤ 28,500- ≥ 2,800 BP at Anuradhapura and to ≤28,500->1,700 BP at Site 43a.

While these time brackets are patently wide, there is the constant necessity of pooling the data from independent sources of dating so as to secure a reliable overall chronology. (For radiocarbon dating of gravel of Anuradhapura v. Addendum II.)

With regard to the *teris* of South India, the 17m+msl deposits at Tinnevelly did not, apparently, yield Balangoda Points, whereas the 10m *teris* did (Allchin 1966:115). This could signify that this artefact category makes its first appearance in the region at a date subsequent to the deposition of the 17m *teri*; or else its absence in these sediments can be ascribed to inadequate sampling. Note that geometric microliths are also said to be lacking in the case of the 17m *teri* (ibid.); whereas they do occur in the 17m sands at Site 50a. Allchin herself advocates caution in assessing the techno-chronology of the *teris* (Allchin and Allchin 1968:94), due, presumably, to sampling inadequacies; moreover, the stratigraphic distinction between the sands and the gravels of the *teris* has not been given any consideration. It would be interesting to attempt the correlation of the *teris* with the implementiferous fluviatile terraces of Tamilnadu, as at Poondi. Such an exercise could prove productive for the chronology of both sets of sediments, and their techno-traits could reinforce each other. Of course, this presupposes that correlative deposits exist; but it is a hypothesis worth testing.

## 3.4 CAVES AND BELLAN-BANDI PALASSA

*3.4.1 Radiometry.* As regards the dating of late Quaternary deposits in Lanka, it is the caves that have provided the most reliable information in the form of radiocarbon dates on charcoal from sealed stratigraphic horizons. In this respect Lanka is in a much stronger position than India and the dates are of considerable importance for the prehistory of South Asia (v. Addendum I for further dates and calibration).

(*a*) Beli-lena Athula cave, near Maniyangama, Avissawella (v. Agrawal and Kusumgar 1975), has yielded a date of 7,860±110 $^{14}$C BP (1/2-life 5,730 years; TF-1094). The associated lithic industry included several pitted pebbles (Type 109 of Type List) and is very probably assignable to the Mesolithic. The dating material comprised carbonised seeds of *Canarium zeylanicum*, an edible nut, from ca. 0.45m -gl. The Birbal Sahni Institute has produced a date of 7,406±155 $^{14}$C BP for a specimen of this sample (Rajagopalan et al. 1978:398).

(*b*) Beli-lena Kitulgala: The excavations conducted at Beli-lena in 1978, 1979 and 1983 yielded several samples of charcoal comprising primarily the carbonised outer skin of the wild breadfruit of Lanka, *Artocarpus nobilis*. The associated lithic industry was Mesolithic, with geometric microliths. The radiocarbon assays on the charcoal have produced the following dates (1/2-life 5,730 years):

i. BS-287; square 10G Stratum Va(3), upper level, ca. 10cm thick; 10,506±170 BP
ii. BS-288; 10G Va(3), upper middle, ca. 10cm; 10,588±170 BP
iii. BS-289; 10G Va(3), lower middle, ca. 6.5cm; 10,310±160 BP
iv. PRL-861; 10G Va(3), lower middle, ca. 6.5cm; $12{,}260\pm^{450}_{420}$ BP
v. BS-290; 10G Va(3), lower, ca. 8cm; 11,897±180 BP
vi. Fra-91; 11G Va(3), lower ca. 8cm; 12,133±220 BP
vii. BS-291; 10G Va(3), lower ca. 2cm; 11,917±210 BP
viii. BS-292; 10G Va(2), upper middle, ca. 18cm; 11,866±220 BP
ix. BS-293; 10G Va(1), middle, ca. 8cm; 12,607±160 BP
x. BS-294; 10G IVb(2), lower, ca. 3cm; 12,103+390 BP; sample size stated to be inadequate (G.Rajagopalan 1981:pers. comm.).

The above series is very consistent and can therefore be considered reliable: note that three laboratories are in agreement. As for contamination, older carbonates have not been observed at the site. It can be concluded that Strata IVb(2) to Va(3) (75cm thick) range between ca. 12,500 and 10,500 $^{14}C$ BP. The results from ca. 1.5m of strata beneath Va(2), also containing geometric microliths, are being awaited. It is very likely that these basal strata date back well into the final Würm stadial as at Batadomba-lena with a similar lithic industry – (yes, indeed; v. Addendum I).

(*c*) Batadomba-lena: Excavations conducted at this cave in 1982 have produced a series of dates on charcoal. The strata range from the lowermost, 7c, overlying bed-rock, upwards. The associated lithic elements are Mesolithic, with geometric microliths, as at Beli-lena. The dates are as follows (1/2-life 5,730 years):

i. PRL-855; square 16K Stratum (4a), ca. 50cm thick; $11{,}530\pm^{340}_{420}$ BP. This is the uppermost undisturbed stratum. (Upper Stratum 4.)

ii. PRL-856; 16K (4b), ca. 50 cm; $13{,}140\pm^{490}_{460}$ BP (Lower Stratum 4)

iii. PRL-860; 16H (5), ca. 65cm. $13{,}510\pm^{450}_{430}$ BP

iv. PRL-859 16H (6a), ca. 35cm; $14{,}280\pm^{380}_{370}$ BP (Upper Stratum 6)

v. PRL-858; 16H (6b), ca. 15cm; $15{,}830\pm^{680}_{580}$ BP, associated with human skeletal remains analysed as Specimen 2 (Kennedy et al. 1986; 1987). (Lower Stratum 6.)

vi. PRL-920; 17 (7b), ca. 30cm; $20{,}730\ \pm^{760}_{690}$ BP

vii. BS-784; 15 (7b), ca. 30cm; 23,030±670 BP

viii. PRL-857; 16 (7c), ca. 40cm; $28{,}510\pm^{2150}_{1710}$ $^{14}C$ BP. This stratum overlies bed-rock.

The above series of dates, representing ca. 2.5m of deposits overlying bed-rock, are, once again, very consistent and complements the Beli-lena series neatly. It can be concluded that the Mesolithic deposits at Batadomba-lena date from ca. 28,500 up to ca. 11,500 $^{14}C$ BP (the uppermost strata have been stripped for fertiliser and hence the sequence is incomplete for this site).

(*d*) Alu-lena, Attanagoda near Kegalle: a large rock-shelter with Mesolithic artefacts, tested by W.H. Wijepala (1983; report pending). Stratum (3), which comprised the only undisturbed (and lowermost) prehistoric layer at the site, has been dated to 9,410±150 $^{14}C$ BP (charcoal; PRL-976).

(*e*) Bellan-bandi Palassa, the open-air midden *cum* burial site with Mesolithic artefacts, near Embilipitiya, was the first site in Lanka to have been radiocarbon dated (1958, Isotopes Inc., by courtesy H.Shapiro; v. Deraniyagala 1958*a*:259; 1959:E27; 1960*a*:97; Kennedy 1965:179; 1974:101). Two dates are available on charcoal:

i. Sample 394K, from ca. 80cm -gl and 30cm +bed-rock: 508±150 BP. The provenance of this sample is definitely above the Mesolithic horizon, as checked by me in 1970 (v. S.Deraniyagala and Kennedy 1972). This date does not even refer to the irrigation dam with Middle Historic pottery that overlies the Mesolithic. The charcoal probably represents a charred root of a tree that has been swiddened in recent times.

ii. Sample 394L, from ca. 1m -gl and just above bed-rock: 2,070±200 BP, the age being ca. 100 BC with a range of BC 385-AD 125 when calibrated after Stuiver and Pearson (1986:836). This specimen is said to have been found in close proximity to one of the Mesolithic burials (Deraniyagala 1958*a*:259; 1959:E27), and with reference to the stratigraphy delineated subsequently (S.Deraniyagala and Kennedy 1972) it does seem to represent the undisturbed Mesolithic horizon – particularly as Early Historic pottery assignable to ca. 2,000 BP has not been found at the site.

The age of 394L at ca. 2,070 $^{14}C$ BP is, in a broad sense, consistent with the results of a uranium assay ($eU_3O_8$: 6 ppm, by courtesy, K.P.Oakley) conducted on a human leg-bone from the Mesolithic horizon, which Oakley (v. Deraniyagala 1960*a*:98) interpreted as signifying an age to be measured in millennia rather than in centuries, while its nitrogen quotient of 1.3 per cent was thought as referring, in the circumstances of its occurrence, to a post-Pleistocene age (ibid.). Subsequent uranium assays on several specimens of bone have indicated that they are all approximately coeval ($eU_3O_8$:10±2; Oakley in Kennedy 1965:180). A nitrogen quotient of 0.25 per cent on a human rib is anomalous (Deraniyagala 1965:188), although this need not be significant in terms of the variables involved in causing possible differences in nitrogen content. Attempts at securing collagen for radiocarbon dating failed due to extensive mineralisation of the bones (Oakley 1968:pers. comm.).

Considering that sample 394L had been contaminated by shellac consolidant and cotton wool packing (Deraniyagala 1966:pers. comm.), it is necessary to exercise caution in accepting the date of ca. 2,070 $^{14}$C BP as representing the correct age of the Mesolithic horizon at Bellan-bandi Palassa. Ancient inscriptions of the Sinhalese, ranging from ca. 2,200 to 1,300 BP, occur in the general region of the site (Collins 1933:180-3). This makes it very likely that the Mesolithic habitation at Bellan-bandi Palassa antedates 2,200 BP, although a symbiotic relationship between Mesolithic man and the Iron Age Sinhalese cannot be ruled out. In this connection it is significant that thermoluminescence dating applied to an artefact of burnt quartz found in association with one of the Mesolithic skeletons (BP3/15*a*) yielded a date of 6,500+700 BP (Wintle and Oakley 1972:277-8). The level of gamma dose-rate on the site was estimated from soil samples secured from the excavation of 1970. Oakley (1972:pers. comm.) considered 6,500 TL BP to supersede the date of 2,070 $^{14}$C BP. However, it is impossible to assess the relative reliability of these two dates due to possible contamination, sampling error and the technical vagaries of thermoluminescence dating. It can perhaps best be concluded that the Mesolithic horizon at Bellan-bandi Palassa has radiometrically been dated to between 6,500 and 2,070 BP.

(*f*) Mantai: Excavations at the historical port of Mantai (Matota) by J. Carswell, M.E. Prickett and myself in 1982 brought to light a Mesolithic camp site in one of the basal levels underlain by inter-tidal deposits from which three radiocarbon dates have been secured on charcoal (by courtesy of R.Knox, British Museum; calibrated after Pearson and Stuiver (1986)):

i. BM-2340: 3,519±45 BP; ca. 1,883 cal BC
ii. BM-2341: 3,549±70 BP; ca. 1,898 cal BC
iii. BM-2342: 3,786±70 BP; ca. 2,202 cal BC

These dates establish the upper boundary of the Mesolithic in Lanka at ≤ 1,800 cal BC.

The radiometric assays on material from occupation deposits in caves and from the open-air sites at Bellan-bandi Palassa and Mantai have yielded a series of twenty-six dates ranging from ca. 28,500 to 2,000 BP. Of these, the dates from Beli-lena Athula, Beli-lena Kitulgala, Alu-lena Attanagoda, Batadomba-lena and Mantai (ca. 28,500-3,800 BP) can be considered reliable in view of the adequacy of the sampling procedure and the dating material being charcoal (which consisted mostly of annuals associated with fruits). It is very significant that these dates refer to Mesolithic stone tool assemblages characterised by indubitable geometric microliths (v. Addendum I). The category of specialised tools termed Balangoda Points received its first radiocarbon date at ca. 22,000 BP at Batadomba-lena, which is in agreement with the TL date of ca. 28,000 BP for Site 49 with such artefacts in the I Fm. On the basis of the above data, the Mesolithic in Lanka can be considered to be at least 28,500 $^{14}$C years old, making it the oldest geometric microlithic technology to have been dated in Asia or Europe so far, with only Africa being able to claim comparable antiquity (cf. van Noten 1977).

*3.4.2 Technology.* Whenever stylistically diagnostic, the stone artefacts in the prehistoric occupation deposits in the caves of Lanka point exclusively to a Mesolithic stage of stone tool technology. So far, there has been no evidence of an Upper Palaeolithic blade and burin industry as has been claimed for India. A possible exception is Ravanalla cave (Deraniyagala 1953*a*:27-9) which, despite extensive sampling, does not appear to have yielded any geometric microliths, the industry being characterised by untrimmed medium-sized and small flakes (v. collection in Colombo Museum). The early levels of Fa Hien's cave are similar.

The radiocarbon dates for Beli-lena Athula, Beli-lena Kitulgala and Batadomba-lena have convincingly demonstrated that the Mesolithic stone tool technology is at least as old as 28,500 $^{14}$C BP in Lanka (Figs.54-9; Addendum I). Hence, it can be hypothesised that the lower age boundary of the Stone Age deposits in the caves of Lanka where geometric microliths occur could be as early as 28,500 BP, if not earlier. Deposits without such microliths, as has been excavated at Ravanalla, could be considerably older; but in the absence of radiometric dates, or chronologically distinctive stylistic traits in the stone tools, their age cannot be estimated as yet.

As for the upper boundary of Mesolithic stone tool technology in Lanka, there has, so far, been no evidence of ceramics being found in association with stone artefacts. Instances where they do occur together, as in the upper horizons of Bellan-bandi Palassa (S.Deraniyagala and Kennedy 1972), Beli-lena Kitulgala and Batadomba-lena, have on investigation proved to be the result of anthropogenic admixture of strata. Similarly, there is as yet no indication that, unlike in peninsular India, the Mesolithic in Lanka was succeeded by a Neolithic with stone celts or a Chalcolithic. Wherever sequences are available, the Mesolithic has been followed by a full-fledged iron and pottery using culture, for instance:

(*a*) Galge caves (Sarasin and Sarasin 1908)
(*b*) Nilgala cave (ibid.:112)
(*c*) Bendiya-galge, lower cave (Seligmann and Seligmann 1908:162; 1911:23)
(*d*) Beli-galge Bambarabotuva (Hartley 1911:198; Sarasin 1926:87)
(*e*) Bambaragala shelter (Deraniyagala 1943:2)

An inscription of the Sinhalese, in Brahmi script of ca. 2,200 BP, carved into the drip-ledge of Udupiyan-galge with its Mesolithic deposit (ibid.:99), and a similar inscription indirectly associated with Bendiya-galge (Seligmann and Seligmann 1911:22), do indicate (as in the case of Bellan-bandi Palassa) that the Mesolithic had an upper boundary of ⩾2,200 BP – although, symbiosis between Mesolithic and iron using technologies could have been possible.

*3.4.3 Fauna.* None of the faunal assemblages excavated so far from the cave sites, notably Beli-lena Kitulgala and Batadomba-lena, possess extinct elements apart from a tooth suspected of being a dhole's from Kitulgala (P.B.Karunaratne 1986:pers. comm.). For instance, they have not yielded evidence of the palaeoloxodonts, hippopotamus and rhinoceri found in the Ratnapura Beds. The gaur bones claimed to have been excavated from Bellan-bandi Palassa by Deraniyagala could have belonged to a water buffalo, in the absence of diagnostic parts such as teeth or horn cores. In any case it appears as if this animal had survived on the island until the nineteenth century, and Knox (1681) listed it as a member of Lanka's fauna (Deraniyagala 1958:141). It is thought that organised gaur hunts, such as when "the king tested the courage of his warriors periodically by arming each with a spear or a sword and then ordering them to encircle a herd of gaur and face their charges without giving ground" (ibid.), as mentioned in old chronicles, were an important factor in the recent extinction of this animal.

The above data suggest that by 28,500 BP the fauna of Lanka was entirely modern in its components – although further study might reveal specific or sub-specific differences between the living forms and some of the specimens found in the cave deposits. Hence, the faunal elements occurring at these sites cannot be employed as chronological indices. (Note, lion in Batadomba-lena contexts 4, 5 (Addendum I).)

## 3.5 INDIA: MESOLITHIC

The dating of the Lower and Middle Palaeolithic of India has already been dealt with in connection with the Ratnapura Beds of Lanka (Chap. 3.2.4), and since Lanka has not yielded an Upper Palaeolithic comparable to that of peninsular India (v. Murty 1968), it is worth examining the chronology of the Indian Mesolithic for any light it may shed on the age of its counterpart in Lanka. India has several radiocarbon dates for its Mesolithic. These are as follows (Sankalia 1974:564; Agrawal and Kusumgar 1974:56, 61; Agrawal et al. 1975:7; 1985; Thomas 1975:323) (1/2-life 5,730 years) (for further data v. Addendum IV):

(*a*) Adamgarh (M.P.):
  i. TF-116; material, uncharred bone from 1.9m -gl; 2,845 + 105 BP
  ii. TF-120; shell from near the surface; 7,450±130 BP
  Note the reversal of age according to depth. These dates cannot be considered reliable, particularly in the case of TF-116 (v. Thomas 1975:22; Misra 1976:46).

(*b*) Langhnaj (Gujarat) (Misra 1976:32):
  i. TF-744; uncharred bone from both the lower and the middle levels (I and II); 3,990±110 BP.

(*c*) Lekhahia (U.P.) (ibid.:42):
  i. TF-417; uncharred bone; 3,660±110 BP
  ii. TF-419; uncharred bone; 4,360±115 BP

(*d*) Bagor (Rajasthan), phase I (pre-ceramic) (Thomas 1975:324):
  i. TF-1011, 1012; charred bone; 5,235±90 BP
  ii. TF-1007; charred bone; 5,785±130 BP
  iii. TF-786; charred bone; 6,430±200 BP

(*e*) Bagor, phase II (with hand-made pottery and copper tools) (Misra 1976:37):
  i. TF-1005, 1006; charred bone; 4,060±90 BP
  ii. TF-1009; charred bone; 4,715±105 BP

(*f*) Sarai Nahar Rai (U.P.) (Agrawal et al. 1975:7):
  i. TF-1356; 1359; charred bone; 2,940±125 BP
  ii. TF-1104; uncharred bone; 10,345±110 BP
  The discrepancy in age between the two samples is very indicative of the unreliability of dates on uncharred bone.

(*g*) Bhimbetka shelter (M.P.) (Agrawal et al.1985):
  i. PRL-536; charcoal; 979±110 BP
  ii. PRL-535; charcoal; 1,195±150 BP
  iii. PRL-534; charcoal; 2,860±150 BP
  The provenance depth increases from PRL-536 to 534. The cultural horizon has been designated late Mesolithic, but the dates seem to be very recent for such a status.

(*h*) Baghor (M.P.) (Agrawal et al. 1985):
  i. PRL-715; charcoal, 8,333±230 BP

(*i*) A date of ca. 7,000 $^{14}C$ BP has been obtained on caliche from the B/c horizon of a Black Cotton *regur* soil in the lower Narmada (Rajaguru and Hegde 1972:76). These soils are known to contain Mesolithic assemblages as, for instance, on the central Narmada (de Terra and Paterson 1939:323). Hence, the above date could point indirectly to the age of some of these assemblages. However, soil formation is not necessarily coeval with the parent material on which they form, and all *regurs* need not be synchronous; besides, caliche is not a very suitable dating medium.

Of the above dates it is only the ones on charcoal and perhaps charred bone that can be considered reliable, the risk of contamination in unburnt material being very high. Shell (e.g., TF-120 from Adamgarh) is also liable to yield erratic results. Apart from the somewhat enigmatic Bhimbetka series, this leaves us only the dates from Baghor (M.P.), Bagor (Rajasthan) (for which phase II appears to have been technologically confirmed by Harappan parallels for copper artefacts) and TF-1356 from Sarai Nahar Rai to work with, which is not much.

The lower age boundary of the Mesolithic in India could conceivably be estimated from the age of the sub-continent's Upper Palaeolithic. A few radiocarbon dates are available for the latter (also v. Addendum IV):

(*a*) Belan river, Gravel III (G.R.Sharma in Mujumdar and Rao 1970:97; Agrawal and Kusumgar 1975:220):
   i. TF-1245; shell; 19,160±330 BP
   ii. PRL-86; shell; $25{,}070\pm^{810}_{730}$ BP

(*b*) Patne, Dhulia District, Maharashtra (Joshi 1975:13):
   i. ?Shell; ca. 25,000 BP

Once again, the dates are unreliable due to the nature of the dating medium; namely, shell. Besides, there is always the possibility that the so-called Upper Palaeolithic blade and burin industries constituted merely a technological facies of the Mesolithic and that they existed contemporaneously with microlithic Mesolithic industries in different parts of the sub-continent. In the light of the dates for the Mesolithic in Lanka, its lower boundary in India is likely to have been at ≥30,000 $^{14}$C BP.

The upper boundary of India's Mesolithic can, in general terms, be defined from the advent of the Neolithic and Chalcolithic technologies at ca. 4,500-4,000 $^{14}$C BP. The Mesolithic is known to be overlain by a pre-Harappan Chalcolithic at Rangpur with a possible date of ca. 4,500 BP (Sankalia 1974:379,565), and Malwa Ware of ca. 4,000 BP has been observed to overlie the Mesolithic at one of the Bhimbetka shelters in Madhya Pradesh (ibid.:259). In the southern Deccan, the Neolithic succeeds the Mesolithic, and the inception of the former has been reliably dated to ca. 4,000 $^{14}$C BP. That microlithic technology characteristic of the Mesolithic persisted well into the Chalcolithic and even into the Iron Age (ibid.:251-2, 258,262) is attested by Bagor II with hand-made pottery and copper tools, Bagor III with wheel-thrown pottery and iron objects, by the upper levels of the Lekhahia shelters where microliths occur with pottery and perhaps by the series of radiocarbon dates from Bhimbetka (Thomas 1975:324; Misra 1976:32,42). Despite the possibility that some of these occurrences represent an admixture of strata of varying ages, they do suggest that Mesolithic lithic technology had survived into the first millennium BC in various "refuge" habitats of India, possibly in symbiosis with more advanced technologies.

The above discussion indicates that the lower boundary of India's Mesolithic is poorly defined, whereas its upper boundary in general terms would have been at ca. 4,000 BP with survivals into the first millennium BC. Pending further radiocarbon dates on charcoal, the Indian Mesolithic is far less securely dated than that of Lanka and, hence, the former is in no position to clarify the chronology of the latter, except that the radiocarbon dating (shell) of the Upper Palaeolithic on the Belan river at ca. 25,000 BP can be hypothesised to be close to the lower boundary of the Mesolithic. Indeed, this view is corroborated by the age of the Mesolithic in Iran, which is ca. 25,000 BP at its base (Hole and Flannery 1967:160), and (indirectly) the Mesolithic at Shanidar cave in Iraq (Solecki 1966) appears to have a similar lower date. Further afield, assemblages with a prominent component of geometric microliths are known to appear with the Umguzan Complex of southern Africa at ca. 30,000 BP (Sampson 1974:240) and in Zaire's Matupi Cave at ca. 29,000 $^{14}$C BP (van Noten 1977). Further chronological details on the ages of geometric microlithic industries in West Asia and Africa are provided in Chapter 5.2.12. These data do indicate that Lanka's Mesolithic, as defined technologically by the presence of geometric microliths, is by no means anomalous at 28,500 BP.

## 3.6 CONCLUSIONS

*3.6.1 Ratnapura Beds.* The Ratnapura Industry, representing human activity in Lanka during the Pleistocene, is undatable by typological methods. It thus became necessary to date it using radiometric and faunal data. The former are sparse and not very reliable. The latter had to be viewed on a comparative basis, correlating with Pleistocene faunas of much of the Oriental Faunal Zone so as to squeeze out any dating information that might accrue relating to the Ratnapura Industry. Since all of Lanka's mammalian fauna had necessarily to come from India, the age of the Indian Pleistocene faunas came to be pivotal in this exercise. The identification of *Hexaprotodon sinhaleyus* in the Ratnapura Beds as most probably synonymous with *H. palaeindicus* has led to a correlation being proposed between the Ratnapura Beds and Aggradation II of peninsular India.

It then became necessary to date Aggradation II in India. Apart from a few radiocarbon dates, on dubious material, registering 30,000-20,000 BP, scarcely any other dating evidence had been processed and synthesised by researchers on this subject. This led me to spread the net wide in a two-pronged attack comprising technological and faunistic correlations further afield. The former ranged into Africa and Europe, while the latter encompassed most of the Oriental Faunal Zone and probed eastwards as far as China. For the first time the semblance of a cohesive picture has emerged for India's Pleistocene chronology. This in turn can be selectively transposed to the Ratnapura Industry representing Pleistocene human activity in Lanka. A summary of the conclusions follows:

(*a*) The Ratnapura Industry cannot be dated on typological grounds: no Acheulean or Mousterioid elements have been identified.

(*b*) Two radiocarbon dates are available for the Ratnapura Beds: ca. 7,500 and > 47,000 BP. The latter indicates the indubitable presence of a Pleistocene component.

(*c*) The uranium assays on the Ratnapura Fauna are inconclusive due to inadequate sample size.

(*d*) The faunal associations within the Ratnapura Fauna, inclusive of *Elephas maximus*, do not suggest a sequential series. Possible exceptions are *E. hysudricus* and *E. namadicus* which, if correctly identified, might be earlier than the rest.

(*e*) The closest correlate of the Ratnapura Fauna is the later Narmada Fauna of peninsular India's Aggradation II. Hence, it became vital to date Aggradation II and its fauna. In attempting to date Aggradation II, the age of several other Pleistocene deposits in India fell into a composite scheme.

  i. Radiocarbon dating has fixed an upper boundary of ⩾25,000 BP for Aggradation II.
  ii. Technological and geo-chronological data from the Himalayas, Europe and Africa have suggested a lower boundary of Riss age (ca. 200,000 BP) for Aggradation II.
  iii. Geo-chronological data from Tamilnadu suggest an Eem (ca. 125,000 BP) age for Aggradation II.
  iv. Faunistic and radiometric data from Java's Notopuro Beds date Aggradation II to less than 500,000 K/Ar BP and possibly to Riss.

Synthesising the data, Aggradation II is datable to ca. 200,000 - ⩾25,000 BP, more probably to the Eem interglacial which is transposable to the Ratnapura Fauna and thence to the Ratnapura Industry.

(*f*) The earliest evidence of man in India is in the Boulder Conglomerate of the

Potwar (Mindel), although there is a suspicion that it might be Cromerian (ca. 0.7 my) in Tamilnadu to match the dating of an Acheulean assemblage in northern Pakistan to 0.7-0.4 my. (In the absence of an alternative, I have adhered to the time-honoured four-fold glaciation scheme which, however, is currently being contested (v. Isaac 1975:876).) It is, hence, reasonable to hypothesise that the low sea levels during the Mindel (perhaps Günz) glaciation would have enabled man to cross over to Lanka via a land connection and hence it can be further hypothesised that man was in Lanka by ca. 0.4 (?0.7) my BP. *Elephas hysudricus* and *E. namadicus* (if correctly identified), and *Hexaprotodon sinhaleyus* (if partly representing *H. namadicus*) of the Ratnapura Fauna can qualify for such an early date as per the correlations with India and Java.

(*g*) Artefacts assignable to the historical period of ⩽2,500 BP have, very occasionally, been found in the Ratnapura Beds; these suggest redeposition of at least some of the strata.

(*h*) It is very clear that without conducting a thorough stratigraphic survey of the Ratnapura Beds, with their bewildering array of fauna and artefacts ranging from the early Middle Pleistocene to the historical period, no further chronological resolution can be achieved. Uranium series assays on faunal remains could yield valuable information. In the absence of a sequence of river terraces associated with the Ratnapura Beds, samples from several borings will require to be compared and correlated before even a rudimentary picture of the sequence of deposition (?and redeposition) can begin to emerge. The thalasso-static river terraces of the lower Kelani can provide more straightforward dating evidence which, perhaps, can usefully be correlated with data from Tamilnadu in India.

It is a cliché, but nonetheless true, that chronology constitutes the backbone of archaeology. I have here attempted to provide some form of time-scale against which the earliest evidence of human activity in Lanka can be viewed. The artefacts, due to their typological vagueness, have been of no assistance in this attempt. Considering the paucity of radiometric data available, I had perforce to turn to faunal correlations to secure chronological definition for the Ratnapura Beds which contain the artefacts. Working on the premise that fauna is a reliable chronological index, due to the irreversibility of evolution, the Ratnapura Fauna, and thence the Ratnapura Industry, have been allocated a set of chronological brackets spanning the entirety of the Pleistocene and into the Holocene, with the modal range being contemporaneous with peninsular Indian Aggradation II at ca. 125,000 BP.

*3.6.2 Iranamadu and Reddish Brown Earth Formations.* The chronology of the prehistoric coastal deposits of Lanka has been evaluated in Chapter 3.4, the focus of scrutiny being the Iranamadu and Reddish Brown Earth Formations. The results of this study can be summed up as follows.

The I Fm, with its counterpart in the *teris* of south-eastern India, comprises basal gravels deposited in a coastal facies as a result of fluvio-marine interaction. The gravels are overlain by dune sands of a coastal *cum* shore facies, which have been weathered into the very diagnostic Red-Yellow Latosol soil category. The aeolean component of these sands are not of an inland facies, as evinced by their co-extensiveness with the underlying fluvio-marine gravels in an arcuate belt which is strongly reminiscent of the Miocene marine trangression which produced the Jaffna Limestone. Both members of the I Fm are implementiferous.

The basal gravels of the I Fm have not been radiometrically dated in Lanka: datable deposits have yet to be discovered. As for India, R. Gardner's date of ca. 38,000 BP for an 8m terrace appears to be a *terminus ante quem*; but one could tentatively propose a final Eem date (Late Monastirian) to the basal gravel at Site 49, which is also at 8m +msl. Despite some indications that Lanka's coasts have not been uniformly tectonically stable, thus vitiating any serious attempt at worldwide altimetric correlations with glacio-eustatic sea levels, the elevations of the basal gravels of the I Fm appear to be quadri-modal at 50, 30, 15 and 10m +msl respectively. The Indian data suggest a bimodal pattern of 15-20 and 8-10m +msl which fit Lanka's lower terraces.

It can almost certainly be hypothesised that the elevated basal gravels of the I Fm represent periods of interglacial or interstadial high sea levels and, tentatively, the 50, 30, 15 and 10m modes can be correlated with a pre-Holstein, Holstein, Eem and late Eem (or Würm interstadial) altithermals respectively. I have pointed out in some detail the risks inherent in attempting to date past high sea levels solely through altimetry in the absence of evidence from isotopic assays. It is crucial that plate tectonics of the South Indian region be considered in any evaluation of land/sea relationships in this area during the Quaternary.

The artefactual content of the basal gravels of the I Fm seems to be devoid of geometric microliths, which, by analogy with the dating of this artefact category at Batadomba-lena, would make these deposits earlier than ca. 28,500 BP. The apparent presence of non-geometric microliths (Class III of Type List, Chap.5.2.3) on the basal gravels of Site 50a does, however, suggest an age not exceeding that of the Eem interglacial, by analogy with the typology of the European Mousterian – which is in agreement with the hypothesised eustatic dating of 50a II. Non-geometric microliths have also been found in the northern *vembus* which however are chrono-stratigraphically indeterminate. It is noteworthy that certain artefact categories with apparent Mousterioid stylistic traits have been found in the *vembus*, for instance Type 70 from Site 40. These could well be coeval with a Riss or Eem episode.

The geo-chronological relationship between the basal gravels and the overlying sandy clay loams of the I Fm is difficult to establish, beyond the fact that they both represent shore-associated or coastal sediments: the sandy clay loams could be approximately coeval with a marine regression represented by the basal gravels, or they might belong to a much later date as seems to be the case with the upper horizons of the Latosol at Site 50. Reworking of the sands in the shoreline dunes could also have resulted in the mixing of any artefactual horizons which they might have contained. Moreover, deflation could have caused these artefacts to form a lag deposit on the basal gravels, thus making the interpretation of artefacts sampled from the surface of the gravels, as in the case of the *vembus*, a risky procedure. Particle size analyses of the sandy clay loams at Sites 49b,c and 50a (App.III) do not suggest more than a single type of aggradational environment in their respective vertical sections.

As Butzer has pointed out (1971:221), the glacio-eustatic dating of sandy shoreline features is an exercise that is fraught with hazard; except perhaps in the case of lagoons as at Mantai where the transition between aquatic-lagoonal and terrestrial facies, which represents the associated mean sea level, can be precisely determined by an examination of the lagoonal sediments. Dune cordons formed in front of a transgressive sea (v. id. 1975:34), even if they should be identified as such, would only be very approximately indicative of the associated sea level maximum. Note, for instance, that there are two shoreline dune cordons currently forming on Kalpitiya peninsula at ca. 2m and 6m +msl respectively (Cooray 1967:165), thus highlighting the variability of dune heights relative to the prevailing sea level. (7m dunes are forming in Vilpattu (Katz 1975:86), where the vegetation serves to check their movement inland.)

The sub-heading on the stratigraphy of the I Fm (Chap.3.3.3) has, however, argued rather strongly in favour of the view that the sands of the I Fm represent phases of glacial advance which would be reflected in glacio-eustatic regressive hemi-cycles of the oceans. The I Fm sands, representing the coastline, appear to have prograded rapidly, as suggested by the degree of variability in the rounding of the quartz particles, the absence of buried soils on the surfaces of the basal gravels and the sharp contact between the basal gravels and the overlying sands which is indicative of a rapid depositional succession, with a coastal alluvial facies giving place to one of shoreline dunes.

Two radiocarbon assays, designed to date the I Fm sands, have been conducted on lagoon shells – an unsuitable medium. Of these, it is only the one for 50a IV that can even remotely be considered noteworthy, in that it indicates the deposition of the underlying dune sands and their stabilisation at a date prior to ca. 5,300 cal BP. From among the Indian assays purporting to date the *teris* directly, Sarma's (1976) dates for the south-eastern Indian coastlines do not warrant confidence as to provenance or dating medium. However, Gardner's (1981; 1983) dating of the sands overlying the 8m raised beach to ca. 25,500-21,000 $^{14}$C BP seems to be reliable. These latter are in excellent agreement with the age of ca. 28,000-23,000 TL BP which have been obtained for the Latosol sands above the 8m terrace at Site 49 and for the upper horizon of the Latosol of Site 50 of the I Fm in Lanka. Gardner's date of ca. 38,000 $^{14}$C BP for the 8m terrace itself is a *terminus ante quem* for the implementiferous basal gravels at ca. 8m +msl at Site 49; a Late Monastirian date of ca. 75,000 BP is more plausible for the latter.

The lower horizon of the Latosol at Site 50 has yielded two dates of ca. 74,000 and 64,000 TL BP, which would place its deposition in the final Eem (Late Monastirian) or early Würm (?Amersfoort). A palaeo-sol appears to intervene between the 28,000 and 74,000-64,000 BP horizons of the Latosol at the site, although further investigtions are required on this subject.

Zeuner's and Allchin's (1956) hypothesis that the *teris* are amenable to eustatic altimetric studies has been shown to be tenable as per the two sets of dates from Sites 50 and 49, which indicate that the age of the basal gravels are directly proportionate to their respective elevations above present sea level. It will be recalled that this was one of the primary hypotheses that had to be tested (Chap.2.4). However, it should be noted that a local altimetric sequence has necessarily to be formulated, as neo-tectonics could have modified the absolute elevations of Lanka's (?and India's) prehistoric coastlines.

The dating of the lagoon shells at Site 57 does not seem to have any direct relevance to the dating of the I Fm's sands. However, it has served to suggest that technologically Lanka was in the Stone Age at $\leqslant$3,200 BP, as is corroborated by the radiocarbon date of ca. 3,800 cal BP for a level preceding a Mesolithic occupation horizon at Mantai.

The geometric microliths and Balangoda Points excavated from the sandy clay loams of Sites 49b,c and 50a suggest an antiquity of less than 28,500 BP by analogy with the radiocarbon dates for Batadomba-lena. The absence of protohistoric ceramics within the Red-Yellow Latosols of Lanka has been tentatively interpreted as signifying an age in excess of 2,800 years for these sediments, and pedological observations indicate that they are definitely over 1,700 years old, while ceramic evidence combined with that of soil formation processes indicate that it is in excess of 4,000 years.

It can be concluded that the sandy clay loams of the I Fm are ca. 28,000 years old at Site 49 and in the upper levels of Site 50. The lower levels of the sandy clay loams at Site 50 have been dated to 74,000-64,000 TL BP, although it is not known whether this horizon is represented in the excavations at Site 50a. Some of these sediments, perhaps in the hinterland at high elevations, could be much earlier in origin, despite subsequent denudational disturbance. It is hoped that thermoluminescence dating will shed further light on the chronology of these deposits.

The RBE Fm has no radiometric dates – (but v. Addendum I). Its basal gravels contain artefacts distinguished by geometric microliths and Balangoda Points, which indicate an age of ≤28,500 BP. The evidence from Anuradhapura indicates an upper age limit of >2,800 BP. As with the basal gravels of the I Fm, it is important to bear in mind that those of the RBE Fm could represent several episodes of gravel deposition according to locality, and they could also be superimposed upon one another. The attempt to compare and correlate the artefactual contents of the basal gravels of the RBE Fm and I Fm as a means of establishing a techno-chronological link (to serve as a basis for reconstructing the mode of genesis of the I Fm's basal gravels (v. Chap.2.4)) has not borne results, as the assemblages could not be compared due to physical attrition of potentially diagnostic traits. However, the artefact types found in the basal gravels of Site 43a and in the ancient dunes at 49b,c, correlate exceedingly well, and it may plausibly be hypothesised that the former can be cross-dated to ca. 28,000 BP as per the thermoluminescence dating of the latter.

It can be affirmed in conclusion that the chronology of the implementiferous I Fm and RBE Fm is still imperfectly known. However, the above treatment of this topic has served to shed a great deal more resolution on it than has been achieved hitherto. It is noteworthy that de Alwis (1971) did not venture to assign the Latosols to anything more specific than the Quaternary in general. Radiocarbon and perhaps thermoluminescence dating would of course provide the most reliable chronology for these deposits. Artefact typology comes in useful from the Upper Pleistocene onwards, although it certainly does not afford adequate resolution. Glacio-eustatic altimetry is of very limited applicablity for dating these sediments. What is required is a further series of excavations in the I Fm at different elevations above sea level, excluding those localities which have obviously undergone tectonic movement during the Cainozoic. The excavations at Sites 45, 49 and 50 constitute only a beginning in this venture, and much more data from a wide range of sites are required. Perhaps one should commence with the high elevation sites in the north around Iranamadu and then proceed to the lower elevations towards the present shoreline. Thermoluminescence (?and radiocarbon) dating, and artefact typology and seriation might then, conceivably, provide useful chronological clues. As for the RBE Fm, the outlook for radiometric dating is not as poor as it may appear, as samples suitable for radiocarbon dating (charcoal) and thermoluminescence assays (burnt stones) may be forthcoming. Artefact typology is likely to be only a coarse means of dating the deposits. Stratigraphic correlation with the I Fm can perhaps be attempted via the H Fm in the south, or through some of the apparently intermediate basal gravels in the northwest. The terrace gravels of the west coast cannot as yet be correlated with the basal gravels of the I Fm or the RBE Fm, although this should be feasible with intensive field studies.

*3.6.3 Caves and Bellan-Bandi Palassa.* The discussion in Chapter 3.4 of the age of the implementiferous prehistoric cave deposits of Lanka, together with that of the open-air midden *cum* burial site of Bellan-bandi Palassa, brought out the following salient points:

(*a*) The radiocarbon dating of Mesolithic Bellan-bandi Palassa is suspect; however, the thermoluminescence age of ca. 6,500 BP is somewhat more acceptable.

(*b*) The Mesolithic at Beli-lena Athula cave has secure radiocarbon dates on charcoal of ca. 8,100 BP, while Alu-lena Attanagoda has been similarly dated to 10,350 BP.

(*c*) The Mesolithic at Beli-lena Kitulgala has 27 radiometric dates from four laboratories. The samples of charcoal were obtained from clearly defined stratigraphic horizons. The dates form a consistent series ranging from > 27,000 to ca. 4,000 BP. The lowermost micro-stratum at this site, also containing Mesolithic artefacts, has yet to be dated to over 27,000 BP (v. Addendum I).

(*d*) The Mesolithic at Batadomba-lena has ten radiocarbon dates on charcoal, from the basal stratum upwards. Once again, the samples are from secure contexts and the dates range from ca. 28,500 to 11,500 BP (Figs.54-9).

(*e*) The majority of the charcoal samples submitted for dating comprises annuals such as carbonised shells of the nut *Canarium zeylanicum* or the epicarp of the wild breadfruit, thus minimising the difference between the date of death of plant material and the date of deposition.

(*f*) The faunal assemblages associated with the prehistoric cave strata and with Bellan-bandi Palassa do not, on present evidence, include extinct forms, and hence cannot be employed as chronological indicators.

(*g*) Evidence from techno-traits, such as the presence of protohistoric pottery and Early Historic inscriptions, indicates that the Mesolithic in Lanka was superseded by a full-fledged Iron Age by ca. 2,800 BP as at Anuradhapura.

(*h*) Deposits representing pre-geometric microlithic technological phases have yet to be radiometrically dated, the age of 74,000-64,000 TL BP for the Latosol at Site 50 requiring confirmation in an implementiferous context. The basal gravel at this site, with artefacts, antedates the above-mentioned Latosol and is probably assignable to the Eem (Main Monastirian) at ca. 125,000 BP.

The very early dates for Mesolithic stone tool technology in Lanka (Fig.59) places it on par with the evidence from Iran (and perhaps Iraq), Zaire, Zambia and southern Africa, where geometric microlithic assemblages of similar antiquity have been found (Chap.5.2.12). These recent discoveries are likely to revolutionise existing concepts as to the origins of geometric microlithic technology. The latter can no longer be considered diagnostic of Postglacial cultural phases: it dates from at least as early as the inception of the Paudorf interstadial in Lanka. One may no longer dismiss any random discovery of geometric microliths in Lanka, and hence also in India, as being typologically Holocene: they could be much older.

*3.6.4 Conclusions.* The present radiometric evidence indicates that man was certainly in Lanka by ca. 28,500 $^{14}$C BP, probably by 74,000-64,000 TL BP and earlier during the last interglacial at ca. 125,000 BP. It is also possible that some of the higher level thalasso-static basal gravels of the Iranamadu Formation, tentatively assigned to the Cromerian interglacial of ca. 500,000 BP, are implementiferous. Certain elements of the Ratnapura Industry could conceivably be even older, bio-stratigraphically, although, so far, this is highly speculative.

I have, in the above discussion, presented the current state of knowledge concerning the Quaternary chronology of Lanka. It is a very basic chronology, referring to the Middle Pleistocene (now defined as commencing at the Brunhes-Matuyama geomagnetic reversal at ca. 700,000 BP (Butzer 1975*a*:865)), and thence into the Upper Pleistocene of the Eem and Würm and finally the

Holocene. It requires to be fleshed out with results from numerous further deep probes. What is required is a high density of radiometric dates; and there is no substitute for this. Apart from the case of the Ratnapura Industry and, indirectly, the dating of the 8m *teris* in India, the sub-continent – which has been the source of Lanka's prehistoric settlements – has unfortunately not been able to provide any additional resolution to Lanka's prehistoric chronology. Indeed, it appears as if the chronology of the Mesolithic of India, and further afield in Pakistan and West Asia, will have to be viewed from a fresh perspective in the light of the very early dates (ca. 28,500 BP) from Batadomba-lena cave and the Latosols at Sites 49 and 50 of the I Fm.

Having outlined, as best as possible, the chronology of prehistoric man in Lanka, it becomes necessary to assess the nature of the environment he had to cope with: a prelude to knitting together the man/environment interaction system.

# 4
# QUATERNARY ENVIRONMENT

## 4.1 INTRODUCTION

The Quaternary chronology of man in Lanka has been considered in Chapter 3. The next step is to assess the nature of the environment which he had to contend with.

As for the Lower and Middle Pleistocene, data on environment are absent or very sparse. The main cause of this situation is the lack of suitable deposits for in-depth research, as is apparent from the foregoing survey of the Ratnapura Beds. The recently retrieved material from the Iranamadu Formation, Beli-lena Kitulgala and Batadomba-lena is, however, significant for the Upper Pleistocene. I shall attempt to bring together whatever data there are available and interpret them against the backdrop of information from further afield – starting with India, which is very important for comparisons due to its Southwest Monsoon-dominated weather pattern which is akin to that of Lanka, and then on to other regions which might be relevant to the field of enquiry. These latter data will be evaluated as to possible parallel developments in Lanka. Much of this terrain is uncharted; but it is hoped that the results of the present study will constitute the springboard for future research on Lanka's Quaternary environment.

## 4.2 SOILS AND GEOMORPHOLOGY

*4.2.1 Ratnapura Beds and Other Alluvia.* As has been demonstrated in Chapter 3, the Ratnapura Beds contain an early Upper, and possibly Middle, Pleistocene component. The stratigraphic data which I have presented in that chapter (3.2.1) invariably suggest an overall state of progressive aggradation in these fluviatile deposits, with the lowermost, fossiliferous and implementiferous, gravels being at a modal depth of ca. 7m below present ground level, although certain deposits, such as in the Kuruwita basin, can be as much as 30m -gl. Our knowledge of these deposits is so limited as to make it impossible to isolate any episodes of down-cutting that may exist within the overall sequences; although such episodes would most probably have occurred.

Considering this state of knowledge, any environmental inferences which can be drawn from the data can only be simplistic in the extreme. The evidence is typified at the Kamaranga-pitiya gem pit, Pelmadulla (Deraniyagala 1958:25). The depth of alluvia ranged from 7-9m -gl, while the channel of the present stream is a mere 1m

-gl upon the alluvia. Boulders and gravels were found in the basal horizons of the old alluvia, whereas the sediments deposited by the now meandering stream are silts and clays. This can be interpreted as representing an originally fast-flowing stream which progressively reduced its load capacity. The bedding can suggest minor episodes of increased stream velocity, as in the occurrence of sandy deposits above clays in Pit 1, although this can perhaps be better explained by lateral shifts of the channel. What then were the factors responsible for the pattern of deposition as evidenced in the Kamaranga-pitiya pits?

There is no gainsaying the fact that the present stream cannot carry the load represented in the basal boulders and gravels. The most it can carry are fine sands and silts. This situation can be interpreted as due to one or more of the following causes:

(*a*) Progressive maturation of the overall profile

(*b*) The "ponding" of the stream due to the appearance of an erosion-resistant barrier of hard rock during the course of profile maturation.

(*c*) The ponding of the stream due to the appearance of a barrier caused by tectonic disturbances.

(*d*) Reduction of the amount of water in the stream due to river capture. It is known that such occurrences in the Ridge and Valley country, with its trellis of joints, are not rare (id. 1947:2), a particular instance being the Adam's Peak area where it is rampant. (On the other hand sub-specific regional differentiation within the lowland Wet Zone (D1) of the freshwater cyprinid fishes *Rasbora vaterifloris* and *Puntius titteya* (id. 1958*d*:136) suggests that river capture in the Quaternary was not drastic enough to destroy this differentiation.)

(*e*) Reduction of the amount of water in the stream due to decrease in the feeder system comprising surface run-off and a lowering of the water-table, both a function of a decrease in rainfall. Under conditions of climax equatorial rain-forest, such as would probably have been prevalent throughout the Quaternary in the Ridge and Valley country of Lanka, there would be a direct proportion between rainfall and surface run-off, unlike in situations where the vegetation could change into a new configuration with an increase in precipitation (v. Madduma-Bandara 1972:95).

Considering the above causative variables, it is impossible to interpret the Kamaranga-pitiya alluvial beds in climatic terms. Although fluviatile deposition patterns are determined by the ratio of load to discharge,

> a difficulty inherent in the evaluation of an alluvial fill is that sediments accumulated during a long period of aggradation must be distinguished from those deposited during a single exceptional flood... It is difficult to draw inferences as to climate from alluvial stratigraphy because of variable factors such as amount of precipitation, distribution of precipitation throughout the year, mean and seasonal temperature and the like. The response of a stream, in terms of discharge and load, to a change in one or more of the climatic variables will be affected by area and range of altitude of watershed, local topographic texture, slope angles, character of vegetation cover [sediment yield is said to be at a maximum under grassland conditions (Mueller-Dombois 1972:96)], and other circumstances [such as pulsating tectonics (Mujumdar and Rajaguru 1972:104) and availability of loose sediments from earth-slips]. Hence, a change in only one climatic factor might lead to different responses in two different streams, and even in two different segments of a single long stream [Flint 1971:305-6].

As for employing drainage density, the "ratio of cumulative channel segment lengths within a drainage basin to the basin area" (Madduma-Bandara 1972:95), as a means of assessing Pleistocene precipitation configuration, I am not aware of its being attempted anywhere under conditions of equatorial rain-forest where this method is scarcely feasible.

Regarding eustatic determination of the pattern of deposition of the Ratnapura Beds, it could apply, naturally, only to those alluvia within the range of elevations of Pleistocene high sea levels. For instance, the Kuruwita alluvia reaching depths of ca. 30m -gl could conceivably be linked with eustatic pulsations; but the type of intensive (and extensive) investigation that is called for to elucidate this picture is a far cry from the nature of the studies undertaken so far. Note that "the response of a stream to a change of sea level depends on the shape of its long profile, the volume and grain sizes of the load of sediment it is carrying, the configuration of the sea floor off the stream's mouth, the local stability of the crust, and other factors" (Flint 1971:341). Conversely, eustasy is another variable to be added to those determining the pattern of sedimentation in the case of the low-lying Ratnapura Beds, thus further complicating any strictly climatic interpretation.

It appears to be reasonably clear that tectonics have indeed been an active element in determining the configuration of Lanka's Quaternary strata. Nearly all of the watersheds of the streams which have deposited the Ratnapura Beds are situated in the central highlands in the so-called third peneplain (v. Spate and Learmonth 1972:796). As for the genesis of Lanka's peneplains, one theory is that the island has been elevated relative to the sea level in three stages, causing the receding knick points to form escarpments (Adams 1929:438); and the other (Wadia 1941*b*:19,20; 1943) postulates block uplift in stages, with the third peneplain constituting the most recent in the series of horsts. It was the series of waterfalls fringing the third peneplain which led Wadia to hypothesise that the plateau has been horsted into its present position, although Cooray (1967:61,67) attributes these falls partly to the resistant nature of the Charnockite escarpment. Wadia's hypothesis is supported by Dupuis (1959), and the Nilgiri and Palni hills of southern India are said to constitute similar horsts.

The tectonic stability of Lanka is important for any palaeo-geomorphological study of its deposits, as will be apparent from the discussion of the Iranamadu Formation in a subsequent sub-heading. Adams postulated generalised uplift, whereas Wadia suggests a more fragmented succession of horsting. Although Lanka forms a part of the so-called "stable" South Indian shield of Precambrian rocks, its stability has to be questioned. Some further indications of tectonic movements are as follows:

(*a*) Aerial photographs showing several faults in the Vijayan Series (Cooray 1967:123)

(*b*) Dolerite dykes, probably of Cretaceous age, intruding into the Precambrian crystallines (ibid.:245; Pattiarachchi 1961:26).

(*c*) The Andigama and Tabbova Beds of Jurassic age have been faulted down into the crystallines (Kularatnam 1959:7; Cooray 1967:125,135).

(*d*) The slight folding of the Miocene Jaffna Limestone in an easterly and north-easterly direction. Vertical movements are more marked (Wayland and Davies 1923:580; Cooray 1967:244). The 10m -msl isobath (Deraniyagala 1958:13) suggests regional uplift of northern Lanka.

(*e*) The post-Miocene (?Pleistocene) localised uplift of Minihagal-kanda (Site 40) in the south, and the Cainozoic dyke at Uda Pottana (App.III).

(*f*) The post-Miocene localised horsting of Arnakallu (Site 30) in the northwest (Hanreck and Sirimanne 1968).

(*g*) Modification of the Mahaweli, Kelani and Maha-oya river drainage due to faulting (Wadia 1941*b*:19; Kularatnam 1959:7; 1966:44).

(*h*) The confusion of strikes and dips in the Hantana-Uduvela area near Kandy point to complex tectonic disturbances (Kularatnam 1967:48).

(*i*) The five gravel terraces at over 13m above the Uma stream, Welimada (Deraniyagala 1958:23; 1963*a*:2), suggesting Quaternary down-cutting due to tectonic uplift. Note that the eastern boundary of the third peneplain falls on to the Uma-oya (Wadia 1941*b*:19).

(*j*) The 16m terrace of the Belihul-oya on the Horton Plains at Locality 19 (S.Deraniyagala 1972*a*:9,22,Map) is situated very close to the escarpment, thus suggesting rapid down-cutting due to uplift.

(*k*) There is said to be a ridge of pumice under 12m of water ca. 3km off the northeast coast of Lanka, between Matadam and Mullaitivu and pieces are found washed up along the east coast (Wadia 1941*d*:21,22; Deraniyagala 1961:150). It is impossible to date the event; it is observed (Wadia 1944:1) that between Chundikulam and Kokkilai in the northeast the pumice is restricted in its incidence to a raised beach. Wadia mentions a submarine eruption off Pondicherry, South India, in 1756 which threw up large quantities of ash and pumice. This is close to Lanka and serves to cast doubt on the tectonic stability of the southeast coast of India, an area vital for estimating the Pleistocene chronology of India (v. Chap.3.2.4).

(*l*) The thermal springs of the Dry Zone (Cooray 1967:264), once thought to be of magmatic origin, have been chemically established to be deep-circulation water in fractures and joints of the crystallines (Sirimanne 1967:70,73). However, this verdict is controversial, since the springs coincide with the distribution of intrusive dolerite dykes (Seneviratne and Balendran 1968:51).

(*m*) Earthquakes are of relatively frequent occurrence. Portuguese records of the seventeeth century mention heavy earthquakes and the formation of numerous fissures in 1615 (Deraniyagala 1961:152; 1965:166).

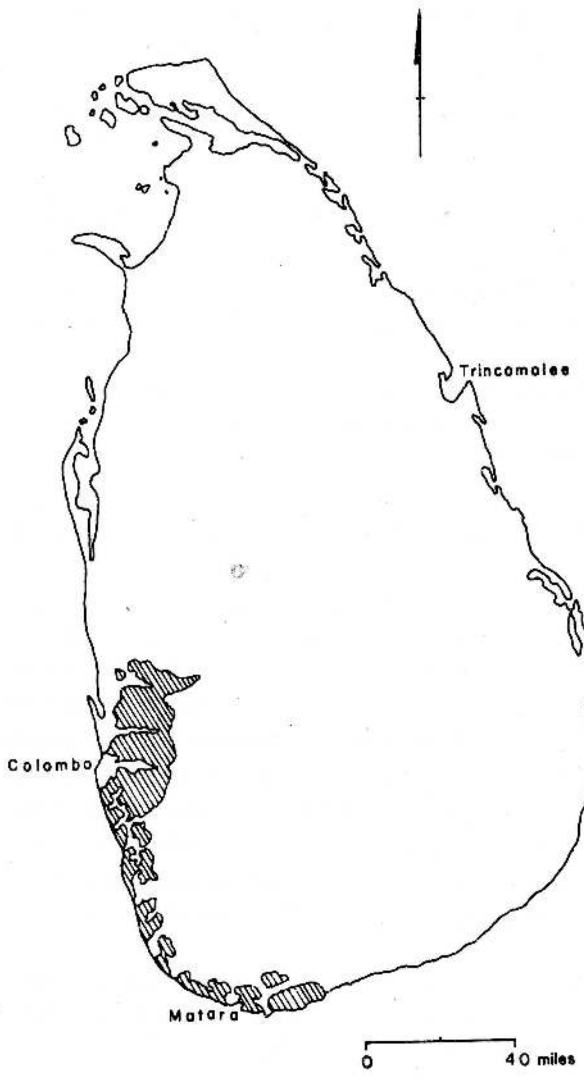
(*n*) Specimens of glass, dull wine-red, yellow, light green, dark blue and a luminous corn-flower blue, have frequently been found in the gem gravels. These were thought to represent tectonic activity (ibid.:167). However, a sample sent to D.P. Agrawal of the Physical Research Laboratory, Ahmedabad, India, has tentatively been identified as being artificial (1982:pers. comm.). On the other hand, the discovery of a specimen of diamond could be significant (Deraniyagala 1965:167).

The combined evidence of the above data indicates that both large-scale uplift, as in the north, and localised horsting have been prevalent since at least the Miocene in Lanka. Hence, in interpreting the geomorphology of the Ratnapura Beds, we cannot, unfortunately, discount the variable of tectonics as an influencing factor.

Deraniyagala (1955*a*:295) has attempted to interpret the four horizons of travertine on the banks of the Kirindi-oya and its tributary Dambakota-ara (lat. 6° 8′N by long. 81°5′E) and elsewhere (id. 1958:30) as indicative of arid phases. However, the interpretation of travertine deposits in the tropics is fraught with hazard (Butzer 1971:210); for instance, an investigation of Vavulpane cavern at Colombage-ara, Uda Valave, revealed that travertine is currently forming along the associated stream. It appears as if the local micro-environment, with particular reference to the availability of carbonates, rather than general climatic factors, is predominant in determining the formation of travertine (v. Cooray 1967:182).

*4.2.2 Laterite.* The above account indicates that no environmental inferences can be drawn from Lanka's Pleistocene on the basis of inland fluviatile geomorphology. As for pedological data, Appendix I.5 delineates the different soils of Lanka. Considering that little by way of evidence of buried soils has so far come to light, it becomes necessary to scrutinise any fossil soils there might be for clues to Quaternary shifts in climate. This forces one to look for a soil which once formed cannot be altered into a different soil under humid, equatorial conditions; in other words, if a soil which has formed under one set of climatic conditions is liable to change into a different soil under a different set of climatic conditions, its value as an index to past climates becomes limited. The only soil in Lanka which has potential as a climatic index and which once formed does not alter (as far as is known) with the vagaries of subsequent climates is the Red-Yellow Podsol with Laterite, otherwise simply termed "laterite".

In accordance with a modern tendency to recognise soil-forming processes in the humid tropics as essentially podsolic, the soils of most parts of the Wet Zone of Lanka are classed as "Red-Yellow Podsolic" (Spate and Learmonth 1972:798). These, as is shown in Appendix I.5, develop on a wide range of parent material and in differing topographical situations and comprise several sub-groups. Laterite (v. Pattiarachchi et al. 1962) is one of those sub-groups and it can develop on a variety of parent rock, such as Charnockites, garnet-biotite gneisses and amphibolites, as well as on secondary sediments (Wadia 1941*a*:13; Cooray 1967:78). It is "a highly weathered, clayey rock material, rich in secondary iron or aluminium oxides but poor in silica; it is usually reddish, purplish, brownish or yellowish in colour, and very few




**Map 18** Laterite; its distribution in Lanka (*after Panabokke 1969*)

minerals are present in it" (Cooray 1967:177). A laterite cap of 6-30m thickness is not uncommon. The concentration of sesquioxides is the outstanding single feature of a laterite (Sivarajasingham 1959). A typical profile in Lanka is as follows (Cooray 1967:178):

(*a*) Iron-stone (ferricrete) forming a hard crust, which where exposed, is breaking down to nodules and pellets.

(*b*) Laterite, hard and cellular, with a skeleton of iron oxide and clay-filled cavities

(*c*) Soft clayey laterite in various colours

(*d*) Weathered bed-rock showing traces of the structure of the parent rock and in which the feldspars are kaolinised.

(*e*) Parent rock of garnetiferous gneiss

In Lanka, the laterites are primarily ferruginous (goethite and haematite) and, due to the acid character of the rocks, the high-alumina varieties resembling bauxite are absent. They are, typically, rich in combined and free silica (Wadia 1941*a*:13; Sivarajasingham 1959; Herath 1971:58). The kaolinite horizon is due to the latter factor and the formation of a hard crust, which occurs on exposure, is irreversible and resistant to the action of air and water (Zeuner 1950:16,18).

The genesis of laterites is very imperfectly known (Butzer 1971:88). Strongly oxidising and leaching conditions are apparently a prerequisite, as well as perennial soil moisture and high temperatures. In Lanka this can be interpreted as warm temperature, high rainfall, high water-table and excellent drainage; apparently if the last is poor, a resynthesis of clay minerals will occur, which will block the decomposition of the rock (Sivarajasingham 1959). Alternation of wet and dry periods is said to be necessary. During the wet season, when the water-table is high, silica and several other minerals are leached out and carried away, while during the dry season, when the water-table is low, hydrated iron and aluminium oxides are deposited in the laterite-forming zone (Cooray 1967:177).

In Lanka, laterites are practically restricted to the south-western coastal lowlands (physiographic Sub-Zone 1) on rocks of the South-Western Group of the Highland Series at elevations below 30m +msl in climatic Sub-Zone 6 (App.I). The map published by Panabokke (1969) shows a one-to-one relationship between laterites and these physical conditions. A so-called weakly developed laterite is found extending northwards towards Chilaw (physiographic Sub-Zone 3; climatic Sub-Zone 5) on rocks of the Vijayan Series (v. Panabokke 1971: *Soil Map of Ceylon*). As to whether these two laterites belong to the same sub-group or not has yet to be established, and meanwhile we can assume that they are distinct entities.

It has been established that laterites can form under varying climatic conditions: King (1962) has apparently demonstrated that a tropical climate is not essential for laterite formation. They are known to form in regions with strongly contrasted seasons, while others are associated with humid and temperate climates (G.G.Majumdar and S.N.Rajaguru in Joshi 1965:251).

> Laterite is not uniquely identified with any particular parent rock, geologic age, single method of formation, climate *per se*, or geographic location. It is a rock product that is a response to a set of physico-chemical conditions which include an iron-containing parent rock, a well-drained terrain, abundant moisture for hydrolysis during weathering, relatively high oxidation potential, and persistence of these conditions over thousands of years [*Encyclopaedia Britannica (Micropaedia)* 1974].

> Lateritic weathering...could perhaps be accomplished under a wider range of climates than has been generally believed.... [They] apparently grade into the Red-Yellow Podsolic soils... making it difficult to relate lateritic soils to specific minimum values for the temperature and precipitation necessary to bring about lateritic weathering [Flint 1971:294-5].

Lateritisation is at least as common in the humid tropics as in the savanna regions [Butzer 1971:88].

The above statements refer to a general class of laterites. However, the sub-group in Lanka appears to be tightly controlled by temperature, rainfall and possibly geology and topography. In its properties it is akin to the sub-group in Kerala (Wadia 1941*a*:13). As Butzer (1971:88) affirms, "the significance of laterites and lateritic soils is still not satisfactorily established"; but, perhaps, future research will bring into clearer relief the factors peculiar to the genesis of each laterite variant. Meanwhile, one can rest content that in Lanka there is a very definite correlation between the laterite distribution and other environmental factors.

Having explained the nature of laterite in Lanka, and having observed that lateritic crusts are irreversible as chemical compounds (ibid.), it is necessary to see what clues it can provide concerning Quaternary climatic shifts. It has been noted that the laterite in Lanka is restricted in its distribution almost precisely according to the present boundaries of the South-Western Series of rocks, climatic Sub-Zone 6 and physiographic Sub-Zone 1 at below 30m+msl. It thus becomes apparent that whatever climatic and water-table fluctuations there might have been during the Pleistocene, laterites, as typified above, did not form outside this circumscribed area. Considering the durability of lateritic crusts, if they had occurred in any other area one would assume that they would have survived. Since such crusts have not been discovered outside the circumscribed zone detailed above, it is possible to hypothesise that conditions conducive to laterite formation did not extend during the Pleistocene beyond the present boundaries, the primary conditions being geology, temperature and rainfall.

This forces us to look within the present laterite zone itself. Cooray (1967:178) affirms that lateritisation is a continuing process. But is this really so? No one has as yet plotted the fossil laterite as distinct from the living laterite within the existing laterite zone. Until this is done it is impossible to assess whether Pleistocene laterites had a different distribution from that of the currently forming ones; and it is only then that we could attempt to evaluate the meaning of their differential distributions in climatic terms.

Meanwhile, one could hypothesise that geology plays a relatively negligible role in the formation of laterites in Lanka and that it is primarily governed by temperature and rainfall. The 30m+msl elevation limit is a clear demarcation of the temperature limit within climatic Sub-Zone 6 which also has its very special rainfall characteristics. It would thus be possible to conclude, hypothetically of course, that Pleistocene climatic conditions during the glacials and interglacials were such that climatic Sub-Zone 6 at $\leqslant$ 30m +msl did not exceed its present boundaries, and that if at all it could have been less in extent than it is today. The corollary to this hypothesis is that the temperature and rainfall in this region of Lanka were not at any period significantly higher during the Pleistocene. Note that a basic assumption in this theory is that all of the present laterites are currently forming and that the fringe of the range of distribution does not comprise fossil laterites. It is important to realise that the eustatic lowering of sea level would have led to a corresponding lowering of the water-table (Flint 1971:324), which could have halted the formation of laterite. If at all, laterites would have formed then on the exposed marine sediments; on the other hand, no laterites are known to have formed on the predominantly silica sands of Lanka. If it is established that the periphery of the present laterites comprises living laterites, one could conceivably construct an elegant hypothesis as to the manner in which laterite formation regressed and transgressed with the different sea level fluctuations; however, at the present juncture, this would be excessive speculation and one cannot do more than present

Basal gravels, Iranamadu Formation: Kudiramalai *(R.Y. Deraniyagala del. 1978; aquarelle x 1)*

the above hypothesis concerning climatic Sub-Zone 6 at $\leqslant$30m+msl for testing.

With regard to the Ratnapura Beds, Deraniyagala (1958:25) mentions on several occasions the occurrence of lateritic horizons. My view is that they are probably not laterites but simply secondary deposits of the modal variant of the Red-Yellow Podsols (App.I.5), and hence do not suggest a climate different from that prevailing in the area today. As for the 17m and 8m terraces on the Kelani river, these do contain laterites (Wadia 1941*a*:10). As to whether these laterites formed during the hypothesised Eem and Würm interglacial and interstadial phases respectively (Chap.3.2.1) or during a subsequent (?Holocene) phase cannot be established, since it is known that very old sediments can be lateritised at a much later stage.

*4.2.3. Iranamadu and Reddish Brown Earth Formations.* As indicated in Chapter 3.3, the Iranamadu Formation comprises basal gravels of Würm interstadial, Eem and perhaps even pre-Eem interglacial age. The overlying Latosols on sandy shoreline dunes could have been almost coeval with the basal gravels, although they could also represent much later depositional phases. The thermoluminescence dating of the dunes at Sites 49 and 50 points to two episodes of dune formation synchronous with the final Eem or early Würm at ca. 74,000-64,000 BP and the final Würm interstadial, namely the Paudorf, at ca. 28,000 BP (for Paudorf v. Bouchud 1966).

As observed in Chapter 3.3.3, the I Fm comprises a coastal *cum* shore deposit. With regard to its basal member, the gravels, it is very clear that none of the fluviatile systems prevailing today within the I Fm's range of distribution are capable of carrying the loads represented in the basal gravels, even as channel deposits, and certainly not as sheet gravels. The main rivers of the southern ecozone A, the Kumbukkan-oya and Menik-ganga, do not transport gravels anywhere nearly as large as those commonly found in the I Fm. As for the widespread occurrence of the I Fm in the north, there are no associated rivers which even remotely reach the transport capacity of either of the rivers referred to above. Hence, one could infer that the basal gravels of the I Fm were deposited by fluviatile systems with a much greater transport capacity than is evinced in ecozone A today.

Two factors, either singly or in combination, appear to have been responsible for this increased transport capacity of the prehistoric rivers debouching onto the coastal plains of ecozone A. The first is rejuvenation of the fluviatile profiles due to tectonic uplift. This could have been associated with the supposed horsting of the so-called third peneplain. However, despite indications that Lanka has not been tectonically static during the Quaternary (Chap.3.3.4), the movements are unlikely to have been of a cataclysmic nature, since Lanka is situated in a relatively stable part of the earth's crust. The stratigraphy and artefactual content of the gravels at Sites 49 and 50 indicate deposition during the Eem or one of the Würm interstadials, and it is unlikely that the horsting of the so-called third peneplain occurred as recently as that: the present rate of uplift in the central mountains has been estimated at a maximum of 1m for every 500 years, which would signify 500,000 years for 1,000m of uplift (Vitanage 1983:1). The second, and more plausible, factor is that the basal gravels are the result of intense and widespread denudation under conditions of intermittent and heavy rainfall.

The unsorted texture of the basal gravels of the I Fm and the high range of angularity of the larger particles suggest turbulent depositional conditions, possibly during violent seasonal floods. The thalasso-static gravels in the northwest (Chap.3.3.3) are also unsorted and associated with streams which are not capable of transporting the loads represented in the gravels (Cooray 1963). I have hypothesised that these gravels would have been deposited during one or more interglacials or interstadials.

It is apparent that the gravels of the I Fm and the terrace gravels were laid down under conditions when atmospheric circulation was more active than it is today, marked by seasonal rainfall with longer periods of effective drought. It is likely that conditions drier than those of the present reduced the vegetation cover, thereby exposing the ground surface to sheet erosion. Since drought in the Dry Zone is primarily a result of the *Foehn* effect of the katabatic Southwest Monsoonal winds in the rain-shadow of the central mountains (App.I.4.7), it is possible to postulate that this so-called "Palugahaturai Dry Phase(s)" (S.Deraniyagala 1976:21) was coincident with increased activity of the Southwest Monsoon.

Although the island's water balance, the function of the interaction between precipitation and evapo-transpiration, is a subject that is little known, due primarily to points of methodological controversy (App.I.4.5), and although a clear regional division or seasonal pattern cannot be established for Lanka even on the basis of potential evapo-transpiration (Domrös 1972:26), the annual rates of evapo-transpiration in ecozones A and B are said to be close to or greater than the annual precipitation (de Alwis 1971:15,17). Hence, any increase in Southwest Monsoonal winds, with their drying effect, could have had drastic results on the configuration of the vegetation. As affirmed earlier, wind activity appears to have increased with the global rise in temperatures as reflected in the glacio-eustatic high sea levels which are represented by the I Fm's basal gravels. Apart from interglacials and interstadials, minor altithermals such as the Atlantic of ca. 8,200-5,300 BP (Butzer 1974:736), or perhaps more accurately the Older and Younger Peron levels of 6,300-5,300 and 4,900-3,000 sidereal BP respectively (Fairbridge 1976:533), would have had similar effects on Lanka's climate (Addendum I).

The pattern of rainfall during the altithermals was also probably marked by greater cyclonic activity during the Northeast Monsoon (Chap.4.4.3), when sudden torrential rainfall would have caused extensive denudation of the Dry Zone with its reduced vegetation cover as hypothesised above. These denudation products probably constitute the basal gravels of the RBE Fm in the hinterland as well as the terrace gravels and the I Fm's basal gravels along the coasts. Note that such gravels are not found in the Wet Zone, where cyclonic storms are not pronounced. These storms, which are thought to originate in the Siberian and Pacific streamlines (App.I.4.7), arrive primarily in November across the Bay of Bengal (Thambyahpillay 1965:22-7), although stray occurrences are known from the First Intermonsoon in March-April (ibid.:14). They can create havoc with the vegetation, as exemplified by some of the cyclones which have affected the Dry Zone in recent years. It is noteworthy that their impact on the Wet Zone has scarcely been felt. The bulk of the Dry Zone's annual precipitation is caused by these storms, as is also the case with South India's *teri* country (Pate 1917:30): in a single day certain stations in Lanka's Dry Zone are known to have received almost 50 per cent of the mean annual rainfall through such cyclonic storms, and these at times register a 500 per cent increase over the Southwest Monsoonal totals at these stations (Thambyahpillay 1965:22-6). The impact of these rains are felt over wide areas, such as are represented in the basal gravels of the RBE Fm. The vagaries of cyclonic frequencies appear to account for the considerable inter-annual variability which characterises the island's rainfall totals. This variability decreases with increasing annual rainfall totals, although localised anomalous situations do occur, and the wettest areas have the lowest variability and vice versa (Domrös 1972:107-13). It is indeed very likely that cyclonic storms played a similar role in the Dry Zone of Lanka, with maximum impact on the drier localities, throughout the Quaternary.

As for the RBE Fm, the geomorphology of its basal gravels indicates that they have been deposited under an environmental regime that was similar to that postulated for the I Fm's gravels. The vegetation cover would have been scantier than that prevailing in ecozones A and B today. Since the gravels of the RBE Fm constitute a lag deposit with a generalised distribution in the middle and upper aspects of the topography, it is scarcely possible to affirm that they could have been deposited had the dense natural vegetation typical of Series A and B today then been present. According to C.R. Panabokke (1968:pers. comm.), evidence of the prevalence of a predominantly dry climate when the basal gravels of the RBE Fm were being deposited is to be found in the weathering characteristics of the under-surfaces of the gravel and cobble particles. The unsorted texture and variable angularity of these gravels (S.Deraniyagala 1972:57) are also suggestive of intense erosion due to exceptionally dry seasonal conditions (Addendum I).

As mentioned above, the basal gravels of the RBE Fm can be correlated with warm climatic episodes. The artefactual contents of the gravels at Site 43a, specifically Balangoda Points, suggest a date correlative with Site 49 III and Batadomba 7b at 28,000-22,000 BP – which in turn is suggestive of the Paudorf interstadial being represented in these deposits.

That the primary depositional factor with regard to the basal gravels of the RBE Fm is climatic can be established unequivocally by the exact correlation between Lanka's lowland Dry Zone (ecozones A and B) and the distribution of the gravels. Further corroboration of this hypothesis is available in the triple sub-division of the RBE Fm on the basis of the prominence of its basal gravels (de Alwis and Panabokke 1972:19-21). It is noteworthy that there appears to be a correlation, in direct proportion, between the relative conspicuousness of the gravels, the most prominent being in ecozone A, and the aridity of the region. For instance, the conspicuous basal gravels in the region of Site 43 (Embilipitiya) can be accounted for by the desiccating Southwest Monsoonal *Foehn* winds which reach the area having traversed the Kakwana massif to the west (v. Domrös 1972:160). This substantiates the view that the main factor responsible for the genesis of these gravels is climatic. A secondary factor could be the relative durability, in the face of chemical weathering, of the rocks constituting the gravels: the quartz-rich rocks would survive better as gravels or stone-lines than feldspathic or ferro-magnesian silicate-rich rocks.

It has been established beyond reasonable doubt that the sandy clay loams of the I Fm, which overlie the basal gravels, represent weathered shore *cum* shoreline dune sands and that they are not continental aeoleanites (Chap.3.3.3, also v. Gardner 1981*a*). This would mean that, despite the increased wind activity postulated for the altithermals, there was adequate vegetation to check the movement of the coastal dunes inland – even though the lowering of the water-table due to fluviatile entrenchment accompanying glacio-eustatic lowering of sea level might have altered the vegetational configuration of the coast (v. Flint 1971:249). On the other hand, the thermoluminescence dating evidence at Site 50 (Chap.3.3.4) does indicate that shoreline dunes were being blown up to considerable elevations above mean sea level. This process can be observed today on the Jaffna peninsula and at Kalmunai, where coastal dunes are accumulating at over 30m +msl. The increased atmospheric circulation during the altithermals probably resulted in dunes being blown onto higher elevations relative to the sea level than is the case today. The high-level Latosols on Kudiramalai, Arnakallu and Minihagal-kanda are probably largely due to this factor – other influences could have arisen from higher sea levels than that prevailing today and, perhaps, post-depositional tectonic uplift. The currently forming dunes are not being blown onto the Latosols at these locations.

As for the direction of the effective winds responsible for the formation of the coastal dunes represented in the I Fm, Katz and Comaner (1975:100) refer to certain fossil dunes near Pilinnawa in Yala, which show a northeast-southwest alignment on aerial photographs. Since the dunes forming today in this area, as in the rest of the island (Cooray 1967:165; Katz 1975:86), have a similar alignment, namely, linear or parabolic dunes parallel to the effective winds of the Southwest Monsoon, it is possible to postulate that the effective winds relating to the fossil dunes were also of the Southwest Monsoon. It remains to be established whether the so-called fossil dunes at Pilinnawa refer in fact to the I Fm's sands. If so, as appears to be the case, one could infer that the effective winds relating to the coastal dunes represented in the I Fm were S.W. Monsoonal. Frontal dunes, normal to the effective wind direction (Zenkovich 1974:Fig.6), have not been observed in Lanka. It would be productive to assay the reconstruction of effective wind direction by evaluating the orientation of the I Fm's dune forms and by the directions of dip of the steep foreset laminae (v. Flint 1971:246). Similarly, it is necessary to make wind speed studies on the aeoleanites in the I Fm on the basis of the procedure suggested by Butzer (1975:44). Particle size analyses of individual Latosol profiles (de Alwis 1971:57-8; App.III) do not indicate strong fluctuations in effective wind velocity. In this connection the distinction between effective and prevailing winds should be borne in mind (v. Butzer 1971:196-7). As for the basal gravels of the I Fm, if it should be established that the elongate ridges found particularly in the south, as at Site 47, are remnants of ancient berms, it will be possible to affirm that these were formed when the winds were considerably stronger than those prevailing today – thus corroborating the hypothesis concerning increased wind activity during the altithermals as represented in the I Fm's basal gravels. Berms comprising large gravels and cobbles, as are found in the I Fm's basal gravels, are not forming today along any of Lanka's coasts. Considerably greater wind strength (since wave fetch would have been constant throughout the Quaternary) would have been required to throw up these gravels as storm ridges.

The aeolean component of the I Fm's sandy clay loams could tend to increase in relation to the shore component in direct proportion to the chronological proximity to the altithermals – on the basis of the hypothesis that wind activity would have increased with temperature. This proposition does not affect the fundamental hypothesis that the sands of the Latosols were deposited during the initial phases of glacio-eustatic regression (Chap.3.3.3). Hence, an evaluation of the relative proportions of the shore/dune components in various Latosol localities could be informative as regards the sequences of climatic change associated with the sands of the I Fm. The mineralogical variation observed by de Alwis in the Latosol series studied by him is not, apparently, due to any climatic factors but due to the three series representing parent materials derived from different primary sources in the biotite gneisses, granites and schists of the Vijayan Series (de Alwis 1971:12-4).

The map of the continental shelf around Lanka (Malpas 1926) indicates that it is very extensive in the northwest, as opposed to the south and the east. Hence, one could expect fine and very fine sands to be blown inland from the exposed north-western shelf (with its shallow gradient) during marine regressions, to form continental dunes in the hinterland. This, according to available evidence, has not happened. The most likely explanation for this is that the pattern of annual rainfall ensured a vegetation cover that sufficed to check dune movement. In western India an annual rainfall in excess of 200-275mm is said to stabilise dunes, and in West Africa the threshold is at ca. 150mm (Goudie et al. 1973:245). It can, hence, be affirmed that the region with the I Fm, namely ecozone A, did not have an annual rainfall of less than ca. 200mm when the I Fm's sands were being deposited at the onset of the glacio-eustatic regressions when the continental shelf in the northwest would have been exposed to deflation by strong altithermal winds. Data on temperature changes in the sea should become available through oxygen isotope analyses on molluscs associated with the Indian *teris*.

I have already outlined the climatic regime that is likely to have prevailed when the basal gravels of the I Fm were being deposited. Since the gravels and the I Fm's sands are both altithermal deposits (Chap.3.3.3), the climatic conditions postulated for the basal gravels can be considered to apply, in large measure, to the I Fm's sands as well. It is noteworthy that while shore and coastline dune sand deposition is likely to have continued throughout the glacial episodes, since these sediments are not affected to any significant extent by shifts in the climatic regime, examination of submarine cores would be required to assess the extent to which the deposition of the basal gravels continued into the cool conditions associated with the progressive glacio-eustatic drop in sea level. On the other hand, such cores are likely to yield negative evidence, since transgressive seas would probably have scoured away the gravels. This leads to the point that the fine delineation of climatic conditions relating to the two members of the I Fm cannot be effected without embarking on detailed geomorphological studies – which would seldom result in unequivocal interpretations. Such an investigation is beyond the scope of the present research design – which merely seeks to sketch the broad outlines – to be refuted or amplified by future research.

The sands of the I Fm have been considered by Wayland (1919:106) to represent an arid, desert-like environment. To support this hypothesis he cites the occurrence of ventifacts (*Dreikante*; Class XIX of Type List, App.II), namely wind-faceted stones, in the *vembus* (id. 1916:170). The slightly convex facets, usually numbering two or three, have been produced by wind-blown sand acting upon gneissic pebbles which lie exposed in the *vembus*. However, my observations indicate that these objects do not occur within the I Fm. They are found on the *vembu* gravels. In several instances, as at Site 14, I have noted the blasting action of the sand deriving from the Latosols forming facets on these stones. Hence, one may conclude that Wayland's *Dreikante* do not signify a desert-like depositional environment for the I Fm, but that they continue to be formed wherever suitable material is exposed on the *vembus* for attrition by currently moving sands – usually during the Southwest Monsoon. Ventifacts can be formed within a few decades, given strong winds, lots of sand and no protective vegetation, as is the case with the *vembus* (Butzer 1971:195). Sarma (1976:185), on the other hand, makes the error of confusing shoreline *teri* dunes of southeast India with continental dunes as found in Rajasthan, and thence concluding that the *teri* sands represent an arid climate. This view is, of course, not tenable, since there are no traces of continental dunes associated with the *teris*. The presence of a bone suspected of having belonged to the spotted deer *Axis axis* in the sandy clay loam of Site 50a III(5) (App.III) suggests that the average rainfall per annum was in excess of ca. 750mm during the deposition of the sediments, a conclusion based on the lower limit of this deer's habitat tolerance in India (v. Schaller 1967:40).

The above discussion indicates that exceptionally arid, desert-like conditions were not prevalent when the sands of the I Fm were being deposited. Wayland's view on this subject has therefore been modified. With regard to the post-depositional environment of the I Fm's sands, pedogenesis has resulted in the highly distinctive Red-Yellow Latosols (Chap.3.3.3). The depth of the weathering in these Latosols apparently implies an intensity of rainfall such as is found in ecozone A today (de Alwis 1971:138), although this depth is in large measure accounted for by the very high permeability of these sands.

The pattern of distribution of the I Fm's Latosols indicates that it is an exclusively Dry Zone soil. A soil category termed Latosols on Old Red and Yellow Sands occurs along the coastal stretch between Chilaw and Colombo (de Alwis and Panabokke 1971:Map). An excellent example of such a soil occurs on the raised sandy spit associated with the Beira lagoon at Galle Face in Colombo (v. Wadia 1941*a*:15), and a similar ridge intersects Turret Road in the vicinity of Green Path. Geomorphologically, the Latosols on Red and Yellow Sands have formed on shore *cum* coastal dune sediments, as is the case with the Red-Yellow Latosols of the I Fm. Hence, it can be postulated that the difference between these two soil categories is not due to the nature of their respective parent materials as to the different climates affecting these materials: this is attested to by the approximate coincidence on the west coast of the boundaries of the two soil categories mentioned above and the climatic line of demarcation between the Wet and Dry Zones – which, in the hinterland, happens to coincide with the boundary between the Dry Zone's Reddish Brown Earths and the Wet Zone's Podsolic soils.

The absence of gibbsite and goethite, and the scarcity of free aluminium oxide, in the Red-Yellow Latosols (Kalpage et al. 1965; de Alwis 1971:147) serve to indicate the type of climate that would have prevailed in ecozone A after the deposition of the sands of the I Fm (de Alwis 1971:137-9,147-9). These Latosols have indeed undergone advanced chemical weathering, as demonstrated by the near-absence of feldspars and ferro-magnesian silicates, the low silt/clay ratio, and the clay fraction dominated by iron oxides. However, the kaolinite has stabilised, as evidenced by the results of electron microscopy, and no further breakdown into gibbsite has been observed. Gibbsite formation in the tropics is only known to occur when the annual precipitation is in excess of ca. 1,200mm, when the silicate minerals are broken down into gibbsite due to concentration of soil solutions. In Hawaii, both gibbsite and goethite are said to be confined to the 2,000-6,000mm rainfall zone, with kaolinite typifying the 750-2,000mm range (Rajaguru 1973). In Lanka, the Wet Zone's Podsolic Laterite is characterised by iron in the form of goethite and free alumina as gibbsite (Sivarajasingham 1959; Herath 1971:58). Hence, it could be concluded that the mineralogy of the I Fm's Latosols indicate that post-depositional rainfall affecting the shore *cum* shore-dune sands has not, for any appreciable length of time, been in excess of the ca. 1,450mm of annual precipitation characterising the drier parts of ecozone A today. The absence of oxides of iron and aluminium segregated into zones or mottles in the horizons above the fluctuating water-table corroborates this hypothesis. (The mottling present in the lower horizons of the Latosol at Site 50a (App.III) can be attributed to groundwater fluctuation.) The Hawaiian evidence concerning kaolinite suggests that the rainfall in the Latosol zone of Lanka would have been in excess of ca. 750mm, although due allowance will have to be made for differences between parent materials, the Hawaiian rocks being basaltic. The Latosols on the Tinnevelly *teris* in South India are known from regions receiving ca. 600-800mm of rain per annum (Pate 1917:28; Spate and Learmonth 1972:728,780; Blasco and Thanikaimoni 1974:Map 1), although they might extend into the ca. 1,000mm range in the vicinity of Pondicherry (v. rainfall map in Subbarao 1958:13). Their absence in the latitudes of Madras and northwards is noteworthy. This lower rainfall boundary is in agreement with the conclusions based on the suspected presence of *Axis axis* suggesting rainfall in excess of ca. 750mm, and also the absence of continental dunes in the I Fm which indicates that annual precipitation did not drop below ca. 200mm (v. above). There is, however, a possibility of annual precipitation rates of ca. 200-650mm having prevailed during certain altithermal episodes when the *Foehn* wind currents with their drying effect would have reached their maxima in Lanka's Dry Zone.

There is a remarkable correspondence between the drier parts of climatic Sub-Zone 2, with an annual rainfall of 914mm to above 1,270mm and less than 1,625mm (rainfall figures for 1911-1960), and the distribution of the Red-Yellow Latosols (v. Wikkramatilleke 1963:20,Fig.12; Thambyahpillay 1965:38,41; de Mel 1971:232; Spate and Learmonth 1972:Fig.26.3; App.I.4.8). This strongly suggests that rainfall has been the primary determinant for the genesis of the highly distinctive Latosols. The bioclimatic atlas of Southeast Asia, based on the rhythm of temperature and rainfall during the course of the year (Meher-Homji 1963), shows clearly the regions in South India which are characterised by temperatures of over 15°C and a seven to eight month dry spell. These regions tally almost exactly with the distribution of the Latosols. Since temperature is almost a constant along the seaboard of the entirety of South India and Lanka (v. isotherms in Domrös 1972:Fig.41), it can definitely be surmised that, given the coastal sands, it is the rainfall pattern, as denoted by the number of dry months, that has been predominant in the formation of the Latosols. The atlas of xerothermic index of Meher-Homji (1963) produces a similar picture with regard to those areas in South India and Lanka with 150-200 dry days per annum (for the rainfall regime of the Indian *teri* region, as against the area further to the north towards Madras, v. Spate and Learmonth 1972:729). Even if there should have been a major increase in annual precipitation in the past in the Latosol region, this, considering the rainfall pattern in the Dry Zone and in the *teri* region, could only have been in the nature of intensified cyclonic storms of short duration, which would have resulted in stronger denudation but not necessarily in increased rates of pedogenesis which brings us back to Meher-Homji's (1963) concept of rhythms of temperature and precipitation.

As for mineralogical variability in the Latosols, de Alwis (1971:3,25,140) concludes that it is best explained by differences in the mineralogy of the parent materials, as opposed to the differential operation of post-depositional climatic factors; namely, there is no evidence to indicate that significantly differing climatic regimes have prevailed in the various parts of the range of Latosol distribution. It would be interesting to compare the postulated conditions for the genesis of Lanka's Latosols with those for the Red Earths of Australia, the Kaolinitic Red Latosols of Brazil, and perhaps the Magwe Sands on the Irrawaddy in Burma, which resemble Lanka's Red Latosols (v. de Terra et al. 1943:306-7,310,378; de Alwis 1971:152).

The pH values of the Reddish Brown Earth soils are said to indicate that they have sustained lesser intensities and/or shorter periods of leaching than the Latosols (de Alwis 1971:42). This relative pedological immaturity can be attributed to the permeability of the Reddish Brown Earths being much less than that of the Latosols and also to the frequent addition of fresh parent material through colluvial processes and earthworm activity. It should be borne in mind, after all, that the RBE Fm extends into ecozones B and C which are wetter than ecozone A with its Latosols, and that since this pattern of relative precipitation intensity is not likely to have been different in the past, the RBE Fm probably underwent more intense weathering than did the I Fm, except that fresh parent material kept being added to the former sediments. Note that the primary cause behind the distinction between Latosol and Reddish Brown Earth soil categories lies in the nature of their respective parent materials and not in the climatic regimes associated with them: in Vilpattu, for instance, the coastal sands have weathered into Latosols, whereas the hinterland (with an identical climatic regime) has Reddish Brown Earths on Vijayan gneisses and colluvia (Eisenberg and Lockhart 1972:6).

The discussion on the chronology of the I Fm (Chap.3.3.4) has indicated that many of the sands on which the Latosols have formed are likely to be of Pleistocene age – for instance, the Paudorf at Site 49 and Eem or early Würm at Site 50, or one of the late phases of one of the preceding altithermals when the sea commenced regressing with the onset of cold conditions. The absence of gibbsite in the Latosols can therefore be considered to imply that glacial episodes did not witness an increase in rainfall amounting to a total of over ca. 2,000mm per annum, by analogy with Hawaii and the rainfall totals of Lanka's Wet Zone. Since the climate of the Dry Zone is dominated by the *Foehn* effect of the Southwest Monsoonal winds, the above hypothesis concerning the climate of the Latosol region during glacial episodes would be of general applicability to the entirety of the Dry Zone.

With regard to the Wet Zone, intensified atmospheric circulation during interglacials and interstadials, as evinced by the basal gravels of the I Fm, probably meant more convectional rain during the Intermonsoonal months, a stronger Southwest Monsoon, and possibly more rain during the Northeast Monsoon as well, since somewhat ameliorated cyclonic storms do traverse the Wet Zone. As for the glacial episodes, the malacological evidence relating to the Würm upper pleniglacial at Batadomba-lena (Chap.4.3.2) does not suggest conditions that were significantly drier than those prevailing today.

The above discussion of the depositional environment and post-depositional weathering of the I Fm and RBE Fm can be summarised as indicating that the basal gravels of the two formations and the I Fm's sands represent interglacial or interstadial (altithermal) episodes. While it is not possible to estimate the temperatures prevailing during these phases, the annual rainfall in the drier parts of ecozone A appears to have averaged between 200mm (perhaps ca. 750mm at times) and less than 950mm. The climatic regime of the Dry Zone seems to have undergone longer periods of drought than are prevalent today, thereby depleting the vegetational cover and making the terrain more susceptible to sheet erosion from tropical cyclonic storms classically associated with the month of November. This weather phenomenon appears to be assignable to increased atmospheric circulation, accompanied by intensified *Foehn* effects in the Dry Zone, during the altithermals. This in turn would have meant increased precipitation – orographically determined Southwest Monsoonal, convectional and perhaps cyclonic – in the Wet Zone. The distribution of the I Fm's sandy clay loams does not indicate that the vegetational cover had been depleted sufficiently during the altithermals for the coastal dunes to have migrated inland. Perhaps palynological studies would show whether the vegetation series in the Dry Zone had been altered to accommodate more deciduous forms.

As for glacial episodes, the rainfall in the Dry Zone's ecozone A does not appear to have increased to over ca. 2,000mm per annum, nor had it dropped below ca. 200mm. Conversely, the Wet Zone was certainly not much drier than it is today, thus suggesting depressed atmospheric circulation during glacial episodes which probably merely served to mute the present rainfall configuration of the island. It is apparent that in any evaluation of Quaternary climatic conditions in Lanka the key role would be assumed by the dynamics of the Southwest Monsoon, which constitutes perhaps the most complex weather phenomenon in the world. Tropical cyclones assume second place in this respect, as being responsible for the bulk of the Dry Zone's annual precipitation. A brief survey of this subject will be afforded in Chapter 4.4, which, it is hoped, will serve to indicate to the unwary that Monsoonal weather constitutes a variable that may aptly be termed an unpredictable meteorological monster which, in any deductions concerning Quaternary climates, one must perforce take into account.

*4.2.4 Caves.* Ravanalla cave in ecozone E revealed a series of strata, the lower (unexcavated) ones being firmly cemented with calcium carbonate whereas the upper (excavated) layers were unconsolidated (Deraniyagala 1953*a*:127). However, the latter were observed to include bands, or micro-strata, which are consolidated with calcium carbonate. These bands, interspersed with unconsolidated layers, have been interpreted by the excavator as being representative of fluctuations in rainfall (ibid.). However, in the light of the excavations at Beli-lena and Batadomba-lena, these consolidated bands are much more likely to comprise shelly strata, where the molluscs had been eaten and the shells discarded next to (or into) the hearths, resulting in the shells being burnt into quick-lime, with subsequent transformation into slaked lime through hydration and thereafter into calcium carbonate by reaction with atmospheric carbon dioxide. Hence, pending further investigation, it is premature to interpret these consolidated versus unconsolidated micro-strata in Ravanalla in terms of climatic fluctuations coeval with the deposition of these beds.

The colluvial basal strata at Beli-lena and Batadomba-lena have been dated to >27,000 and ca. 28,500 $^{14}C$ BP respectively. Pedologically these strata comprise redeposited Red-Yellow Podsols of the modal variant. This soil category is typical of this area of ecozone D1 today. Hence, it can be hypothesised that during the upper pleniglacial of Würm the temperature and rainfall factors affecting pedogenesis at ca. 400m +msl in physiographic Sub-Zone 2 of the Wet Zone were not appreciably different from those prevailing today. Note, however, that, pending further taxonomic delineation, Red-Yellow Podsols of the modal variant have a wide range of distribution in the Wet Zone and that they exist under climates which are drier and several degrees cooler than is prevalent around Beli-lena and Batadomba-lena. They do not, on the other hand, occur in the lowland Dry Zone, and hence the prehistoric soils deposited within these two caves could be considered to represent present-day conditions in ecozones D1 and D2. There is also the possibility that these redeposited soils were already relicts and that they did not represent the depositional climate: climatic inferences stemming from these soils have therefore to be viewed with a certain degree of caution.

## 4.3 FAUNA AND FLORA

*4.3.1 Ratnapura Beds and Other Alluvia.* Plants (and snails) generally provide the most reliable data on climatic change; small vertebrates are less reliable and larger forms even less so (Hole and Heizer 1965:137). The Ratnapura Beds frequently yield fossilised and semi-fossilised wood as well as reeds, the latter at times forming entire horizons of their own. It is not at all unreasonable to term this flora the Ratnapura Flora on the same basis as the Ratnapura Fauna. Hence, my interpretation of the former can be considered to relate directly to the environment of the latter, a part of which at least has been demonstrated to be of early Upper Pleistocene age. The data on the Ratnapura Flora, though meagre, deserve to be scrutinised:

(*a*) *Provenance*: gem gravel at 18m -gl at Balahapuva, near Ratnapura (Chowdhury 1965:189-91).
*Identification*: seven specimens of *Lagerstroemia speciosa*
*Habitat*: banks of rivers in ecozone DI at less than 600m +msl (Trimen 1894:229; Worthington 1959:280).
*Remarks*: radiocarbon dated to 7,520±150 BP. Growth rings clearly visible, suggesting a climate with stronger seasonality than today, correlating with a Monsoon-African pluvial.

(*b*) *Provenance*: gem gravel at 22m -gl, Pelmadulla (Chowdhury 1965:189-91)
*Identification*: five specimens of *Mesua ferrea* or *Mesua thwaitesii*
*Habitat*: if *M. ferrea*, it occurs in both the Wet and Dry Zones, mostly in the former, at less than 1,200m +msl. If *M. thwaitesii*, it is restricted to the river and stream banks of

the wet lowlands (D1) (Worthington 1959:39,41).

*Remarks*: found in association with a rhinoceros fossil and radiocarbon dated to >47,000 BP. The growth rings are indistinct (Chowdhury 1965:189), suggesting a climate without strong seasonality, thus resembling that of today.

(*c*) ***Provenance***: **gem gravel at 6m -gl, Balahapuva (Deraniyagala 1960:3,5)**
***Identification*** **(by Chowdhury)** ***and habitat*** **(v. Trimen 1895:434-5; Lewis 1902:30, 43,50,127-9):**

i. Seeds of *Myristica iriya* (S. *iriya*); very common in ecozone D1 at <300m +msl, especially beside swamps.
ii. **Seeds of** ***Myristica laurifolia*** **(S.** ***malaboda*****); very common in ecozones D1 and D2 at 1,600-300m +msl, extending into lower elevations. Rare in the Dry Zone.**
iii. ***Doona zeylanica*** **(S.** ***dun*****); quite common in ecozones D1 and D2, mostly at 1,500-500m +msl. Absent in the Dry Zone.**
iv. Seeds of *Canarium zeylanicum* (S. *kekuna*); common in ecozone D1 at <500m +msl. Absent in the Dry Zone.
v. **Seeds of** ***Elaeocarpus subvillosus*** **(S.** ***gal-veralu*****); not common, but found in ecozone D1 and extending into D2 up to 1,300m +msl (also v. Trimen 1893:186). Fairly common in the region of Kuruwita.**

*Remarks*: see Chap. 3.2.3 for uranium assays on associated faunal remains. It is to be noted that the stratigraphy provided by Deraniyagala (1960:5) indicates a bed of leaf fragments and sand at 5m -gl. There is a slight possibility that these specimens of seeds originated in this horizon, although the published accounts do not suggest this. Considering that the above assemblage of plants does not point to an environment any different from that of ecozone D1 in the Ratnapura area today, it is interesting to observe that the fauna found in association comprised *Homopithecus, Hexaprotodon sinhaleyus, Rhinoceros kagavena, Elephas maximus, Cervus unicolor* and *Axis axis* (id. 1951:30-1). Assuming that the plant remains were contemporaneous with these forms, it signifies that these animals lived in a lowland tropical rain-forest environment. However, *Axis axis* today is not found in ecozone D; it is restricted to the lowland Dry Zone. While it is possible that the range of habitat for *Axis axis* might have extended into ecozone D1 at some time during the Pleistocene, and that it has since restricted itself to the Dry Zone, it can tentaively be hypothesised that the *Axis* fossil is not contemporaneous with the flora described above, and that the fossil suggests a climate which was more akin to that of the Dry Zone today – or else, it could be a misidentification of *Axis porcinus*.

(*d*) ***Provenance***: **gem gravel at Mativala-deniya, Pohorabava, Ellawala (id. 1958:60)**
***Identification***: **wood of** ***Caryota urens*** **(S.** ***kitul*****)**
***Habitat***: **ecozones D1 and D2; very common in the former. Very occasionally found in the Dry Zone, possibly due to cultivation.**

(*e*) ***Provenance***: **miscellaneous gem pits in the Ratnapura Beds (ibid.:30)**
***Identification***:

(i) *Alsophila zeylanica* (S. *pini-baru*)
(ii) *Bambusa vulgaris* (S. *bambu*)
(iii) *Ochlandra stridula* (S. *bata*)
(iv) *Onchiosperma fasciculata* (S. *katu-kitul*)
(v) *Coscinium fenestrum* (S. *veni-val*)
(vi) *Wrightia flavidorosea*

***Habitat***: **all of the above forms occur frequently in ecozone D1**

Four samples of pollen from four gem pits associated with the discovery of gaur and hippopotamus fossils in the vicinity of Manan-ela, Ellawala (id. 1963:6) have been analysed (Vishnu-Mittre and Roberts 1965:185-88). The provenances are clays within the sequence of bedding and these are as follows: sample 1 from pit A at ca. 2-4m -gl and 1m above the gem sand; sample 2 in pit B ca. 2m -gl and 2m above the gem sand; sample 3 from pit C ca. 2-3m -gl and 4m above the gem sand; sample 4 from pit D ca. 2.5-3m -gl and 4m above the gem sand (ibid.:186). It is clear that the samples come from horizons considerably higher than the fossiliferous gem sands; however, the possibility of their being of Pleistocene age cannot be discounted and any information we may derive from them can be significant.

A mere 250 pollen and spores were counted in each slide and the ensuing identifications (ibid.:187-8) did not attain the generic level, remaining at orders. Sample 1 reveals a Myrtaceae forest with considerable undergrowth, sample 2 indicates less Myrtaceae, while other forms dominate, and there is a marked reduction in the undergrowth and ground flora. Sample 3 once again shows Myrtaceae dominant, with poor undergrowth, but a fairly strong component of ground flora including the ferns *Polypodium* and *Pteris*. The grasses suggest an open forest. Sample 4 resembles sample 3, except that the undergrowth increases and the ground flora decreases; but *Polypodium* and *Pteris* show an increase.

Although Vishnu-Mittre and Roberts affirm that the pollen spectra suggest a rain-forest akin to that of ecozone D2 at above 1,300m, it is impossible to interpret them for the purpose of climatic inferences. All of the orders represented in the spectra occur in both Wet and Dry Zones, and at least generic identification is required before attempting to interpret in terms of climate. The only category which is restricted to the Wet Zone (D1,2,3) is the Ilicineae (Trimen 1893:264-5). However, although the samples are in a chronological vacuum relative to each other, the differences between them do suggest fluctuations in the components, as for instance in sample 3 when the forest displays an open configuration. As to the cause of these fluctuations, it would be futile to hypothesise: considering the stratigraphy, they could even represent human activity during the Holocene. On the other hand, if for some reason Vishnu-Mittre and Roberts are correct in their hypothesis that the spectra represent a vegetation at above 1,300m+msl today, and considering that the altitudinal lapse-rate for ecozone D is 0.65°C per 100m (App.I.4.3), the vegetation, if representative of the surroundings of the Ellavala region, would indicate a mean annual temperature of ≥8.45°C below that of the present. But this hypothesis is cluttered with too many "ifs" and scarcely deserves testing.

The dating and palynological analysis of some of the lowland marshes, as at Muturaja-wela, can be instructive concerning environmental fluctuations during the Holocene. The same is true of the peats on the Horton Plains in ecozone D3. Any such investigation, although very worthwhile, should, however, be conducted with an acute awareness of what Muller (1975:83-4) affirms:

> [Pollen analysis of peaty sediments is complicated by] the restricted dispersal of most of the pollen grains and spores produced by the peat swamp vegetation. . . . The result will not yield much information on the vegetation history outside the peat swamps and will reflect climatic history in so far as it has influenced the succession of peat swamp communities. Since peat accumulation in the lowland tropics only takes place under wet climatic conditions, a change in climate can only be towards less humid, either average or seasonal conditions, which will tend to decrease the probability of peat accumulation and lead to a hiatus.
>
> Far more likely to be present and difficult to separate from any climatic causes are edaphic changes caused by subsidence and marine transgression or elevation – increased drainage of the swamp surface.

The Ratnapura Fauna provides very few clues as to the existence of an environment different from that of ecozone D1. Apart from *Axis axis* and *Bubalus bubalis*, there is no reason to infer that the remaining forms suggest a climate and vegetation different from that of the present. *Elephas maximus* has an enormous tolerance for differing environments (Deraniyagala 1955) and is found in every one of Lanka's ecozones. *Hexaprotodon* was probably as adaptable as *Hippopotamus amphibius* which is known to ascend up to elevations where the temperature never exceeds 3°C (Flint 1971:743; also v. Clark 1970:32). *Hexaprotodon sinhaleyus* remains, however, have only been found in an area circumscribed by Getahetta and Ratnapura and they do not occur in the fossiliferous deposits of Pelmadulla, 18km east of Ratnapura (Deraniyagala 1958:134). Considering that, after *Elephas maximus*, *Hexaprotodon* remains are the most common among the Ratnapura Fauna (id. 1944:44), a suitable explanation for the phenomenon of their restricted distribution has yet to be offered. One hypothesis (id. 1965*b*:291) is that a lake, ca. 30km long and 12km wide, would have existed between Getahetta and Ratnapura, thus ensuring a concentration of hippopotami. The find-spots, when plotted, do give such an impression. But then, the gem gravels in which the fossils have been found do not indicate sedentary water and Deraniyagala's hypothesis cannot be maintained. However, there is a strong possibility that swamps potentially favoured by *Hexaprotodon* did exist, as they still do around Kuruwita (id. 1936:Fig.3; 1943:99; 1963:Fig.1), and reeds as found in the upper silt and clay members of the Ratnapura Beds (id. 1940*a*:358) would have been ideal habitat for this animal. Thalasso-static swamps of the Ratnapura District might have been much more extensive than they are today during phases of high sea level during the Holstein and Eem interglacials.

*Rhinoceros unicornis*, possibly synonymous with *R. sinhaleyus*, occurs today in the Assam Plain and Nepal and was previously common in grassy jungle and swampy ground throughout the peninsula of India (Clutton-Brock 1965:10). Hence, it is safe to assume that it would have been at home in all of Lanka's ecozones. The same appears to apply to *R. kagavena*, since its supposed correlate, *R. sondaicus*, inhabits a wide range of environments in Burma, the Malay Peninsula, Sumatra, Java and Borneo (ibid.). The Asiatic rhinoceri are adapted to both open parkland and forest (Butzer 1971:147).

The Ratnapura Fauna has none of the open parkland forms of the Narmada Fauna, such as antelope and horse (Deraniyagala 1940*a*:352; 1955*d*:223), which probably indicates that even during the driest phases (?during glaciations when a land bridge existed between India and Lanka enabling the passage of animals) the vegetation of ecozone D1 was equatorial rain-forest and never open parkland.

It has been noted above that *Axis axis* remains were found with *Homopithecus* and others at Balahapuva. It has also been found in a gem pit at 8m -gl at Rilhena, Pelmadulla (id. 1957*b*:E16) and at 3m -gl in a gem pit at Valikumbura, Pahala Pohorabava (id. 1961*c*:301). *Axis axis* remains are much scarcer than those of *Cervus unicolor* (id. 1958:139), but it is a puzzle as to why they should occur in ecozone D1. The present distribution of *A. axis* is restricted to the lowland (< 500m +msl) Dry Zone, in ecozones F, A, B and C (Storey 1907), where its requirements of forage grass can be met, unlike in the rain-forests of ecozone D (v. Schaller 1967:39). Does the presence of *A. axis* remains in the Ratnapura Beds suggest one or more phases when the climate was drier than it is today, probably resembling that of ecozone C, with a weak Southwest Monsoon? Although some caution is necessary as regards the tendency for certain animals to alter their tolerances to climatic conditions – for instance, *A. axis* in India has a somewhat different range of habitat (up to 1,200m) compared to its Lankan counterpart (ibid:39) – this hypothesis concerning *A. axis* and the decrease of the Southwest Monsoon in Lanka during the Pleistocene is well worth testing. It is also probable that the hog-deer *Axis porcinus* has been misidentified as *A. axis*. The former occurs today as a relict in the coastal swamps of the Kalu river where it is (?mistakenly) considered to have been naturalised.

Another Dry Zone animal, with a present distribution akin to that of *A. axis*, among the Ratnapura Fauna is the water buffalo ***Bubalus bubalis***. A part of a mandible has been found in a gem pit at Kuruwita (Deraniyagala 1958:146). No stratigraphic data are given and there is some probability that this specimen belonged to a domesticated animal used for ploughing the paddy fields in which the gem mines occur. However, it is implied that the mandible is fossilised; which, in the context of the Ratnapura Beds, could mean a considerable antiquity. Should this *Bubalus bubalis* indeed be a Pleistocene form, the reasoning concerning *Axis axis* applies in like manner: possible evidence of a drier climate. The fossil ***B. bubalis*** atlas vertebra from Deniya-kumbura, Panamure, from a gem sand at 5m -gl (ibid.) is not unexpected, since Panamure is situated within the lowland Dry Zone and wild buffaloes are still to be found in the area. Should it be established that the water buffalo is indeed a Pleistocene form in Lanka, Eisenberg and McKay's (1970:90) view that it has been introduced to the island in historical times will have to be revised. Note, however, that although wild water buffaloes are not found south of the Godavari river in India (Deraniyagala 1953*c*:103), its remains have been found with Stone Age deposits at Alu-galge Telulla (id 1955*a*:300), and also in the Upper Palaeolithic (?Upper Pleistocene) horizons of Muchchatla Chintamanu Gavi of Kurnool District (Andhra Pradesh) in southern India (Sankalia 1974:217), the Mesolithic levels of Adamgarh (Madhya Pradesh) and at Bagor (Rajasthan) (Thomas 1975:326; Misra 1976:45).

There is nothing to make one think that the lion, *Leo leo*, would not have found equatorial rain-forest, as in ecozone D1, an uncongenial habitat. Lions do occur in the rain-forests of Africa. In fact there is a tradition that they inhabited the Sinharaja rain-forest in ecozones D1 and D2 near Ratnapura (Gunn 1873; Deraniyagala 1944:27). As for the dhole (red dog) *Cuon javanicus*, it has a very wide range of distribution from southern Siberia to India, the Malay Peninsula and Java, and it is worthless as a climatic index.

The gaur, *Bibos gaurus*, is said to have lived in the rain-forests of Adam's Peak (ecozones D1-3) until as late as the early nineteenth century (d'Oyly 1810-15:97; Forbes 1841; Tennent 1859). It is also said to have lived in the Dry Zone's ecozone B around Siyambalanduva (Spittel 1924:112). While it is essentially a grazer inhabiting forested montane (600-2,000m) regions, the gaur is known to have lived in recent times in the dry lowlands of Tinnevelly District, South India, which correlates with ecozone A of Lanka (Pate 1917:335; Simoons and Simoons 1968:16-20). Hence, the gaur too is useless as a climatic indicator. The same applies to *Cervus unicolor* (its dentition and long bones are difficult to distinguish from those of the nilgai (Clutton-Brock 1965:21)) which is still fairly common throughout ecozone D; and the conclusion is that the lion, gaur and sambhur do not suggest a climate necessarily different from that of the present during the Pleistocene in the Ratnapura area.

*4.3.2 Caves and Bellan-bandi Palassa.* The recent excavations in the caves of Beli-lena Kitulgala and Batadomba-lena have yielded important results. The lower to middle horizons of the strata in Beli-lena have ten radiocarbon dates ranging from >27,000 to 10,500 BP, forming a very consistent series (Addendum I). Batadomba-lena comprises seven major strata, of which, strata (7) to (4) have ten radiocarbon dates of ca. 28,500 to 12,000 BP. These strata, at both sites, have yielded large quantities of contemporaneous remains of land and aquatic mollusca.

Among the molluscs at Beli-lena were numerous specimens of the arboreal forms *Acavus prosperus* and *Acavus roseolabiatus*. The former is today restricted to ecozones D1 and D2; but it is the latter that is very significant. *A. roseolabiatus* has a very limited distribution in Lanka today: its range encompasses a radius of a mere ca. 20km about Beli-lena. Undoubtedly this has been conditioned by micro-environmental factors peculiar to this area. That *A. roseolabiatus* was found in an unbroken succession from ca. 12,500 to 10,500 BP at Beli-lena is very strong evidence that the climate at this locality during this period was very similar indeed to that of today (for distribution of Lanka's land mollusca v. Ratnapala and S.Deraniyagala under prep.). Considering the altitudinal lapse-rate of 0.65°C per 100m of elevation for the Wet Zone (App.I.4.3), and the known distribution of *A. roseolabiatus* today, two hypotheses emerge: (*a*) if the shells represent harvesting by prehistoric man in the immediate vicinity of the cave at ca. 400m +msl, the temperature during 13,000-11,200 cal BP could not have dropped by over 1.3°C below that of the present, since anything in excess of this would have been too cold for this species; (*b*) if, however, the molluscs had been harvested in the Kelani river valley ca. 10km away at ca. 300m below the elevation of the cave, then the temperature drop during 13,000-11,200 cal BP could not have been more than ca. 3°C. In view of the great abundance of molluscan remains in the cave, the former hypothesis is probably the more tenable of the two.

As for Batadomba-lena, its strata dating from ca. 28,500 to 12,000 $^{14}$C BP have yielded numerous specimens of, once again, *A. prosperus* and of *A. phoenix*, which are the same as the species occurring in the vicinity of the cave today and which are restricted in their distribution to ecozones D1 and D2 (*A. prosperus*) and D1 (*A. phoenix*) respectively. Hence, the snail fauna at Batadomba-lena too does not register any major shift in climate during Würm, even at its peak at ca. 16,000 BP. The average temperature in ecozone D2 is ca. 6°C lower than it is in D1. The presence of *A. phoenix* at Batadomba-lena during 28,500-11,500 $^{14}$C BP signifies that the temperature during this period (omitting any stratigraphic hiatuses that might exist at the site) did not drop in excess of ca. 6°C, despite the contemporaneity of the upper pleniglacial of Würm in northern latitudes. This hypothesis gives allowance for the harvesting of the molluscs from the valleys situated some 300m below the elevation of the cave which is located at ca. 400m +msl. These valleys occur within a radius of 10km of the site.

*Acavus* has been found in numerous Stone Age cave habitations in ecozone D1, denoting the prevalence of climatic conditions similar to those of the present. Notable instances are Alu-lena Attanagoda at ca. 10,400 cal BP, Kabara-galge (Deraniyagala 1955*a*:300), Beli-galge Bambarabotuva (id. 1943:110; Hartley 1911:198) and Beli-lena Athula at ca. 8,000 BP (Gunaratne 1971). This is entirely in agreement with the distribution of the various *Acavus* species in the Wet Zone. However, the following occurrences in cultural deposits are anomalous:

(*a*) *A. prosperus* (n=2) and *A. roseolabiatus* (n=1) in the Mesolithic deposit at Bellan-bandi Palassa (Deraniyagala 1957*a*:12; 1963*a*:88; identified by R.Ratnapala 1982:pers. comm.). This site is situated in ecozone B. It has been established that *Acavus* does not occur in this region today (id. 1958:71; hence, how does one explain its presence at Bellan-bandi Palassa at 6,500 ± 700 TL BP (v.Chap.3.4.1)? The answer appears to lie with *A. roseolabiatus*. As has been noted earlier, this form occurs today in a very restricted area around Kitulgala. Its presence at Bellan-bandi Palassa can, therefore, best be ascribed to its having been transported there by a human agency – perhaps as an item of trade or as an ornament. It is noteworthy that the rest of the faunal assemblage from this stratum is identical with the typically Dry Zone fauna of the region today, characteristic being *Axis axis*, *Melursus ursinus*, *Testudo elegans* and *?Bubalus bubalis* (id. 1957*a*:12; 1958*a*:228-31; 1963*a*:88). These do not suggest a climate any different from that of today, as none of these, unlike *Acavus*, are Wet Zone forms.

(*b*) Remains of *A. waltonii* were found in the Stone Age levels of Udupiyan-galge, not far from Bellan-bandi Palassa, in ecozone B (id. 1940*a*:366). In association, once again, were typical Dry Zone forms such as *Testudo elegans*.

(*c*) Two species of *Acavus* were found in the Stone Age horizon at Bambaragala shelter, near Udupiyan-galge, in ecozone B (id.1943:102).

(*d*) A species of *Acavus* was noted in the Stone Age horizon of Alu-galge shelter, near Telulla, in ecozone B. *Bubalus bubalis* and *Testudo elegans*, Dry Zone forms, were found in association (id. 1955*a*:300).

(*e*) The Stone Age level of Stripura-galge subterranean cavern, near Arukwatte in ecozone C, yielded a species of *Acavus* (id. 1956*a*:118). *Axis axis* was found in association.

(*f*) Nilgala cave yielded large quantities of remains of *A. phoenix* from its Mesolithic levels (Sarasin and Sarasin 1908:83,Pl.9). The excavators observed that few of the shells had been broken and that many displayed artificial perforation through the body-whorl. Associated with *Acavus* were *Melursus ursinus* and *Axis axis* (ibid.:78,Pl.8).

(*g*) My test excavation in Cave 18 of Sigiriya in ecozone B yielded an *Acavus* species in layer (5) at ca. 2.5m -gl. Pottery of the Middle Historic period was found in association (S.Deraniyagala and Kennedy 1972:43).

(*h*) Two specimens of a relatively small species of *Acavus*, similar to *A. superbus*, were found by me associated with a Yellow Latosol near Arnakallu in the northwest and Bundala in the south. These localities fall within ecozone A.

The above data suggest that *Acavus* was brought into ecozones A, B and C by Stone Age man, perhaps as an ornament or as an item of exchange. The factor which militates against the view that they represent a shift in climate in the Dry Zone into conditions resembling those of the Wet Zone is that the fauna associated with the *Acavus* specimens, where such data exist, are typically Dry Zone forms such as *Axis axis*, *Melursus ursinus* and *Testudo elegans*. Besides, it is inconceivable that *Acavus* should have ecozone A as its natural habitat, considering the very dry conditions.

The different species of *Acavus* have been observed to have select area preferences in the Wet Zone, as in the case of *A. roseolabiatus* and *A. superbus* (Ratnapala and S.Deraniyagala under prep.). It would therefore be informative to compare *Acavus* specimens found in the various prehistoric deposits with the distribution of their living counterparts. There is some possibility that such a study will reveal the patterns of human communication between the Wet and Dry Zones in prehistoric times and, as far as the Wet Zone is concerned, any shifts in micro-climate that might have occurred during the Quaternary. In conclusion, it is known that evolutionary changes in non-marine mollusca have been negligible (sub-specific at the most) during the Quaternary (Sparks 1969:397; Evans 1972:132). Considering the apparent sensitivity of *Acavus*, particularly *A. roseolabiatus*, to any changes in micro-environment, as suggested by the highly circumscribed distribution of certain species within ecozone D1, this mollusc constitutes an excellent index by which past climatic fluctuations could be assessed – although it is well to bear in mind that "the absence or low level of suitability of a particular [environmental] factor may be compensated for by other factors if the value of these is optimum or above with respect to the species concerned. At the same time, competition which might otherwise exist under more severe conditions, is, in very favourable habitats, relaxed, allowing several species which may be very close in their habitat requirements for food and shelter, to co-exist" (Evans 1972:110). The malacological data from Beli-lena and Batadomba-lena do, however, suggest that the temperature in Lanka had not dropped by more than 6°C between 28,500 and 13,000 cal BP and not in excess of 3°C between 13,000 and 11,200 cal BP. The conspicuous presence of the wild breadfruit *Artocarpus nobilis* from the lowermost stratum upwards at Beli-lena corroborates the former hypothesis, since this tree has an upper elevation limit of ca. 700m +msl, and a temperature depression in excess of ca. 6°C would have resulted in its eradication from the Kitulgala area. The occurrence of

*Canarium zeylanicum* throughout the sequence at Batadomba-lena (28,500-11,500 BP) further corroborates this view.

The excavation at Beli-lena included the retrieval of rodent and insectivore remains, as well as those of micro-molluscs through flotation sampling. There is a strong likelihood that the latter two categories will supply valuable palaeo-environmental data: insectivores are known to be sensitive to micro-environmental change in the tropics. A study of the aquatic molluscs found in the prehistoric deposits of Batadomba-lena and Beli-lena, from the Würm upper pleniglacial onwards, is also likely to shed light on the hydrology of the region during this period (for habitat data v. Hadl 1974; Starmühlner 1974). For instance, *Unio* and certain other aquatic molluscs found in the Mesolithic deposit at Udupiyan-galge were observed to be absent in the stream associated with the site today (Deraniyagala 1940*a*:367).

The Stone Age horizon at Kabara-galge cave, near Hangamuva in ecozone D1, has yielded parts of a sloth bear *Melursus ursinus* (id.1955*a*:300). This animal, as noted earlier, is only found in the Dry Zone today, despite the odd specimen which strays into the boundaries of the Wet Zone as exemplified by the animal shot in Mirigama in 1890 (id. 1965:196). It is possible that the remains at Kabara-galge accompanied a pelt or dried meat as a trade item from the Dry Zone into the Wet Zone in prehistoric times. The two alternative explanations are (*a*) that it was an animal which had strayed into the vicinity of Hangamuva – which is most unlikely since this locality is situated in the heart of ecozone D1, or (*b*) that it really does represent a climatic phase at Hangamuva which was akin to that of the Dry Zone today – which once again is unlikely in view of the malacological data from Batadomba-lena. Hence, the hypothesis that the remains were introduced by humans is the most tenable of the three alternatives.

The Mesolithic horizon at Beli-lena Athula (ca. 8,000 cal BP) in ecozone D1 has yielded large quantities of the edible nut *Canarium zeylanicum* (Gunaratne 1971:3). This tree is not found in the Dry Zone of Lanka, and hence it can be surmised that at ca. 8,000 BP the climate was not akin at this locality to that of today's Dry Zone, and that it was similar to that of the present. The occurrence of *Acavus* in the prehistoric deposit at this site corroborates the latter view. It is conceivable that the so-called nut-stones (lithic Type 111) were used for cracking nuts of *C. zeylanicum*. The absence of this lithic type in the prehistoric deposits of the Dry Zone, as opposed to those of the Wet Zone where it is common, could signify that this tree did not at any time, during the Stone Age of Lanka, grow in the Dry Zone, which in turn could mean that a Wet Zone type of rain-forest never existed during this period in what is today the Dry Zone.

The excavations into the protohistoric levels of Anuradhapura, Stratum IIIa, produced the remnants of a large log of *Schleichera oleosa* (S. *kon*) which is typical of this region today (ecozone B) (v. Worthington 1959:140). This deposit has been dated to ca. 2,800 $^{14}$C cal BP (Addendum II). The climate during this period, hence, would have been similar to that of today, as is corroborated by the faunal remains from this stratum, which included typical Dry Zone forms such as *Axis axis* and *Bubalus bubalis* (Deraniyagala in ibid.:155). Stratum IVa dated to ca. 2,250-2,000 BP had a similar faunal component.

The Knuckles Range of mountains in central Lanka (App.I.3) is said to comprise many of the ecozones found on the island within a very restricted area (de Rosayro 1958). Hence, any serious effort at evaluating Lanka's prehistoric environments should concentrate on the numerous caves within this range of mountains, particularly at the ecotones where climatic shifts would best be registered.

*4.3.3 Discontinuous Distribution.* An overview of Lanka's faunal components could provide certain clues concerning prehistoric environmental conditions in southern India and Lanka. All terrestrial faunal migrations during the Quaternary into and from Lanka had (perforce, due to geographical considerations) their sole route via southern India. Eustatic oscillations would not have created links with any other land mass such as Southeast Asia.

Lanka has eighty-three species of mammals. These are, in varying degrees, akin to the mammalian fauna of India: "inhabitants of continental islands usually differ little from those of the continents with which the islands were connected in geologically recent times. Endemic species and even well-marked endemic races are relatively infrequent on continental islands" (Dobzhansky 1963:66). However, taxonomists have observed that the Dry Zone species in Lanka are nearly identical with their Indian counterparts, whereas the Wet Zone forms depict varying degrees of differentiation from those living in corresponding habitats in southern India (Phillips 1935:xvii). Within the Wet Zone itself, it is Sub-Zone D3 which displays this latter tendency most markedly. "There are a number of endemic species confined to . . . [Sub-Zone D3] and they represent the most conservative faunal elements least disturbed by recent invasion from south India" (Eisenberg and McKay 1970:69). These are most notably highland shrews and rodents, and then there are the purple-faced leaf monkey, the golden palm civet and two species of spiny mice having a slightly larger range of distribution (ibid.).

The avifauna of Lanka corroborates the picture presented by the mammals. Over forty species of birds are peculiar to the island (Wait 1920:286), and these are mostly to be found in the Wet Zone, whereas the Dry Zone forms are nearly identical with those of south-eastern India (id. 1914:4,23-4). The sequence as per Wait (ibid.) can be postulated as follows:

(*a*) One or more glacial phases saw a continuous distribution of certain species from the Himalayas to Lanka, via the Malabar coast. It is possible that these forms would have been forced to migrate south to a warmer climate in peninsular India and Lanka during glacial phases. There are about a dozen of these species surviving in Lanka and over half of them are birds of weak powers of flight which could not have reached Lanka had there not been at least a semi-complete land connection between the island and the mainland, presumably during one or more phases of low eustatic sea level.

(*b*) During the final Pleistocene, as the climate became warmer, the Himalayan birds in the Dry Zone of Lanka would have retreated northwards into cooler environments in India while others persisted as relicts in the highlands of Lanka – hence, a situation of discontinuous distribution.

(*c*) With the onset of present-day climatic conditions during the Holocene, a series of avifaunal invasions would have occurred. There are said to be at least two strata: the first comprises the lowland Dry Zone birds found distributed throughout ecozones A, B, and F, and the second, presumably subsequent, stratum is restricted to the north. The latter forms diminish southwards, despite identical environmental conditions. Note that the gecko *Lophopholis scabriceps* and the skink *Mabuya bibroni* are also restricted to the north (Deraniyagala 1940*a*:356).

The above is a highly simplified picture of what could have been a complex series of interlocking events with variables such as differential adaptation by the same species in different localities playing significant roles in determining the final configuration of its distribution. However, this set of hypotheses does serve as a toe-hold for further research on the subject.

Among the relict forms constituting a discontinuous distribution between the cooler environments of Lanka and India are certain mountain stream fishes such as *Nemacheilus botia*, the freshwater lamellibranch *Pisidium vincentianum* and several varieties of ants such as *Acantholepis capensis lunaris* (ibid.:355-7; 1965:173). As with the birds and mammals, these too probably formed a continuous distribution with India during glacial phases. The hog-deer *Axis porcinus* which is found in the Indo-Gangetic plain (Clutton-Brock 1965:20) and in the swamps of south-western Lanka, but which is absent in peninsular India, is thought to have been introduced into Lanka in Late Historic times by the Dutch (id. 1965; Eisenberg and Lockhart 1972:37), although this seems not to have been the case (also v. Willey 1903:11). It is also significant that in specialised micro-habitats certain forms evolved sub-specific characters not represented in India, as in the case of the giant swamp elephant *E. maximus vilaliya* which is restricted to an area of ca. 50km by 30km in the swamps of the lower Mahaweli river in ecozone B (Deraniyagala 1955:104-5).

With regard to Lanka's flora, this once again corroborates the faunal evidence. There are very few endemic genera and species in the Dry Zone, contrary to the Wet Zone (Trimen 1893:xiii); and within the Wet Zone, it is Sub-Zone D3 which has the highest number of endemics: 186 genera at Nuwara-eliya in D3, as against 121 at Ratnapura in D1 and 29 at Anuradhapura in B (Sultanbawa 1969:90-1). (The same applies to the highlands of South India (Blasco and Thanikaimoni 1974:639); for further discussion on this topic v. Chap.4.5.1.)

There are certain animals which are found in Lanka and some other countries, but which do not occur in India (Willey 1903:6-8; Deraniyagala 1940*b*:9-10; 1947:3,9; 1952:1; 1953:1; 1965:172-3). For example, there are the fish genera *Channa* and *Belontia* (Lanka, Malayan area); the limbless skinks of the sub-family Acontianinae (Lanka, Madagascar, southern Africa); the arboreal lizard *Cophotis* (montane Lanka, Java, Sumatra); snakes of the genera *Sibynophis, Cylindrophis* and *Aspidura;* the bat *Leuconoe hasseletti*; and other forms. The environmental significance of these distribution patterns cannot be evaluated on present evidence. The absence of the flying lizard *Draco* (despite rumours that it does occur in the forests of Nilgala, ecozone C), the tiger and the king cobra *Dendraspis hannah* in Lanka, although they are found in southern India, can be attributed to their late arrival on the peninsula (id. 1940*a*:352,356; 1960*b*:56-9). The tiger was known to the Indus Civilation around 2,500 BC (Fairservis 1971:23), and hence the final land link between Lanka and India appears to have disappeared prior to this date.

The absence in Lanka of the four antelopes of peninsular India, namely, the nilgai, four-horned antelope, black buck and Indian gazelle (Willey 1903:2), could simply have been a result of the lack of open parkland environments in Lanka, particularly since antelopes (and horses) are known from the Narmada Fauna and there would have been numerous land links during the Middle and Upper Pleistocene which would have facilitated their crossing over had they been so inclined.

The discontinuous distribution of animals, and possibly of some of the plants, between the cooler environments of Lanka and India does provide clues as to the nature of temperatures during prehistoric times. As postulated above, periods of glaciation appear to have resulted in the continuous distribution of these forms between the two countries, to be disrupted by interglacials. Considering that the mean annual temperature in the highlands of Lanka (D3) is 10-15°C below that of the coastal lowlands, it is possible to affirm that the continuous distribution of plants and animals (found in ecozone D3 today) between Lanka and India during the Pleistocene could only have been possible if there had been a general lowering of temperature by 10-15°C. Two assumptions basic to this hypothesis are that the fauna and flora concerned have not changed their temperature requirements during the period under consideration (this being somewhat unlikely) and that the period referred to is indeed the Quaternary and not some earlier epoch (once again a not unreasonable assumption, although we cannot even estimate the rate of evolution of the forms concerned).

It has been noted that most of the endemic genera occur in ecozone D3. However, there are also the non-endemic genera in this ecozone, but which are discontinuously distributed between Lanka and India. This could be interpreted as representing one or more migration strata assignable to different glacial phases, or else certain forms have evolved more rapidly than the others. It is very likely that both factors were at play. Questions such as the reason why the genera endemic to Lanka did not populate India during cool phases when India and Lanka were linked cannot as yet be assayed due to the lack of data upon which any adequate hypotheses can be induced. However, as in the case of the mollusc *Acavus*, which is found only in the Wet Zone of Lanka, and not in India (ibid.:9), it is possible to hypothesise that this form did not populate India during the Pleistocene due to the absence of a congenial habitat bridging Lanka's Wet Zone and southern India, even during the coolest phases: "snails may not always occupy their full potential range not because of the absence of suitable habitats but because of their inability to reach them . . . barriers to dispersal between refuges of life" (Evans 1972:123). This hypothesis can be further expanded to suggest that the distribution of *Acavus* was primarily governed by the type of vegetation, which in turn (in Lanka) is principally determined by rainfall (App.I.6), and that despite the lowering of temperature during glacial phases, the rainfall was never high enough to support the type of vegetation found in the Wet Zone today. The conclusion is that during the Pleistocene Lanka's Dry Zone never had the equivalent of today's Wet Zone rainfall.

## 4.4 METEOROLOGY

*4.4.1 Introduction.* Appendix I outlines the biotic and abiotic environments of Lanka and it is very apparent that rainfall is the most important component of the island's environmental sub-system. It is also demonstrated that this rainfall is a function of various wind factors, namely the interaction between Southwest Monsoonal, cyclonic and convectional elements, modified by orography: climate depends more on prevailing winds and their air-masses than on any other single element, as stated by Kendrew (1961:21). The following account concerns the winds affecting Lanka's rainfall configuration.

*4.4.2 Southwest Monsoon.* The Southwest Monsoon (App.I.4.7) has been referred to as possibly "the largest local perturbation in the general circulation of the atmosphere" (Spate and Learmonth 1972:63 after Rao). The effective environment of Lanka, as it would relate with a hunting and gathering subsistence economy, is dominated by the S.W. Monsoon, with tropical cyclones taking second place. The rainfall configuration of the island, with the consequent zoning of soils, vegetation and fauna – best expressed in the Dry vs. Wet zonal dichotomy – is primarily a function of the S.W. Monsoon, particularly in its interaction with the central mountains. I need not elaborate on the symptoms of the S.W. Monsoon since these are described in Appendix I.4.7 (also v. Jayamaha 1954:277-9; Thambyahpillai 1955:8,14,27; 1963:30,37; 1965:17-21; Spate and Learmonth 1972:54-61; Domrös 1974:25) and Chapter 3.3 discusses its potential for far-reaching effects on Quaternary environments. However, apart from "describing" the S.W. Monsoon, tropical cyclones and convectional activity, it is necessary to assay the possibility of "explaining" their behaviour in terms of their inner structure and genesis. Should these elements be comprehended, it could become feasible to thereby deduce the nature of past climatic fluctuations, and an important tool would have been forged for assessing Quaternary environmental variation in Monsoon Asia.

Until the advent of upper atmosphere studies during the Second World War, the genesis of the S.W. Monsoon in Lanka and India was ascribed primarily to the northward migration of the thermal equator during the summer, with the difference in the heat coefficients of land and sea inaugurating the Monsoon circulation (v. Spate and Learmonth 1972:52,54,56). The contrasts between tropical continental and equatorial maritime air was thought to be very important in determining the Monsoonal climatic configuration of the Indian region. This traditional "thermal" concept has been stated thus (Thambyahpillai 1963:32-3):

> In conformity with traditional considerations, beginning with the vernal equinox (March), thermal intensity over the Indian sub-continent increases northwards; by April over eastern India and Burma, two clearly defined "heat centres" become established. Except for localised wind circulation, these two features do not involve the rest of the South Asian environment. Pressure conditions continue to be similar to those prevalent during early March, i.e. gradients are slight and winds are yet variable. By May, however, certain changes are beginning to be evident and it might be said that atmospheric conditions are "beginning to intensify"; the thermal and consequent pressure patterns tend to epitomise the ultimate picture. Isotherms are concentric about the 95°F thermal centre, which by now has moved from its easterly location to a central position (Nagpur-Jubbulpore region) and average temperatures over the sub-continent amount to 85°F and above. By June the process of intensification tends to culminate and by July the "heat centre" is strongly entrenched over the Thar desert. While these conditions were being established, the wind components have varied, ranging from a variable nature to southerly and south-westerly; the north-easterly winds of early March now are truly absent. Furthermore, while the atmospheric conditions over the Indian region tended to exhibit such variance, changes have also been taking place over the South Indian oceanic region. In consequence of the apparent migration of the sun, the thermal or meteorological equator also exemplifies a poleward migration from its mean position about 5°N.L. The wind systems in turn accompany this northward migration. The characteristic Doldrum Zone gradually decreases in intensity and by May-June this zone is assumed to be completely eliminated from the Indian region; the whole area extending from the sub-tropical high pressure belt (in the south Indian Ocean) to the Himalayan-Burma limits, is dominated by the persistent South-Westerly Monsoonal streamlines. The Southwest Trades... moving into the northern hemisphere, suffer deflection to the right and hence blow as south-westerly winds. It is claimed that the intensifying Thar "low" acts as a magnet to exercise a "pull" on the deflected S.E. Trades....The S.W. Monsoonal streamlines continue to prevail over this region until late September, when they begin to exhibit a "retreat" phase to be replaced eventually in October by variable and north-easterly winds.

World War II necessitated upper air studies, resulting in the "thermal" concept being relegated to second place by the "upper air and perturbation" school which maintains that while the Thar low is a factor to be considered, it is to be regarded as performing at most only a secondary role, and not any more the main role, in the onset of the S.W. Monsoon (ibid.:53). This new school of thought has served to explain several features of the Monsoon which could not be accounted for by the "thermal" school; but many aspects of the Monsoon continue to defy explanation despite recent advances in data retrieval: the earth's annual progression of wind systems, in which the S.W. Monsoon features prominently, "reflect upon the interacting, multivariate components of the atmosphere that build up repeatedly until reversed by a complex system of balances" (Butzer 1974:739), and meteorology is still a long way off from a "final" comprehension of the genesis of these systems. Meanwhile, the "upper air and perturbation" viewpoint can be summarised as follows. (For mean winter and summer circulation at 8km over the Indian region v. Thambyahpillai 1963:Fig.3. The annual course of winds over Lanka (1961-1965), up to an elevation of 18km+msl, is illustrated by Domrös (1974:Fig.46). The seasonal change in N.E. and S.W. Monsoons is expressed in the seasonal shifts of the wind directions up to 6-8km. Above this level, the upper air circulation is characterised by winds from an easterly direction throughout the year (ibid.:144).)

Three circumstances appear to be involved in the inception of the S.W. Monsoon over the Indian region (Thambyahpillai 1963:50): (*a*) an abrupt westward displacement of an upper air trough from ca. 90°E.L. in winter to ca. 75-80°E.L. in summer (ibid.:46), which results in upper air divergence over the lower troposphere convergence near the surface of the earth, leading to heavy precipitation in northern India (Spate and Learmonth 1972:56); (*b*) a rapid northward migration of the Upper Westerlies and of the westerly jet-stream from south of the Himalayas to a position north of the Tien Shan (ibid.). (Jet-streams are narrow bands of high winds at ca. 10km +msl in a cloudless sky and a means of equilibrium in the global circulation (ibid.:49); they are associated with the horizontal temperature gradients that accompany a front and with an increase of wind speed with height (Sawyer 1974:394).); (*c*) a northward displacement of the Inter-Tropical Front (for definition v. Chap.4.4.4) from ca. 10°N.L. in April to ca. 23°N.L. after late May. These three changes are effected rapidly and it is surmised (Thambyahpillai 1963:50) that the S.W. Monsoon is related to meteorological circumstances occurring as far north as the Siberian region. Thambyahpillai states (ibid.):

> The question, however, still remains whether the large-scale readjustments in the Siberian region are the cause or the result of the adjustments that have been noticed to take place in the Indian environs.... It may even be justified to consider whether the total atmosphere of the earth itself is involved. The latter consideration is warranted in view of the concept of the Circumpolar Vortex Circulation ... as providing the clue to climatic aberrations. If this new concept of the general circulation of the atmosphere be accepted ... climatic "singularities" like the S.W. Monsoon must surely be related to the total atmospheric activity.

Then, there is the easterly jet-stream, a relatively unstudied phenomenon associated with the S.W. Monsoon. It appears in the lower stratosphere above the upper troposphere Easterlies at about 15°N.L., and it is thought to be related to the intense heating of the air above the Tibetan plateau during summer. Periods of heavy rainfall over South India are considered to become more intense and widespread by "acceleration of the easterly jet-stream at about 15°N.L. up to its trajectory over South India (thereafter it decelerates), with upper vorticity of advection, therefore vertical ascent, expected around its right entrance and left exit sectors" (Spate and Learmonth 1972:59). The upper air S.W. Monsoonal sequential progression has been described as follows (Gentilli 1974:389-90):

> The change of the upper tropospheric circulation above northern India from westerly jet to easterly flow coincides with a reversal of the vertical temperature and pressure gradients between 600-300 millibars. On many occasions the easterly aloft assumes jet force. It anticipates by a few days the "burst", or onset, of the surface South-Westerly Monsoon some 1,500 kilometres (900 miles) further south, with a definite relationship, although the exact cause is not known.... During June the easterly jet becomes firmly established at 150 to 100 millibars. It reaches its greatest speed at its normal position to the south of the anticyclonic ridge, at about 15°N.L. from China through India [and it continues into the Sahara at this latitude (Spate and Learmonth 1972:63)].
>
> A stratospheric belt of very cold air, analogous to the one normally found above the Inter-Tropical Convergence near the equator, occurs above the anticyclone ridge, across southern Asia at 30°-40°N.L. and above the 6,000 metres (500 millibars) level. These upper air features that arise so far away from the equator are associated with the surface Monsoon and are absent when there is no Monsoonal flow.

> *The position of the easterly jet controls the location of Monsoonal rains* [my italics].... The surface flow, however, is a strong, south-westerly, humid, and unstable wind.... Various factors, and especially topography, combine to make up a complex regional pattern.
>
> In September dry, cool, northerly air begins to circle the west side of the [Himalayas] and speed over north-western India. The easterly jet weakens and the upper tropospheric Easterlies move much further south. Because the moist South-Westerlies at lower levels are much weaker and variable they are soon pushed back [i.e., the dying of the S.W. Monsoon. There is now a return of the Westerlies and the westerly jet-stream to their position south of the Himalayas, and by October the S.W. Monsoon is no more (Spate and Learmonth 1972:61; for the mean latitudinal position and zonal velocity of the westerly jet-stream in winter v. Thambyahpillai 1963:Fig.2)].

Breaks in the S.W. Monsoon over peninsular India are said to be related to westerly disturbances arriving in close succession over the Himalayas, where Westerlies continue to prevail even during the S.W. Monsoon (Spate and Learmonth 1972:59). These disturbances are thought to attract the Monsoon trough northwards into the Himalayas, which causes heavy precipitation in the northern plains but drought in the area to the south of the sub-montane tract (ibid.).

*4.4.3 Tropical Cyclones.* Tropical cyclones are only second in importance to the S.W. Monsoon with regard to the genesis of the climatic configuration of Lanka. These have been described in Appendix I.4.7 and their significance in relation to the annual rainfall of the Dry Zone is delineated in Chapter 4.2.3. It suffices to repeat here that the bulk of the annual precipitation in the Dry Zone is accounted for by these cyclones. As for the genesis of these weather phenomena, it is as yet shrouded in mystery (Thambyahpillai 1955:15; Sawyer 1974:394). They are, however, related to Pacific streamlines entering the Northeast Trades and to polar outbreaks from Siberian streamlines (App.I.4.7). It is known that during the northern winter the central region of the Asiatic land mass develops into an intense, stable centre of out-blowing winds. Although the Himalayas to the north of India and the mountains of Burma, Yunan and Indo-China to the east largely prevent the Siberian high pressure system from reaching India, wind currents from Central Asia do appear to penetrate this barrier through gaps in the Himalayan-Arakan and Yunan mountain wall and thus reach the environs of India eventually. Maps showing seasonal flow-patterns at ca. 8km +msl reveal that exchange of air between India and Central Asia does take place across the Himalayas (Thambyahpillai 1963:42). There is also the possibility of such streamlines flowing in from the Pacific along with the Pacific Trades (id. 1955:14; Spate and Learmonth 1972:50). Hence, as with the S.W. Monsoon, the tropical cyclones affecting Lanka are inextricably interwoven with global weather phenomena, and with the Asiatic anticyclone in particular.

*4.4.4 Inter-Tropical Convergence Zone.* The third weather phenomenon affecting Lanka comprises the convectional winds of the two Intermonsoons, which may be considered to constitute a factor that is less important than the S.W. Monsoon and tropical cyclones in relation to the overall rainfall pattern. These winds probably increase and decrease in intensity in direct proportion to the amount of solar radiation received, but they are smothered by Monsoonal and N.E. Trade streamlines except during the Doldrum conditions of the Intermonsoons. It is, however, during the Intermonsoons that the Inter-Tropical Front (ITF) of the Inter-Tropical Convergence Zone (ITCZ) crosses the island.

The ITCZ (also termed the Equatorial Convergence Zone) straddles the earth's thermal equator. It comprises a belt of converging Trade winds, which constitute the equatorial low pressure band termed the "Doldrums" with a mean width of over 1,500km in the Indian area (Thambyahpillai 1955:3.18; 1965:22). The ITCZ is flanked by the sub-tropical highs, and within it the Trades converge at the ITF (also termed the Equatorial Front, or, in the northern hemisphere, the Northern Convergence Zone). The latter crosses and recrosses the geographic equator during the course of the year, shifting seasonally with the thermal equator, and its position varying day by day (ibid.:9; Jayamaha 1954:277). The precise location of the ITF at any given time is modified by the distribution of land and sea. Where large land masses occur, as in southern Asia and Africa, the annual latitudinal range of the ITF can be considerable (40-45°), whereas over large expanses of ocean the range is very much less (Verstappen 1975:4). In southern Asia the winter position is at ca. 10-12° S.L., and it spurts northwards during the early summer.

The rising air at the ITF produces frequent thunderstorms and heavy rainfall (ibid.:397). Upper tropospheric (ca. 8-10km+msl) divergence of air currents induces the upward movement of moist air (in the case of South Asia) to altitudes where, due to expansion and the resultant cooling of air, condensation takes place producing precipitation (Spate and Learmonth 1972:49; Sawyer 1974:393). The annual course of the ITF in southern Asia has been described thus (Thambyahpillai 1963:34,Fig.1):

> [In April] the S.E. Trades are still confined to the southern Indian Ocean and continue to be "rooted" to the west Australian coast. The ITCZ persists south of the equator.... A profound change [then] takes place, in that the S.E. Trades are no more welded to the west Australian coast, and some part of the S.E. Trades has moved into the north [N. lat.] Indian Ocean, being strongly evident off the Somaliland coast of Africa. The [ITF] now appears "bifurcated" and a significant local south-westerly circulation occurs over Ceylon.... [The ITF is known to cross the island in April while on its northward migration (id. 1965:13).] In June, [July and August] the [ITF] appears to be eliminated.... In September [it reappears] and is bifurcated [once again, and it recrosses Lanka in October (ibid:22-3)]. When the [ITF] is over the island the weather deteriorates suddenly and disturbs the regular convectional sequence.

The mechanics of the movement of the ITCZ appear to be complex and, as with most large-scale weather phenomena, tied to global temperature exchanges. For instance, its shift into the summer hemisphere is not readily predictable (Hare 1974:872), and there are indications that the ITF spurts northwards to occupy the place vacated by the westerly jet-stream which would have shifted abruptly into its summer position north of the Himalayas (Thambyahpillai 1963:50).

*4.4.5 Conclusions.* The above scrutiny of the mechanics governing the behaviour of the three major weather phenomena affecting Lanka's climate, namely the Southwest Monsoon, tropical cyclones and the Inter-Tropical Front, has indicated that they owe their genesis and subsequent behaviour to patterns of thermal exchanges on a global scale. It has also been established that large-scale exchanges of winds do take place at upper levels between high and low latitudes and that these interrelations of air flow affect tropical weather profoundly (ibid.:41). However, despite recent advances in techniques for studying the upper troposphere and the stratosphere, the complexities of upper air circulation continue to baffle meteorologists and progress in this field is slow.

Meanwhile, investigations of the island's rainfall data for the Wet Zone (1870-1952) and the Dry Zone (1881-1960) have revealed, empirically, that the climate of Lanka has undergone a number of phase changes correlating apparently with sunspot cycles (id. 1958:93,106; 1958*a*; 1958*b*; 1965:34-5). These results have been corroborated by studies of river flow patterns (id. 1967:24). In general terms, a dry phase had prevailed up to 1876, wet from 1877 to 1902, dry from 1903 to 1922, wet from 1923 to 1943, and dry into the '60s. The residual mass curve, a cumulative deviation graph about the overall mean for the period under investigation (1877-1944) (v. id. 1965*a*:35), has shown progressive increases in precipitation of up to 50 per cent above the mean and decreases of down to 25 per cent below it on a periodicity of 20-26 years (ibid.:38). Note that these are cumulative deviations and that they do not signify a $\pm^{50}_{25}$ per cent deviation in annual rainfall, which tends to be ca. ±10-15 per cent for the phases in the Wet Zone (id. 1958:106). What is particularly significant is that rainfall fluctuations in the Wet and Dry Zones are in phase during these cycles, as is also the case with S.W. Monsoonal, cyclonic and convectional (including ITF) rains (v. moving averages curves for Dry Zone in id. 1967:Fig.3; id. 1958:96-7,106). This means that an increase or decrease in rainfall in the Wet Zone is accompanied by a corresponding increase or decrease in the Dry Zone, and that a positive or negative fluctuation in S.W. Monsoonal precipitation sees a corresponding increase or decrease in cyclonic and convectional (plus ITF) activity. As is to be expected, fluctuations of pressure (1870-1953) correlate with these rainfall fluctuations (id. 1960*a*:124).

The wet and dry phases mentioned above have been noted to correlate remarkably well with fluctuations in sunspot activity. In fact, this correlation applies to the entire tropical zone, for instance the Indo-Australian region (ibid.:123), and perhaps even to the mid-latitudes (id. 1962; 1965:2; 1967:24; Kraus 1955). There does indeed appear to be a real (but complex) relationship between sunspot activity, latitudinal heat exchange and the intensity and patterns of general circulation (Butzer 1975:739) as evinced in the weather phenomena over Lanka. This activity comprises cycles ranging from 16 to 32 years duration, but averaging 22.2 years, and they are related to fluctuations of ultra-violet, electro-magnetic and high energy particle radiation from the sun (ibid.). Pressure conditions tend to be accentuated during hemi-cycles of sunspot maxima, and vice versa for sunspot minima (Thambyahpillai 1960*a*:121). The relationship between sunspots and weather is best exemplified in the tropics (ibid.:114), and this is clearly borne out by the strengthening of the S.W. Monsoon with increased sunspot activity (Fairbridge 1976:532). (It is noteworthy that increases in sunspot activity create a decrease in temperature at the earth's surface, due probably to opacity being induced by increased haze which would impede the transmission of solar radiation to the surface (Thambyahpillai 1960*a*:120,123).)

As stated above, the association between sunspot cycles, pressure and rainfall in Lanka indicates that there is indeed a positive correlation between the quantity of incoming solar radiation and rainfall. The present day phenomenon can be extrapolated into the Pleistocene which is thought to have witnessed several oscillations in the amount of radiation received by the earth. Milankovitch (v. Zeuner 1959:173-274) has computed a series of curves depicting the relative amounts (expressed in canonic units) of solar radiation received at the upper limits of the earth's atmosphere during the Quaternary. These curves are based upon postulated periodicities of the earth's orbital geometry relative to the sun, with reference to (*a*) the angle of the ecliptic, (*b*) the precession of the equinoxes and (*c*) the eccentricity of the orbit. Despite controversy concerning the applicability of Milankovitch's curves to Quaternary climatology (Butzer 1971:38-41), comparison with the glacial/interglacial chronologies in the higher latitudes (e.g., at 65°N.L.) have apparently yielded a considerable degree of correlation between glacial episodes and phases of summer radiation minima on the one hand and interglacials and phases of summer radiation maxima on the other (Fairbridge 1976:532). The periodicities involved are considered to be around 41,000 years, with retardation estimated at ca. 5,000 years, although the occurrence of sudden changes lasting a few thousand years (as in the Upper Dryas cold spell) cannot be explained by the curves (Butzer 1974:740). On the basis of the correlation between sunspot phenomena and rainfall in Lanka, it can hence be hypothesised that the rainfall increased with phases of radiation maxima during the Pleistocene, which in turn correlate with interglacials, and that it decreased with phases of radiation minima which correlate with glacial episodes. This hypothesis is in agreement with Flohn's (1953) conclusion that interglacials in northern latitudes coincided with increased precipitation (pluvials) in the equatorial zone, the reverse being the case with glacial phases (v. Flint 1971:418-9). Geomorphic data supporting Flohn have been forthcoming in recent years, notably from Brazil, the Guianas and Venezuela, Nebraska and Kansas, the Sahara, the Nile, the Kalahari, Central Asia and north-western Australia, when compared with the well-established climatic sequences for the Upper Pleistocene and Holocene of north-western Europe and Alaska (Butzer 1971:531; 1974:735; Larsen 1972:55-6; Fairbridge 1974:1004-5; 1976:539-43). Reduced evaporation during glacial phases resulting in diminished cloud cover and winds in the tropics is thought to have produced 20-50 per cent less precipitation than is prevalent today (Joshi 1970:62; Butzer 1971:286; Ollier 1974:342; Fairbridge 1976:539). Quantitative estimates of Pleistocene Trade Wind strength, using deep sea cores off West Africa, showing that wind speeds were ca. 50 per cent greater than they are today (Shackleton 1975:14), probably refer to interglacial episodes. (Of course, it is clear that each glacial or interglacial had its own special characteristics and that some were more intense than others.) Considering the intimate genetic relationship between the Trades and the S.W. Monsoon, one could postulate that a 50 per cent increase in the former meant a corresponding, perhaps greater, increase in the latter; which in turn would have resulted in proportionately greater rainfall in the Wet Zone of Lanka and a more pronounced summer drought in the Dry Zone. It is significant that, together with tropical cyclones of the N.E. Monsoon, the S.W. Monsoon is much more sensitive to fluctuations in solar radiation than is the case with convectional currents (Thambyahpillai 1958:106). Since the S.W. Monsoon and the tropical cyclones constitute the island's predominant meteorological features, Pleistocene oscillations in solar radiation and the accompanying glacial/interglacial episodes could have had a major quantitative impact on Lanka's rainfall. Intermonsoonal convectional rains can be assumed to have been directly proportional to the amount of solar radiation received. The hypotheses inherent in the Milankovitch curves can usefully be tested in this respect and their verification would provide the palaeo-climatologist with an important chronological tool as well as a means of assessing the intensity of each climatic episode.

Apart from the generalisations set out above, it is impossible to conceptualise the global patterns of upper air circulation during the Quaternary which would have played such a significant role in the genesis and behaviour of the weather patterns over Lanka and the Indian sub-continent. It is known that the influence of the relative positioning of the oceans and continents is very pronounced in the case of South Asia – as opposed to Southeast Asia and northern Australia – and as such would have constituted a stable variable during the Quaternary. It is also known that in Europe and North America dune orientation indicates that the same planetary circulation, in general, prevailed at and after the Würm maximum, with only local and temporary differences and changes occurring at various points in space and time (Flint 1971:247). However, despite the apparent stability of the South Asian meteorological configuration, local and temporary differences could well have been on a sufficiently large scale as to alter the climate of the region drastically. For instance, it is possible to speculate that during glacial episodes the latitudinal shifts of the westerly (55-35° N.L.) and easterly jet-streams differed from the patterns prevailing today – in the manner that Flohn perceives the lower troposphere's tropical weather belts to have decreased in their amplitude (ibid.:418; Verstappen 1975:5). The Circumpolar Vortex Circulation could then have been depressed, in both hemispheres, towards the equator (v. Thambyahpillai 1963:41-2) during glacial episodes. A consequence of this could be that the westerly jet-stream did not move into its summer position north of the Himalayas, and that the S.W. Monsoon did not function as it does today: it might have been much less pronounced or failed entirely. That this is not idle speculation is apparent in that late heating over the Himalayas and the Tibetan plateau is said to be related to a delayed retreat of the westerlies over the sub-continent, resulting in a late onset of the S.W. Monsoon, and *vice versa* (Spate and Learmonth 1972:61). Similarly, a southward depression of the easterly jet-stream, which occurs over Kanya Kumari and Lanka during the S.W. Monsoon and which is important for the rainfall configuration of this area, could have resulted in a pattern of precipitation quite unlike that of the present. Besides, the failure of the westerly jet-stream to shift north of the Himalayas could have had repercussions on the northward movement of the ITF, although this may not have affected the impact of the latter in the equatorial latitudes in which Lanka is situated. (Note that in regions peripheral to the annual range of the ITF, its vagaries can cause up to 25 per cent deviation about the mean annual precipitation, as for instance in Southeast Asia (Verstappen 1975:6,10).) As for tropical cyclones, it is impossible to evaluate whether polar outbreaks from the intensified Asiatic anticyclone would have increased during glacial episodes. As indicated by Thambyahpillai (1958:106), they display strong incidence during phases of increased solar radiation; but then again they might also have intensified during glacial episodes, as suggested by Willett and Flohn (v. Sawyer 1974:393), with "massive latitudinal air mass exchange in the middle latitudes leading to frequent cold air outbreaks into lower latitudes" (Butzer 1971:394). Butzer (ibid.) discusses this complex subject, where oversimplification has to be avoided. He concludes that changes of circulation patterns "cannot conveniently be grouped into glacial and interglacial units. Instead, the dominant circulations accompanying glacial advances, glacial standstills and glacial retreats must each be considered as distinct".

## 4.5 INDIA

*4.5.1 Peninsula.* The Quaternary fluviatile stratigraphy of peninsular India has been outlined in Chapter 3.2.4. I have tentatively assigned a Holstein age to Aggradation I, and dated Aggradation II to the Eem, on the basis of faunistic, technological and glacio-eustatic correlations. Aggradation III, which is typically said to contain an Upper Palaeolithic blade and burin industry, can technologically be assigned to the Würm glaciation, possibly one of its earlier interstadials (v. below), while Aggradation IV with its Mesolithic artefacts appears to be late Würm interstadial or early Holocene in age. This scheme requires to be viewed with an awareness of the problem of the tectonic instability of parts of western and central India, which could have radically influenced the patterns of fluviatile sedimentation (v. Shrivastava 1968; Allchin and Hegde 1969; Vishnu-Mittre 1965:17,26; Joshi 1970:60; Sali 1970:217-14; Ahmad 1972:128,183,192; Rajaguru and Hegde 1972:74,77; Spate and Learmonth 1972:23,643,645; Agrawal and Kusumgar 1974:51; Agrawal 1975:4; Corvinus 1976:8). Climatologically, with reference to Gravel I on the central Narmada, Shkurkin (1976:7) affirms that the gravels "are in reality about 20m from the top of a 250-300m section of depositions. These gravels are not continuous but are the product of the interaction of river meanders with the bed-rock of the northern scarp of the valley, and therefore are products of normal fluid dynamics not related to climate". However, in the absence of an alternative, and pending the accumulation of data for its testing, it is expedient to retain the somewhat hypothetical four-fold aggradation scheme as representative of peninsular India's Quaternary chrono- and litho-stratigraphy leading up to climatological interpretation (for updated information v. Addendum IV).

A lateritic weathering phase is said to precede Aggradation I in certain instances, as on the central Narmada (de Terra and Paterson 1939:315-6). Since laterite is not known to form in Madhya Pradesh today, the pre-Gravel I laterite appears to suggest a wetter climatic regime than that prevailing today, possibly during the early Holstein or a previous altithermal. Note that laterites have been observed to underlie Gravel I at Vadamadurai (ibid.:328), and in Kurnool District, A.P., on the Tungabhadra (Sankalia 1974:57,174), which probably correlate with the laterite of the central Narmada. The presence of lateritised bed-rock beneath the aggradations in $T_1$, $T_2$ and $T_4$ at Poondi (Wainwright and Malik 1967) does indeed suggest that this is an altithermal phenomenon. The thin cover of laterite found in certain localities of the Chota Nagpur plateau of Bihar (Sankalia 1974:44) could also represent such a phase: laterites have been found associated with Acheulean assemblages, for instance, in Singhbhum and Monghyr Districts of Bihar and in Midnapore District of West Bengal (ibid.:46-7,51,178,180,223-4). However, the laterites of India (Ahmad 1972:178; Spate and Learmonth 1972:96,741) need to be studied intensively and classified according to modern pedological norms (akin, perhaps, to the methodology employed in Lanka) before it is possible to interpret them as to the conditions of their genesis. It is not even clear as to which of these are fossil soils as opposed to currently forming ones.

The Quaternary Aggradations I-IV of the peninsula (Mujumdar and Rajaguru 1970:102; Rajaguru and Hegde 1972:72) are said to display a progressive decrease in fluviatile activity, which can tentatively be considered to be a function of decreasing atmospheric circulation. Gravel I is frequently coarser than Gravel II, which in turn is coarser than Gravel III; for instance, at Hunsgi Nullah, Shorapur doab, Karnataka (Paddayya 1970:168-9) and on the central Narmada (de Terra and Paterson 1939:319). Gravels I and II, and possibly Gravel III as well, are thought to represent fluviatile activity which was much more pronounced than it is today – note that Holocene Aggradation IV is predominantly of aeolean facies. The boulders in Gravel I of the central Narmada at Maheshwar exceed by far the transport capacity of the present river (Sankalia 1974:118). The silts associated with Aggradations I and II are thought to be flood deposits indicative of pluvials, and Shkurkin (Kennedy and Possehl 1976:7) affirms that the clay analysis of Silts I and II on the central Narmada indicates a depositional environment akin to that of today, which could refer to the terminal phases of the two aggradational cycles.

As for the red clay upon which an Upper Palaeolithic is said to occur at Nandi-Kanama, Andhra Pradesh, and which is thought to represent a phase of strong subaerial weathering (Gordon 1958:22), this deposit cannot be assigned any particular age, since it can be anything antedating the lithic industry (?mid-Würm) which rests on it.

The Narmada Fauna associated with Aggradations I and II does not suggest climatic conditions which would have been appreciably different from those prevailing today. The presence of *Equus namadicus* indicates that the rainfall was not adequate to maintain a dense tropical vegetation; it is likely to have been relatively open. This suggests that the torrential fluviatile activity represented in, for instance, Gravel I would have been marked by strong seasonality with long droughts which were not conducive to the prevalence of tropical rain-forests. The molluscan fauna in Aggradation II on the central Narmada has been interpreted as representing conditions that were somewhat moister than those of today (de Terra and Paterson 1939:318); however, the basis of this deduction has not been defined adequately.

The Billa Surgam caves in Kurnool, Andhra Pradesh, are said to contain an Upper Palaeolithic industry (Murty 1975), which can typologically be assigned to Würm. The associated fauna, for instance, *Equus asinus*, *Gazella* and antelope (now extinct in this region, ?anthropogenically), in the Muchchatla Chintamanu Gavi cave does not suggest climatic conditions that were significantly different from those prevalent today. However, the occurrence of the langur *Presbytis entellus*, the sloth bear *Melursus ursinus*, and the chemical analysis of the associated sediments, are said to indicate conditions that were somewhat moister (ibid.:134-8), although this interpretation has yet to be established on secure grounds. This climatic episode could refer to one of the Würm interstadials, when conditions were warm and moist, and man had not yet caused the extinction of *Equus*, *Gazella* and antelope. On the other hand, remains of ostrich shell from an Upper Palaeolithic level at Patne, Maharashtra, dated to ca. 25,000 $^{14}$C BP (?shell; Joshi 1975:13), could refer to relatively arid conditions during the upper pleniglacial of Würm, which is in conformity with the evidence from several other tropical regions (Chap.4.6.5).

Environments that are marginal to arid or desert conditions, ecotones, are likely to have registered climatic shifts during the Quaternary with greater sensitivity than in regions falling well within clear-cut ecozones (v. Flint 1971:304). Northern Karnataka is one such environment, and I have already cited the case of Hunsgi Nullah. Perhaps, an even better index of climatic shifts than Karnataka would be Rajasthan, leading into Gujarat (Allchin and Goudie 1971:250), bordering that well-defined ecozone, the Thar desert. In this respect the differential rainfall patterns of India, in terms of probability as set out by Spate and Learmonth (1972:64-5), are instructive as to which areas are sensitive to climatic fluctuations. The region relating to the southern boundary of the Thar, namely in Rajasthan and Gujarat, has a climate dominated by the S.W. Monsoon, and as such this region can serve as an index, in relative terms, to the climatic shifts experienced by peninsular India and Lanka during the Quaternary. Palaeo-climatic research in India has latterly tended to focus on Rajasthan and Gujarat and the results merit scrutiny. The data from the central Narmada (v. above) form a continuum with those from Gujarat and Rajasthan, since the former region is in many ways a geographical extension of eastern Gujarat and Rajasthan.

The initial phase on the Sabarmati and Orsang rivers in Gujarat is one of lateritic weathering (Zeuner 1950) as on the central Narmada, which probably refers to an altithermal that is at least as early as the Holstein interglacial. The laterite is overlain on the Sabarmati by what is probably the equivalent of Gravel I (Holstein) with an Acheulean industry. The sea level then appears to have dropped, most probably due to the inception of the Riss glaciation, the progressive accumulation of fluviatile sediments ceased, and pedogenesis occurred (?final Holstein) on the Sabarmati and the lower Narmada (ibid.; Wainwright 1964). The soil on the Sabarmati is said to represent climatic conditions akin to those prevalent in this part of Gujarat today (Zeuner 1950:10). The post-depositional calcretisation of slope-wash sediments at Hokhra in central Rajasthan (Allchin and Goudie 1974:65), probably during the Holstein interglacial, appears to confirm this interpretation of the climate as resembling that of the present, since calcretisation is said to be occurring in this region today (annual rainfall 900-500mm) (Goudie et al. 1973:252). (Note, however, that the interpretation of soil formation on thalasso-statically deposited sediments along the western Indian coastline has to be viewed with some caution due to the tectonic instability of this region (v. Zeuner

1950:22,32), which could have led to elevation and exposure independently of glacio-eustasy.)

The interglacial conditions suggested above were succeeded by an arid phase (rainfall < 250 mm), as represented in the aeolean sediments overlying the slope-wash at Hokhra (Allchin and Goudie 1974:65; 1974*a*:254,365). This arid episode can tentatively be assigned to the Riss glaciation. Aeolean sediments assignable to this phase are also observable at Budha Pushkar, ca. 6km from Hokhra, near Ajmer (Allchin, Hegde and Goudie 1972:544-53; Goudie et al. 1973:249,252,254; Allchin and Goudie 1974*a*:359), Bandada, near Deosa in Mewar (Goudie et al. 1973:250-3), and at Pavagarh in central Gujarat (ibid.:251,253).

The next phase at Hokhra is the formation of a red soil (*Rotlehm*). Middle Palaeolithic assemblages are found resting on this soil in a sealed context, and hence are considered synchronous with the process of soil formation (ibid.:252). A similar situation prevails at Pushkar, Bandada and Pavagarh; and the red soil (associated with stone artefacts) formed on aeolean sediments at Sukkur and Rohri in Sind (de Terra and Paterson 1939:332) could conceivably correlate with the *Rotlehms* in Rajasthan and Gujarat. Technologically the latter, namely in Rajasthan and Gujarat, can be assigned to the Eem interglacial, and it is very likely that it correlates with peninsular Aggradation II (v. Mohapatra 1972:54): fluviatile silts accumulated thalasso-statically on the Sabarmati and the lower Narmada, and a Middle Palaeolithic industry was found in fluviatile sands capped by silt on the Orsang. The period of low sea level which followed (Würm) appears to have been inaugurated during the late Eem by a phase of soil formation, grading into Gravel II upstream, on the Sabarmati, Mahi and the lower Narmada (v. K.T.M.Hegde in Vishnu-Mittre 1965:28). West and east Rajasthan, and central Gujarat, bordering the Thar, witnessed a phase which was distinctly moister than the present, as indicated by the red soil (Goudie et al. 1973:249) with its total decalcification due probably to leaching by humic acids derived from relatively heavy vegetation, clay formation and the precipitation of iron. Since calcrete forms in today's environment with 900-500mm of annual rainfall, the *Rotlehms* can be considered to represent an annual rainfall which was well in excess of 900mm – which at Pushkar would signify at least a two-fold increase above that of the present total.

Hokhra and Pushkar are situated in the head-water valleys of the Luni river, and hence it is evident that vestiges of the Eem pluvial as found at these localities will have found their counterpart in the fluviatile sediments of the region. The Luni, a discontinuous river with a sand-choked channel today, but which is the major river of the area, has remnants of a Pleistocene gravel associated with a Middle Palaeolithic industry, which can be correlated technologically with peninsular Gravel II (Goudie 1973:32; Goudie et al. 1973:254; Sankạlia 1974:105,188-94). It is significant that the Luni, and other rivers in Marwar, arise in the Aravalli mountains of central Rajasthan, and thus they can be considered to reflect local climatic conditions – a catchment situated in the periglacial Himalayas, for instance, could have resulted in a depositional sequence which was not representative of the climate prevailing in Rajasthan itself or in peninsular India in general (for the Luni and its environs v. Goudie 1973:32; Allchin and Goudie 1974*a*:358; Misra 1976:33). As for southern Rajasthan, the Wagan and Kadmali basins of the Berach system are also known to have gravels with Middle Palaeolithic artefacts, which correlate with Gravel II (Sankalia 1974:194-5).

Moving down into lower latitudes, sedimentological and pedological investigations on Aggradation II in Saurashtra and western Maharashtra have indicated that the rainfall during deposition was not in excess of 25-30 per cent of the present average for these regions: for instance, the soils on the Mutha and Krishna sediments are rich in montmorillinite and deficient in kaolinite (Vishnu-Mittre 1974:621; Sankalia 1976:5). This suggests that the intensity and degree of climatic fluctuation during the Pleistocene decreased with latitude – which, logically, would signify that Lanka had a smaller amplitude than, for instance, Maharashtra.

Following the pluvial in Eem, Aggradation II on the Sabarmati and lower Narmada is succeeded by fluviatile silts, which probably correlate with peninsular Aggradation III (?Würm I/II interstadial) and which could also correlate with a phase of dune reactivation in central Rajasthan and Gujarat (evidence from Hokhra, Pushkar, Bandada, Pavagarh and Visadi near Pavagarh) due to an increase in aridity when the annual rainfall at <200-275mm would have been less than half (central Rajasthan) to one-third (Gujarat) of what it is today (Allchin, Hegde and Goudie 1970:24; Allchin and Goudie 1971:252; Goudie et al. 1973:245). The Thar desert had expanded eastward by ca. 500km into central Gujarat where today's rainfall is ca. 850mm. (The former extension of the Thar follows a line from Baroda to Hissar near Delhi, via Ajmer and Jaipur (Allchin, Hegde and Goudie 1972:544; Goudie et al. 1973:244).) The reactivated dunes at Pushkar, Pavagarh and Visadi are suspected of having contained Upper Palaeolithic stone tools, although such an industry has only been found in a derived state and has yet to be discovered *in situ* within the dunes (Allchin 1973:47; Goudie et al. 1973:253-4). On the lower Narmada (Wainwright 1964), two episodes of soil formation occur within this cycle of aeolean aggradation (K.T.M.Hegde in Vishnu-Mittre 1965:27), and these could represent the peaks of the interstadials Würm I/II and Paudorf respectively. The upper soil on the lower Narmada was then buried by aeolean sands which might be assigned to the Würm upper pleniglacial. The above two episodes of soil formation are not represented on the Sabarmati, where aeolean silts appear to have accumulated, without any pronounced breaks, until the postglacial stabilisation of dunes.

So much for the Pleistocene. I have set out above a very hypothetical scheme for the climatic episodes that would have accompanied the four-fold glaciation model that I have adhered to in the absence of a more reliable alternative. The scheme, while neat, can probably be considered simplistic. However, I have been careful to synthesise technological, pedological and geomorphological criteria in the formulation of this scheme, which can hence be considered broad-based. What does emerge is that the Würm glaciation in higher latitudes was synchronous with a relatively arid interpluvial in peninsular India, as established by the presence of ostrich during the upper pleniglacial at Patne and by Singh's radiocarbon dated sediments in Rajasthan (Addendum IV). The ostrich almost certainly indicates arid conditions, as it does during the upper pleniglacial of north China. This picture conforms with the evidence from other tropical countries. It is likely that pre-Würm glacials were also correlative with interpluvials in peninsular India as per Flohn's hypothesis of depressed atmospheric circulation during glacial episodes. The Eem interglacial, as well as the Würm interstadials, appear to have corresponded in Rajasthan and Gujarat to pluvial conditions of varying intensity. The interglacial/pluvial correlation was probably true of earlier interglacial episodes as well. Aggradation I (?Holstein) appears to represent very strong pluvial conditions. After an arid interpluvial (Riss) the next pluvial as found in Aggradation II (Eem) was less intense than the previous one, although stronger than the present Holocene pluvial. The amplitude of pluvial/interpluvial oscillations appears to have decreased with latitude, which would signify that Lanka had a relatively low range for its climatic (primarily rainfall) fluctuations during the Quaternary glacial/altithermal episodes.

The Holocene's record of climatic change in peninsular India is best illustrated by conclusions based on the analysis of pollen from certain sediments in

Rajasthan (once again that sensitive ecotone) against a backdrop of some radiocarbon dates for the early Holocene (Singh 1971; Singh et al. 1972). The data stem from sediments associated with the saline lakes of Sambhar, Didwana and Lunkaransar in western Rajasthan, and Pushkar in central Rajasthan (ibid.; also v. Rajaguru 1973:69,70; Goudie 1973:31; Goudie et al. 1973:254; Gupta 1974:644-7; Agrawal and Kusumgar 1974:64; Fairbridge 1976:542). Phase I, hypothesised at over 10,000 BP by inference from the depth of sediment beneath the radiocarbon dated lower Phase III, is marked by dune activity suggestive of the Würm upper pleniglacial interpluvial as recorded in central Gujarat and central Rajasthan at sites such as Pushkar (v. above). Phase II, estimated at ca. 10,000-9,500 BP, saw freshwater lakes forming over the Würm dunes (sedimentological data) indicating greatly increased precipitation which would have exceeded the present annual average by at least 250mm. Phase III, at ca. 9,500-5,000 $^{14}$C BP, witnessed a slight reduction in the pluvial conditions (pollen data). Phase IVa, at ca. 5,000-4,500 $^{14}$C BP, saw very moist conditions when the annual rainfall would have exceeded that of the present by ca. 500mm and tree pollen appeared for the first time (pollen data). This was followed by IVb, hypothesised at 3,800-3,500 BP, which was relatively dry, which in turn was succeeded by IVc, estimated at ca. 3,500-3,000 BP, which reverted to moist conditions (pollen data). Phase V, estimated at 3,000-1,700 BP, displayed conditions that were drier than those obtaining in the region today (pollen data), which was succeeded by the present climatic phase (pollen data). The chronology of the above events is only secure for Phase III and the early part of IVa, but the whole sequence suffices to indicate that the Holocene constitutes a pluvial phase (comprising several sub-phases) as opposed to the arid Würm interpluvial. Singh's interpretations of the Holocene pollen spectra have been contested by Vishnu-Mittre (1974*a*:622) on the basis of chemical analyses on sediments and a reinterpretation of the habitat requirements of certain plants. Vishnu-Mittre (also v. Agrawal 1975:3) affirms that the pollen in the three Rajasthani localities indicate a continuation of Würm's arid conditions during the Holocene. Several workers are of the opinion that the period spanned by the Indus (Harappan) Civilisation (4,500-3,800 BP) was not moister (in northwest India) than it is today, contrary to Singh's claim, and that conditions would have been similar to those of the present (for general discussion v. Raikes and Dyson 1961:265-81; Mughal 1973:16-8; for re-evaluation of Singh's pollen data v. Meher-Homji 1973; evidence from flora, Chowdhury and Ghosh 1951:18; Agrawal 1971:212-5; Vishnu-Mittre and Sharma 1972; Vishnu-Mittre 1974*a*:624-7; faunal data, Marshall 1931:673; Agrawal 1971:213-4; for anthropogenic aridity of Holocene north-western India, Hora 1952; Agrawal 1971:223-4; also v. Allchin and Allchin 1968:127; Suraj Bhan 1972; Flam 1976:81). However, Singh appears to have gained general acceptance, and Fairbridge (1976:542) presents the sequence of rainfall fluctuations for Rajasthan during the Holocene, as reconstructed by Bryson, thus (Fig.1):

> Holocene rainfall record for Rajasthan . . . based on pollen profiles. . . . Note that the . . . annual precipitation tends to reflect the strength of the winter westerly precipitation. The incidence of modes with stronger Westerlies coincides with strengthened [S.W.] Monsoons. The dramatic peak around 6,200 BP (sidereal) or 5,500 BP ($^{14}$C) coincides with the highest recorded Holocene (eustatic) sea level and with the peak of the climatic optimum in Scandinavia. The catastrophic desiccation around 3,600 BP (sidereal) coincides with a mode of extreme aridity in the Sahara, with a 4m drop of world sea level, and with Neoglacial II ice advances. The declining Monsoonal rainfall after 3,600 BP marked the end of the Harappan Culture in the Indus valley. Neoglacial I (at 5,000 BP, sidereal) is registered by a 50% drop in Monsoonal rains. In each case, these abrupt climatic departures occur within the course of a century, or even less.

Given the state of development of the science of climatology, it is possible to assume that Bryson's reconstruction of Holocene climatic fluctuations in Rajasthan is acceptable – although Singh's dating of the post-4,500 $^{14}C$ BP horizons needs to be improved upon. If this be the case, one could postulate for Lanka the following climatic episodes:

(*a*) Very dry at >10,000 BP (Würm upper pleniglacial)
(*b*) Dramatically wet at ca. 6,200 sidereal BP (5,500 $^{14}C$ BP)
(*c*) Dry, with considerable decrease in S.W. Monsoonal activity (Neoglacial I) at ca. 5,000 sidereal BP.
(*d*) Dry (Neoglacial II) at ca. 3,600 sidereal BP

The climatic departures would have been abrupt and effected within the course of a century or less, and they would have reflected fluctuations in the intensity of the S.W. Monsoon as well as of cyclonic activity. This scheme is as yet very much in the realm of hypothesis, and there is an urgent necessity for the generation of data for its testing.

Apart from Singh's pollen data, relatively humid postglacial conditions are said to be represented in the *regur* soils that are forming today on apparently late Pleistocene aeolean sediments bordering the lower Narmada (Allchin and Hegde 1968:145). Besides, in central Rajasthan and central Gujarat the calcretisation of aeolean sands, which, as at Bandada and Pavagarh, is thought to have set in with the Holocene, is apparently continuing at present (Misra 1976:39).

The presence of Mesolithic artefacts upon, as opposed to within, dunes in Rajasthan and central Gujarat, as at Hokhra, Pushkar, Bandada, Pavagarh and Visadi (Allchin, Hegde and Goudie 1970:24-5; Goudie et al. 1973:252-3; Allchin and Goudie 1974*a*:364; Misra 1976:39) and at large numbers of other sites in Gujarat (Misra 1976:29-30), further suggests that climatic conditions during the Holocene were pluvial, causing the dunes to stabilise, contrary to conditions in the Würm upper pleniglacial when the dunes were active. Protohistoric ceramics of ca. 4,000 BP found on such dunes, as at Pushkar and other localities in Rajasthan, the eastern Punjab and Gujarat (Goudie et al. 1973:249), corroborate this conclusion, despite the relatively dry conditions postulated by Fairbridge for ca. 5,000 and 3,600 BP (v. above). The occurrence of Mesolithic artefacts within dune sands at Langhnaj (Sankalia 1974:249-55) has been attributed to the anthropogenic reactivation of surface sands due to factors such as over-grazing (Goudie et al. 1973:245,253): "any deductions about the effects of climatic change *per se* [are] highly questionable in areas where man has been active" (Dimbleby 1967:155). Besides, the Mesolithic fauna at Langhnaj, adapted as it was to dry deciduous forests (for discussion of this vegetation and its degenerative phases through biotic factors v. Spate and Learmonth 1972:83-4), does not indicate a climate that was any different from that of today (Clutton-Brock 1965:4; Thomas 1975:323-4; Misra 1976:31,40). *Rhinoceros unicornis* and *Axis porcinus* found at the site could well have lived in a riparian habitat with anomalously dense vegetation (Zeuner 1963:28) – the rhinoceros inhabited the banks of the Indus as recently as 300 years ago (Agrawal 1971:214). There is some controversy regarding the presence of a buried soil at Langhnaj (Zeuner 1950:5; Misra 1976:40); but should it exist, it need not signify conditions moister than those prevailing today. The Mesolithic faunas from Bagor and Tilwara in Rajasthan, Adamgarh in Madhya Pradesh and Sarai Nahar Rai in U.P. are also said to represent environments similar to those obtaining in these regions today.

In the case of Bagor, the Mesolithic artefacts occur within dune sands. However, the latter are said to be derived from the deflation of the dry channel of the neighbouring stream, a process which is apparently continuing today, and these sands do not necessarily represent arid conditions (Goudie et al. 1973:253). Changes in the calcium content in the soil profile of these sediments have been interpreted as signifying small-scale fluctuations in rainfall (Mujumdar in Sankalia 1976:4). On the other hand, considering that some of the Mesolithic assemblages in Lanka date from the Würm upper pleniglacial, it is most likely that some of the Indian assemblages (v. Agrawal 1975:3; Misra 1976:39) occur *in situ* within Würm dunes. This hypothesis cannot be confirmed until the Indian Mesolithic has been more securely dated.

Apart from the localities considered above, particularly in Gujarat and Rajasthan, the rest of peninsular India has not been forthcoming with any

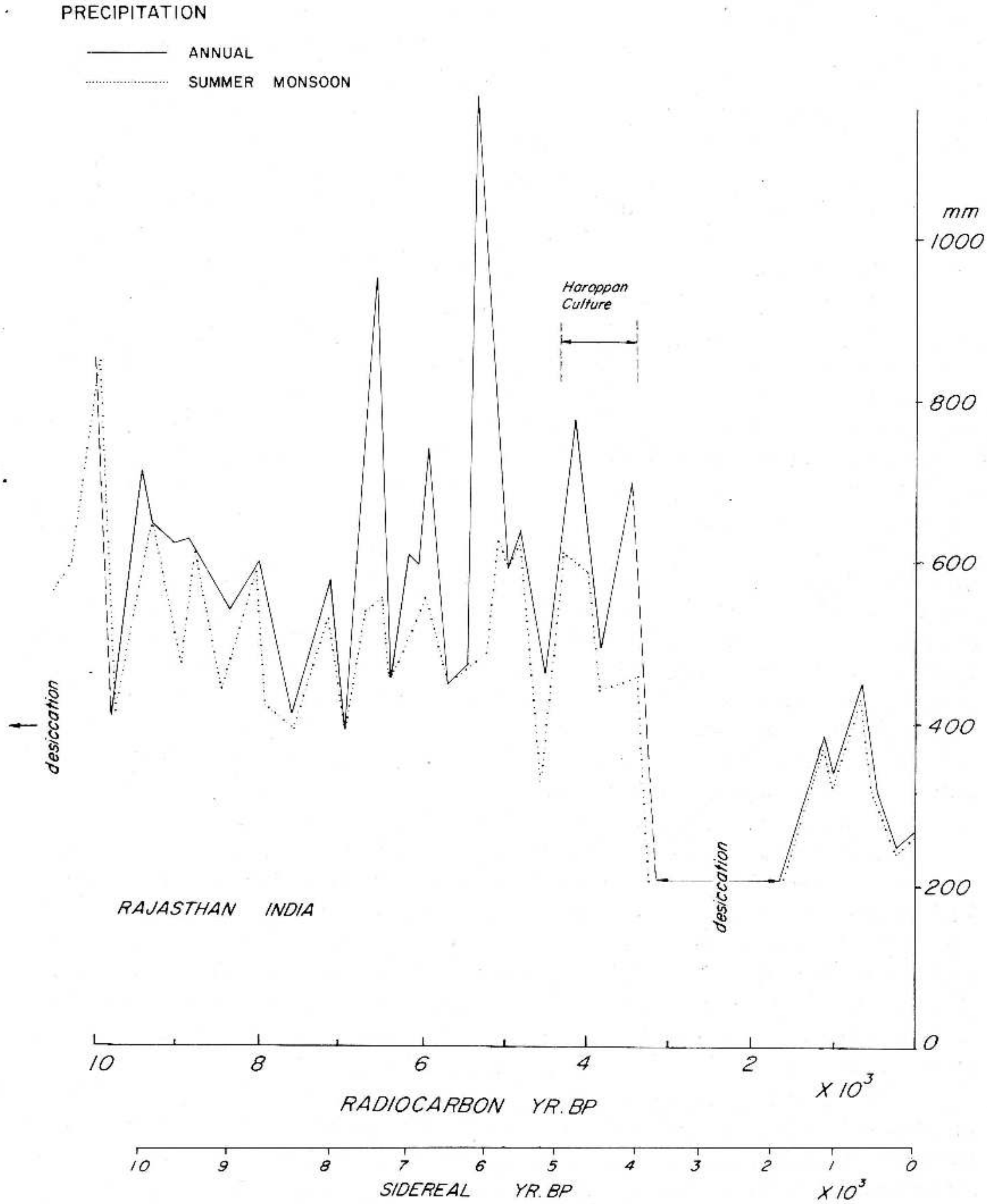



Fig. 1. Holocene rainfall for Rajasthan, based on pollen profiles by Singh and climatic reconstruction by Bryson (*after Fairbridge 1976:542; courtesy, author and publisher*). (Annual precipitation tends to reflect the strength of the westerly precipitation (ibid).)

palaeo-climatic data for the Quaternary within a reliable chronological framework. Perhaps the most significant among these are the data from the highlands of southern India, comprising the Nilgiris, Anaimalais and Palanis, with their wet montane *shola* forests interspersed with grasslands. These are almost identical with the vegetation of ecozone D3 in Lanka. A slight adjustment for a somewhat more northerly latitude in the case of the Indian highlands would be theoretically necessary; but in the context of palaeo-climatological data this adjustment would scarcely be feasible and can generally be disregarded.

The flora of South India's highlands (v. Spate and Learmonth 1972:87) is supposed to show marked affinities, as yet unexplained, with that of Assam and Manipuri in the northeast (ibid.:86). On the other hand, there are certain extra-tropical forms which are common to these highlands and the Himalayas, and Vishnu-Mittre (1969) has attributed this discontinuous distribution to Quaternary climatic fluctuations. However, Blasco and Thanikaimoni (1974:639-40), in a reappraisal of Vishnu-Mittre's data, come to a different conclusion:

> It seems possible to explain the presence of the few species common to Ceylon, South India and Himalayas (setting aside the species . . . which have a wide distribution) by their actual means [apparently zoochorous] of dispersal, rather than by a palaeogeographic hypothesis . . . . Birds like woodcocks (*Scolopax rusticola*) are known to traverse the whole distance from Himalaya to Nilgiri at a stretch.

But there are situations, such as the Nilgiri wild goat, which resembles its Himalayan counterpart, and the floristic penetration of tropical African forms down the east of the Western Ghats (Spate and Learmonth 1972:74), which do suggest that Vishnu-Mittre's hypothesis might have a certain degree of validity. Hence, on the present evidence, it can be affirmed that there are some indications that Quaternary glacial episodes could have witnessed a continuous distribution of extra-tropical faunal and floral elements from the southern highlands to the Himalayas. The rest of the discontinuous distribution can be explained by citing zoochorous dispersal. In the former instance, considering the difference in temperatures between highlands and lowlands in South India, there would have had to have been one or more episodes with a decrease in average temperature of at least 10-15°C for the biotic distribution to have been continuous between southern and northern India. In view of what is known about temperature depression in the tropics during Würm, which was one of the least intense of the Pleistocene glaciations, it seems likely that this degree of cooling would have been synchronous with the Mindel and/or Riss glaciations. These hypotheses are highly speculative and need to be tested rigorously (for further discussion of this topic v. Chap.4.3.3).

Certain peat cores from Kakathope, near Ootacamund in the Nilgiri highlands, have been sampled by Vishnu-Mittre and Gupta (1972; also v. Vishnu-Mittre 1972:208; Blasco and Thanikaimoni 1974:639; Chanda and Chatterjee 1974:613). Stage A with a date of ca. 38,000 $^{14}$C BP saw the gradual colonisation of extensive grasslands by shrubs and trees (e.g., *Rhododendron*). Stage B, undated, saw an increase in shrubs and warmth- and moisture-loving forms. Stage C, commencing at ca. 15,000 $^{14}$C BP, witnessed the final emergence of the wet montane *shola* forests that typify these highlands today.

The Kakathope pollen sequence represents a situation where grasslands are progressively colonised by montane forests. The radiocarbon dates point to a time-span ranging from the Paudorf interstadial to the Holocene, through the upper pleniglacial of Würm. The grasslands of India, including those of the Nilgiris, are thought to be anthropogenic (Spate and Learmonth 1972:74,77; Whyte 1975:220-1). This would ascribe their presence in Phase A at Kakathope to localised human activities at ca. 38,000 BP, and no climatic deductions can be drawn except that the occurrence of *Impatiens* and rosaceous members is said to denote a climate free of frost (i.e., warmer than that of today, since frosts do occur occasionally in these highlands) and of low humidity (Chanda and Chatterjee 1974:613). The radiocarbon date and the warm-habitat plants suggest the Paudorf interstadial; but the evidence from Rajasthan and Gujarat has unequivocally pointed to pluvial conditions accompanying such altithermals, and hence a relatively arid interpluvial on the highlands during the Paudorf constitutes an anomaly requiring explanation. Perhaps the Paudorf did witness warm, dry conditions in southernmost India; but this is unlikely.

Stage B apparently terminated before ca. 15,000 BP. This suggests that it represents the initial half of the Würm upper pleniglacial. But this is belied by the increase in warm- and moist-habitat plants. Stage C, said to commence at the peak of the upper pleniglacial at ca. 15,000 BP, suffers from the same incongruity. Hence, it is apparent that the chronology of Stages B and C is suspect. In view of this situation it is possible that the dating of Stage A is also unreliable, particularly considering the unusually early date for anthropogenic grasslands at 38,000 BP. Since there are these seemingly irreconcilable strands of evidence, it appears as if the dating of the Kakathope peats requires revision: perhaps, at most, Stages A-C represent a sequence from the Würm upper pleniglacial to the late Holocene. Should the grasslands be non-anthropogenic, it would then be possible to postulate the replacement of dry pleniglacial grasslands with the *sholas* which constitute today's climax vegetation (v. Spate and Learmonth 1972:87) of these highlands which could agree with the climatic sequence established (on firmer evidence) for north-western India (v. above). However, I would prefer to ascribe the entire pollen configuration of the Kakathope sequence primarily to the activities of man, with climatic factors playing a very secondary role. The same appears to be the case with the grassland-fernland-grassland sequence obtained by Menon (1966; 1968; also v. Blasco 1972; Blasco and Thanikaimoni 1974:635,638; Chanda and Chatterjee 1974:613) for Pykara, near Ootacamund, which has been estimated to represent a time span of ca. 4,000-0 BP by calibrating the depth of sediment against two radiocarbon dates of ca. 900 and 200 BP for similar deposits in Palni.

The dating and climatic interpretation of the Nilgiri peats are of direct pertinence to palaeo-environmental studies concerning Lanka's ecozone D3, since these two environments are almost identical. It is unfortunate that suitable deep peat deposits have as yet not been located in Lanka's highlands for this research to be conducted on a two-pronged basis. However, it is likely that such deposits do exist, and their investigation will undoubtedly yield interesting results.

With regard to certain other data from peninsular India relating to late Quaternary climatic fluctuations, these are far from conclusive and they could be enumerated as follows:

(*a*) *Karnataka.* Kupgal, in the Tungabhadra valley of Bellary District, has a red soil which has apparently been dated to an estimated 11,000 BP. Its calcrete content is said to indicate conditions that were somewhat moister than those which prevail in the region today (Sankalia 1974:171,174). Although this would seem to agree with the climatic optimum from other tropical countries of ca. 12,000 BP (v. Chap.4.6), both the dating and the interpretation of the soil need verification.

Certain faunal elements at Kupgal, such as *Axis axis* are said to indicate relatively wet conditions during the Neolithic at ca. 4,000 BP (Paddayya 1975:332). Besides, it is opined that there is evidence of a change of climate at ca. 4,000 BP at the juncture between the Mesolithic and Neolithic horizons at Sangankallu and Palavoy, as determined by the presence of certain soil horizons (Mujumdar and Rajaguru 1966). However, all this evidence is inconclusive in the light of the part human interference with the natural environment would have played during the period succeeding the appearance of a Neolithic subsistence economy.

(*b*) *Maharashtra.* The macro-flora from the Chalcolithic horizon (ca. 3,800-2,700 BP) at Prakash, Dhulia District, indicates a climate similar to that obtaining at present (Sankalia 1974:472). However, sedimentological evidence is said to suggest increasing aridity at Prakash and Nevasa during this period (Vishnu-Mittre 1974:625) which can perhaps better be attributed to anthropogenic influences on the sediments. The soil associated with the Chalcolithic horizon at Nevasa is said to be representative of much milder pluvial conditions than the one (chronologically indeterminate; ?late Eem plus Holocene) on Silt II along the Pravara (Vishnu-Mittre and Guzder 1971; Vishnu-Mittre 1974:626), which can be attributed to anthropogenic causes.

(*c*) *Madhya Pradesh.* The Mesolithic at Adamgarh is said to occur within a matrix of aeolean sediments (Joshi 1965:247). This could indicate conditions that were much drier than those prevailing today. However, the associated fauna does not suggest conditions differing from the present ones. The sedimentology of this site requires a reappraisal.

The macro-flora from Chalcolithic Navdatoli (ca. 3,800-2,700 BP) indicates an environment akin to that of the present (Sankalia 1974:472).

(*d*) *West Bengal.* The Mesolithic horizon at Birbhanpur on the Damodar (Lal 1958; Sankalia 1974:35,234-5) occurs upon a lateritic gravel of indeterminate age which probably represents a pluvial (?Eem). The overlying loam, containing the Mesolithic artefacts, has been evaluated on the basis of mechanical and chemical analyses as representing conditions that were drier than those referring to the basal gravels although, geomorphologically, this need not follow, as much depends on the depositional facies. Finally, there are ca. 0.6m of aeolean surface sediments, which can be attributed to anthropogenic causes.

Pollen profiles from peat secured from the Bengal basin do not, apparently, reflect any climatic changes since ca. 6,000 $^{14}$C BP (Vishnu-Mittre and Gupta 1972; Chanda 1974: 653-4; Chanda and Chatterjee 1974:609).

As mentioned earlier, the data enumerated above are of not much use for the reconstruction of Quaternary environments in peninsular India, due primarily to chronological and methodological inadequacies.

*4.5.2 Himalaya.* The Quaternary palaeo-environments of peninsular India have been considered in the foregoing account, and the data from Rajasthan, Gujarat and Madhya Pradesh were found to be particularly significant in this respect. However, before attempting to conclude on the varying lines of evidence from the peninsula, it is expedient to survey the data from the Himalayan tract; although, in view of their periglacial and near-periglacial provenance, their applicability to peninsular India would be limited, and hence my treatment of this topic will be commensurately brief (for definition of Himalayan tract v. Spate and Learmonth 1972:Fig.2.9).

Kashmir has yielded evidence of four glaciations during the Pleistocene, and their climatic implications have been advanced as follows (as in Chap.3, I am adhering to the Alpine terminology for convenience):

(*a*) *Pre-glacial.* Oak, alder pollen in the lower horizons of the Lower Karewa lake deposits (for sequence v. de Terra and Paterson 1939:221). Warm, moist climate (Vishnu Mittre 1972:207; 1974:616; 1974*b*:657-60).

(*b*) *Günz glaciation.* Blue pine pollen in the lower horizons of the Lower Karewas. Conditions were colder than the present (de Terra and Paterson 1939:224; Rajaguru and Hegde 1972:70; Vishnu-Mittre 1972:207; 1974:618).

(*c*) *Cromerian interglacial.* Oak-deodar-spruce pollen and macro-remains in middle and upper horizons of the Lower Karewas. Warmer and more humid than today; interglacial of long duration (de Terra and Paterson 1939:225; Vishnu-Mittre 1972:207; 1974:617-8; 1974*b*:657-60; 1974*c*:605).

(*d*) *Mindel glaciation.* Karewa Gravels representing the most intense of the four Himalayan glaciations, with at least two stadials (de Terra and Paterson 1939:222,225-6; Vishnu-Mittre 1974:617). The staining of the gravels has been interpreted as indicative of heavy precipitation, although this hypothesis requires testing.

(*e*) *Holstein interglacial.* Aeolean silts of the Upper Karewas. Lots of erosion during a considerable period of time (de Terra and Paterson 1939:222,227-8; Vishnu-Mittre 1972:207; 1974:617). The climate cannot be assessed with any degree of reliability due to the lack of pollen in the sediments.

(*f*) *Riss glaciation.* Somewhat milder than the Mindel, with four stadials, and correlating with the Potwar Loess of West Punjab (de Terra and Paterson 1939:228-30; Vishnu-Mittre 1974:617).

(*g*) *Eem interglacial*

(*h*) *Würm glaciation.* The weakest of the four glaciations, with at least three stadials (de Terra and Paterson 1939:230-1).

(*i*) *Postglacial.* Two glacial advances have been observed in the moraines (ibid.:232; de Terra and Hutchinson 1936; also v. Singh 1963:75). It would be interesting to see if these correlate with the Neoglacials I and II postulated by Fairbridge (1976:542) at 5,000 and 3,600 sidereal BP respectively.

The above description does indicate that there were four major glaciations in the Himalayas of Kashmir. To what extent de Terra and Paterson were influenced by European glacial classifications is indeterminate; however, pending data to the contrary, their scheme can be considered acceptable. The relative extents of the Himalayan glaciations have been presented by de Terra and Paterson (1939: Fig.150); but tectonics associated with the Pir Panjal appear to have had a major influence on the Monsoonal precipitation available for glaciation during the Pleistocene: "indeed, the interplay of geologic and climatic forces was so constant and thorough that it is impossible to segregate the various processes and consider each separately" (ibid.:222). It is significant, as far as Quaternary palaeo-climatic research in Lanka is concerned, that there would have been (and still is) a direct relationship between glaciation in the Himalayas and S.W. Monsoonal precipitation (ibid.:33), although its effects would have been complemented by depressional precipitation and world-wide fluctuations in temperature.

De Terra and Paterson's geomorphological investigations have been complemented by Singh's (1963) palynological work on four late Quaternary mires on the slopes of the Pir Panjal in south-western Kashmir. Toshmaidan mire has provided the most complete palynological evidence of the series, backed up by radiocarbon dates on peat and organic muds (ibid.:102-3; Singh and Agrawal 1976:232). The ca. 3.5m of sediments had accumulated in a lake overlying a moraine of the Würm glaciation. The pollen stages are as follows ($^{14}C$ 1/2-life 5,568 years):

(*h*) Undated; (*g*) 2,790±160 $^{14}C$ BP; (*f*) undated. Progressive decline of thermophilous elements from (*h*) to (*f*), with a corresponding increase of cold, moist forms. Anthropogenic influences are likely to have been very active. De Terra and Hutchinson's (1936) postulated climatic deterioration at $\leq$4,000 BP possibly correlates with these stages.

(*e*) Undated; climatic optimum when conditions would have been warmer and moister than at present. The oak and alder of this stage are absent in this region today.

(*d*) $9{,}650\pm^{245}_{340}$, $10{,}005\pm^{340}_{480}$, $11{,}360\pm^{585}_{600}$ $^{14}C$ BP respectively, in proportion with depth of provenance; progressive increase in warmth and moisture; much warmer and moister than stage (*c*).

(*c*) $13{,}980\pm^{520}_{565}$, $15{,}250\pm^{760}_{820}$ $^{14}C$ BP; a brief reversion to cold, dry interpluvial, but not as cold and dry as in stage (*a*).

(*b*)-(*a*) 14,760$\pm^{1015}_{925}$, 13,850$\pm^{900}_{785}$, $^{14}$C BP; progressively warmer and moister from very cold and dry conditions in (*a*).

The above sequence is thought to reflect the late Quaternary environment of the Kashmir valley in general (Singh 1963:106) and, despite attempts at faulting it (v. Vishnu-Mittre 1974:627; 1974*b*:663; 1974*c*:606), remains the only acceptable scheme available. (Approximately similar pollen records of cold-warm-cold conditions have been secured from other localities in the Kashmir valley and in Kumaon (id. 1974*b*:660-1; 1974*c*:606), but these do not possess an adequate chronological framework.) What is most significant in Singh's interpretation of the Toshmaidan pollens is that the Himalayan glacials were synchronous with periglacial interpluvials. This is contrary to de Terra and Paterson's interpretation of the Quaternary geomorphology of the region (v. below), and, although Singh appears to have the stronger case, further investigations are required in Kashmir's numerous river terraces, loesses, moraines and bogs before this question can be resolved. It is also possible that both points of view are valid, namely that certain glacials correlated with pluvials whereas others were synchronous with interpluvials. The interaction between the oceanic climate of the peninsula and the periglacial conditions of the Potwar would undoubtedly have led to highly complex weather configurations, which would have been further compounded by westerly depressions entering the region. (Note that Charlesworth (1957:1136; also v. Joshi 1970:60; Mujumdar and Rajaguru 1970:104) has mentioned that the frontal conditions created between Himalayan glaciations and S.W. Monsoonal currents would have resulted in pluvials. However, a less active S.W. Monsoon during glaciations, due to depressed atmospheric circulation in general, could have resulted in interpluvial conditions.)

The Pleistocene sequence in Kashmir has been geomorphologically correlated with the fluviatile sediments of the Potwar (v. Chap.3.2), and the climatic inferences with regard to the latter region are as follows (v. de Terra and Paterson 1939:234-5,264-9,271-8,290; also v. Rajaguru and Hegde 1972:70-1; Agrawal and Kusumgar 1974:35-6; Vishnu-Mittre 1974*c*:604-5):

(*a*) *Würm glaciation ($T_4$)*: pluvial, by analogy with the Boulder Conglomerate and $T_2$ (geomorphological data). The aeolean silt capping, with pottery artefacts, appears to represent a deposit where anthropogenic factors have played a significant role in its origin.

(*b*) *Eem interglacial ($T_3$)*

(*c*) *Riss glaciation ($T_2$)*: pluvial (geomorphology). However, the upper horizons with their loess deposits and typically dry fauna of horse, bison, wolf and camel suggest interpluvial conditions, which would be in agreement with Singh's pollen data from Kashmir (v. above).

(*d*) *Holstein interglacial ($T_1$)*: interpluvial, drier than present (geomorphology)

(*e*) *Mindel glaciation (Upper Boulder conglomerate)*: cold pluvial, wetter than present (geomorphology).

(*f*) *Cromerian interglacial (Pinjor)*: warm, warmer than preceding Tatrot (fauna)

(*g*) *Günz glaciation (Tatrot)*: temperate, but cooler than today (fauna)

It is evident that the climatic interpretation of the Potwar deposits is fraught with hazard. The periglacial fluviatile terrace sequence in the Himalayas has yet to be related firmly to the glacial sequence (Flint 1971) and, besides, "periglacial terraces are of limited importance in lower latitude highlands. They are difficult to isolate from alluviation due to increased moisture and fluvial action" (Butzer 1971:181). De Terra and Paterson (1939:299-300) have stated the problems associated with interpreting the Potwar deposits thus: uplift of the sub-Himalayan tract was more or less continuous during the post-Pinjor Pleistocene, which "prevented the drainage from achieving any degree of maturity or, if such was temporarily established, its records were subsequently destroyed by erosion". Then again, the pattern of the sequence was "caused by the interference of two cyclic processes in which the climatic was superimposed on the structural" (ibid.).

Moving away from the central area of research, namely Kashmir and the West Punjab, the Beas river in the Kangra valley of Himachal Pradesh, East Punjab, has been investigated by Rozychi and Chmileswski of the University of Warsaw (v. Joshi 1965*a*:20; 1968; 1970:54-7; Rajaguru and Hegde 1972:71; Agrawal and Kusumgar 1974:39). These workers have apparently observed traces of four stages of cone formation, which has been attributed to S.W. Monsoon-derived snow and water moving down the mountain slopes. These cones have yet to be tied in with any glacial deposits or with the implementiferous fluviatile terraces of the Beas and Banganga rivers. It is, however, tempting to correlate the four cone building episodes with the four Kashmiri glaciations – but this is highly speculative. The macro-floral remains from archaeological sites in Himachal Pradesh do not, apparently, suggest any climatic changes since ca. 4,000 BP (Vishnu-Mittre 1974:627).

In Bengal, there are four major fluviatile terraces which have been assigned to the Pleistocene. These cannot, once again, be interpreted climatically due to their close association with the subsidence of the Gangetic flood-plain and the tectonic instability of the Lalmai hills during the Quaternary (Morgan and McIntire 1956; Vishnu-Mittre 1974:620). As for Swat, Porter (1970) has reported three major glacial episodes, including some stadials; but no climatic interpretations of these sediments are available. In Ladakh and Tibet there is said to be evidence correlating glacials with pluvials. Lakes Panggong, Yaye and Mitpal Tso apparently held much more water during the Würm glaciation than they do today (de Terra and Paterson 1939:231-2) – although anthropogenic factors may be responsible for the latter situation.

It is clear that discrete studies will eventually lead to a synthesis which will provide a general view of Pleistocene climatic events in the Himalayas. At present it is impossible to correlate the sequences, for instance in Kashmir, Kangra and Bengal. Even as regards case studies, "a vast mass of evidence was adduced in support of these complicated orgies of river piracy and capture, and it is almost with regret that one admits that theories so ingenious and elegantly worked out are now generally regarded as untenable" (Spate and Learmonth 1972:39,40). However, the main points to have emerged from this apparent muddle are important for Quaternary studies in Lanka. These, until invalidated, can be enumerated as:

(*a*) There seem to have been four major glaciations.

(*b*) The relative duration and intensities of the glacial/interglacial episodes conformed closely with the Alpine sequence – assuming that the investigators were not unduly biased towards such an interpretation by the Alpine data at their disposal. In the Himalayas, Mindel appears to have been the strongest glaciation, followed by Riss and then Günz and Würm. The Holstein interglacial is thought to have been of considerable duration.

(*c*) The pollen sequence suggests that glacial episodes correlated with relatively dry interpluvials in the periglacial zone – which agrees with the evidence from the Würm and the Postglacial in peninsular India, as in Rajasthan and Gujarat. It is, however, conceivable that this correlation between glacial and interpluvial was not invariable, and that some of the pre-Würm glaciations were synchronous with pluvials as per de Terra and Paterson's conclusions for Mindel and Riss in the West Punjab.

(*d*) It is likely that periglacial pluvials correlated with increased S.W. Monsoonal activity in peninsular India. But this proposition is not unequivocal since winter depressional rains constitute a significant element today in the western sub-Himalayan tract (Spate and Learmonth 1972:50) and glacial episodes could have witnessed an increase in such depressional rains which amounted to pluvial conditions in this region. However, such rains might have been relatively insignificant in the eastern sub-Himalayas – which would make the latter a better index to S.W. Monsoonal behaviour during the Pleistocene than the west.

Pending the accumulation of further data, it is possible to surmise that, as per Singh's evidence for the Würm glaciation and the early Holocene, glacial episodes witnessed interpluvials throughout sub-Himalayan India, while interglacials were marked by pluvial conditions. As for the middle and late Holocene, the anthropogenic factor has undoubtedly influenced the pollen record, which has hence to be viewed with caution. This hypothesis is in general agreement with the evidence from peninsular India and Lanka.

Finally, it is necessary to attempt to assess the meteorological configuration of India during the Quaternary. Since glacial advance in India during the Pleistocene was limited to the Himalayas, the weather pattern in the peninsula (v. Mellor 1976:104) would not have been drastically affected. The Himalayas would have acted as a screen against the cold winds blowing in from continental Asia, while the Indian Ocean would have ameliorated any climatic fluctuations which might otherwise have occurred. In this context it is interesting to observe that there are vestiges of evidence that the basic weather configuration of India was the same during the Pleistocene as it is today. The first clue is that the present ecozoning of the Himalayas from west to east, with the associated progressive increase in rainfall, is thought to be represented in the Pleistocene fluviatile terrace records of this region, as for instance in Sikkim and Bhutan relative to the West Punjab (Vishnu-Mittre 1974:619). Then there is Rajaguru's work in Maharashtra which indicates that the three rainfall-determined ecozones which occur today along ca. 70km of the Mutha river, eastwards across the Western Ghats (6,350-1,500mm, 1500-750mm, 750-375mm annual rainfall respectively) did not shift their boundaries noticeably during Aggradation I (Holstein). These two sets of evidence suggest that the meteorological phenomena controlling the rainfall pattern during the Quaternary were essentially the same as those prevailing today with the S.W. Monsoon assuming dominance. That it was indeed the S.W. Monsoon, and none other, that took prime place is suggested by the pattern of discontinuous distribution of anemochorous plants in the southern highlands. Forms occurring in the Nilgiris were apparently unable to colonise the highlands to the south of these mountains due most probably to the effective winds having been westerly and south-westerly throughout the Quaternary (Blasco and Thanikaimoni 1974:640). The orientation of the fossil dunes bordering the Thar desert would undoubtedly shed very significant light on wind direction during the Würm glaciation, since the present dune genesis is orientated to S.W. Monsoonal winds. Hence, despite the possibility of S.W. Monsoonal failure due to jet-stream behaviour during glacial episodes, which I have stated in Chapter 4.4, it certainly does not appear to have been replaced by another wind system of any distinctiveness. The implications for Lanka's palaeo-climatology are clear: it is the S.W. Monsoon that must be kept in focus, there being no valid reason to relegate it to a minor position among the factors which would have affected Lanka's weather configuration at any period during the Quaternary. Indeed, it is likely to have dominated the scene, as it does today.

*4.5.3 Land Links with Lanka.* The fauna and flora of peninsular India clearly suggest prehistoric land connections with Lanka at various times during the Quaternary, as firmly indicated by the presence of *Elephas maximus*, an Upper Pleistocene form, on either side of the Palk Strait. Land connections with the mainland would of course have been of prime importance for prehistoric human settlement of the island prior to the advent of seafaring.

Eustatic fluctuations of sea level would have been the main cause of the sequence of land links between India and Lanka. Note that Adam's Bridge, separating the two countries today, is only ca. -10m at its deepest (Deraniyagala 1958:Fig.4; Flint 1971:774) and considerable stretches of the approximately 40km wide strait are within wading depth. However, it has already been mentioned that Lanka might not be quite stable tectonically, despite its being a part of the south Indian shield. There are, for instance, indications that northern Lanka has been undergoing regional uplift. On the other hand, considering that Miocene beds in the north have not, on an average, been elevated above ca. 40m +today's msl, and considering that the inter-tidal zone during the Mesolithic occupation of Mantai in the northwest (excavation data, 1982) indicates a mean sea level at that date of a mere 1m above present msl, tectonics appear to have assumed a relatively minor role in the sequence of land connections which occurred during the Quaternary. For instance, the sea level is known to have dropped by ca. 100m during the last glaciation at ca. 20,000 BP (Agrawal, Avasia and Guzder 1973:10) and tectonic uplift, on the scale envisaged for Lanka, could not have made much of an impact on the relative heights of land and sea. Hence, in any evaluation of Quaternary land links between Lanka and India, eustasy assumes prime importance and an examination of generalised glacio-eustatic curves can be of considerable relevance.

The late Würm and Holocene eustatic curve, commencing ca. 30,000 BP, has been plotted by Emery et al. (1971:383), and it is compiled from "published dates and depths of the present continental shelves of the world on the basis of shallow-water shells, oolites, salt-marsh peat, wood, coralline algae, and coral.... A few of the very many more published dates and depths for peats in modern salt-marshes have been added to show the sea levels of the period from 8,000 years ago to the present" (ibid.). The dashed lines on the diagram, serving as an envelope to enclose most of the data points (which increase considerably in density from 15,000 BP onwards), suggest that the mean sea level approximated to that of the present at ca. 35,000 BP (also v. ibid.:382,389). In terms of Lanka and India, the curve compiled by these workers suggests that, assuming tectonic stability, a late Würm land link would have been created at about this time. (ca. ?25,000 BP), although further investigations might reveal the existence of a land link through the entirety of Würm (for detailed curves commencing ca. 18,000 BP v. Butzer 1971:Fig.44; Bloom 1971:Fig.4; and from 10,000 BP onwards v. Flint 1971:326-7; Fairbridge 1974:Fig.5). These curves are smooth (asymptomatic), implying that glacier melting decreased continuously during the time periods they represent (for discussion v. Fairbridge 1976:544). If this should be the case, Lanka's last land link with India would have been severed at ca. 7,000 BP. On the other hand, Fairbridge's curve (ibid.:531-50) indicates a rise of sea level marked by considerable fluctuation, which, while conforming with the others in implying the submergence of the late Würm land link between Lanka and India at ca. 7,000 BP, indicates a series of oscillations in Holocene sea levels; none of which, however, were sufficient in their negative aspects to create even brief connections between Lanka and the mainland. Hence, for our purpose, the various eustatic curves constructed on a worldwide basis suggests that Lanka was connected to India from ca. ?25,000-7,000 BP, and not since.

As for the period prior to 35,000 BP, there undoubtedly would have been numerous occasions on which Lanka had been linked to India during the early

Würm and earlier glacial phases. However, the current state of knowledge with regard to the pre-35,000 BP worldwide eustatic curves becomes progressively inadequate. It can perhaps be hypothesised that the high sea level at ca. 35,000 BP represents the Paudorf interstadial of Würm (Movius 1960:Fig.1), and that early Würm at ⩾40,000 BP saw the penultimate land link between the two countries. The Eem interglacial at ca. 125,000-75,000 BP would undoubtedly have seen the submergence of the strait, as would the Holstein and Cromerian interglacials and perhaps some of the interstadials of the pre-Würm glaciations.

Butzer (1971:217) presents the Würm and pre-Würm situation concisely:

> As a result, estimates of glacial sea levels vary considerably. For the Würm-Wisconsin maximum Valentin (1952) gives a value of -95 to -100m; Woldstedt (1954:293) gives -90 to -100m; Donn et al. (1962) give -115 to -134m. For the maximal pre-Würm glaciation (Riss complex?), Valentin (1952) and Woldstedt (1954) suggest -115 to -120m; Donn et al. (1962), -137 to -159m. There are a great number of submerged shoreline features that can be freely correlated with any of these values, but they do not prove the reliability of the one or the other. It should be realised that precise estimates are impossible at present, and a general estimate of -100 to -150m is quite sufficient for all practical purposes. Greater precision would be misleading, both theoretically and in specific application, since any local area may have since been affected by small or large tectonic movements.

As mentioned earlier, tectonics appear to have modified the glacio-eustatic land-sea relationship along Lanka's coasts. No detailed evaluation of the degree of this modification has as yet been undertaken and is in urgent need of rectification. In Lanka the following localities hold potential for an investigation of the evolution of the coasts during the Quaternary:

(*a*) Deposit of marine shells of inshore species within a consolidated sandy gravel at the causeway near the 18th milepost from Batticaloa to Kallar (Deraniyagala 1958:12). This could represent a raised beach.

(*b*) The 4-6m of peat found in the Muthuraja-wela marshes, just north of Colombo (Cooray 1967:122,124). The surface of this deposit is at the present mean sea level. The peat could be dated and the vegetation sequence studied, and these might represent the last 8,000 years or so of the Holocene transgression. Layers of marine molluscs occur within these beds.

(*c*) Investigation of the drowned river valleys found on the continental shelf between Lanka and India in the northwest (Deraniyagala 1958:7,11-4). The submerged forest at 0-6m -msl just south of Karaduva island is worthy of special note. Submarine valleys are also associated with several river mouths around Lanka, for example, the Mahaweli, Kumbukkan, Nilvala rivers, and at ca. 7km north of Batticaloa and at Panadura (Cooray 1971:73; Arudpragasam 1974:66).

(*d*) The ancient estuary of the Kelani river, as represented in the Beira lagoon. 10m of deposits are known from borings, and these have been described and interpreted thus (Wadia 1941*c*; Cooray 1967:166,169):

| | |
|---|---|
| 1.0m | Lacustrine silt with marine shells of living species; marine submergence |
| 1.0m | Peaty silt, with no marine shells; land slightly above contemporary sea level |
| 2.5m | Silty clay with lots of marine shells; marine submergence |
| 4.5m | Clay with decayed wood of trees; slightly submerged marshland |
| 1.0m | Fluviatile sand |
| | Lateritised bed-rock at ca. 10m -msl |

If tectonic influences can be discounted, this 10m deposit can be judged to approximately represent the last 10,000 years of the Quaternary, as per the eustatic curves referred to earlier. If so, it is noteworthy that lateritisation of the bed-rock had occurred prior to ca. 10,000 BP. But when? The deposits can be radiocarbon dated and the floral succession investigated for further environmental data.

(*e*) The forest of dicotyledonous trees at 3.5m -msl, west of the Colombo-Kandy road between the 4th and 5th milestones. Peat and fluviatile sands overlie the tree horizon (Deraniyagala 1958:14).

(*f*) Raised beaches of shelly sand and coral debris on headlands at a few feet above sea level near Trincomalee and Kalkudah (Cooray 1971:164).

(*g*) A wide, level, sand platform at ca. 2m +msl, between Batticaloa and Tirukovil (ibid.)

(*h*) Deposit (ca. 0.3m thick) of estuarine facies with fossil crabs and window-pane oysters at ca. 3m -gl. This is associated with the Salape-aar estuary, just south of Kuchchaveli, 3.5 km inland from the present coast (Coomaraswamy 1905; Deraniyagala 1958:16-7).

(*i*) The alluvia on the lower Mahaweli river, where it is ca. 25m deep; the Kelani river alluvia at Malwana reaching down to ca. 6m -msl; and the bed of the Kalu river at ca. 20m -msl a few miles upstream from its mouth (Cooray 1967:174-5).

(*j*) Estuarine deposits with *Placenta* oysters at ca. 2.5m -msl at Attudava, near Matara, ca. 6km inland from the coast (Deraniyagala 1958:21-2). This would have been associated with the ancient estuary of the Nilvala river.

(*k*) Pamban Island, between Lanka and India, with a raised fringing reef of 1-2m +msl (Ahmad 1972:33,41).

(*l*) Drowned river valleys in the southwest, such as Ratgama, Bolgoda and Koggala lakes (Cooray 1971:76).

(*m*) Ridges and runnels denoting old strandlines along the coastal belt south of Puttalam lagoon, on the west side of the Kalpitiya peninisula, the coast between Batticaloa and Kalkudah and around Point Pedro (ibid.:161,164). These are considered to be old beaches formed by the tide flowing over a shallow sea floor.

(*n*) Coral reefs fringe most of the island (Malpas 1920). Debris is found from the coast, as between Ambalangoda and Matara, particularly at Akurala, sandwiched between sand barriers and the mainland (Cooray 1971:175-6). Some of these corals are said to be standing *in situ* (Deraniyagala 1958:15). Dating of these *in situ* corals could supply information on the chronology of sea level changes in this region. Littoral sandstones (beach-rock) are known from various parts of the island's coast (Cooray 1967:160). I am not acquainted with any "raised" deposits of beach-rock. The deposits which yield the Miocene fossils at the base of Arnakallu (Deraniyagala 1969*a*; 1969*b*) do not appear to represent an ancient beach-rock; my view is that the consolidation is related to the present sea level.

The evidence from Sarma's (1976) sixteen radiocarbon dates from the southern Indian coast is rather confused (v. Chap.3.4.4.). It does not correspond with any of the generalised eustatic curves referred to above. This lack of correspondence can be attributed to poor dating material (shell, coral and limestone) coupled, possibly, with tectonic instability. Gardner's (1981; 1983) dating of the 8m raised beach to ca. 38,000 $^{14}$C BP suggests generalised uplift, although, once again, the dating medium was shell.

Apart from tectonics and glacio-eustasy, there is another mechanism which could have contributed towards establishing land links between Lanka and the mainland. The shoreline in the northwest, southeast and east of the island is known to be advancing, whereas the southwest is retreating through erosion (Cooray 1967:76-9; Arudpragasam 1974:71). The advancing shoreline is the result of the construction of sandy spits and bars along the coast. "A gently shelving shoreline, such as that of Ceylon, is highly sensitive not only to structural disturbances but also to movements of sediments along the coast through tides, currents and the action of waves" (Wadia 1941*a*:16). The progression is uneven – new islands appear, while others disappear almost overnight (Deraniyagala 1947:1; 1958:12); but, on the whole, the coast in the northwest and east is advancing. Most of the islands between India and Lanka, in the Gulf of Mannar and the Palk Strait, consist of marine alluvia

(Ahmad 1972:30) which would have shifted around during the past. They would have been very convenient as transit stops for prehistoric "traffic" between Lanka and the mainland.

It is difficult to conclude as to which played the more dominant role in Quaternary land connections between Lanka and India, tectonics or glacio-eustasy, although, as mentioned above, the present evidence points strongly towards the latter. The former is not understood adequately for southern India and Lanka. Marine alluvial sedimentation can be considered the least important of the factors affecting land connections. Since the general pattern of tectonics in northern Lanka and south-eastern India appears to be progressive uplift, the glacio-eustatic evidence that the last connection was at $\leqslant$25,000-7,000 BP will probably need modification; namely, that the inception of the last land link was earlier than 25,000 BP and that the final submergence would have occurred at a date somewhat later than 7,000 BP. The degree of modification required for these glacio-eustatic dates cannot as yet be evaluated on the available evidence. There is a further possibility that the land link survived unbroken throughout the Würm: researches in eustatic altimetry have yet to achieve adequate resolution for the period prior to the Würm upper pleniglacial.

## 4.6 CONCLUSIONS

*4.6.1 Soils and Geomorphology.* The discussion on the soils and geomorphology of the Quaternary in Sri Lanka (Chap.4.2) has served to indicate that no environmental inferences can be drawn from the Ratnapura Beds. Laterite, on the other hand, due to its apparently irreversible traits, constitutes a useful climatic index. Its distribution in Lanka suggests that climatic conditions during the glacials and interglacials were such that climatic Sub-Zone 6 at below ca. 30m+msl did not exceed its present boundaries, although it could have been less than it is today. This estimate is complicated by our not having precise data with regard to the distribution of fossil laterites as opposed to those that are forming today: it is possible that pedogenesis in the laterites of Lanka was intimately linked with current sea levels and that today's high level laterites refer to past high sea levels and that they are relicts.

The pedological data from the colluvial strata at Beli-lena Kitulgala and Batadomba-lena caves indicate that Wet Zone conditions akin to those of the present were prevalent at these loci during the final stadial of Würm. However, since these soils are not *in situ* the contemporaneity between their formation and the deposition of the colluvia can be questioned. Besides, these Red-Yellow Podsols of the modal variant have a wide range of distribution today (ecozones D1, D2) and their presence could as well signify appreciably cooler temperatures with lower annual precipitation.

The study of the geomorphology and pedology of the I Fm and RBE Fm (Chap.4.2.3) has led to the important conclusion that the basal gravels of these two formations and the sands of the I Fm represent altithermal episodes when the climatic regime of the Dry Zone as a whole seems to have undergone longer periods of drought than are prevalent today. The annual rainfall in the drier parts of ecozone A would have been higher than 250mm and lower than 950mm. These dry conditions would have been the result of exceptionally strong S.W. Monsoonal activity, compared to the present, with increased summer droughts in the Dry Zone due to the drying effect of katabatic S.W. Monsoonal winds on the leeward aspect of the central mountains. The vegetational cover would have been depleted in the Dry Zone, making the terrain more susceptible to sheet erosion from tropical cyclonic storms which were probably more intense and frequent than those occurring today. There is likely to have been a corresponding increase in the orographically controlled precipitation in the Wet Zone.

During glacial episodes the annual rainfall in ecozone A does not appear to have increased to above ca. 2,000mm; instead, it is very likely that glacials witnessed depressed atmospheric circulation, which probably served merely to mute the present rainfall configuration of the island. This would have been the converse of altithermal conditions which, as per the evidence from the I Fm and RBE Fm, saw increased atmospheric circulation (for corroboration v. Addendum IV).

*4.6.2 Fauna and Flora.* It is apparent from Chapter 4.3 that the flora from the Pleistocene Ratnapura Beds does not suggest a climate significantly different from that of today. As for the Ratnapura Fauna, the presence of *Axis axis* and perhaps *Bubalus bubalis* does point to phases which, in ecozone D, were drier than the present – at least approximating the conditions of ecozone C – indicating a decline in S.W. Monsoonal activity. It is not possible as yet to correlate this decline with any particular phase of the Pleistocene; but it is here tentatively hypothesised that depressed atmospheric circulation, leading to a weakened S.W. Monsoon, was symptomatic of glacial episodes.

The discontinuous distribution of today's montane faunas of Lanka and India suggests a decrease of at least 10°C during some of the glacial phases, although it is not possible to stipulate which glacial phase or phases were involved (?Mindel, ?Riss). The evidence supplied by the arboreal snail *Acavus phoenix* at Batadomba-lena indicates unequivocally that the Würm upper pleniglacial at 28,500-11,500 $^{14}$C BP was not colder by more than ca. 6°C below the present average and that the annual rainfall was in excess of 2,000mm. *Acavus roseolabiatus* at Beli-lena Kitulgala provides a firm indication that the climate in ecozone D1 was nearly identical with that of the present at ca. 12,500-10,500 $^{14}$C BP, and that the temperature during this period was not lower than 3°C below the present average.

*4.6.3 Meteorology.* An in-depth assessment of the Quaternary meteorology, and its impact on the climate, of the Indian region requires a clear comprehension of the "many singularities in assemblage, and interplay of local topography and climate with the currents and waves at various atmospheric levels up to the stratosphere – in fact, a rich and by no means fully studied climatology. . . ." (Spate and Learmonth 1972:63); and these have to be viewed within a global perspective. "The science of meteorology has not yet been able to properly explain the rationale of the general circulation, and some decades may elapse before its mechanics will be understood" (Butzer 1974:739). However, summarising what is known concerning the structure of the weather over Lanka (Chap.4.4), it can be hypothesised that glacial episodes saw depressed atmospheric circulation resulting in a lowering of all types of rainfall received on the island, whereas altithermals saw an increase, as indicated by the evidence from the I Fm and RBE Fm. A stronger S.W. Monsoon during altithermals would have resulted in a correspondingly more pronounced summer drought in Lanka's Dry Zone. However, it is also likely that increased circulation during altithermals resulted in tropical cyclonic storms affecting the Dry Zone in a more drastic manner than would have been the case during glacial episodes. These hypotheses concerning the S.W. Monsoon and tropical cyclones appear to be corroborated by the geomorphology of the Iranamadu and Reddish Brown Earth Formations (Chap.4.2.3). I have, in Chapter 4.4, merely probed the potential of palaeo-meteorological study in South Asia. Specialist attention needs to be focused on this complex field before hypotheses concerning the Quaternary weather in this region can confidently be set forth. Butzer (1971:398) sums up the current position of the young discipline of palaeo-meteorology succinctly:

> Those few meteorologists with an interest in the Pleistocene are unfortunately hampered by difficulties of two kinds: (*a*) the empirical palaeo-climatic data are painfully inadequate so far, and (*b*) meteorological theory concerning the modern general circulation is not considered to be satisfactory as it is. In fact . . . it has not yet been convincingly shown that the climate of the earth should be distributed as it actually is. . .
>
> The meteorologist obviously cannot be expected to collect and evaluate the specialized palaeo-climatic data he is to analyse. This must be provided by the Pleistocene specialist who should attempt to interpret his data with great caution, so that better catalogued materials with qualified evaluations such as "reliable", "probable", or "possible" may be accessible to the meteorologist. A great deal more satisfactory palaeo-climatic information must be available before this major barrier to palaeo-meteorological study is removed. . . .
>
> Further work, such as that on the secondary effects of particularly snowy winters on radiation, temperature, pressure distributions, etc., seems highly promising. . . . Indeed, it remains to be determined whether a relative change of circulation patterns might by itself induce higher latitude glaciation, with planetary temperature depression as an indirect result rather than a primary cause. . . . It is to be hoped that more meteorologists will devote attention to related problems. Only then can the present impasse in palaeo-meteorological interpretation be overcome.

Meanwhile I have, in Chapter 4.4, attempted to inaugurate an era of palaeo-meteorological research in Lanka by providing direction for such enquiry and by highlighting the problem areas.

*4.6.4 India.* India's Quaternary environment has a long history of research and I have reviewed the data at some length for the light they may shed on Quaternary climatic events in Lanka, considering that Lanka is but a continuation of India (Chap.4.5). The conclusions can be summarised thus (v. Addendum IV).

It will have become evident that most of India's Palaeolithic deposits have been found in a fluviatile context. The limitations inherent in climatological interpretations based on fluviatile deposits require no stressing. It suffices to affirm that India has numerous regional variations on its basic climatic themes, and that these variations would have found expression in the fluviatile records throughout the Quaternary. This complexity would have been compounded by tectonic factors, as demonstrated for western India and the Himalayas; and even within an apparently homogeneous area, the catchment characteristics could have differentially influenced the configuration of sets of fluviatile deposits.

Despite the above handicaps, it is somewhat surprising that India has managed to yield a fairly consistent Quaternary fluviatile stratigraphy, particularly in the peninsular part of the sub-continent. The sedimentology and pedology of these strata have been of some use in the reconstruction of Middle Pleistocene climates in the peninsula. In the case of the Upper Pleistocene and early Holocene, the coupling of sedimentological data from fluviatile and aeolean deposits of the ecotones in Rajasthan and Gujarat on the one hand, and palynological evidence from the Himalayas on the other, has resulted in the emergence of the following picture:

(*a*) The Himalayas, at least in Kashmir, witnessed four glaciations during the Pleistocene. Of these, the second was the coldest, followed (in degree of intensity) by the third, first and fourth respectively. The second interglacial was apparently of exceptionally long duration. Cold stadials have been postulated within the glacials: two in Mindel, four in Riss and three in Würm. The Holocene saw two glacial advances, which could conceivably correlate with Neoglacials I and II at 5,000 and 3,600 sidereal BP.

(*b*) The periglacial Himalayas have strong palynological evidence that as far as Würm was concerned, the glaciation was synchronous with interpluvial conditions, whereas the Holocene witnessed the onset of a pluvial.

(*c*) Geomorphological and pedological evidence from the desert ecotones in Rajasthan and Gujarat points clearly to a corroboration of the Himalayan periglacial data: that Würm corresponded to a dry interpluvial, succeeded by moist pluvial conditions during the Holocene. Remains of ostrich shell from an apparently Würm (Upper Palaeolithic) deposit in Maharashtra also point to interpluvial aridity.

(*d*) With regard to the Holocene, Singh's palynological investigations in central Rajasthan have yielded the following sequence:

v. Climatic record disturbed by anthropogenic factors; $\leqslant$ 4,500 $^{14}$C BP;
iv. Strong pluvial; 5,000- <4,500 $^{14}$C BP
iii. Slight amelioration of pluvial conditions; 9,500-5,000 $^{14}$C BP
ii. Strong pluvial; undated
i. Basal layer; arid interpluvial; undated (?Würm)

Bryson and Fairbridge have reinterpreted Singh's data and come to the conclusion that 6,200 sidereal BP (5,500 $^{14}$C BP) represented a postglacial optimum followed at intervals by two cold spells, Neoglacials I and II at 5,000 and 3,600 sidereal BP respectively. The graph presented by Fairbridge (1976) for Holocene climatic fluctuations is jagged, representing changes in the intensity of the S.W. Monsoon as well as of cyclonic activity – which certainly would have affected Lanka as well. These climatic departures are thought to have occurred within the course of a century or so, thus making their delineation in the prehistoric sedimentary record a matter of considerable difficulty.

(*e*) As for the pre-Würm geomorphological and pedological data from Rajasthan and Gujarat, they indicate an arid Riss interpluvial succeeded by an Eem pluvial which was moister than the Holocene pluvial (as typified at Hokhra). Similar categories of data from Saurashtra and Maharashtra have suggested that the rainfall during the Eem pluvial was not more than 25-30 per cent above the present average, whereas during the Würm interpluvial it was not less than by 25-30 per cent.

(*f*) There appear to be pedological indications on the lower Narmada that there were three Würm stadials.

(*g*) Sedimentological data from schematised Aggradations I-IV typical of peninsular India suggest a progressive decrease in pluvial intensity from the Holstein interglacial (Aggradation I) through Eem (Aggradation II) and Würm interstadials (Aggradation III) and the Holocene (Aggradation IV). This is well exemplified in the Karnataka ecotone at Hunsgi Nullah.

The gravels of Aggradation I, and to a lesser extent those of Aggradation II, seem to indicate marked seasonality in rainfall – which is in agreement with the evidence from the altithermal gravels of Lanka's I Fm and RBE Fm. However, the Narmada Fauna of Aggradations I and II does not suggest a faunal habitat that was significantly different from that of today. Forms such as *Equus namadicus* do not point to the existence of tropical rain-forest in Madhya Pradesh during the Eem pluvial, and the rule of thumb for rain-forests is an annual rainfall requirement in excess of 2,000mm.

Since these aggradations seem to have correlated with Himalayan interglacials, it can be hypothesised, on the basis of the relative intensities of the Himalayan glaciations, that Mindel saw the strongest interpluvial followed by the equivalents of Riss, Günz and Würm in their respective order of intensity. That the effect of Würm on Lanka was mild is denoted by its faunal record at Batadomba-lena (Chap.4.3.2).

(*h*) The discontinuous distribution of fauna and flora in India suggests a decrease in average annual temperature by ca. 10-15°C in southern India during one or more of the Quaternary glaciations. In view of the relatively mild intensity of Würm, this is likely to have occurred during Mindel and possibly Riss.

(*i*) The amplitude of the pluvial/interpluvial fluctuations in peninsular India appears to have decreased with latitude. This could signify a small amplitude for Lanka compared to Gujarat, Rajasthan or the Himalayas. Of course, within this broad framework, localised ecotone situations would have registered pronounced fluctuations.

(*j*) There is some geomorphological and biotic evidence to show that the predominant weather factor during the Quaternary in India was (as it still is) the S.W. Monsoon. There are no indications of its having been supplanted by another distinctive wind system at any time during the Pleistocene.

(*k*) The data from the highlands of South India lack a reliable chronological framework and hence are of limited utility. The grasslands appear to be anthropogenic.

(*l*) Since at least 5,000 BP "man and his animals comprising the biotic factor emerged in India ... to exercise their influence upon the environment of which the changes hitherto had largely been influenced by climatic, edaphic, physiographic and diastrophic factors" (Vishnu-Mittre 1974:623). "Millennia of clearing for cultivation and of unregulated grazing, both often promoted by burning the jungle ... have stripped the forest from nearly all the plains and much of the lower hills and plateaus, or turned it into scrub" (Spate and Learmonth 1972:73).

(*m*) The glacio-eustatically determined land links between Lanka and India across the 10m deep Palk Strait would have greatly influenced the movements of man between the mainland and Lanka throughout the Quaternary. It is difficult to reconstruct a chronological scheme for this sequence of links due to the uncertainty shrouding pre-Eem sea levels and the indeterminate factor of tectonic movement in the region. The worldwide eustatic curves suggest the existence of a land connection during the Würm upper pleniglacial, commencing with the end of the Paudorf interstadial at ca. ?25,000 BP, and that this connection finally terminated at ca. 7,000 BP. This chronology might have been somewhat modified by local tectonic influences; although this is unlikely to have been considerable. (The mammalian faunas of Lanka and India definitely suggest an upper pleniglacial land link.)

It can be affirmed with a fair degree of certainty that altithermal episodes saw Lanka separated from India and that, considering the shallowness of the Palk Strait, land links were established with the lowering of sea level at the very onset of glacial conditions.

*4.6.5 Tropics.* The Quaternary environments of Lanka can be considered integral with those of peninsular India, since it is the same basic weather phenomena that are prevalent in both instances. I have indicated in the foregoing accounts (Chap.4.5) that there seem to have been four major glacial episodes in the region (a concept which might require revision in the light of recent data from other parts of the tropics, v. Chap.4.6.6). For the Middle Pleistocene (ca. 700,000-150,000 BP) the data are somewhat nebulous, but they become less inscrutable as one approaches the Upper Pleistocene (ca. 150,000-10,000 BP). It appears as if the Eem was characterised by a pluvial of stronger intensity than that of the Holocene, and that Würm, particularly the upper pleniglacial, represented an unusually arid interpluvial. Within these macro-phases of pluvials and interpluvials were several short-term fluctuations, lasting less than a few centuries at a time as represented by Fairbridge (1976: Fig.4) for India's Holocene. This general scheme, particularly for the Upper Pleistocene, is in agreement with the evidence from several other tropical and equatorial localities: some of this evidence and related data are as follows:

(*a*) Monsoon Southeast Asia

i. *Central Burma*: A four-fold aggradation sequence, with three erosional intervals, has been postulated for the Irrawaddy river (de Terra et al. 1943:291,298,308,310,343-7). These aggradations could conceivably be related to Tibeto-Burmese glacial episodes, which in turn might be coeval with the Himalayan glacials. This scheme is very tentative and the question is the extent to which de Terra had been influenced by the four-fold Alpine sequence. The sedimentology of the Pagan Silt on the Irrawaddy (?Würm upper pleniglacial) suggests arid conditions.

ii. *Java*: It is thought that there was an increase in aridity from Lower to Middle Pleistocene, according to faunal evidence (Verstappen 1975:14-5); and the Ngangdong Fauna (Upper Pleistocene) had *Grus grus*, a crane which is not found south of North China today (Movius 1949:334). The implication is that progressive desiccation was a concomitant of a decrease in temperature. There is fairly firm evidence of overall temperature deterioration throughout the world during the course of the Quaternary (v. Chap.4.6.6).

Eastern Java has black, clayey soils which are formed in an alkaline environment with a particularly dry summer Monsoon. These have been found submerged in the sea, indicating that a glacial period of low sea level (?upper pleniglacial) was synchronous with interpluvial conditions (Verstappen 1975:17).

iii. *Borneo*: At ca. 6° north latitude (i.e., approximately the latitude of Lanka) the Würm upper pleniglacial snowline has been estimated at ca. 500m lower than it is today, implying a decrease in temperature by ca. 3-4°C (Flint 1971:681).

iv. *New Guinea*: The Würm upper pleniglacial is thought to have witnessed a depression in the tree-line of the central mountains (ca. 4-5°S.L.) by ca. 1,000m (Golson 1977:11), suggesting a temperature that averaged 5-6°C colder than it is today (Mulvaney 1975:134). However, it is possible that the mountains have been undergoing uplift and that hence, as per the tree-line record, the drop in temperature was in excess of 6°C (Verstappen 1975:8).

v. *Monsoon Southeast Asia* witnessed the extinction of several grazing mammals at the end of the Pleistocene. This phenomenon, together with the presence of a discontinuous distribution of an arid environment flora in lower Burma, eastern Java and Sumatra, indicate that Würm (and perhaps earlier glacials) was an interpluvial and that the Holocene represents a pluvial.

(*b*) Monsoon Africa

Mt. Kilimanjaro has morainic evidence of four major glaciations, of which the second is older than 460,000 BP (Butzer 1975*a*:867). Throughout the Lower and Middle Pleistocene in East Africa the climate is thought to have undergone only minor fluctuations of aridity and semi-aridity (sedimentology) which did not succeed in affecting the faunal configurations (Isaac 1969; Butzer 1975*a*:867-8). The climatic oscillations during the Lower and Middle Pleistocene appear to have been of low amplitude, probably because large ice sheets were not involved (Isaac 1969:7). The faunas of tropical Africa have been relatively unchanged since the Pliocene, and the Ethiopian faunal zone does not provide useful temperature indicators. The sedimentology of Olduvai Bed IV indicates progressive desiccation with the onset of the Middle Pleistocene at ca. 0.7 my – which agrees with the Southeast Asian data relating to climatic deterioration during the Lower and Middle Pleistocene and which indicates that progressively colder conditions meant correspondingly drier climates in Monsoon East Africa, namely that glaciation equated with interpluvials throughout the Quaternary and not just during Würm. However, it is well to bear in mind that sedimentological evaluation of Quaternary environment is not unconditionally reliable, particularly in view of the interference caused by tectonic factors in East Africa (Clark 1960:307; Butzer 1975*a*:868).

There is, however, ample evidence to show that the Würm pleniglacial in Monsoon-dominated tropical and equatorial Africa witnessed arid, interpluvial conditions, whereas the altithermals such as the Eem, Paudorf and the Holocene were synchronous with pluvial conditions:

i. *East Africa* (Flint 1971:699; Butzer 1971:337-8,349; 1975*a*:868; Clark 1975:618; Fairbridge 1976:532): The Paudorf, and possibly the Eem as well, witnessed a pluvial in the Omo-Rudolf basin, with the Paudorf being probably more pluvial than the present. The upper pleniglacial was an arid interpluvial on Lake Victoria, the Nile and the Rift Valley lakes. Geomorphological evidence from the highlands indicates that the temperature was ca. 5-6°C cooler than it is today during this pleniglacial. Warming up set in at ca. 15,000 BP.

ii. *Kalambo Falls, Zambia* (Butzer 1971:342): The Würm lower pleniglacial was probably 3-4°C cooler than it is today, and the Paudorf witnessed a pluvial.

iii. *Southern Sahara*: The southern border of the Sahara, registering the summer Monsoon's fluctuations, witnessed an arid, interpluvial upper pleniglacial and pluvial Eem, Paudorf and Holocene altithermals (Fairbridge 1976:542). Instances are: Lake Chad (ibid.:536-7; Butzer 1971:333), with pluvial Paudorf, interpluvial upper pleniglacial and pluvial Holocene; Senegal (Flint 1976:536; Butzer 1971:330,333) with pluvial Eem, interpluvial upper pleniglacial and pluvial Holocene; and Niger (Fairbridge 1976:536) with an interpluvial upper pleniglacial. West Africa in general is thought to have had an arid upper pleniglacial when tropical rain-forest was reduced in extent (ibid.).

iv. *Kalahari, northern margin* (Butzer 1971:345,349): The two Würm pleniglacials were arid, whereas the intervening Paudorf interstadial was moist. There is, for instance, Lunda in northeast Angola with a pluvial Paudorf and interpluvial upper pleniglacial.

As regards the Holocene climatic events in Monsoon Africa, independent data from several localities, such as the middle Nile and the East African Rift Valley lakes, have provided the following sequence (Fairbridge 1976:536-40; cf. Butzer 1971:331,333,339,349,376; 1974:735-7; 1975*a*:868):

i. >15,000 BP: arid upper pleniglacial with pluviosity beginning on a small scale at ca. 15,000 BP.

ii. 13,000-8,000 sidereal BP: strong pluvial, with a short dry spell at ca. 10,000 BP. There were two peaks of rainfall at ca. 12,000 and 9,000 BP, correlating with northwest Europe's Alleröd and early Boreal pollen stages. The intervening dry spell at ca. 10,000 BP would have been synchronous with Europe's Younger Dryas.

iii. 8,000-6,800 sidereal BP: dry

iv. 6,800-5,400 sidereal BP: pluvial; postglacial climatic optimum falling within Europe's Atlantic.

v. 5,400-4,300 sidereal BP: dry; Neoglacial I

vi. 4,300-3,500 sidereal BP: wet

vii. 3,500-2,900 sidereal BP: dry; Neoglacial II

viii. 2,900-0 sidereal BP: oscillations between wet and dry at 200-300 year intervals, the present being a dry sub-phase.

The evidence relating to the Quaternary environments of Africa has been interpreted by Butzer (1971:300) as suggesting that

> Pleistocene climatic changes followed predictable patterns, symmetrical about the equator, and related to the planetary wind and weather belts [for instance, the upper pleniglacial climatic oscillations in the Vaal-Orange basin of South Africa were apparently closely paralleled in the northern hemisphere (ibid.:348)].... Throughout the continent, the maximum of the late Würm-Wisconsin was dry, although there were a number of wetter intervals prior to 25,000 BP, varying in their intensity and duration.... Across the central axis of the Sahara and through several of the tropical savanna climates there is good evidence

for one or two pluvials beginning 9,500 BP and terminating about 5,000 BP.... Within the [tropical] climate zone the [Paudorf] interstadial... was decidedly moist.... It is... likely that... pluvials marked parts of the Eem and earlier interglacials.... The African pluvials [despite the non-validation of the classic East African pluvial chronology and terminology (ibid.:351)] show sufficient synchronism within certain climatic provinces to suggest a genetic association with climatic changes on a continental or worldwide scale.

It is significant that the above interpretations of Quaternary climate apply to parts of tropical Africa dominated by the summer Monsoon, which is genetically akin to the Southwest Monsoon of South Asia (v. Fairbridge 1976:536), for instance, the Nile valley and Ethiopia, and as such its fluctuations are transposable in general to the Quaternary climate of peninsular India and Lanka. Indeed, there appears to be considerable correspondence between the climatic sequences in peninsular India, Monsoon Africa, Alaska and north-western Europe (Larsen 1975:55-6).

There are also the examples (Fairbridge 1976:534) of eleven-year sunspot cycles being in phase with fluctuations in the Monsoon-determined levels of Lake Victoria–which agrees with Thambyahpillai's findings in Lanka (Chap.4.4.5). There does appear to be an intimate connection between incoming solar radiation and Monsoonal activity. Perhaps the Milankovitch radiation curves can usefully be employed to generate hypotheses for testing with regard to the entirety of the Quaternary in the tropics.

(*c*) Miscellaneous tropical

i. *Atlantic Ocean.* Oxygen isotope analyses have indicated that the Würm upper pleniglacial temperatures were ca. 5°C lower than those of today (Flint 1971:725). Cores from the Indian Ocean agree with this estimate (ibid.:727). Micro-palaeontological data from the equatorial Atlantic indicate an upper pleniglacial temperature that was ca. 5°C cooler than today's (Emiliani 1971:189). The temperate, higher latitudes are thought to have had a depression of ca. 10-12°C (Butzer 1971:284). Oxygen isotope analyses suggest that the Eem was ca. 1°C warmer in the tropical Atlantic than it is today – once again as opposed to a much greater difference in temperature in higher latitudes (ibid.:390).

ii. *Tropical Brazil, Central Asia, Australia, Nebraska* and *Kansas* show evidence of an arid upper pleniglacial (Fairbridge 1976:539).

The above data suggest that the Würm upper pleniglacial was ca. 3-6°C cooler than it is today in the maritime tropics (Flint 1971:4), although under tropical rain-forest this might have been mitigated to as low as 1-2°C according to Budel (1957). It is conceivable that the temperature during some of the interglacials were 1-3°C higher than that of the present in equatorial regions (Verstappen 1975:8-9).

*4.6.6 Conclusions.* As a matter of convenience I have, thus far, adhered to the classic Alpine terminology and chronology of Günz-Würm for the worldwide climatic oscillations of the Quaternary (v. Butzer 1971:43-4; Cooke 1972:7). Recent findings, however, indicate that this scheme might no longer be tenable, and that it might be an over-simplification of complex sequences of oscillations which have yet to be evaluated as to their chronology and relative intensities. Butzer (1975*a*:862-3) affirms:

The state of resolution of the till and outwash stratigraphies in the Alpine piedmonts and the North European Plain is incomplete, contradictory at the scale of interregional comparison, and unsuitable for time stratigraphic applicability.... The Alpine terminologies... [have] become quite meaningless. Recent fieldwork in each of the type-areas is therefore directed towards establishing local litho-stratigraphic units.... Both the glacial stratigraphy and terminology have proved to be of little or no value for resolution of the mid-Pleistocene record.

Isaac (1975:876) states that Turner's (1975) pollen data from Europe emphasise "the possibility that distinct sequential interglacials were, under conditions of less than optimal correlation criteria, been lumped into categories such as 'Eemian', 'Holstein', or 'Cromerian'" and that Shackleton's (1975) analysis of deep-sea sediments indicate that "since the non-interglacial intervals do not group together into definable 'macro-pluvials', terrestrial stratigraphers can finally lay to rest the time-honoured four-fold climato-stratigraphic scheme of Günz, Mindel, Riss and Würm, plus correlatives". However, despite these assertions of the *avant garde*, there are yet those four glacials in Kilimanjaro, as well as those postulated for India, Burma and China which have to be accounted for – or possibly rejected. Perhaps, future investigations will indicate that these (and the four Alpine glaciations) did in fact exist and that the oscillations occurred within the main framework of the classic four-fold scheme, with the oscillations correlating in part with the stadials/interstadials of the old concept. Meanwhile, the general conclusions concerning the Pleistocene record, with particular reference to the higher latitudes, has been summarised thus by Butzer (1975*a*:865):

> (*a*) The European interglacial and Rhine alluvial records indicate a minimum of six, the Czechoslovakian loess a total of eight cold-warm cycles since the Brunhes-Matuyama geomagnetic reversal. Since eight comparable cycles are also indicated in both the Pacific and Atlantic deep-sea cores, this must be seen as evidence for eight glacial intervals of hemispheric or global significance during the past 700,000 years.
>
> (*b*) With the possible exception of the designation Würm that can probably be applied to the last glacial complex, the till or outwash stratigraphies are hopelessly inadequate to provide a valid or practicable nomenclature for the preceding seven glacials.
>
> (*c*) At least five of the glacials since 700,000 BP were sufficiently severe to produce permafrost conditions in mid-latitude Europe. For the lower Rhine Basin this implies a mean temperature depression of at the very least 11°C. Consequently the "glacial Pleistocene" unquestionably extends back to the Brunhes-Matuyama boundary.
>
> (*d*) An uncertain but nonetheless substantial number of cold-warm cycles can be recognised prior to 700,000 BP, although the severity of the cold intervals did not match that of the glacial phases during the Brunhes normal polarity epoch.
>
> (*e*) Each cold hemicycle prior to 700,000 BP appears to have led to floral decimations in western Europe while providing an environment suitable for loess accumulation in east-central Europe. Furthermore, the deep-sea record indicates extensive glaciation for at least the later of these cold phases. The available evidence could in fact be interpreted with recourse to repeated cold impulses characterised by a progressive intensification of climatic stress.... Only by 700,000 BP were the cold intervals sufficiently severe to bring permafrost to mid-latitude Europe.... A variety of palaeo-climatic criteria can be mustered to argue for a Lower/Middle Pleistocene boundary about 700,000 years ago.... Practicable stratigraphic boundaries must be tied to chronometric horizons.... In addition, a geomagnetic reversal of event can be identified in a diverse range of sediments not amenable to radiometric dating, thus providing optimal opportunities for valid, worldwide correlation.

With regard to tropical and equatorial latitudes, Shackleton's (1975) oxygen isotope analyses of deep-sea cores from the Pacific and, more notably, from the Atlantic where conditions are said to have been akin to those of the Indian Ocean, have indicated that there were at least twenty-two cold/warm climatic oscillations over the last 800,000 years (as calibrated by the Brunhes-Matuyama reversal).

> The amplitude of variation between maximum glaciation and maximum deglaciation varies in detail, but remained basically comparable through time, suggesting some fundamental constraints to the planetary glacial-interglacial pendulum.... (1) Apparent glacial-interglacial oscillations extend backwards in time for at least 800,000 years. (2) At the very least nine such "cold" stages can be identified prior to the Upper Pleistocene, with a variable duration of about 18,000 to 67,000 years, compared with

23,000 to 73,000 for the "warm" stages. (3) In its detail, each glacial and interglacial hemicycle was different, so that one cannot speak of repetitive climatic events.... (4) Correlation of Shackleton's multiple deep-sea units with existing, continental time-stratigraphic schemes is impossible [Butzer 1975*a*:860-1].

As mentioned above, one wonders whether these data may not eventually fit into the classic four-fold glacial scheme. Apparently all available evidence points to the worldwide synchroneity of cold/warm oscillations during the Quaternary (id. 1971:111).

There are also the Milankovitch radiation curves which deserve to be tested rigorously for their applicability as predictive models for Quaternary climatic fluctuations (v. Fairbridge 1974:1004; 1976:547-8), with particular reference to equatorial Lanka. Summing up, Fairbridge (1976:529-30) affirms:

> Multiple cycles of astronomic origin control the $10^3$ to $10^6$-year pattern of climate change, of which the Milankovitch mechanism is most important. For shorter cycles, or "fluctuations", we also accept in broad lines a *deterministic* model, in view of the overwhelming coincidences with observed phenomena of solar radiation, the geomagnetic field, and so on.... The stochastic models are regarded simply as "control" exercises.
>
> Apart from the gross controls of climate (latitude factors, continental hemispheric asymmetry, eustasy, palaeo-geographic/palaeo-oceanographic barriers, etc.), there are regional effects that control additional modifications and sometimes generate powerful feedback loops. Examples include the West Coast/East Coast effects of the Westerlies, the oscillations of the polar front, and the north-south displacements of the tropical high pressure belts and their regional results, especially on the Monsoons of Asia and Africa; in addition, of course, there are the numerous orographic, lacustrine, and maritime regional controls. All these cause climatic modulations with persistent variables on time scales in excess of 100 years that are often synchronous globally. We *must* learn to understand more about them. If it is true that they coincide with various exogenetic variables, then these climatic extremes may well be predictable from astronomic data.

There is no doubt whatsoever that Lanka would have been affected by Quaternary climatic fluctuations, as clearly indicated in the Iranamadu Formation. For the Lower and Middle Pleistocene, the intensity and chronology of these changes

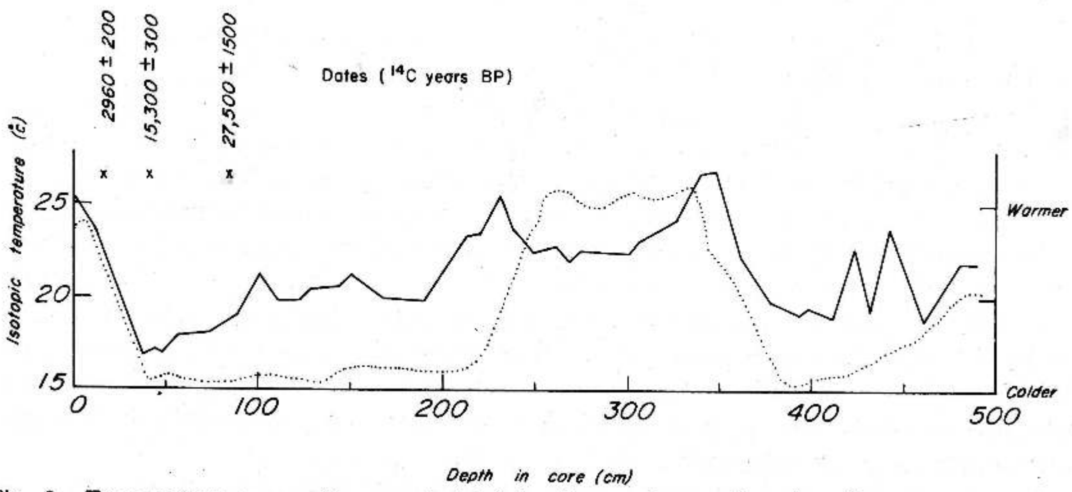



Fig. 2. Temperature curves for equatorial Atlantic: continuous line, isotopic temperture after Emiliani; dotted line, micro-faunal data after Ericson et al. Partial time calibration from three $^{14}C$ dates (*after Flint 1971:72; courtesy, publisher*). Note the plateau at ca. 200-350cm; ?Eem.

are a matter of debate and it is not possible to reconstruct the climatic sequence in Lanka – apart from postulating that Shackleton's cold/warm oscillations or

Milankovitch's summer-radiation minima and maxima were represented by interpluvials and pluvials respectively. As for the Upper Pleistocene and the Holocene, commencing with the Eem interglacial, I have cited extensive evidence to conclude that in equatorial regions altithermals correlated with pluvials, and glacials with arid interpluvials. The synthetic schemes for this period, as set out by Flint (1971:432,726) and Fairbridge (1976:535,Fig.4; also v. Butzer 1971:274-5; Larsen 1975:Fig.3 for north European pollen stages), could be employed as models to be tested in Lanka, for which a dense network of chronological and environmental data ranging over the last 150,000 years will have to be generated. Noteworthy in this respect is the world map of deviation in annual precipitation for 1970-72 (including Lanka), representing short-term climatic fluctuations, the distribution pattern of which is suggested by Fairbridge as a model for the Würm upper pleniglacial (1976:Fig.3). Considering the rapidity with which some of these changes are thought to have taken place, for instance the pluvial episodes for the final Würm and Holocene apparently occurred within a span of 2,000-5,000 years (Butzer 1971:333), the chronological resolution of the data to be generated in Lanka will perforce have to be very high indeed.

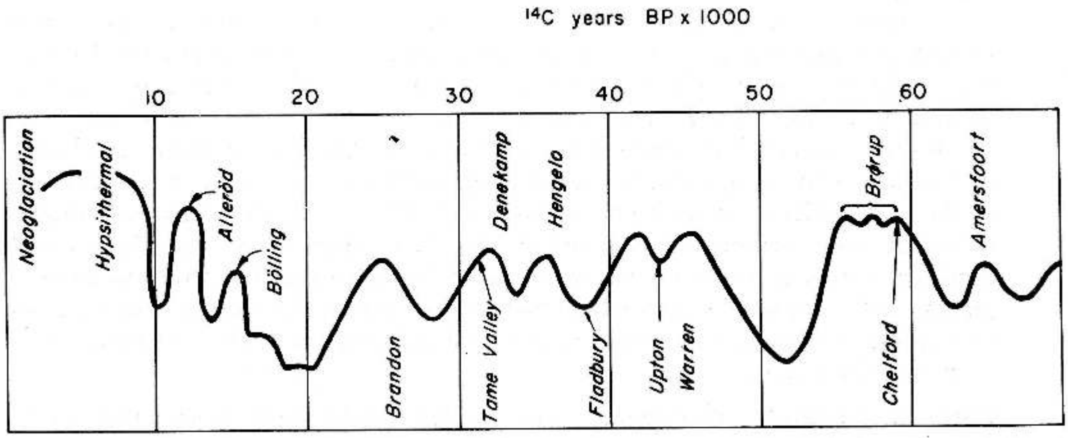



Fig. 3. Würm and Holocene climatic variations in north-western Europe, inferred from terrestrial data (*after Coope and Sands in Flint 1971:432; courtesy, publisher*).

On the basis of the models suggested above, one could postulate in the case of Lanka that during the Lower Pleistocene at >700,000 BP there had been an uncertain number of pluvial/interpluvial oscillations which became progressively more pronounced towards the Middle Pleistocene (for depiction of climatic deterioration from the Eocene onwards, with acceleration in the Pleistocene, v. Butzer 1974:Fig.2). Since ca. 700,000 BP at least eight pluvial/interpluvial cycles had apparently occurred, of which a minimum of five of the interpluvials would have been relatively severe with lowering of temperatures in excess of 5°C below that of the present. It may turn out that these oscillations fit into four major episodes on the model of the classic Alpine sequence. If the latter should be the case, the second and third interpluvials and the second pluvial would have been of exceptional intensity and duration as per the European evidence for its Mindel, Riss and Holstein episodes respectively (v. id. 1971:293).

The evidence from the Eem – there was definitely such an event, apparently – suggests that the temperature averaged ca. 1°C above that of the present. The curves presented by Flint (1971:432,726) and Fairbridge (1976:535,546) suffice to indicate the pattern which Lanka's climate might have assumed, noting that cold correlated with aridity and warm with pluvials. Noteworthy would have been the Paudorf interstadial at ca. 33,000-25,000 BP being somewhat moister than today, and the very arid upper pleniglacial at ca. 25,000-15,000 BP. The temperature would have

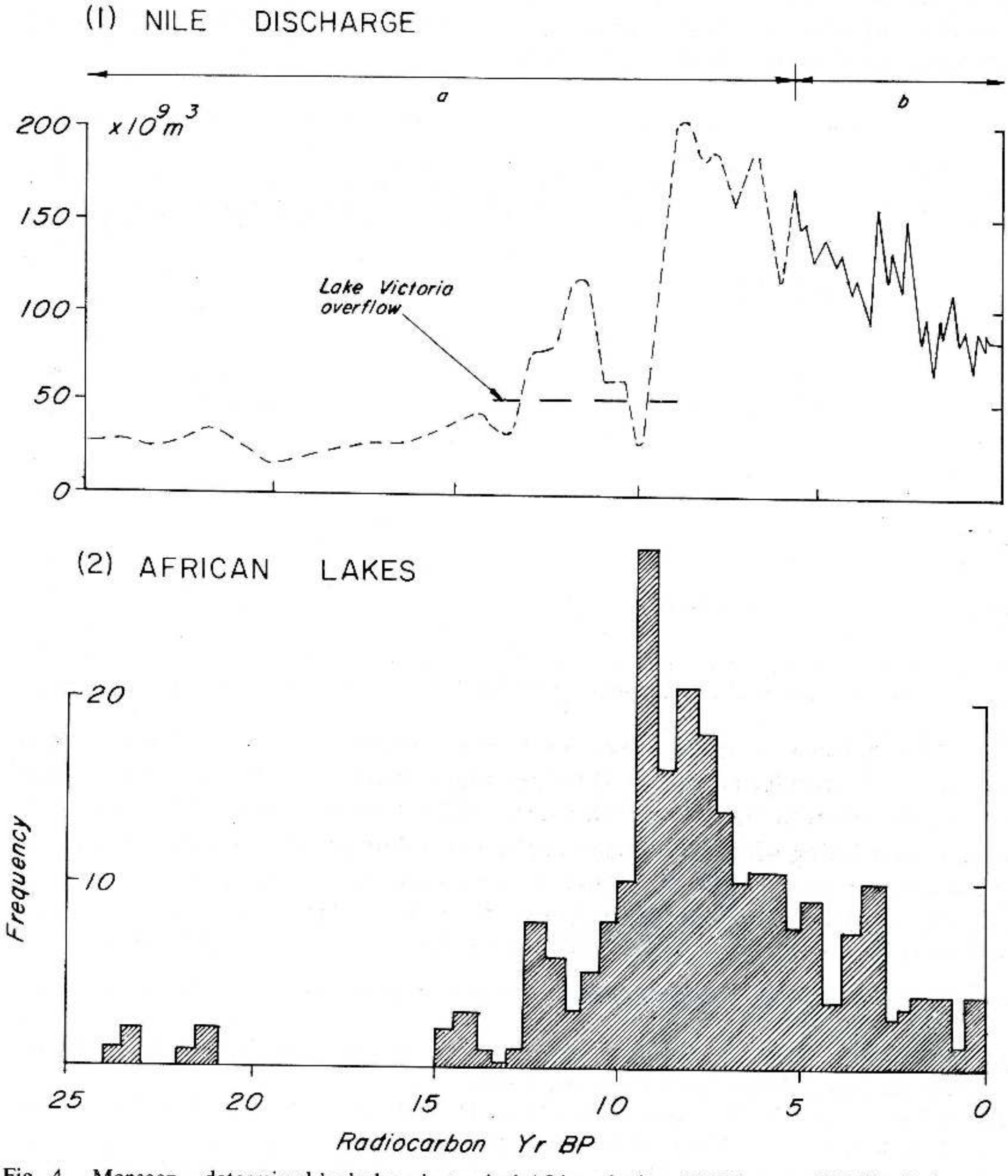



Fig. 4. Monsoon – determined hydrology in tropical Africa, the last 25,000 years: (*1*) Nile discharge: *a*, dated by $^{14}C$; *b*, by historical records. (*2*) Histogram of 238 $^{14}C$ dated records of high lake levels in tropical Africa – Tibesti, Chad, Niger oases, Mauritanian sebkhas, Hoggar, East African rift valley, Ethiopia, Sudan –independent of Nile and Lk. Victoria. Note commencement of pluviosity at ca. 15,000 BP (*after Fairbridge 1976:535; courtesy, author and publishers*).

been 3-6°C cooler than the present during the latter episode, and the boundaries between ecozones D1, D2 and D3 and of E would have been depressed by ca. 500m. Pluvial conditions may have prevailed at 12,800-12,400 BP (Bölling) and 12,200-11,400 BP (Alleröd) separated by a dry spell at 12,400-12,200 BP (Older Dryas). The end of the Pleistocene probably witnessed a brief dry spell at 11,400-10,300 BP (Younger Dryas) and the Holocene would have commenced with a pluvial at ca. 10,300 BP (Preboreal). Oxygen isotope data suggest that throughout the Pleistocene the warming up episodes were much more rapid than the cooling ones

(Flint 1971:425). However, climatically there would have been no direct transition from interpluvial to Holocene pluvial conditions, but rather an irregular oscillation of moister and drier conditions leading up to an overall pluvial during the Holocene (for glacial equivalents v. Butzer 1971:530).

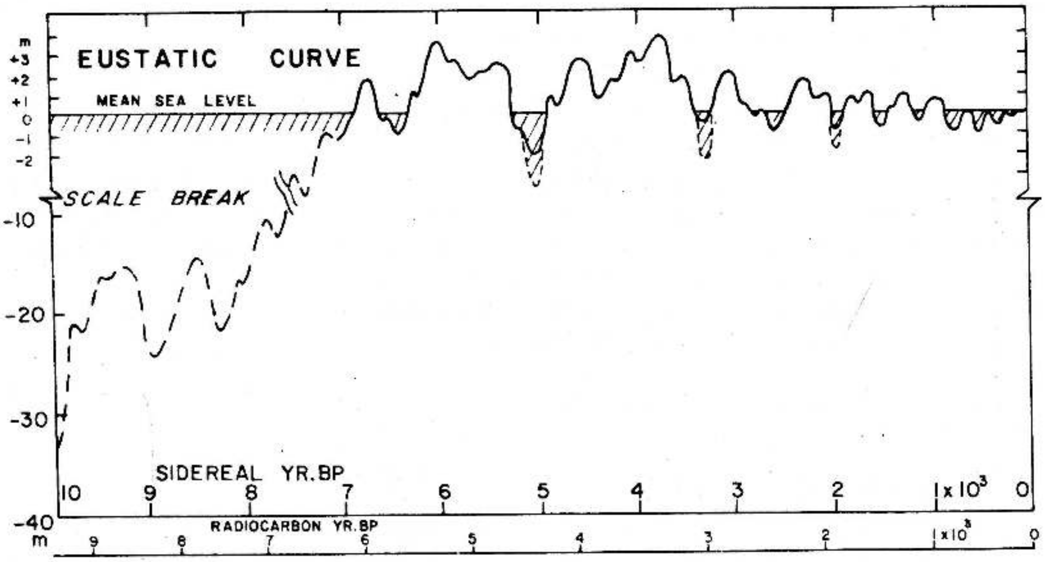



Fig. 5. Holocene eustatic curve based on synthesis of data from the tropics (notably Brazil), Scandinavia and Hudson Bay (*after Fairbridge 1976:546; courtesy, author and publishers*).

The Holocene climatic curve for Lanka probably conformed closely to that postulated by Fairbridge (1976:Fig.4) for peninsular India. There is likely to have been very wet pluvials at ca. 9,200-8,600 (Boreal), 7,000-6,600 and 6,300-5,300 sidereal BP, the latter two falling within the Atlantic optimum of Europe. Dry Neoglacials I and II are thought to have occurred at 5,300-4,500 and 3,600-3,400 sidereal BP respectively. The following scheme synthesised by Fairbridge (1976:Table 1; courtesy, author and publishers) may be employed as the model to be tested in Lanka (v. Addendum I):

*0-100 BP (1850-1950 AD)*: southern Sahara, semi-arid; African lakes, Chad, low; middle Nile, rather low; sea level, 0.

*100-800 BP (1850-1150 AD)*: southern Sahara, arid; African lakes, Chad, minor peaks; middle Nile, low; sea level, Paria regression.

*800-1,000 BP (1150-950 AD)*: southern Sahara, semi-arid; African lakes, Chad, low; middle Nile, low; sea level, Dunkerque III transgression.

*1,000-1,400 BP (950-550 AD)*: southern Sahara, arid; African lakes, Chad, minor high; middle Nile, rather high; sea level, regression.

*1,400-1,800 BP (550-150 AD)*: southern Sahara, semi-arid; middle Nile, low; sea level, Dunkerque II transgression.

*1,800-2,100 BP (150 AD-150 BC)*: southern Sahara, sub-humid; middle Nile, intermediate; world glaciers, Neoglacial IV; sea level, Florida low, -2m.

*2,100-2,400 BP (150-450 BC)*: southern Sahara, humid; African lakes, minor high; middle Nile, high; sea level, Dunkerque I, +1.5m.

*2,400-3,100 BP (2,300-2,800 $^{14}$C BP)*: southern Sahara, semi-arid; African lakes, minor low; middle Nile, rather low; world glaciers, Neoglacial III; sea level, regression.

*3,100-3,400 BP (2,800-3,000 $^{14}$C BP)*: southern Sahara, humid; middle Nile, high; sea level, Gippsland, +1.5m.

*3,400-3,600 BP (3,000-3,200 $^{14}$C BP)*: southern Sahara, arid; African lakes, low; middle Nile, rather low; world glaciers, Neoglacial II; sea level, Pelham Bay, -3m.

*3,600-4,900 BP (3,200-4,300 $^{14}$C BP)*: southern Sahara, humid; African lakes, Victoria, high;

middle Nile, high, maximum 3,700 BP; sea level, Younger Peron, +3m.

*4,900-5,300 BP (4,300-4,700 $^{14}$C BP)*: southern Sahara, arid; African lakes, low; middle Nile, low, minimum 4,900 BP; world glaciers, Neoglacial I; sea level, Bahama low, -5m.

*5,300-6,300 BP (4,700-5,500 $^{14}$C BP)*: southern Sahara, humid; African lakes, Victoria, high; middle Nile, high; sea level, Older Peron, +3m.

*6,300-6,600 BP (5,500-5,800 $^{14}$C BP)*: southern Sahara, sub-humid; African lakes, minor low; middle Nile, low; sea level, Ghana low, -1m.

*6,600-7,000 BP (5,800-6,200 $^{14}$C BP)*: southern Sahara, humid; African lakes, Victoria, Chad, high; middle Nile, high; sea level, Littorina I, Tapes II, Calais II transgressions.

*7,000-7,900 BP (6,200-7,000 $^{14}$C BP)*: southern Sahara, arid; African lakes, minor low; middle Nile, low; sea level, Rhine delta low, -10m.

*7,900-8,600 BP (7,000-7,800 $^{14}$C BP)*: southern Sahara, humid; African lakes, Victoria, Chad, high; sea level, Calais I, Tapes I transgressions.

*8,600-9,200 BP (7,800-8,500 $^{14}$C BP)*: southern Sahara, sub-humid; middle Nile, high; world glaciers, Cochrane; sea level, Ancylus low, -20m.

*9,200-9,800 BP (8,500-9,100 $^{14}$C BP)*: southern Sahara, humid; African lakes, high; sea level, Lytham I transgression.

*9,800-10,500 BP (9,100-10,300 $^{14}$C BP)*: southern Sahara, arid; African lakes, low; middle Nile, low; world glaciers, Valders, Daun; sea level, -35m.

There is always the possibility that cold ocean currents might have intruded into the neighbourhood of Lanka causing aridity during altithermals or intensified aridity during glacials (for a preliminary treatment of this subject of the upwelling of cold water off Lanka, based on faunal data v. Deraniyagala 1960*d*). Seasonal changes in mean daily temperatures could increase or decrease due to changes in ocean currents, particularly when certain currents are cut off due to the depression of mean sea level (Verstappen 1975:10). However, considering Lanka's equatorial location, it is somewhat unlikely that ocean currents would have appreciably modified the generalised sequence and pattern of climatic shifts during the Quaternary, and as such this factor may be disregarded pending evidence to the contrary (for currents around Lanka v. Deraniyagala 1971:207; Ahmad 1972:41; Arudpragasam 1974:66-7).

With regard to the intensities of the climatic oscillations, the evidence from India does not suggest pluvial/interpluvial rainfall fluctuation in excess of $\pm$ 25 per cent (perhaps less) in Lanka during the late Quaternary. This is substantiated by the data from Batadomba-lena and Beli-lena Kitulgala. The fluctuations might have been more accentuated during the Middle Pleistocene. The amplitude of the temperature and rainfall oscillations in Lanka would have been low throughout the Quaternary: temperature differences between the two extremes of glacial and altithermal conditions would have been mitigated by the cloud cover caused by the maritime environment, and as for rainfall, in the equatorial rain-forests of the Wet Zone even large changes in total rainfall would have made little difference since these areas have abundant rainfall in any case as far as the flora and fauna are concerned. The day-length, insolation and the wind systems determining the rainfall patterns would have remained constant, the only variables being the wind intensities, the total rainfall and the average temperature. It does appear as if the Southwest Monsoon was the dominant weather phenomenon of the region throughout the Quaternary. With temperature changes, the altitude-determined boundaries of vegetation Series D1, D2, D3 and E, and of the montane fauna would have fluctuated correspondingly. The data from the I Fm suggest that the vegetation in the Dry Zone had been scantier during certain altithermals, probably with an increase in the deciduous components as a result of increased aridity, which, due to lack of adequate cover, would have led to strong denudation during the winter cyclonic storms. This opening up of the habitat might have resulted in a slight increase of the mammalian biomass.

The theoretical basis of this work requires an examination of the interaction between man and environment in prehistoric Lanka (Chap.1.4). I have evaluated the abiotic and biotic environments of Lanka during the Quaternary, from which has emerged a picture of low amplitude climatic (and thence biotic) pulsations during this period. It is now necessary to consider the nature of the cultural sub-system in the island's prehistory.

# 5
# PREHISTORIC CULTURE

## 5.1 INTRODUCTION

The Quaternary environments of Lanka have been considered in the foregoing chapter. The present account concerns man's cultural adaptations, his "learnt behaviour", to those environments: they represent the cultural sub-system which would have interacted systemically with the environmental sub-system to constitute the human ecosystem.

As stated in Chapter 1.4, archaeological data are in most instances descriptive only of the "culture core" (v. Steward 1955:37) of subsistence economics and exploitative technology. Since it is the latter that is best represented in Lanka's prehistoric record, invariably in the form of stone artefacts, I shall consider technology before dealing with subsistence and settlement.

## 5.2 TECHNOLOGY

*5.2.1 Introduction.* By far the majority of the evidence concerning prehistoric technology in Lanka, as in most parts of the world, is lithic. I shall hence be devoting some considerable attention to the systematics of stone artefact classification as a prelude to the discussion of the substantive data. The classificatory system that is set forth below is designed to describe generalised assemblage-components. It is flexible and can be expanded indefinitely, outwards and within itself, to accommodate the full range of artefact categories that are likely to occur in Lanka – or elsewhere. I need scarcely point out that the basis of this system lies in attribute analysis as formulated by Movius (1968; Movius et al. 1968; Movius and Brooks 1971; Bricker 1973), a concept which I have amplified to deal with a wide variety of artefact categories ranging from those apparently nondescript "chopper/chopping" tools (v. Movius 1939:351,Fig.7) to the most sophisticated microliths.

*5.2.2 Lithic Systematics.* The two primary purposes of a classification comprise (*a*) the summarisation of data for descriptive purposes and (*b*) being an instrument for generating productive hypotheses (Doran and Hodson 1975:159). The relevant analytical units are arrived at by observing data, forming propositions and seeing what traits are relevant to the testing of these propositions (Binford 1968:25).

The basic concept involved in the definition of each category in a classification comprises intra-category cohesion and inter-category isolation (Cormack 1971). The critique of the Noones' (1940) and Allchin's (1958) systems of lithic analysis (Chap. 1.2) has indicated the necessity for a quantitative base as well as for the avoidance of overlap between taxonomic categories – which would nullify the concept of inter-category isolation. The present study does provide quantitative data from a sample of over 200,000 artefacts, which is far in excess of Noones' ca. 2,000 and Hartley's 4,768. With regard to the problem of overlap, the simplest and most direct method of avoiding overlap between, for instance, types and sub-types (the Noones and Allchin have employed these two taxa as their smallest descriptive units) is to break them down into their component attributes and to view types and sub-types as a polythetic patterned conglomeration of attribute-states. This system has been adopted in the present study – for the first time in the context of Lanka's prehistoric studies. It is opportune now to define the terminology employed in the following discussion of systematics, so as to obviate any risk of misinterpretation:

*Polythetic Group*: each entity of a polythetic group, such as a type, possesses a large number of the attributes of the group, and each attribute is shared by several of the entities; and no single attribute is both sufficient and necessary for group membership. This is the opposite of a monothetic group where possession of a unique set of attributes is both sufficient and necessary for group membership (Clarke 1968:38). The intuitive "type" corresponds closely to the concept of polythetic grouping (Doran and Hodson 1975:165; v. Clarke 1968:38 for evaluation of the comparative merits of polythetic vs. monothetic systems, with the former being favoured).

*Attribute*: the smallest qualitatively distinct unit involved in a classification (v. Dunnell 1971:49). Further, it may not exist by itself, since it constitutes a member of the basic unitary entity, the type. An attribute behaves as an independent variable (Clarke 1968:42,138; v. ibid. for detailed definition).

*Attribute-State*: represents an alternative value of an attribute (ibid.:145)

*Types*: are "populations of artefacts that are richly cross-connected amongst themselves in terms of affinity between their sets of attributes" (ibid.:191). Artefacts within a type category share a consistently recurrent range of attribute-states within a given polythetic set (ibid.:228).

*Class (Type-Class)*: a group of artefact-types characterised by a common component sub-set of attributes (ibid.).

*Sub-Type/Variant*: "an homogeneous sub-population of artefacts which share a given sub-set within a specific artefact-type's polythetic set of attributes" (ibid.:229). A variant bears the same relationship to a sub-type as a sub-type to a type.

Over the last two decades, typology, as a method of artefact analysis, has come in for criticism – particularly among the "New Archaeologists". However, on close scrutiny it is apparent that it is not the concept of the "type" that has been criticised, but the manner in which types have been formulated. It is fairly obvious that in considering any sample of stone artefacts each *unitary* artefact requires a taxon to which it can be fitted: namely, without fragmentation at the level of attributes or coalescence at the level of "assemblage" or type-class (v. ibid.:228). In other words, it should be possible to assign each artefact to its type or sub-type categorisation as being descriptive of the artefact as a unitary whole. A partial description, such as that provided by the categorisation of an attribute, or a gross blanket description such as is provided by categorisation under a taxon at a higher hierarchical level than "type", do not describe the artefact with adequate precision: an attribute constitutes one trait of an artefact, and a group, class or assemblage comprises several artefact-types.

The basis of any classification of artefacts is the description of the individual artefacts. As argued above, it is the taxon of "type", as opposed to "attribute" or "assemblage", that constitutes the relevant analytical unit for effecting such a description (v. Smith and Williams 1979:538; Dunnell 1971:76 for definitions of the term "taxon"). It should be noted that even the Binfords' (1966) pioneering efforts in factor analysis still accepted and employed Bordes' (1961) list of intuitively created types as their point of departure. Hence, having adopted the taxon of "type" as the datum for lithic, or, for that matter, any artefactual analysis, it is important to examine how types can best be constructed.

As stated earlier, the most precise and convenient method of creating types is to break each artefact down into its component attributes and to record their "states". It will then be observed that these attribute-states cluster polythetically in apparently non-random fashion to form types. Having created the type it is then possible, if necessary, to break it down into sub-types, and sub-types into variants, on the basis of patterned variation within the type itself (v. Type-List below). It will be noted that the creation of a type from attributes constitutes an ascent up the taxonomic hierarchy, an "agglomerative strategy" (Doran and Hodson 1975:160; v. Clarke 1968:137 for defense of this strategy); whereas the subsequent creation of sub-types and variants is a descent in the taxonomic hierarchy, a "divisive strategy" (ibid.). The clear implication is that the entire classification is grounded on the attribute-system which has been adopted (v. Bricker 1973:706ff for the application of the concept of attribute-system in a tool-specific context).

How does one select an attribute-system for a classification? Before one seeks to answer this question it is necessary to ask what the classification is for in the first place. It is a platitude, but nonetheless true, that all analytical systems should be geared to and moulded to the purposes of a particular project or study (Binford in Collins 1967:300; Dunnell 1971:25). It will be recalled (Chap.1.3) that Lanka's prehistory lacks so much as a basic chronological framework. Hence, the lithic analysis in the present work is designed, primarily, for obtaining as clear an answer as possible as to whether a given artefact or artefact assemblage is technologically and stylistically Palaeolithic or Mesolithic, and if the former, whether it is Lower, Middle or Upper Palaeolithic as per the system employed in India. The classification is devised so as to be applicable beyond the last stage of the present research design while ensuring inter-stage comparability; at the same time a situation of "over-kill" is being guarded against, in terms of the meaningless accumulation of data with reference to foreseeable additional stages to the current research design. In selecting the attributes to form the system designed to meet the above requirements, a prerequisite was the scrutiny of an "artefact" in terms of its non-tool-specific traits (v. Bricker 1973:xvii). In doing so I have adopted the model of an artefact comprising a systemic interaction of stylistic, functional and technological traits, since the generative impulses for an artefact type comprises intended function, available technology and materials, and stylistic tradition (v. Doran and Hodson 1975:165-6).

Style has been defined as the formal variation in material items that is inexplicable in terms of function or technology (Binford and Binford 1966:240). Stylistic traits are considered to result from choice, from a number of possibilities which could produce the same functional end-result (Deetz 1965:46). These traits frequently display quantitative trends through time and space (ibid.:54) and are peculiar to a given space-time locus (Sackett 1977:370). Function concerns the ends an artefact serves and the roles it performs (ibid.). However, it is imperative to observe that "even the most functional attribute has some idiosyncratic [stylistic] degree of freedom" and vice versa (Clarke 1968:142; also v. Sackett 1977:370), and that the style/function dichotomy can, in the final analysis, be interpreted as a convenient heuristic device. As for technology, it constitutes a major constraint on both style and function – hence the concept of systemic interaction between these three (or two) variables of style, function and technology.

With regard to the primary target of achieving chronological resolution for the artefact sample, style and techonology loom significant in their anaytical utility (v. Movius in de Terra et al. 1943:351; Clarke 1968:212-4; Sackett 1977:370). On the other hand, function is relevant to an assessment of subsistence strategy in the culture "core": "a statement about activity concerns the functional mode of artefact variability; a statement about culture-historical context, that is tradition, concerns its stylistic mode" (Sackett 1977:371). In concrete terms, although perhaps not directly applicable in the case of Lanka, there was the stylistic and technological progression through time of amorphous chopping and cutting tools → Acheulean bifaces → Mousterian scrapers and points → Upper Palaeolithic blades → Mesolithic geometric microliths (v. Butzer 1971:609). In terms of function, a chopper remained a chopper, a scraper a scraper, a point a point, and a nucleus a nucleus through this entire span of some 3 million years (in the case of Africa) (v. Mellars 1970:85; Bricker 1973:87). Hence, in the present analytical system certain attributes such as "trimming " and "plan-form" (v. below for their definitions) were selected for their bearing on stylistic and technological factors, while others such as "apparent function", presence of "use marks" and "functional cross-section" were chosen for the light they might shed on past function. The attributes of size and raw material are relevant to all three categories of style, technology and function, depending on individual situations. An attribute-system was selected for the present project and the attributes recorded as present or absent on each artefact. If present, the precise attribute-state was defined (for development of attribute-system v. S.Deraniyagala 1971*a*; 1972; S.Deraniyagala and Kennedy 1972). The concept underlying the choice of this attribute-system is that it always is expedient that attributes be reduced to the smallest number that could reasonably be expected to provide a general description of the shape, size, raw material, detail and contextual data of a given artefact (v. Clarke 1968:141), it being vital to strike a "reasonable balance between simplicity and adequacy" (Doran and Hodson 1975:225), thereby securing operational manageability. Some of my "attributes", such as "trimming" and "apparent function", are in fact attribute-complexes comprising groups or clusters of apparently closely inter-correlated attributes (v. Clarke 1968:141). Further, in accordance with the proposition that it is often only by grouping values that the general characteristics of an attribute are revealed (Doran and Hodson 1975:124), I have (as in the case of cross-section and size) "split the range of a given continuous measurement into divisions and treated each division as a state of an unordered multi-state attribute" (ibid.:170). The attribute-system and the associated range of attribute-states are as follows:

(1) *Provenance,* a self-explanatory contextual attribute

(2) *Trimming* is essentially a technological attribute reflecting the manufacturing process (v. Crabtree 1972:93). It is divisible into primary trimming, which in the case of flakes applies to pre-detachment alteration on the nucleus (v. Bordes 1969:4) (e.g., lunates with primary backing), and secondary trimming which is coterminous with retouch in its generally accepted sense of post-detachment alteration by deliberate flaking (v. Coles and Higgs 1969:55). Wherever trimming is not explicitly designated "primary", secondary trimming is implied. Trimming may take the form of flaking procedure, pecking (hammer-dressing), grinding, polishing or drilling. Unless otherwise stated, the term trimming will refer exclusively to flaking-trimming, which may be executed unifacially (on dorsal or ventral aspect), bifacially or polyfacially. The attribute-states for trimming, as well as the relevant miscellaneous descriptive terms, are as follows:

(*a*) *Form-trimmed*, where the trimming has apparently been directed at securing a specific preconceived plan-form (v. below) such as a triangle. Form-trimming is executed through one or more of the remaining categories of trimming, such as backing or body-trimming, and as such it merely constitutes a qualifier to these latter categories.

(*b*) *Edge-trimmed*, where the trimming has been directed at obtaining a specific morphology for the apparent functional part or parts of a tool. Edge-trimming may take the specific aspect of burin spall, or tranchet flake, removals. The notching in evidence at the fracture point(s) of microburins may also be considered a category of edge-trimming. In point-tools (as opposed to edge-tools), the edge-trimming could comprise blunting retouch – as in the case of an awl on a microlithic backed lunate.

(*c*) *Body-trimmed*, where the trimming has apparently been directed at obtaining a desired size or cross-section, but which (unlike form-trimming) does not significantly control the plan-form. The flaking in evidence on flake-nuclei can be categorised under body-trimming, although the apparent function is not so much to affect the core's size or cross-section as to its being a concomitant of the production of suitable blanks. The explicitly technological traits associated with the production of Levallois flakes and points, flakes from discoidal and spheroidal nuclei, and of true blades, fall within the overall category of body-trimming (v. Type-List for description of spheroidal cores). Note that whenever the exact status of an artefact as to whether it is a blade or flake is unclear, as is often the case with retouched tools, I have opted to describe the specimen as a flake. The pecked or drilled dimple-pitting which occurs on certain nut-stones and hammer-stones could also be considered body-trimming, as could the deliberate alteration of form by abrasion-faceting.

(*d*) *Blunting-trimming* is the converse of edge-trimming (v. Coles and Higgs 1969:60), and is apparently directed at blunting an edge. As for the location of the blunting-trimming, it may be executed along a lateral edge, when it is termed *backing*, or along the distal or proximal end of an artefact, which is termed *truncation* (v. Movius 1968:243), and it can also occur perimetaly. In the case of curved backs, as for example in microlithic lunates and semi-lunates, the backing merges imperceptibly with the truncation and it will be referred to simply as backing rather than backing *cum* truncation. Truncation implies an abrupt break of line with reference to a lateral edge. Blunting-trimming is frequently employed in form-trimming, as in the category of geometric microliths; similarly, edge- and/or body-trimming are at times constituents of form-trimming.

(*e*) *Retouch-scar morphology* has been rather sparsely treated in this classificatory system, since it is not exactly relevant at the present broad scale of attribute analysis (for aspects of retouch-analysis v. Sankalia 1964:41; Movius et al. 1968:4-8; Crabtree 1972:87; Bricker 1973:229-243). However, stepping and feathering of

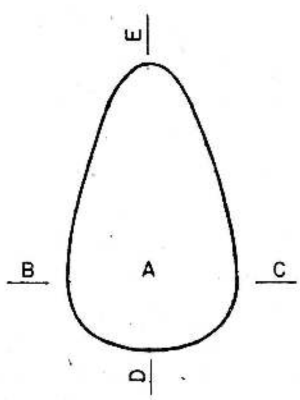



Fig. 6. Planes of orientation: *A*, longitudinal lateral section, or frontal plane; *B-C*, longitudinal transverse section, or transverse plane; *D-E*, transverse section, or sagittal plane.

flake boundaries (v. Crabtree 1972:63 for definitions), depth of removals, nibbling or rasping retouch, and the degree of invasiveness have been described wherever these attribute-states are of apparent significance.

(3) *Plan-form (blank contour)* (refers to the form of an artefact in its longitudinal lateral plane of orientation (for planes of orientation v. Fig.6; Crabtree 1972:74,273). The well-established usage of referring to the general shape of an artefact as lanceolate, amygdaloid, ovate or lunate (v. Mason 1967:744-5; British Museum 1968) is essentially concerned with plan-form. This attribute is of considerable diagnostic value in the case of form-trimmed artefacts, such as geometric microliths (which comprise small lunates, triangles and trapezoidals) with blunting retouch serving to define a specific plan-form. It is, on the other hand, of relatively insignificant analytical utility for non-trimmed artefacts. There are 34 plan-form states; future work will undoubtedly increase this number and it might become necessary to sub-divide some of the present categories, perhaps on a bivariate metrical basis such as that employed by Roe (1964; 1969). However, for present purposes the current list of attribute-states is adequate and these are set out in Fig.7; supplementary descriptions follow:

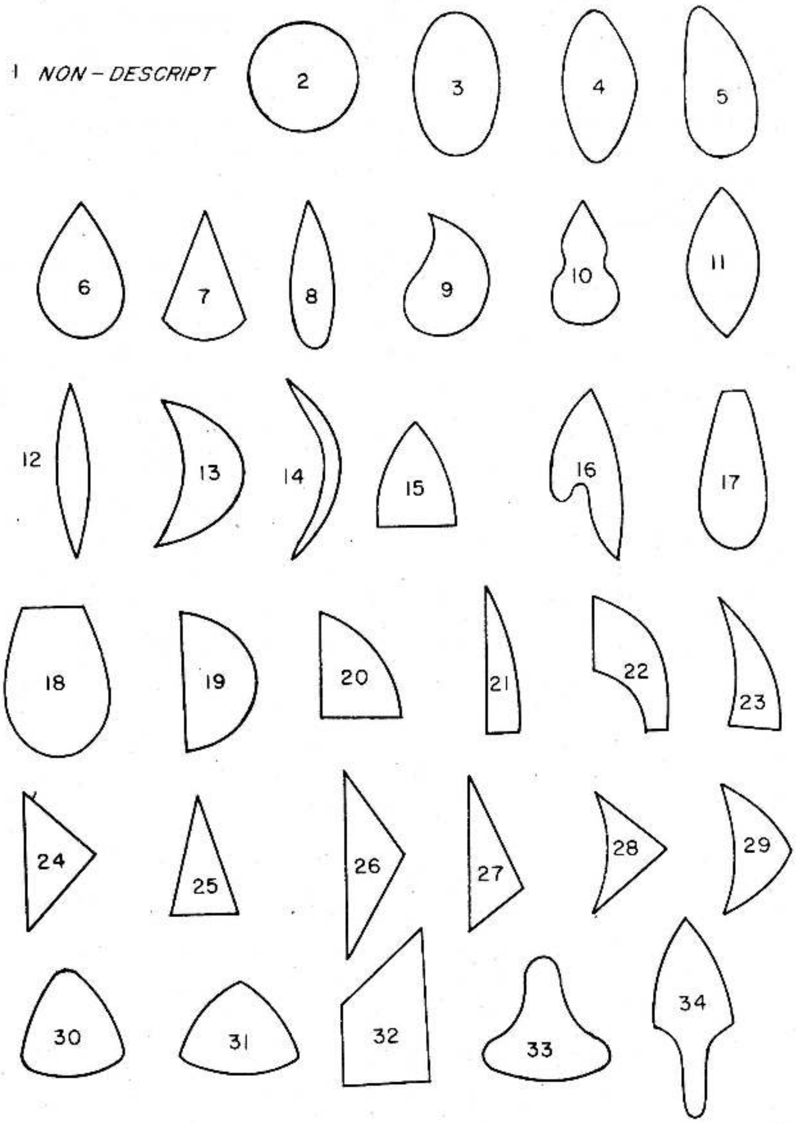



Fig. 7. Classification of lithic plan-forms

1. All non-descript plan-forms
2. Discoidal
3. Ellipse
4. Amygdaloid
6. Hemi-lemniscate (v. Mason 1967:744-5)
7. Sector (v. *Time Saver Standards* 1954:16)
8. Elongate hemi-lemniscate
11. Opposed arc
12. Elongate opposed arc
13. Crescent
14. Elongate crescent
19. Lunate; segment
20. Semi-lunate
21. Elongate semi-lunate
22. Shouldered semi-lunate
23. Semi-crescent
24. Equilateral triangle
25. Acute-angled isosceles triangle
26. Obtuse-angled isosceles triangle
27. Scalene triangle
28. Hollow-based triangle
32. Trapezoidal; quadrilateral
33. "Nosed" form
34. Tanged form

Note that a full range of gradation exists between certain categories such as ellipsoid and opposed arc, semi-lunate and plan-form 15, hemi-lemniscate and amygdaloid. Hence, the precise identification of an artefact with any one of these attribute-states is at times a matter of subjective assessment.

(4) *Apparent function.* It is necessary to stress that this attribute, or rather attribute-complex, is defined by morphological criteria as opposed to strictly functional ones; hence the appellation "apparent" preceding the term "function". Short of embarking on wear pattern analyses, there is no way one can progress into the realm of hypothesising about "actual" function, there being no one-to-one relationship between form and function. The apparent functions are initially categorised under "point-tools", "edge-tools", flake-producing nuclei, waste, bolas-stones, hammer-stones, mullers, grindstones, mace-stones, nut-stones pigments and abrasives.

Artefacts with retouch and/or use marks along the functional part or parts can be referred to as implements. It is often the practice that specimens devoid of these traits are categorised as waste or "debitage" (v. Leakey 1971:108; Bricker 1973:83); however, a methodological innovation which has been devised in the present system is the inclusion of a category of "potential tools". These lack retouch or macroscopic signs of utilisation; but they possess an apparent functional part or parts which in extent of regularity and symmetry, positioning relative to plan-form, and robusticity, have counterparts in the apparent functional parts of retouched or evidently utilised tools. Recent investigations of archaeological kill-sites (Clark 1970), as well as ethnographic evidence (e.g., Elkin 1948; Campbell and Edwards 1966; Gould 1968), indicate in no uncertain terms that a stone artefact need not display macroscopic use marks or retouch as concomitants of its having been in fact employed as a tool. This is common sense; but it is frequently ignored. Hence, any analysis of stone artefacts which does not take into consideration those specimens which do not display signs of retouch or evident use could be accused of throwing away a large segment of potentially useful data, since these objects might well in fact have been used as tools. It is indeed quite probable that several of these potential tools would display physical signs of use on examination under a microscope, and it would be well worth the effort of checking on this hypothesis. Of course, it might be argued that the above definition of a potential tool smacks too much of subjectivity; but there does not seem to be an alternative, and microscopic examination is an extremely laborious process in comparison – to which is added the hazard of totally misinterpreting micro-wear data due to their being dependent on too many independent variables which obviate any possibility of even remotely unequivocal interpretations.

The attribute-states for apparent function are as follows; the first overall category comprises point-tools:

(*a*) *Projectile points*, termed simply "points", are designed for maximum penetration upon impact without any further application of pressure. They are generally more streamlined and symmetrical than other categories of point-tools.

(*b*) *Awls* are designed for penetration, which is not necessarily deep, with continuous application of pressure, coupled perhaps with a rotary action.

(*c*) *Picks* are not pointed enough for convenient penetration of organic materials, but are adequately robust for breaking up inorganic materials.

(*d*) *Barbs* are perimetaly blunted artefacts which could also be classified under edge-tools

The second overall category comprises edge-tools and these are denoted in the strictly morphological terms of (*a*) edge-angle; (*b*) the position of the edge relative to plan-form; (*c*) the degree of concavity or convexity of the edge when viewed in the longitudinal lateral plane of orientation, namely on plan-form; and (*d*) the number and position of edges relative to each other.

(*a*) *Edge-angle* is estimated on the basis of the spine-plane angle as outlined by Tringham et al. (1974:11), the relevant spine being that which is nearest to the edge. Should there be no spine within the hypothetical contact zone of the edge with respect to the material being worked, the measurement comprises the angle at the intersection between dorsal and ventral surfaces as projected from ca. 2mm inside (mesially) of the edge. The attribute-states of edge-angle are:

i. *Cutter*: edge-angle less than 40°; this category includes "transverse points" (v. Sankalia 1964:73).

ii. *Scraper*: edge-angle 40-90°

iii. *Chopper*: edge-angle less than 90°; the edge is too blunt or sinuous in longitudinal transverse or transverse view for scraping or cutting but functional when employed with a chopping action which relies more on impact than steady pressure for its effect. Sinuosity can be defined metrically by an index of sinuosity, although this has not been effected in the present study, the assessment being by eye. Of course, it is often the case that scrapers or cutters could conceivably be employed as choppers; but these are not designated "choppers", since morphologically they are scrapers or cutters.

iv. *Adze*: an end-chopper with a plano-convex longitudinal transverse section through the edge.

v. *Burin*: characteristically formed by the removal of burin spalls to produce a transverse functional edge at right-angles to the longitudinal lateral plane (v. Movius et al. 1968); the working axis (v. ibid.:23,29-30; Bricker 1973:225,706ff) bisects the longitudinal transverse or transverse planes, but not the longitudinal lateral plane.

vi. *Pounder*: edge-angle 90-180°; it is too blunt for chopping but suitable for pounding or crushing. The obtuse-angled edge between striking platform and flake removal face of a nucleus does not qualify for this category in the present study, although an extension of this classificatory system might require its consideration at some future stage.

(*b*) *Position of an edge or edges relative to the plan-form* is expressed, for instance, as side-scraper or end-scraper (v. Movius and Brooks 1971:256). Here, the attribute-states of this category are defined according to the ratio of edge length – which is the chord of the edge, the straight length as opposed to the length over the curves – to the maximum width of the artefact. The attribute-states are (Fig.8):

i. *Side*-edge: which exceeds 1.5 times the maximum width

ii. *End*-edge: which is less than 0.66 of the maximum width

iii. *Intermediate*-edge: This category is left without designation in the descriptions of the artefacts (v. App.II); but wherever neither a "side-" nor "end-" edge is denoted, an intermediate-edge is implied with its length 0.66-1.5 times the maximum width.

It is necessary to note that "edge", as considered above, refers to the hypothetically functional part which may or may not extend along the entire side or end of

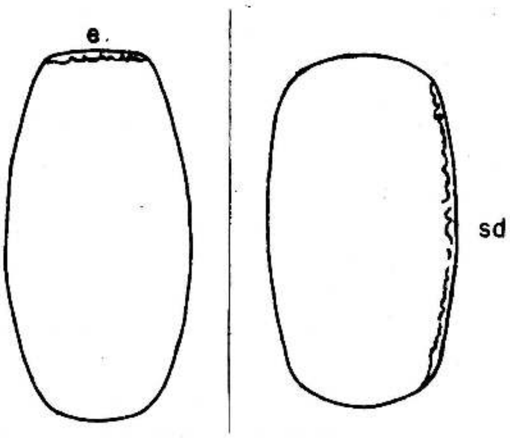



Fig. 8. Edge proportions: $\leqslant e$, end-edge; $\geqslant sd$, side-edge

an artefact.

(*c*) *Edge concavity/convexity* comprise the following attribute-states when viewed in the longitudinal lateral plane of orientation:

i. *Straight*
ii. *Convex*
iii. *Concave*
iv. *Non-descript*, which is not denoted with any designation in the descriptions of artefacts.

Further sub-division of this category of edge-convexity, as envisaged in the metrical scheme of Movius et al. (1968:13,18) and Movius and Brooks (1971:263), has not been assayed, since such detail is redundant for the specific goals of this classificatory system.

(*d*) *Number of functional edges* is denoted by:

i. *Single*
ii. *Double*
iii. *Treble*
iv. *Multiple*

(*e*) *Position of the functional edges relative to each other* is denoted as follows (v. Leakey 1971:6):

i. *Parallel*
ii. *Convergent*
iii. *Perimetal*

The remaining attribute-states of apparent function comprise the following:

(*a*) *Preforms* (v. Crabtree 1972:42,85 for definition)
(*b*) *Nuclei* (flake-production cores)
(*c*) *Waste*
(*d*) *Bolas-stones*, which are near-perfect spheroids manufactured by flaking and probably bouncing stone on stone.
(*e*) *Hammer-stones*
(*f*) *Mullers* (manos)
(*g*) *Grindstones* (metates)
(*h*) *Mace-heads*, which are perforated hammer-stones
(*i*) *Nut-stones* (anvil *cum* grindstones), which are slabs of crystalline rock with numerous dimple pits on one or more surfaces.
(*j*) *Pigments*
(*k*) *Abrasives*
(*l*) *Multiple function* artefacts, such as scraper *cum* point or hammer *cum* muller, will

be described according to the same conventions as those used for single-function artefacts. The apparently predominant function is placed first in the description; for instance, in a "scraper *cum* cutter" the scraper is dominant.

(5) *Use marks.* This attribute, with reference to the postulated apparent function of an artefact, comprises the two states of present or absent as macroscopically apparent to the naked eye. The statements (under apparent function) concerning potential tools are relevant to this attribute as well, in view of the possible presence of microscopic use marks on "potential" functional parts.

It is not always easy to distinguish between retouch and use; for instance, hinge-fractures along the functional edges of large tools could be due to resharpening and need not be the result of use alone (Crabtree 1968:428) and many repeatedly retouched implements may come to the archaeologist in a non-functional condition which could resemble blunting retouch (Frison 1968; Keeley 1974). Hence, I have employed a subjective assessment of regularity of shape and distribution of removals to distinguish retouch from use marks. Use marks are "removals which are too small, too irregular, or too discontinuous reasonably to be considered intentional retouch" (Bricker 1973:305; also v. Tringham et al. 1974:12).

As for micro-wear, the independent variables affecting this sub-attribute comprise (*a*) the flaking properties of the raw material of the artefact; (*b*) the profile of the functional part; (*c*) the mode of use; and (*d*) the nature of the material on which the tool is being used (Keller 1966:501). Depending on the intermeshing of these variables, the degree of visible micro-wear (at up to 40 magnification) can range from none at all to a very high degree of wear and blunting; and it is not at all simple to evaluate the relative significance of each of the controlling variables governing the configuration of the use marks, which diminishes the usefulness of micro-wear analysis in its application in a broad-scale study such as is envisaged in the present project. Hence I have chosen not to indulge in spending the inordinate amount of time which is a concomitant of micro-wear analysis.

(6) *Raw material.* The categories of raw material fall within four major classes: quartz, chert, chalcedony, igneous crystallines (such as gneiss), and pigment materials. Quartz and chert are sub-divided according to opacity and other colour properties, and granularity (which affects flaking propensities) (v. Parker's 1909:63 reference to Pole in *Ceylon Observer* of 8 Aug. 1907; Parsons 1908:176; Leakey 1953:31). Further particulars concerning the raw materials employed will be provided under the sub-heading which deals with stone tool technology. The attribute-states for raw materials are as follows:

(*a*) *Quartz*
- i. *Clear* quartz (rock-crystal)
- ii. *Milky* quartz
- iii. *Granular milky* quartz referred to as granular quartz
- iv. *Rose* quartz
- v. *Granular rose* quartz
- vi. *Rutile* quartz
- vii. *Amethyst*

(*b*) *Chert*
- i. *Translucent* chert
- ii. *Opaque* medium-grained chert (referred to simply as "chert")
- iii. *Granular* chert

(*c*) *Chalcedony*

(*d*) *Igneous crystallines* (v. Deraniyagala 1943:95; Cooray 1967)
  i. *Gneiss*
  ii. *Diorite*

(*e*) *Pigments* and *miscellaneous materials*
  i. *Red ochre*
  ii. *Graphite*
  iii. *Mica*
  iv. *Pumice*

I have not considered patination, specifically of chert, to be an analytically useful sub-attribute, since too many independent causative variables are involved (v. Hurst and Kelly 1961:253-5). These variables are: (*a*) the texture and micro-structure of the material; (*b*) its permeability; (*c*) the variety, proportion and distribution of impurities; and (*d*) environmental factors such as temperature, the concentration of alkalis or acids in the groundwater, and the volume and rate of circulation of groundwater. Hence, it is not possible to employ degree of patination as a chronometric index – not even on a relative basis – and, as for environment, there is no certainty as to which point in the time scale an environmentally diagnostic patina might refer to.

(7) *Cross-section.* The traditional division of lithic artefacts into "flake-" and "core-" tools has been discarded in the present classificatory system, since this flake vs. core dichotomy has little chronological or technological significance. Flake-tools existed side by side with the earlist core-tools, as in Africa (Leakey 1971) and the choice between employing blanks of pebble cores and of flakes derived from massive rock would have, in large measure, been dictated by the nature of the raw material available. On the other hand, cross-section as an attribute supplies data as to the "chunkiness" of an artefact, which is but indirectly afforded by the division into flake and core categories.

Cross-section assessment must necessarily be relevant to the apparent functional part of an artefact (Bricker 1973:227) and it is best executed through a thickness:width or length ratio, which is a development on Movius and Brooks (1971:257,260). The different states of this attribute are denoted in terms of the ratio of the maximum thickness of the artefact to the maximum length of its working axis which intersects the functional part of the artefact at approximately 90° on any one of the three planes of orientation. The following heuristic states, comprising units of subjectively grouped data, are recognised (Fig.9):

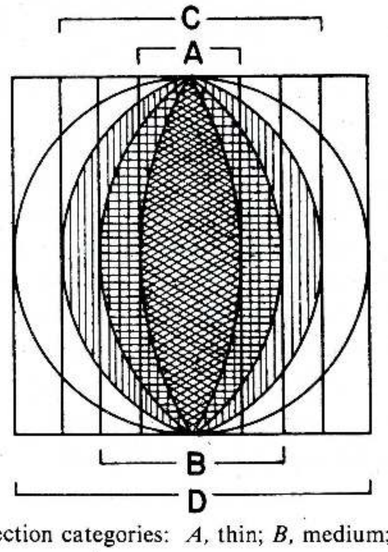



Fig. 9. Lithic cross-section categories: *A*, thin; *B*, medium; *C*, thick; *D*, very thick

(*a*) *Thin*: 1:> 4
(*b*) *Medium*: 1:4 –1:2
(*c*) *Thick*: 1:2 –3:4
(*d*) *Very thick*: 3:4 –⩾ 1:1

As for artefacts with more than one functional part, it is the cross-section through the apparently dominant part that is considered. The attribute of cross-section is non-applicable in the cases of waste, mullers, grindstones, nut-stones, pigments and abrasives. With regard to nuclei, which lack a working axis, the cross-section ratios are given on the basis of maximum thickness:maximum length.

(8) *Size*: is denoted in terms of the maximum straight length of an artefact (v. Movius et al. 1968:9) with the data on plan-form and cross-section supplementing this information (v. Leakey 1971:4). As with cross-section, I have subjectively divided the size categories into three heuristic classes:

(*a*) *Small*: less than 4.5cm
(*b*) *Medium*: 4.5-8cm
(*c*) *Large*: over 8cm

The term microlith is reserved for small artefacts which have been form-trimmed with blunting trimming. Hence, this term is not coterminous with "small" artefacts. Bladelets refer to small (< 4.5cm) blades (v. below for definition of a true blade).

So much for the attribute-system adopted in this classification. It might be objected that the attributes considered are not on adequately small a scale as to be of analytical use. However, considering the very broad nature of the goals involved – unlike for instance a study in variability of a single well-established artefact type such as a Gravette Point (or certain categories of burins) – the scale of the attributes employed cannot be considered excessively coarse. Should it ever become necessary to conduct an attribute analysis at a more detailed level for the specific purpose of resolving a different set of problems, it would always be possible to effect this by referring back to the original collections. It is superfluous and uneconomical to worry about such an eventuality at this stage, since attribute analysis constitutes a phase in lithic analysis which may follow the initial construction of hypothetical types, but it may not precede the latter. With regard to attribute scale, Doran and Hodson (1975:93-102) affirm thus and are particularly relevant:

> If there is a contrast between quantification and a traditional approach it is in the degree of precision rather than in the approach itself.... Superficially, it might seem simplest and most reasonable to reduce different morphological aspects to the lowest feasible descriptive level [i.e., small-scale attributes]; on the other hand, this may give a semblance of objectivity... [which] may be illusory since the more parts that are defined, the more difficult it may be to record structural relationships between them.... It could be argued that the most realistic description of artefacts would be given by attributes defined at the highest [largest scale] and not the lowest possible level of the hierarchy.... One posible approach might be to define low level attributes but then to group them mathematically into attribute *factors* of some kind.... This mathematical approach involves the difficulty of distinguishing between "statistical" and "meaningful" correlation... and also the general difficulties of factor analysis.

Indeed, it will perhaps be noted that the detail in which the lithic finds have been analysed in Stages II and III of this project is in excess of the immediate requirements of testing the hypotheses concerned. This is not entirely due to an error in judgment. It is proposed to store the resultant data on attributes in a data bank to be drawn upon in future studies. The method of analysis is very rapid in its execution, and it cannot be said that there has been a significant waste of resources attendant upon its application. It does succeed in describing the range of variability present within the assemblages with much greater clarity than has been possible under the previous systems, and this alone should suffice to justify its adoption. Select sub-sets of artefacts or attributes could readily be located for detailed treatment, as in modal analysis or partitive classification (Rouse 1966:91; 1972:55), once the data have been suitably stored (v. Sabloff and Smith 1969:278-83 for discussion of the type-variety analytical system used in conjunction with modal analysis, and Soudsky's (1967; 1968) data bank for Neolithic pottery based on the quantification of attribute-states).

The manner in which the traits considered above tend to cluster in a patterned and apparently non-random fashion provided the basis for the construction of an expandable list of classes, types, sub-types and variants. It is no exaggeration to say that after Movius' (in de Terra et al. 1943:351-72) pioneering work on the description of the chopper/chopping tools of Burma no one has assayed a frontal attack on the unglamorous problem of describing and classifying those artefacts which do not conform to clear-cut types such as Acheulean bifaces or Upper Palaeolithic Gravette Points. The tendency among scholars has been to disregard the "amorphous" elements completely or simply to select a set of attributes such as edge-angle or length/breadth ratio (e.g., Clark 1967:34-5; Murty 1968:89) for a specific study in hand; an overall classificatory system which would permit the reader to visualise such an artefact in its entirety has not been devised. The system formulated for the present research project fulfills this requirement to a large extent. It is primarily a descriptive system, a hypothetical entity which has yet to evolve into an explanatory system through controlled testing of hypotheses. The type, sub-type and variant list is very expansive compared to the efforts of previous workers on Lanka's Stone Age, namely the Noones (1940) and Allchin (1958), and the characteristic range of attribute-states for each type, sub-type and variant is stated with adequate explicitness as to avoid the overlapping of categories. Another considerable advantage in the present system is that it is possible to add or subtract categories from the Type-List without recourse to major alterations in the structure of the system; and the agglomerative strategy employed in the formulation of types ensures unequivocally that a type is "a tentative hypothetical class to be re-examined, corrected and amplified from time to time as evidence accumulates . . . it is a category in the process of formulation instead of a fixed standard of reference" (Shepard 1956:315). In this respect the present system avoids one of the major methodological flaws in Bordes' (1961) classification of French Palaeolithic tools, namely that Bordes does not "allow types to be reassessed and if necessary changed as evidence about the target population for which they are intended itself changes. The long-term, fixed, detailed type-list is simply not flexible enough *a priori* for progressive [*sic*] archaeological research" (Doran and Hodson 1975:106).

There is no denying that intuition has played no small role in the selection of what might be termed a "representative" range of attribute-states as well as in the "recognition" of non-random and culturally patterned clustering of attributes which contribute towards the definition of types in the present list (v. Movius et al. 1968:2,54; Movius in Collins 1969:308). But is there really a substitute for intuition at the basic level of creating the structural components, the "bricks", for a taxonomic system? "For . . . multivariate situations (conflicting modality within sets of attributes, or multivariate modality), numerical taxonomy *hopes* [my italics] to provide a solution" (Doran and Hodson 1975:172). There are the sophisticated statistical techniques of clustering, for instance the important variants of Principal Components Analysis such as Principal Co-ordinates Analysis (v. Hodson 1969), which could perhaps lead on to Rotational Fitting and Constellation Analysis (v. Azoury and Hodson 1973; Newcomer and Hodson 1973) or K-Means Analysis, to create types based on quantifiable attribute-states on an interval scale. These techniques cannot be usefully applied when the artefact sample exceeds around 50 specimens (Cowgill 1978:pers. comm.); and when one is dealing with a sample which runs into several hundreds of thousands of artefacts, and when the attribute-states are considered within a nominal scale, the complexities of statistical procedure grow overwhelming and they become very expensive on time and energy – to add to which there arises the considerable probability of losing sight of the wood for the trees (for comments v. Dunnell 1971:184).

> *Problem solving (smart guesswork)*: It is a sobering thought that the only way to solve many complicated problems is still by trial and error. What is more, even the fastest computers take far too long to try all imaginable solutions. The impatient engineer has to start his calculations from a good guess and *then* [my italics] use mathematics to improve on it. . . . The trick has been to guess at the answer, and then see if fiddling with any of the variables gives a better solution. . . . For some problems, with computers to do the respective calculations . . . the computer can get trapped in what is called a local optimum. The snag is that the local optimum [may] not [be] the best of all solutions [*The Economist*, 28 July-3 August 1984:70-1].

Hence, I have opted to rely on those most complex of statistical procedures (with their infinite nuances of weighting and lightening) which operate within that amazing machine, the human brain, in preference to simplistic toying around with explicitly mathematical procedures. No doubt, subjectivity in such matters pays its price in lack of definition and communicability, but it is probably better that way than to go off at tangents into mathematical abstractions with statistical "validity" but with no validity with regard to the problem being assayed. What has been said concerning significance tests in statistics in their application to the social sciences, namely that statistical significance need not be coterminous with "real life" significance (v. Doran and Hodson 1975:54,58,148,168), applies in varying measure to the rest of the discipline of statistics, and it is vital to subjugate that discipline to the "real life" situation (which after all is assessed by the human brain) than the other way around (also v. Cowgill 1977). In any case, statistical procedures employed in creating types from attributes, or in the selection of "valid" attribute-states to be listed on a nominal scale, would be based upon intuitive units of quantification – hence the datum or foundation of the entire analytical super-structure is intuition, whether statistical procedures are employed or not. Therefore, there is no purpose served in trying to avoid the admission that it is intuition (or should we say "educated" intuition?) that pervades the systematics of lithic analysis.

The question is at what level should intuition be replaced by statistics? Should one adopt intuitive attributes and create statistical types? Unfortunately, as mentioned above, statistical procedures are as yet inadequate for the task of creating types, except perhaps within a very restricted range of variation, and an analytical system such as the present one which encompasses a very large range of variation in its attribute-states has perforce to rely on "educated" intuition to create its types (v. Movius et al. 1968:55). As for these types, "a . . . major requirement often demanded of a type is that it shall have 'demonstrable historical significance'. This requirement may only be satisfied at a second stage of a two-stage procedure: the first involving the definition of hypothetical types, the second their testing . . ." (Doran and Hodson 1975:166). The types, as set out below, are as yet in their first stage; further, "the value of [specialised] heuristic types can hardly be exaggerated. Where a distinctive type like this is concerned, testing for 'validity' is not likely to be so much a stage in its definition as in its interpretation" (ibid.).

The conventional view of a type is that it should recur with "reasonable" frequency within a given culture. However, this rule does not apply to the members of this taxon in the present classification which includes non-retouched items within its range of application – items considered debitage by most workers (v. Movius et al. 1968:3). It will be observed that in exhaustively sampled assemblages (from Stage III) artefacts with secondary trimming average around 0.6 per cent of the total assemblage, which is exceedingly low by the general European levels of ca. 4-6 per cent or higher. Among these retouched items, standardisation, except in the cases of geometric microliths and Balangoda Points, is at a minimum. The result is that it is not infrequently the case that an individual retouched artefact meets the requirements, as far as its attributes are concerned, of a distinct type, but it remains unique – an excellent case in point being the large bifacial foliate constituting Type 70. Hence, the existence of a type, as understood in the present classification, does not necessarily signify that it has a high frequency of occurrence. At any rate, within the currently available sample of some 200,000 artefacts, with its exceedingly low percentage of specimens with secondary trimming, a high frequency of occurrence is not a necessary or invariable concomitant of what is understood by the term "type" – and there is no alternative to this situation until the sample of artefacts available for analysis has increased at least one hundred-fold to around twenty million, which might give the relatively solitary "types" a fair chance of turning up more frequently. With regard to the number of types in the present Type-List, I seek to conform with the first of Childe's (1956:81) alternatives: "an arbitrary element must enter into the discrimination of types. If statistical analyses are to be conducted co-operatively by several independent workers, the unit types must be very narrowly defined [first alternative]. The total number of types will then become embarrassingly large. Alternatively [second alternative], using somewhat broader definitions, there could arise so many borderline cases on which no two classifiers would agree. . . ." It is always possible to coalesce types, according to the nature of the study, should they turn out to represent excessive hair-splitting; but there is no excuse for creating a state of non-communicability among researchers by opting for "blanket" types covering a wide range of morphological variation, even if the "embarrassment" of a long type-list is thereby evaded.

In the descriptions of the various lithic categories it will be noted that the intensity of description will be approximately in direct proportion to the degree of stylistic and technological sophistication of a given category of artefacts: for instance, a Balangoda Point will be described with much greater precision than an unspecialised flake-nucleus. The weighting of the analytical system towards those elements with greater analytical utility (i.e., interpretative value), relative to the purpose for which the system was constructed in the first place, cannot but be considered a logical step (Dunnell 1971:6; v. Clarke1968:523-5 regarding problems of weighting and "analytical utility" on a non-intuitive basis). It will be observed that, in general, analytical utility in the present system of classification is weighed in terms of stylistic and technological sophistication, with style and technology being viewed as having a systemic relationship. A suitable measure of style, with reference to stone aftefacts, is the amount of energy input (in terms of man-hours) in proportion to the functional output: how much time and energy was expended on fashioning an implement, with all its deliberately idiosyncratic traits, in producing, for example, a scraper? The greater the amount of time and energy spent on achieving a similar functional end-product, the more stylistcally specialised an object is. On the other hand, technological sophistication has nearly always been accompanied by increasing economy in raw materials, as in the progression from

Acheulean biface to geometric microlith (v. Bordes 1969:11; Bordaz 1970:6,93; Crabtree 1972:85; Smith 1972:4), and it has also been accompanied by increasing economy on the time and energy spent on producing a desired functional end-product. Stylistic and techological sophistication will here be employed as the measure of analytical utility – with style and technology in a systemic relationship.

*5.2.3 Lithic Type-List.* The following type-list is a condensed version of the one given in Appendix II. Type-classes, types, sub-types and variants are formulated in accordance with the methodology outlined above. Note that this list is expandable indefinitely, both internally and externally, without altering the structure of the established categories. Illustrations of the more distinctive specimens are either supplied in Chapter 5.4-5 or, where these have been published elsewhere, the bibliographic references are denoted in Appendix II.

The outline structure of the present taxonomic system for lithic artefacts is based on the attributes of trimming and use. It is organised thus:

(1) Ecofacts

(2) Artefacts
- (*A*) Non-flaked
  - i. Hammer-stones, grindstones etc.
  - ii. Pigments
- (*B*) Flaked
  - i. Trimmed
    - (*a*) Form-trimmed
    - (*b*) Edge-trimmed
    - (*c*) Body-trimmed
  - ii. Non-trimmed
    - (*a*) Use marks present
    - (*b*) Potential tools
    - (*c*) Waste

The remaining attributes of plan-form, apparent function and size also contribute towards the categorisation into classes, types, sub-types and variants. Cross-section is of significance in the definition of a type only in the cases of bolas-stones and the (?allied) spheroidal prepared cores, while raw material does not influence the taxonomic status of any of the artefacts except in the obvious instances of pigments and abrasives. However, data on cross-section and raw material are supplied in Appendix II for potential application in modal analysis. It will be observed that, in general, the various lithic categories are primarily defined on the basis of trimming. Plan-form, function, use marks and size vary their positions within the hierarchy of taxonomic criteria in the formulation of the different classes, types, sub-types and variants. Technologically, it should be noted that unless referred to specifically as a "blade" (v. Class XIII for definition of a true blade), an artefact is assumed to have been manufactured on a flake or a core. In certain cases, such as geometric microliths, it is not feasible to decide whether the blank consisted of a flake or a bladelet, and in such instances I have designated them flakes. Appendix II is referred to for supplementary data on the attributes considered below as well as on sample size and provenance:

*Class I*: Geometric microliths; small geometric forms which have been form-trimmed with blunting trimming; Types 1-6. This is an index class for the late Upper Pleistocene and early Holocene of Europe, Africa, parts of Asia and Australia (for microlithic technology v. Semenov 1964:203; Braidwood 1967:75; Bordaz 1970:93-4). Types are differentiated on the basis of plan-form, sub-types according to apparent function, trimming or plan-form, and variants according to apparent function. The terms sub-lunate, sub-triangle and sub-trapezoidal signify plan-forms which appear to be variants on clear-cut geometric segments, triangles and trapezoidals respectively.

*Type 1*: microlithic lunate
- *Sub-Type* (*a*): cutter (Figs.35(7); 40(28,29))
- (*b*): scraper (Figs.35(3,6,8); 37(13); 40(30); 41(1))
- (*c*): point (Fig.41(4))
- (*d*): awl (Figs.41(3); 35(10))
- (*e*): barb (S.Deraniyagala 1972*a*:Fig.2(2))

*Type 2*: microlithic sub-lunate
- *Sub-Type* (*a*): form 5
  - *Variant* **i.** cutter
  - **ii.** point
- *Sub-Type* (*b*): form 13
  - *Variant* **i.** scraper (ibid.:Fig.2(1))
  - **ii.** awl
  - **iii.** barb (Fig.13(5))

*Type 3*: microlithic triangle
- *Sub-Type* (*a*): form 24
  - *Variant* **i.** cutter (S.Deraniyagala 1972*a*:Fig.2(4))
  - **ii.** scraper (Figs.35(16); 37(22); 41(20))
- *Sub-Type* (*b*): form 25 with backing along 2 long sides (Fig.35(17))
- (*c*): form 25 with backing along 1 long side
- (*d*): form 25 with backing along short side and 1 long side (Fig.35(21))
- (*e*): form 26
- (*f*): form 27
  - *Variant* **i.** scraper (Fig.37(14))
  - **ii.** point (Fig.41(19))

*Type 4*: microlithic sub-triangle
- *Sub-Type* (*a*): form 28 (Pole 1913:Fig.3(5))
- (*b*): form 29 (Fig.41(22))

*Type 5*: microlithic trapezoidal
- *Sub-Type* (*a*): perimetal blunting retouch (Hartley 1914*a*:Fig.1373)
- (*b*): backed along 1 side and truncated at both ends (Fig.35(22))
- (*c*): truncated at both ends; not backed (S.Deraniyagala and Kennedy 1972:Fig.6J)).
- (*d*): truncated at 1 end and backed along 1 side
  - *Variant* **i.** cutter (Fig.37(25))
  - **ii.** scraper (Fig.35(23))
  - **iii.** point (ibid.:Fig.6k)
- *Sub-Type* (*e*): truncated at 1 end; not backed
  - *Variant* **i.** cutter (Solheim and S.Deraniyagala 1972:Fig.3c)
  - **ii.** scraper (Figs.13(19,20); 35(24))
  - **iii.** point (ibid.:Fig.6k)
- *Sub-Type* (*f*) backed along 1 side
  - *Variant* **i.** cutter (Fig.41(23))
  - **ii.** scraper (Figs.41(25); 37(27))
  - **iii.** point

*Type 6*: sub-trapezoidal (Fig.41(26))

*Class II*: Small semi-lunates which have been form-trimmed with blunting retouch; Types 7,8. This is an index class for the Upper Palaeolithic and early Holocene of Europe, Africa, parts of Asia and Australia. Types are differentiated on the basis of plan-form, and sub-types according to apparent function or plan-form. Semi-lunates imply half a segment and are to be distinguished from sub-lunates in Class 1. Sub-semi-lunates, Type 8, display plan-forms which appear to be variants on semi-lunates.

*Type 7*: small, backed semi-lunate on forms 20 and 21

16 –

*Sub-Type* (***a***): cutter (Figs.35(12); 37(15); 40(10); 41(5,6))
(***b***): scraper (Figs.34(4); 37(7,19); 40(27); 41(8))
(***c***): point (Fig.41(9))
(***d***): awl (Fig.35(13))

*Type **8***: small, backed sub-semi-lunate
*Sub-Type* (***a***): form 22 (Fig.41(10))
(***b***): form 23 (Allchin 1958:Fig.2(32))

*Class **III***: Non-geometric microliths; small artefacts form-trimmed with blunting retouch; Types 9-20. This is an index class for the Upper Palaeolithic and early Holocene of Europe, Africa, parts of Asia and Australia. Types are differentiated on the basis of plan-form, and sub-types according to apparent function.

*Type **9***: form 3
*Sub-Type* (***a***): cutter (Figs.34(19,20)
(***b***): scraper (Fig.40(18))

*Type **10***: form 6
*Sub-Type* (***a***): cutter
(***b***): scraper (Fig.34(23))
(***c***): point (Figs.34(25); 35(1))
(***d***): awl (Fig.34(24))

*Type **11***: form 7 (Fig.13(8); (Noone and Noone 1940:Fig.1(13); S.Deraniyagala 1971*a*: Fig.16(25a)).

*Type **12***: form 8 (Figs.35(2); 41(17))

*Type **13***: form 9
*Sub-Type* (***a***): cutter (S.Deraniyagala 1971*a*:Figs.5(2a,b))
(***b***): scraper
(***c***): awl (Fig.41(11))

*Type **14***: form 11 (S.Deraniyagala 1971*a* :Fig.11(14a))

*Type **15***: form 12 (Noone and Noone 1940:Fig.1(14))

*Type **16***: form 14 (Hartley 1914*a*:Figs.761,799,1461)

*Type **17***: form 15
*Sub-Type* (**a**): cutter (Fig.37(18))
(***b***): scraper (Fig.34(14))
(***c***): point (Figs.37(21); 41(14))

*Type **18***: form 16 (Fig.12(17))

*Type **19***: form 19 (Fig.40(7))

*Type **20***: form 34 (S.Deraniyagala 1971*a*:Fig.16(25k))

*Class **IV***: Medium-sized artefacts, form-trimmed with blunting retouch; Types 21-30. This could rather nebulously be considered an index class for the Upper Pleistocene of Europe and the Upper Pleistocene and early Holocene of Africa and Asia. Types are differentiated on the basis of plan-form, and sub-types according to apparent function.

*Type **21***: form 2(Fig.16(8))

*Type **22***: form 3
*Sub-Type* (***a***): scraper (Fig.19(10))
(***b***): chopper

*Type **23***: form 4 (Fig.19(1))

*Type **24***: form 10 (Fig.19(7))

*Type **25***: form 11 (Fig.20(2))

*Type **26***: form 15 (Fig.45(1))

*Type **27***: form 19
*Sub-Type* (***a***): cutter (Fig.18(7))
(***b***): scraper (Figs.13(3,4); 18(9); 35(4))
(***c***): chopper

*Type **28***: form 20 (Figs.13(6); 18(8))

*Type **29***: form 24 (S.Deraniyagala 1971*a*:Fig.7(5a))

*Type **30***: form 32 (Figs.15(3); 20(7))

*Class **V***: Large artefacts, form-trimmed with blunting retouch; Types 31-38. This class has no chronological significance. Types are differentiated on the basis of form, and sub-types according to apparent function.

*Type **31***: form 3 (Fig.25(4))

*Type **32***: form 6 (Fig.39(1))

*Type **33***: form 11

*Type **34***: form 15

*Sub-Type* (***a***): point (Fig.29(1))

(***b***): pick (Fig.32(2))

*Type **35***: form 19 (Figs.30(1,2,3))

*Type **36***: form 20 (Figs.21(3); 30(7))

*Type **37***: form 24 (Fig.32(3))

*Type **38***: form 32 (Figs.33(1,2))

*Class **VI***: Artefacts with blunting retouch, but without form-trimming; Types 39-42. Types are differentiated on the basis of blank-production technology and size, sub-types according to trimming, and variants according to apparent function. In the absence of form-trimming, it will be observed that plan-form does not play a significant taxonomic role.

*Type **39***: small blade (v. Class XIII for definition of "true" blade) with blunting trimming, but without form-trimming.

*Sub-Type* (***a***): backed

*Variant* **i.** cutter (Figs.34(11); 37(4); 44(2))

**ii.** scraper (Figs.34(3,10,12); 37(5); 40(11,12))

*Sub-Type* (***b***): truncated (S.Deraniyagala and Kennedy 1972:Fig.7i)

*Type **40***: small flake with blunting trimming, but without form-trimming

*Sub-Type* (***a***): backed and truncated, without edge- and/or body-trimming

(***b***): backed, with edge- and/or body-trimming

*Variant* **i.** scraper (Fig.11(4))

**ii.** point

**iii.** awl (Figs.11(20); 34(6,7); 40(8,9); 41(15))

*Sub-Type* (***c***): truncated, with edge- and/or body-trimming

*Variant* **i.** scraper (Fig.13(15))

**ii.** point

**iii.** awl

*Sub-Type* (***d***): backed, without edge- or body-trimming

*Variant* **i.** cutter (S.Deraniyagala 1971*a*:Fig.4(1a))

**ii.** scraper (Figs.11(14); 37(3))

**iii.** point

**iv.** awl

**v.** blank

**vi.** waste

*Sub-Type* (***e***): truncated, without edge- or body-trimming

*Variant* **i.** cutter (Fig.11(1))

**ii.** scraper (Figs.12(18); 34(1))

**iii.** awl

*Type **41***: medium-sized flake with blunting trimming, but without form-trimming

*Sub-Type* (***a***): backed, with edge-trimming

*Variant* **i.** scraper (Figs.11(16); 19(9))

**ii.** chopper

**iii.** awl (S.Deraniyagala 1972:Fig.6(A17))

*Sub-Type* (***b***): backed, without edge-trimming

*Variant* **i.** cutter

**ii.** scraper (Fig.20(8))

*Type* ***42***: large flake with blunting trimming, but without form-trimming
*Sub-Type* (***a***): backed, with edge-trimming
*Variant* **i.** scraper
**ii.** chopper
*Sub-Type* (***b***): blunting trimming, without edge-trimming
*Variant* **i.** cutter
**ii.** chopper
**iii.** point (Fig.32(5))

*Class* ***VII***: Small, form-trimmed artefacts without blunting trimming, but with or without edge- and body-trimming; Types 43-57. Types are differentiated on the basis of trimming and plan-form, and sub-types according to plan-form and apparent function. Highly distinctive within this class, morphologically, are the Balangoda Points (Type 43).

*Type* ***43***: Balangoda Point; comprising highly distinctive small, foliate forms with delicate, shallow, feathering retouch. Despite the term "point", Sub-Types i and j may have functioned as scrapers. In South Asia, recorded so far only from the *teri* industries of South India and from Lanka. This is potentially a chronological and cultural index type.
*Sub-Type* (***a***): form 6, point (Figs.34(26,27); 40(26))
(***b***): form 7, point (Fig.35(20))
(***c***): form 8, point (Fig.35(18))
(***d***): form 11, point (Allchin 1958:Fig.2(20))
(***e***): form 15, point (Fig.35(14))
(***f***): form 25, point (Figs.41(16,18))
(***g***): form 25, with apex broken off, point (Figs.35(19); 37(20))
(***h***): form ?25, ?fragmentary, ?point
(***i***): form 4, scraper (Fig.35(5))
(***j***): form 30, scraper
(***k***): form 19, indeterminate apparent function, ?unfinished

*Type* ***44***: form 2 (Figs.12(5,7))

*Type* ***45***: form 3
*Sub-Type* (***a***): cutter (S.Deraniyagala and Kennedy 1972:Fig.6a)
(***b***): scraper (Fig.40(17))
(***c***): chopper (Solheim and S.Deraniyagala 1972:Fig.3e)

*Type* ***46***: form 6
*Sub-Type* (***a***): scraper (Fig.12(16))
(**b**): point (Fig.40(25))

*Type* ***47***: form 7 (S.Deraniyagala 1971*a*: Fig.16(25c))

*Type* ***48***: form 8 (Fig.37(12))

*Type* ***49***: form 11
Sub-Type (***a***): scraper (Figs.41(12,13))
(***b***): point (S.Deraniyagala and Kennedy 1972:Fig.6f)

*Type* ***50***: form 15 (Fig.34(2))

*Type* ***51***: form 16 (S.Deraniyagala 1971*a*:Fig.16(25n))

*Type* ***52***: form 20
*Sub-Type* (***a***): scraper (Figs.13(1); 37(1))
(***b***): chopper (Fig.35(9))
(***c***): point (ibid.:Fig.16(25h))
(***d***): awl

*Type* ***53***: form 20 (Figs. 35(11); 37(16); 40(5))

*Type* ***54***: form 24
*Sub-Type* (***a***): scraper
(***b***): point

*Type* ***55***: form 30 (id. 1972*a*:Fig.2(7))

*Type* ***56***: form 32

*Sub-Type* (**a**): scraper (Figs.13(12,17); 37(26); 41(27))
(**b**): point (Fig.35(27))

*Type* **57**: form 33 (Fig.41(21))

*Class* **VIII**: Medium-sized, form-trimmed artefacts without blunting trimming, but with or without edge- or body-trimming; Types 58-69. Types are differentiated on the basis of plan-form, and sub-types according to apparent function.

*Type* **58**: form 2
*Sub-Type* (**a**): scraper (Fig.12(6))
(**b**): chopper (Fig.16(9))

*Type* **59**: form 3
*Sub-Type* (**a**): scraper (Figs.12(11); 17(4,5,6,))
(**b**): chopper (Fig.17(8))

*Type* **60**: form 6
*Sub-Type* (**a**): chopper (Fig.18(3))
(**b**): point (Figs.18(4,5); 38(2); 42(5))

*Type* **61**: form 7

*Type* **62**: form 9

*Type* **63**: form 11 (Fig.18(6))

*Type* **64**: form 15 (Fig.20(3))

*Type* **65**: form 19 (Fig.19(2))

*Type* **66**: form 20 (Figs.19(3,5))

*Type* **67**: form 32

*Type* **68**: form 33 (Solheim and S.Deraniyagala 1972:Fig.3a)

*Type* **69**: form 34

*Class* **IX**: Large, form-trimmed artefacts without blunting trimming, but with or without edge- or body-trimming; Types 70-84. Types are differentiated on the basis of plan-form; nowever, trimming is also employed as a criterion in the highly distinctive Type 70. Sub-types are differentiated according to apparent function.

*Type* **70**: bifacial foliate point on form 7. The retouch is distinctive in its shallowness, and it covers both surfaces in their entirety; step-flaking is prominent. The general morphology suggests considerable energy expenditure on the manufacture of this artefact, relative to its presumed function; hence its analytical utility is high (Fig.28(2)).

*Type* **71**: form 2 (Figs.10(4); 24(5,6,8))

*Type* **72**: form 3 (Figs.25(5,6,7))

*Type* **73**: form 4 (Fig.30(4))

*Type* **74**: form 5

*Type* **75**: form 6
*Sub-Type* (**a**): chopper (Figs.10(1,2,3); 26(4,5); 27(2,3); 32(6))
(**b**): point (Figs.28(3,4,5); 46(1))
(**c**): pick (Fig.29(3))

*Type* **76**: form 7 (Figs.27(4); 28(1))

*Type* **77**: form 9 (Fig.31(4))

*Type* **78**: form 11
*Sub-Type* (**a**): chopper (Figs.26(1); 27(1); 31(6))
(**b**): point (Fig.31(7))

*Type* **79**: form 15 (Fig.32(1))

*Type* **80**: form 17 (Fig.29(5))

*Type* **81**: form 19

*Type* **82**: form 20 (Figs.30(6); 31(1))

*Type* **83**: form 32 (Fig.32(7))

*Type* ***84***: form 33 (Fig.31(2))

*Class* ***X***: Stone celts, pecked (hammer-dressed), ground and, at times, polished (v. Allchin 1968:158; Crabtree 1972*a*:33 for these techno-traits); Types 85, 86. Types are differentiated on the basis of trimming, sub-types according to size, and variants according to apparent function.

*Type* ***85***: form-trimmed celt; form 32 (S.Deraniyagala 1971*b*:Fig.C5,Pl.II(5))
*Type* ***86***: edge-ground celt
*Sub-Type* (***a***): small (Fig.34(5))
(***b***): medium-sized (S.Deraniyagala and Kennedy 1972:Fig.61)
(***c***): large
*Variant* **i.** chopper (S.Deraniyagala 1971*b*:Fig.C6,Pl.II(6))
**ii.** pounder (ibid.:Fig.C7,Pl.II(7))

*Class* ***XI***: Bolas-stones; Type 87. Form-trimmed, spheroidal artefacts which might conceivably have been employed as missiles either singly or in groups with thongs to entangle the feet of the quarry (cf. Braidwood 1967:45). Bolas-stones, at times, have apparently been manufactured by bouncing stone upon stone (Clark 1970:92), and hammer-stones when employed against stone (as in dressing grindstones) can end up as perfect spheroids (Witthoft 1967*a*:127; Hill 1968:128) – which would place this category of stone artefact in Class XVII (v. below). On the other hand, there are indications that bolas-stones might have functioned as prepared cores, and several specimens suggest preliminary trimming by flaking prior to dressing the surface down to a smooth finish – which would qualify their being classified as celts (Class X). In view of this intermediate position between Classes X and XVII, I have considered it expedient to create a separate class for these artefacts. The chronological significance of bolas-stones is limited, since they are known from at least as early as the Upper Acheulean of Africa (Clark 1970:92). Sub-types are differentiated on the basis of size.

*Type* ***87***: bolas-stone
*Sub-Type* (***a***): medium-sized (Fig.17(2))
(***b***): large (Figs.25(1,2))

*Class* ***XII***: Edge- and/or body-trimmed artefacts without form-trimming, and excluding true blades; Types 88-90. Types are differentiated on the basis of size, and sub-types according to apparent function.

*Type* ***88***: small, edge- and/or body-trimmed flake or core
*Sub-Type* (***a***): cutter
(***b***): scraper (Figs.11(5-9,13,17-19); 13(2,9,18); 37(2); 40(1-4,6,24); 41(7,24); 44(1).
(***c***): point (Figs.11(21); 13(13); 34(8); 35(15); 37(24))
(***d***): awl
(***e***): burin (Noone and Noone 1940:Fig.1(20); S.Deraniyagala 1971*a*: Fig.15(23a)). This is a doubtful category (v. Noone and Noone 1940:13 for corroboration), there being no evidence of a specialised burin technology in Lanka, contrary to Upper Palaeolithic France. In the present classification, the removal of a burin spall or spalls (v. Movius et al. 1968:23-30 for burin attribute-system) suffices to designate an artefact a "burin"; but as to what such a mode of secondary trimming signifies in functional terms is open to debate. Hence "burin", in this case, is strictly a morphological category with no functional connotations.

*Type* ***89***: medium-sized, edge- and/or body-trimmed flake or core
*Sub-Type* (***a***): cutter (Fig.14(2))
(***b***): scraper (Figs.12(12); 14(5,7,10); 15(1,2,4,5); 17(7); 19(6,8); 20(1,6,9); 42(1,5).
(***c***): chopper (Figs.15(7); 17(9); 20(10))
(***d***): point (Fig.13(11))

*Type* ***90***: large, edge- and/or body-trimmed flake or core
*Sub-Type* (***a***): scraper (Figs.29(6); 32(4))

(*b*): chopper (Figs.21(5-7); 22(1-3,5,6); 23(1-3); 24(7); 30(5); 31(5); 37(25)).
(*c*): point (Figs.23(4); 29(2))
(*d*): pick

*Class* ***XIII***: Used artefacts, without secondary trimming; Types 91-92. Types are differentiated on the basis of trimming (namely the techno-trait of blade vs. non-blade), sub-types according to size, and variants according to apparent function. As for the definition of a "true blade", it is a "specialised elongated flake with parallel to sub-parallel lateral edges; its length equal to at least twice its width. Cross or transverse section may be either plano-convex, triangular, sub-triangular, rectangular, often trapezoidal, and, on the dorsal face, one or more longitudinal crests or ridges" (Bordes and Crabtree 1969:1). The "specialised" aspect of blade technology stem from the primary trimming inherent in the preparation of a blade-nucleus. True blade technology constitutes a chronological index trait, since it is not known prior to the commencement of the Upper Pleistocene at ca. 125,000 BP. (For blade technology v. Barnes 1947:101-9; Leakey 1953:62; Semenov 1964:46; Hodges 1964:102-3; Howell 1965:106; Bordes and Crabtree 1969; Bordaz 1970:51-5; Allchin et al. 1972:555; Crabtree 1972:48; Crabtree 1972*a*:31.)

*Type* ***91***: used blade
*Sub-Type* (***a***): small
*Variant* **i.** cutter
**ii.** scraper
*Sub-Type* (***b***): medium-sized
(***c***): large (Figs.24(1,2))

*Type* ***92***: used flake or core
*Sub-Type* (***a***): small
*Variant* **i.** cutter (Fig.11(2))
**ii.** scraper (Figs.11(3,10-12,15); 12(19); 13(10,14,16); 25(2); 37(17,23)).
**iii.** scraper *cum* cutter
*Sub-Type* (***b***): medium-sized
*Variant* **i.** cutter (Figs.14(1,3,4); 20(5); 21(4))
**ii.** scraper (Figs.13(7); 14(6,8,9); 16(4); 19(4))
**iii.** chopper
**iv.** multiple function (scraper *cum* cutter) (Fig.15(6))
*Sub-Type* (***c***): large
*Variant* **i.** cutter (Figs.21(2,3); 25(3))
**ii.** scraper (Fig.21(4))
**iii.** chopper (S.Deraniyagala and Kennedy 1972:Fig.7g)

*Class* ***XIV***: Potential edge- and point-tools, without use marks or secondary trimming; Types 93-94. These possess an edge or point which, in morphological features such as extent of regularity, symmetry, positioning relative to the overall plan-form, and robusticity, display functional potential as cutters, scrapers, points etc. There is particular classificatory significance in this class when dealing with unretouched and apparently unused primary-trimmed categories such as Levallois flakes or true blades. Since specific forms of primary removals (i.e., blanks) were produced for immediate use or secondary conversion into tools (v. Wilmsen 1968:984), a morphological classification of these potential tools becomes a necessity. Types are differentiated on the basis of primary trimming (namely according to the techno-trait of blade vs. non-blade), sub-types according to size, and variants according to apparent function.

*Type* ***93***: blade
*Sub-Type* (***a***): small
*Variant* **i.** cutter (Fig.34(13))
**ii.** scraper (Figs.12(2-4); 37(6))
**iii.** awl
*Sub-Type* (***b***): medium-sized

(*c*): large

*Type* ***94***: non-blade

*Sub-Type* (***a***): small

*Variant* **i.** cutter
**ii.** scraper
**iii.** point
**iv.** awl
**v.** multiple function (scraper *cum* cutter)

*Sub-Type* (***b***): medium-sized

*Variant* **i.** cutter
**ii.** scraper
**iii.** chopper
**iv.** point
**v.** awl

*Sub-Type* (***c***): large

*Variant* **i.** cutter (Fig.21(1))
**ii.** scraper
**iii.** chopper
**iv.** point
**v.** pick

*Class* ***XV***: Nuclei (cores) displaying negative scars from flake or blade production, and which cannot apparently function as tools in their own right. The negative scars are on the one hand designated secondary body-trimming on the core, and on the other hand they represent use marks with reference to the apparent function of the artefact; Types 95-100.

Types are differentiated primarily on the basis of trimming, with plan-form and cross-section playing secondary roles. The techno-traits of core preparation techniques, as revealed in the morphology of the nuclei themselves, form the basis of the type distinctions. Blade-nuclei, Type 95, constitute a chronological index with its lower limit at ca. 125,000 BP. Levallois nuclei, Type 96, are known from as far back as the Upper Acheulean of Africa and the Middle Acheulean of Europe, and hence do not provide a useful chronological marker. However, its distinctive status as a specialised techno-tradition entitles it to be ranked a type (for descriptive accounts of the Levallois techique and its place in technological evolution v. Howell 1965:112; Bordes 1966:83; British Museum 1968:55; Crabtree 1972:74).

One of the categories which closely parallels that of the Levallois nucleus is the spheroidal prepared core, Type 97. This type comprises a nucleus trimmed to a spheroidal form from which primary-backed flakes are detachable, the backing being part of the original trimming on the core. Indeed, it is possible that the so-called bolas-stones are none other than finely trimmed spheroidal prepared cores, and further investigations on these lines are required.

Type 98 comprises discoidal cores which, in Europe at any rate, came into prominence (as indicative of greater efficiency in flake production) during the Mousterian of the Upper Pleistocene (v. Coles and Higgs 1969:60; Bordaz 1970:39). However, it is probable that the origins of this technique lie at a much earlier period and hence its chronological significance is dependent on its frequency of occurrence in a given assemblage – a high percentage probably indicating an Upper Pleistocene or early Holocene age. Type 99 comprising sub-discoidal nuclei could conceivably be submerged in Type 98, since its techno-traits are the same. However, pending further data I have treated it as a different category on the basis of its plan-form. It is noteworthy that the line of demarcation between discoidal cores and technologically non-distinctive cores (Type 100) is not very evident at times.

Sub-types are differentiated according to size, since it is core size that primarily determines the size of the resultant flakes or blades being produced, and flake or blade size could be functionally significant. Bricker (1973:xxii) sets out an attribute-system for nuclei which, while providing more particularised information than the present classification on certain attributes and their states – as in the number of striking platforms present on a nucleus – fails to yield a generalised categorisation into blade-nucleus, discoidal nucleus etc. Hence the present system is more suited to a general survey of morphological and technological variation among nuclei.

*Type* ***95***: blade-core

*Sub-Type* (***a***): small (Figs.11(22,25); 34(15-17); 37(8); 40(13-16); 44(3,4))

(***b***): medium-sized

*Type* ***96***: Levallois core

*Sub-Type* (***a***): small (S.Deraniyagala 1971*a*:Fig.15(24b))

(***b***): medium-sized (Fig.42(6))

(***c***): large (Figs.24(3); 10(5))

*Type* ***97***: spheroidal prepared core

*Sub-Type* (***a***): small (Fig.12(8))

(***b***): medium-sized

(***c***): large

*Type* ***98***: discoidal core

*Sub-Type* (***a***): small (Figs.11(24); 12(9,10,15); 34(18,22); 37(9-11); 40(20-23))

(***b***): medium-sized (Figs.16(2); 17(3); 18(2); 38(1); 42(4))

(***c***): large (Fig.26(3))

*Type* ***99***: sub-discoidal core

*Sub-Type* (***a***): small

(***b***): medium-sized

(***c***): large (Fig.29(4))

*Type* ***100***: core on plan-form 1, non-descript form

*Sub-Type* (***a***): small (Fig.11(23))

(***b***): medium-sized (Fig.15(9))

(***c***): large

*Class* ***XVI***: Waste flakes and blades, namely by-products of knapping; Types 101-104. Types are differentiated on the basis of the techno-traits reflecting the processes employed in their manufacture: blade-waste, micro-burins (a by-product of geometric microlith manufacture, v. Bordaz 1970:94), waste from spheroidal prepared cores, and technologically non-distinct waste. Blade-waste and micro-burins (v. Leakey 1953:45 for technical data on latter) are chronological markers, the former for the Upper Pleistocene and early Holocene and the latter for the early Holocene. In view of the paucity of micro-burins in Lanka, it is very probable that the specimens assigned to this category bear merely a spurious resemblance to a micro-burin on the assumption that the adoption of the technological innovation of geometric microlith production via the micro-burin technique would have left a much higher proportion of micro-burins than is the case in Lanka (v. Noone and Noone 1940:15 for corroboration). Sub-types are differentiated according to size.

*Type* ***101***: waste from blade manufacture

*Sub-Type* (***a***): small (S.Deraniyagala 1972*a*:Fig.13(10))

(***b***): large

*Type* ***102***: micro-burin (id. 1971*a*:Fig.16(26d))

*Type* ***103***: waste from flake manufacture from spheroidal cores of Type 97

*Sub-Type* (***a***): small

(***b***): medium-sized (Fig.16(3))

*Type* ***104***: non-descript waste from knapping

*Sub-Type* (***a***): small

(***b***): medium-sized

(***c***): large

*Class* ***XVII***: Non-flaked stone artefacts; Types 105-111. By virtue of the definition of an artefact, this class excludes manuports devoid of trimming or use marks. Types are differentiated on the basis of trimming (dimple-pitted vs. non-pitted) and apparent function. Sub-types are categorised according to size, an attribute which is of significance particularly in the case of fabricators such as hammer-stones employed in knapping, since different weights of hammer are known to be suitable for different purposes (v. Elkin 1948:110; Campbell and Edwards 1966:177; Crabtree and Swanson 1968:50; Coles and Higgs 1969:56). The term "nut-stone" is employed after the accepted terminology for such artefacts in Europe and Australia, and it replaces the term "anvil *cum* grindstone" of Deraniyagala (1945:127), although this latter term is functionally probably more apt. The Balangoda "celts" referred to by Deraniyagala (1942:124) comprise dimple-pitted hammer-stones, and since these artefacts do not display signs of pecking, grinding or polishing to secure a specific edge morphology or overall form, the designation "celt" is not appropriate. Hence, it is preferable to refer to them simply as dimple-pitted (or pitted) hammer-stones.

*Type* ***105***: non-pitted hammer-stone, with use marks
*Sub-Type* (***a***): small (Figs.12(13,14); 34(21); 40(19))
(***b***): medium-sized (Fig.18(1))
(***c***): large (Figs.23(5); 43(1))

*Type* ***106***: muller, with use marks
*Sub-Type* (***a***): small
(***b***): medium-sized (Fig.15(8))
(***c***): large (Fig.26(2))

*Type* ***107***: multiple function, hammer *cum* muller *cum* pounder, with use marks
*Sub-Type* (***a***): small
(***b***): medium-sized (S.Deraniyagala 1971*a*:Fig.18(29a))
(***c***): large (ibid.:Fig.20(101))

*Type* ***108***: grindstone with signs of use which comprises one or more large depressions, one or more small (ca. 8cm diameter) depressions, or a deep groove. Red ochre, graphite or chalk smears are at times in evidence. Further sub-division of this type might be necessary on the basis of the morphology of the grinding surface or surfaces. (Figs.23(6,7); Deraniyagala 1943:Pl.8(4,5).)

*Type* ***109***: dimple-pitted hammer-stone, some of which display surfaces smoothed by grinding, as well as traces of red ochre. Fractured specimens are common. As to what function the pits served is still unknown; they could have resulted from pressing down on fire-drills.
*Sub-Type* (***a***): medium-sized (Figs.16(6,7); 36(1,2); 42(3))
(***b***): large (Fig.24(4))

*Type* ***110***: perforated mace-head (Deraniyagala 1953*a*:Pl.10(1-3,6,7))

*Type* ***111***: dimple-pitted nut-stone, which is a large, multiple pitted slab, at times with signs of having been used for a grindstone as well. Red ochre has been ground on some specimens. A few display longitudinal grinding grooves. (S.Deraniyagala 1971:Fig.17(26f).)

*Class* ***XVIII***: Pigments and miscellaneous raw materials; Types 112-115. Types are differentiated on the basis of raw material, and sub-types according to the presence or absence of use marks.

*Type* ***112***: red ochre, pigment
*Sub-Type* (***a***): used (Figs.12(1); 34(9))
(***b***): potential pigment, unused

*Type* ***113***: graphite, pigment
*Sub-Type* (***a***): used (Noone and Noone 1940:Fig.2(7))
(***b***): potential pigment, unused

*Type* ***114***: mica, ?pigment

*Type* ***115***: pumice, ?abrasive

*Class* ***XIX***: Non-artefactual lithic ecofacts; specifically, in this instance, ventifacts (stone objects displaying faceting from wind action). (Fig.16(5).)

*5.2.4 Ratnapura Industry.* The artefacts occurring in the Ratnapura Beds, namely the Ratnapura Industry, are typologically non-distinctive, a state of affairs that is compounded by the nebulous stratigraphy of these alluvial sediments (v. Chap.3.2.1). Both choppers and flake-tools are known to occur in this industry. I have illustrated (Fig.10(1-3)) the specimens approximating closest of all to

Acheulean types; but, nonetheless, they cannot be termed technologically Acheulean, as will be apparent to the discerning eye. The coincidental hemi-lemniscate and cordate plan-forms do not display the regular trimming, and the resultant symmetrical cross-sections and regular edges, which are characteristic of the Acheulean. It is of course possible to describe these three specimens as "very crude, Lower Acheulean types", but it is preferable to refer to them as merely resembling such artefacts, pending unequivocal evidence as to the presence of Acheulean artefacts in Lanka. It is noteworthy that the Acheulean tradition has not been observed south of the Kaveri river in South India.

Similarly a discoidal chert artefact, purported to be from the Ratnapura Beds (Fig.10(5)), does indeed resemble a Levallois core. Once again, however, it is premature to conclude that this specimen represents a clear-cut Levallois tradition in Lanka, particularly since obviously Levallois flakes have not been discovered.

Two specimens of pitted hammer-stones (Type 109b) have been found in the

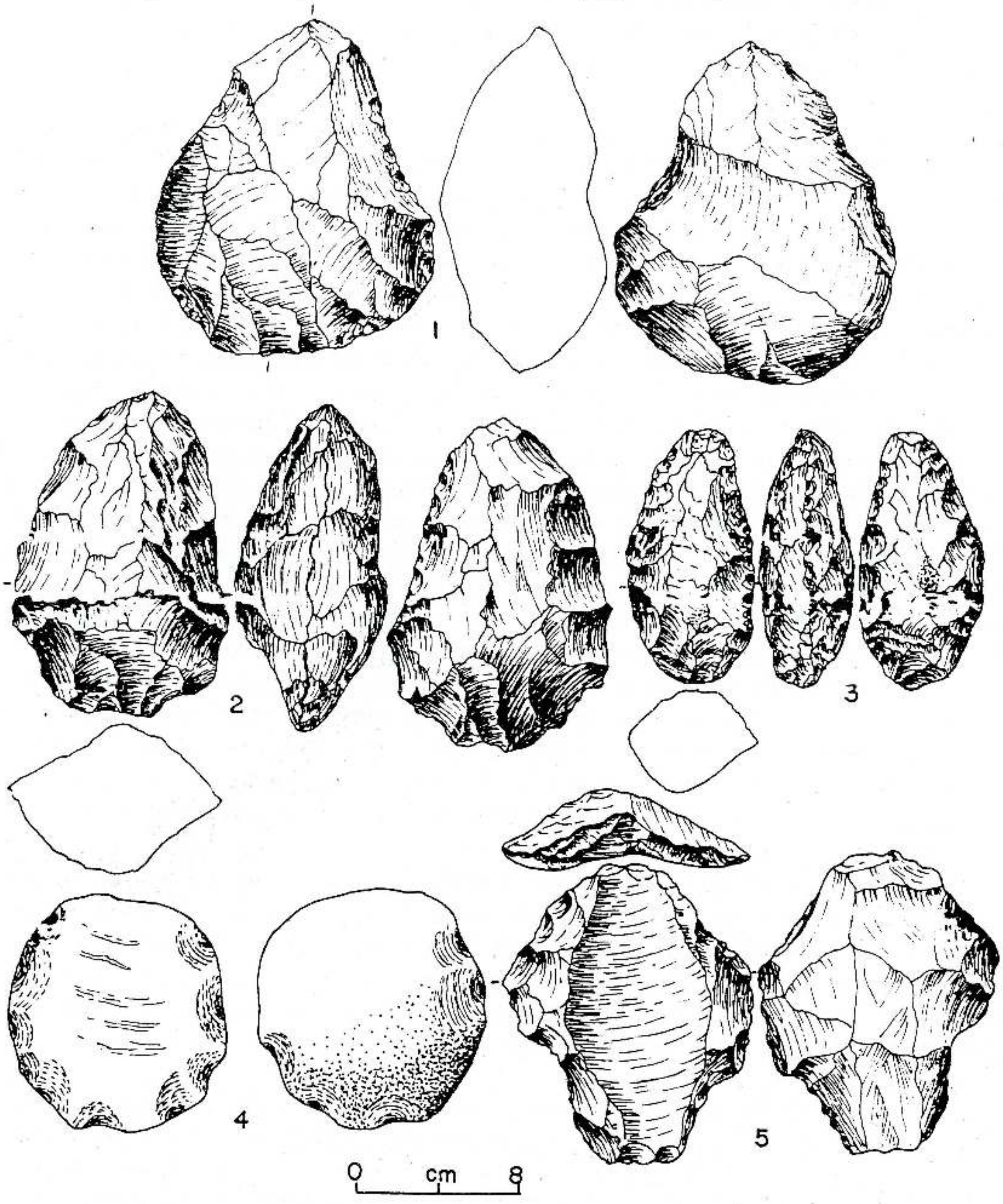



Fig. 10. Stone artefacts from the Ratnapura Beds: the Ratnapura Industry

Ratnapura Beds; namely in the gravel at Achariya-ovita and in a silt overlying the gravel at Pohorabava (Deraniyagala 1945:123-4,138; 1958:76-7). This artefact category occurs in the lowermost stratum of Batadomba-lena cave which has been dated to ca. 28,500 $^{14}$C BP, but the lower age boundary of pitted hammer-stones in Lanka is unknown. It can be hypothesised that the latter is not earlier than the early Würm, since India's Middle Palaeolithic has not yielded any pitted hammer-stones so far. A perforated mace-head (Type 110) from ca. 3.3m -gl in a gem pit at Marapona (id. 1953*a*:131) might be relatively recent, as could also be the case with the specimen from what is apparently a colluvium at Veralupe (ibid.). As to whether the large (10kg) pounder-like artefact of gneiss, purported to be from the Ratnapura Beds (Type 86c(ii); S.Deraniyagala 1971*b*:9,Fig.C(7)) is in fact a polished celt requires further verification.

It is obvious from the chrono-stratigraphy of the Ratnapura Beds (Chap.3.2) that the Ratnapura Industry comprises a regular hotch-potch of lithic industries ranging from the Middle Pleistocene to the Holocene. It is futile to attempt to bring further resolution to the questions concerning the identity, age and characteristic traits of these artefacts on the basis of the evidence at hand.

*5.2.5 Iranamadu Formation.* The chrono-stratigraphy of the Iranamadu Formation has been dealt with in considerable detail in Chapter 3.3. It is necessary, in considering the cultural contents of these sediments, that their depositional environments be borne in mind, namely that the basal gravels represent alluvial sheet gravels on the coastal plain and that the overlying sands (Red-Yellow Latosols) are primarily ancient coastal dunes. Since the basal gravels are deemed to be thalasso-static, and since the sands could have been blown up on to elevations as much as 30m +msl, there need be no chronological correspondence between these two sets of sediments, even if they occur in a single section. Within the basal gravels themselves, unless it can be established that an occupation horizon is present, the cultural materials are likely to be in a state of secondary deposition and they could thus represent several cultural phases. It is also likely that prehistoric man exploited the quartz and chert pebbles on exposures of basal gravels such as the *vembu* dry dolines. There is the other possibility that the surface of the gravels constitutes a lag deposit deriving from the deflation of the overlying dune sands. Hence, once again, several cultural phases can be represented on the surface of the basal gravels, as on the *vembus* or in Stratum II(1) of the excavated deposits (App.III).

As for the Latosol dune sands, artefact-rich horizons within them can represent *in situ* occupation layers and/or lag deposits from the deflation of overlying sediments. Latosols with a diffuse scatter of artefacts could have the latter *in situ*, or else they could be intrusive from higher levels due to the loose compaction of dune sands. As is well known, it is at times difficult to distinguish between *in situ* dune sands and colluvial or alluvial secondary deposits of derived dune sands. In the latter case there could be an admixture of several cultural phases. Hence it is clear that artefacts occurring within Latosols could belong to several cultural phases, although the probability of an artefact-rich horizon (e.g., 49c III(6)) being *in situ* is high. Of course, once the latosolic weathering had occurred, the dunes would have been stable, and their texture and compaction are such that there is no question of artefacts infiltrating lower levels through any natural agency: the Latosol dune is "fossilised".

With the above stratigraphic points in focus, the results of Stage II of the research design, entailing the exploration of the I Fm (App.III), can be examined for their technological data. Most of the samples, it will be recalled, were secured selectively, with an involuntary bias towards "Middle Palaeolithic" types (Chap.2.3).

Besides, they were usually collected from the surface of the basal gravels in the *vembus,* which suggests, strongly, that the sample from any given locus could contain artefacts from several cultural phases. In the case of the high-level I Fm sites, as in the Mankulam area of the north, these cultural phases could conceivably range from the Lower Palaeolithic to the Mesolithic, thus greatly diminishing the diagnostic value of the samples. However, considering the general sampling strategy, this lack of resolution was the result of the decision to secure maximum spatial coverage

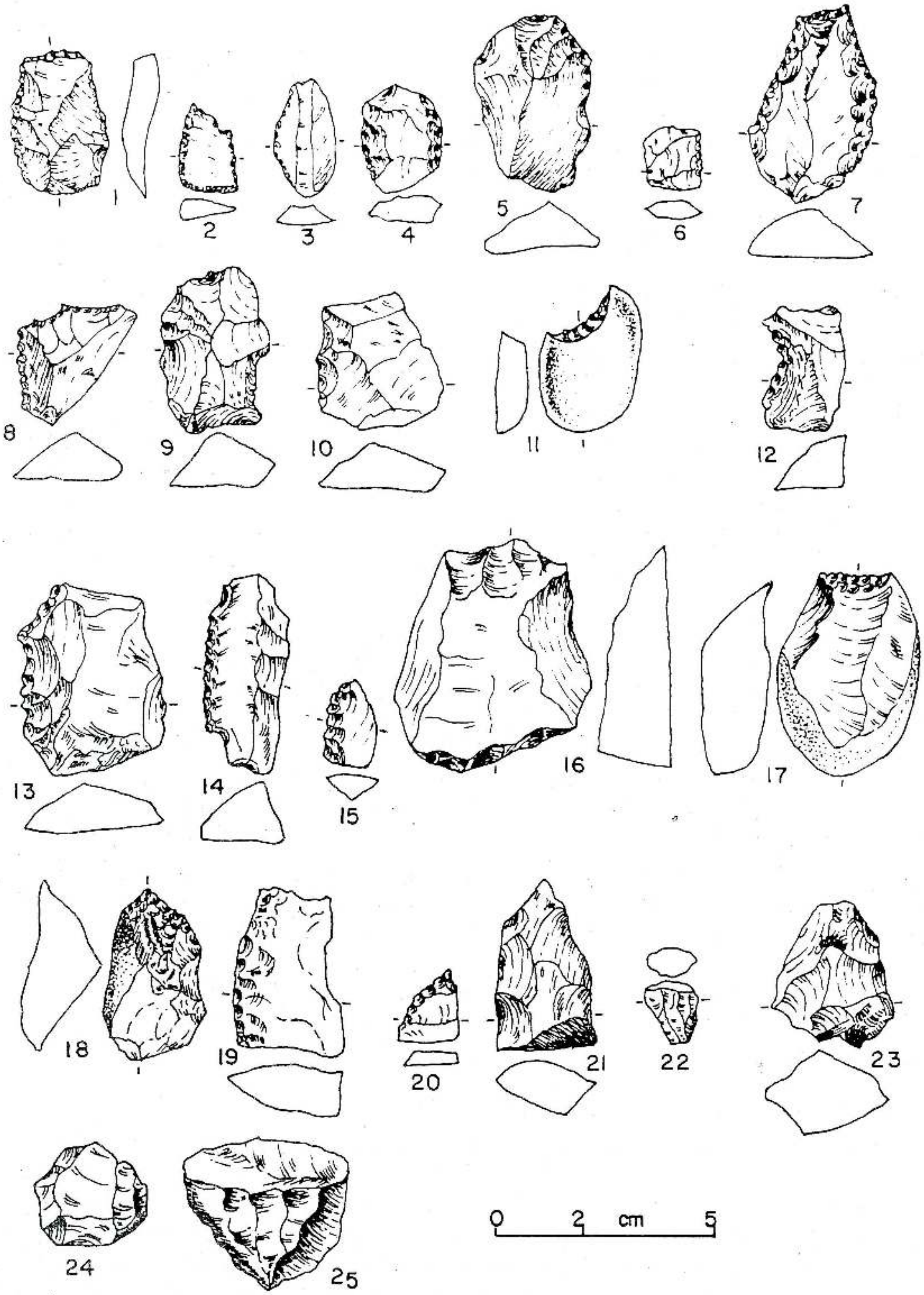



Fig. 11. Small stone artefacts from the I Fm

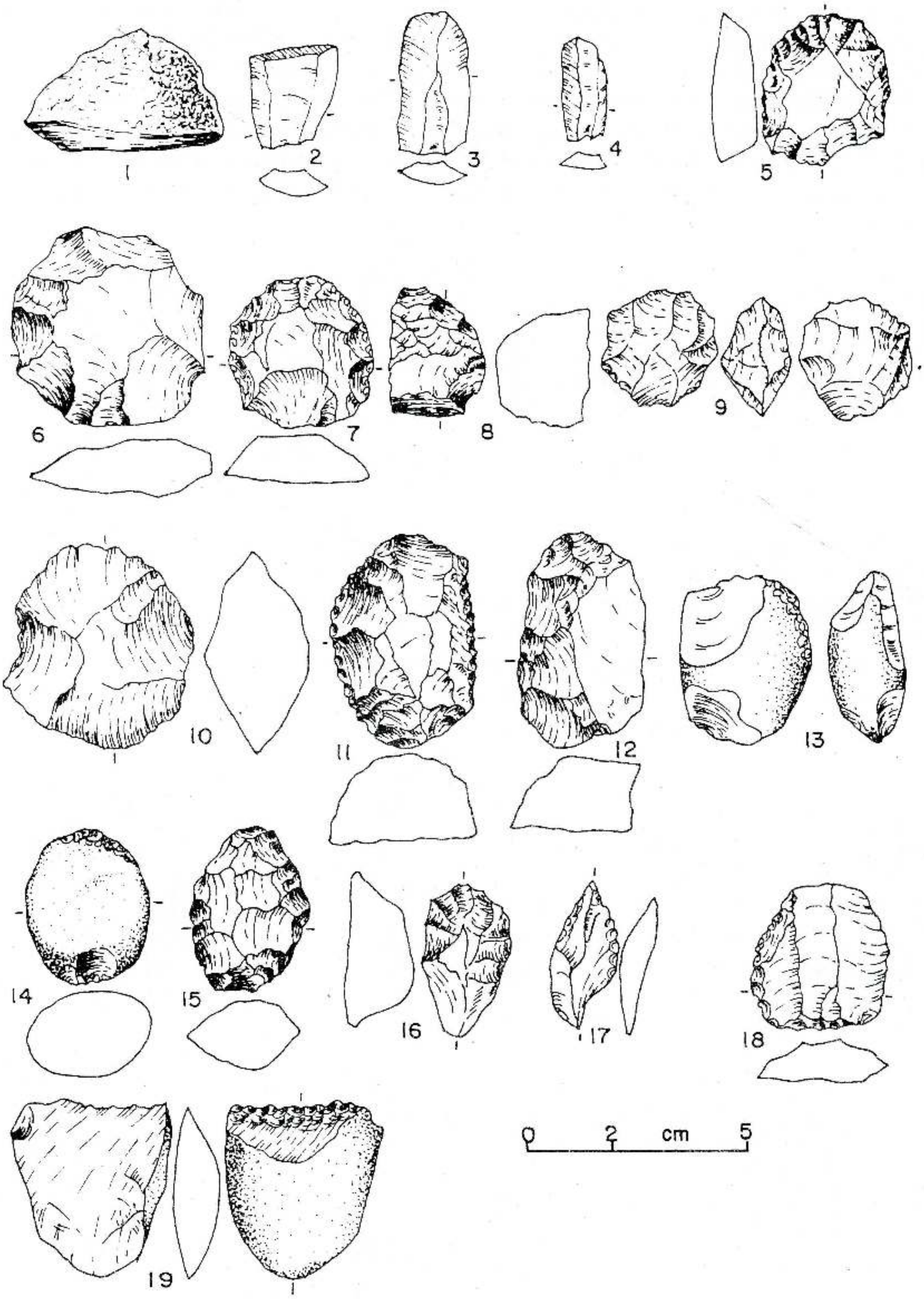



Fig. 12. Small stone artefacts from the I Fm

during the initial survey, and as such it was inevitable and cannot be faulted methodologically.

Since the I Fm represents coastal sediments intimately linked with glacio-eustasy, with neo-tectonics playing an estimated minor role in determining the heights of the deposits above sea level (with the possible exception of sites such as 27, 30, 40 and 56), I shall consider the sites in order of their elevation above present sea level. It is hypothesised that the highest, tectonically undisturbed, gravels are the oldest

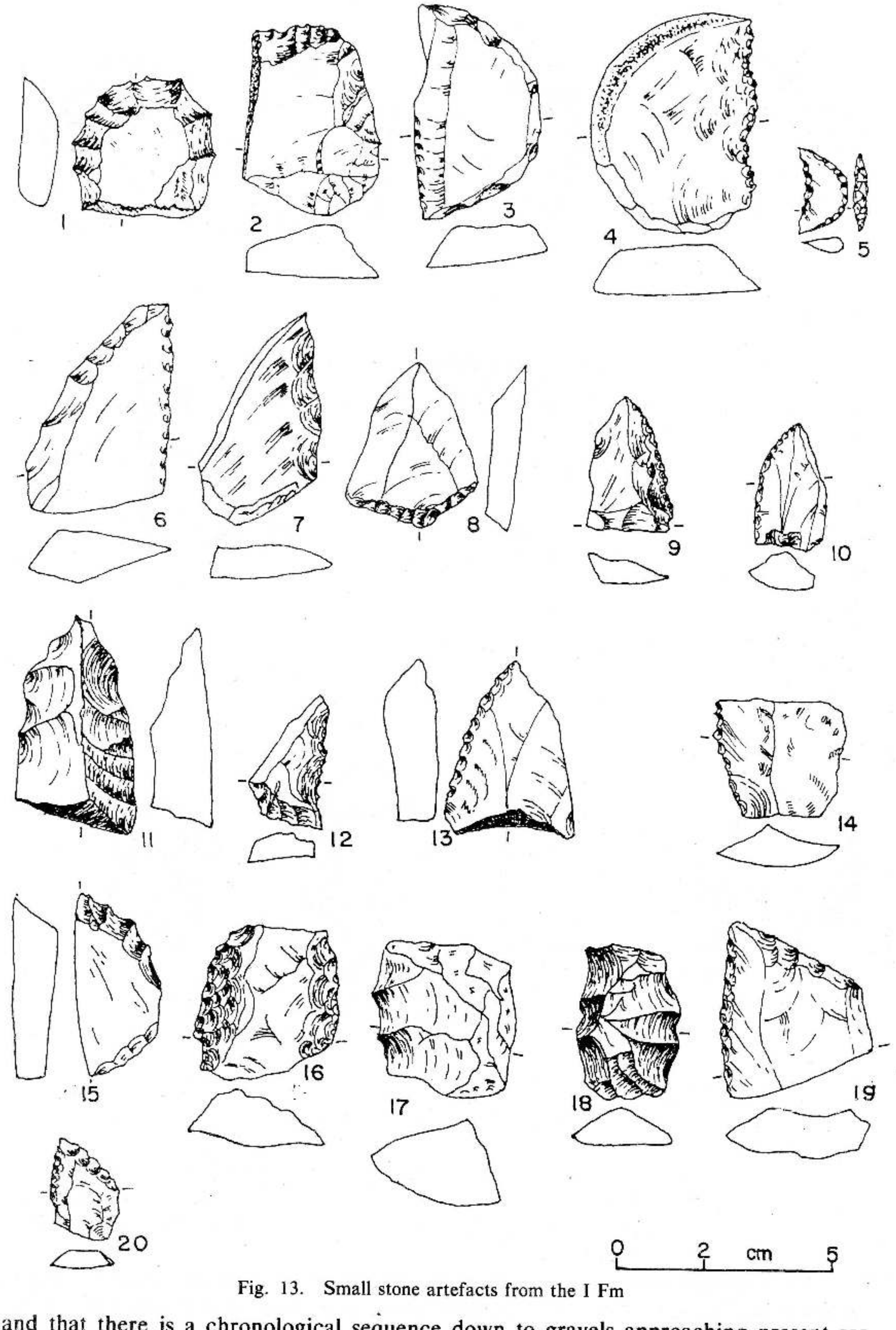



Fig. 13. Small stone artefacts from the I Fm

and that there is a chronological sequence down to gravels approaching present sea level. Of course, considering the pulsating nature of eustatic oscillations, it is quite likely that two gravels at the same elevation could represent two different episodes of high sea level which were widely separated in time. However, since this problem cannot be assayed with the sketchy geomorphological data at our disposal, I shall deliberately

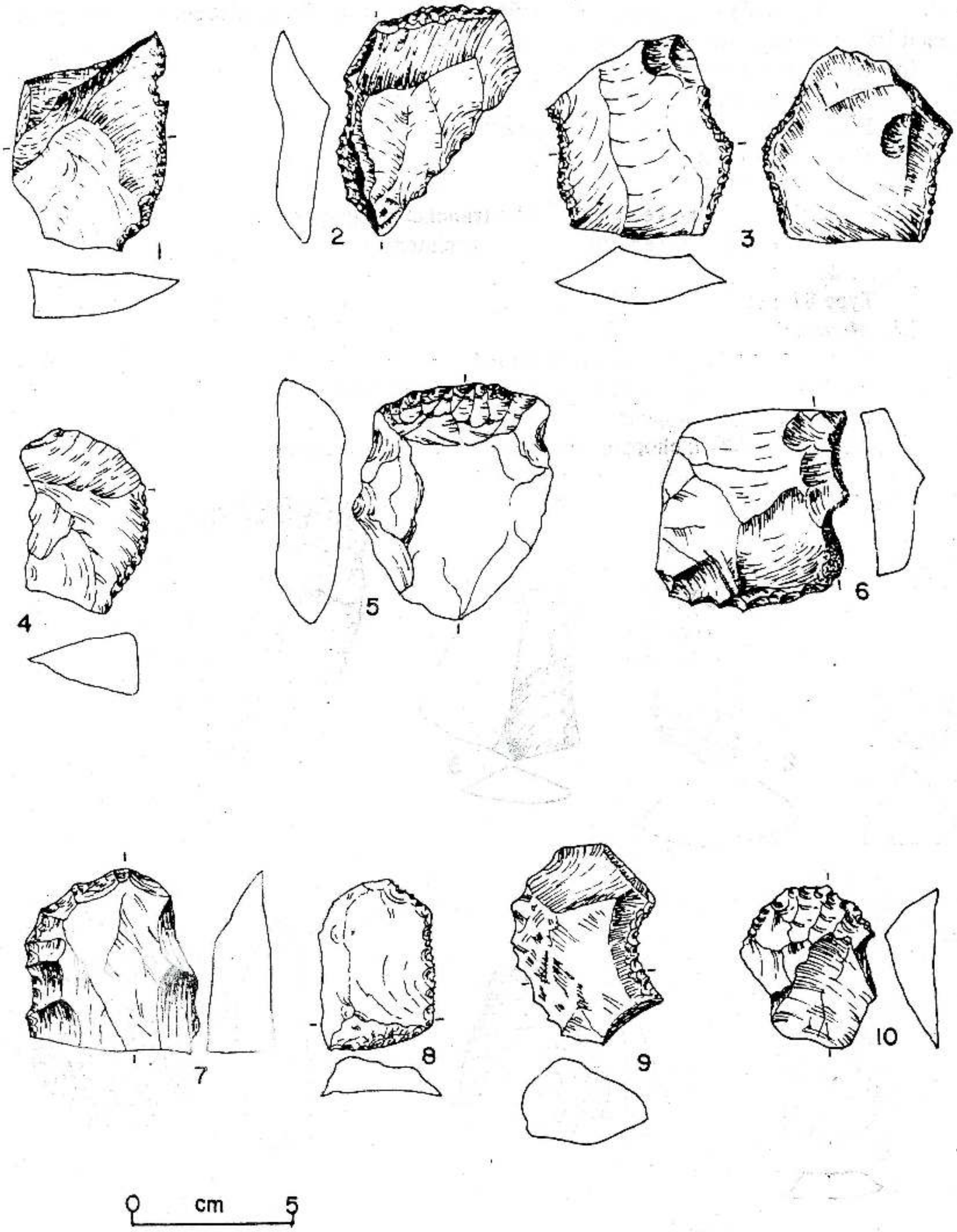



Fig. 14. Medium-sized stone artefacts from the I Fm

disregard this potentially complicating variable and choose to see a general regression of the coastline as represented in the I Fm from the Holstein interglacial (perhaps even Cromerian) down to the Holocene altithermals – with an awareness that pre-Eem sea levels are a subject of debate.

The sampling procedure employed in Stage II of the research design has been described in Chapter 2.3-4, the site data being presented in Appendix III. The technologically salient results are set out below, in descending order of the elevations of the sites above sea level. Note that references to Acheulean and Mousterioid traits need not necesarily signify anything more than spurious resemblances to these techno-complexes – although there is a fair probability that Mousterioid traits do indeed occur (at times in the Acheulean tradition, as in the MTA of France).

Site 27: *vembu* at ca. 80m+msl; possible tectonic uplift; rich in artefacts, with several large, form-trimmed implements; some noteworthy specimens are:

(*a*) *Crude, massive choppers*
Figs.24(6), 27(4), 28(1)
Fig.31(6): large chopper on a gneiss flake

(*b*) *Quasi-Acheulean*
Figs.27(2), 28(3)
Fig.30(2): cleaver-like and edged by tranchet technique
Step-flaking notably absent on these specimens

(*c*) *Bolas*
Type 87a: medium-sized bolas (n=1)

(*d*) *Mousterioid*
Figs.19(7), 32(2): perimetaly trimmed
Fig.26(5): large form-trimmed chopper on chert flake
Fig.30(6): large chopper
Figs.27(1), 32(4): choppers with regular, invasive trimming

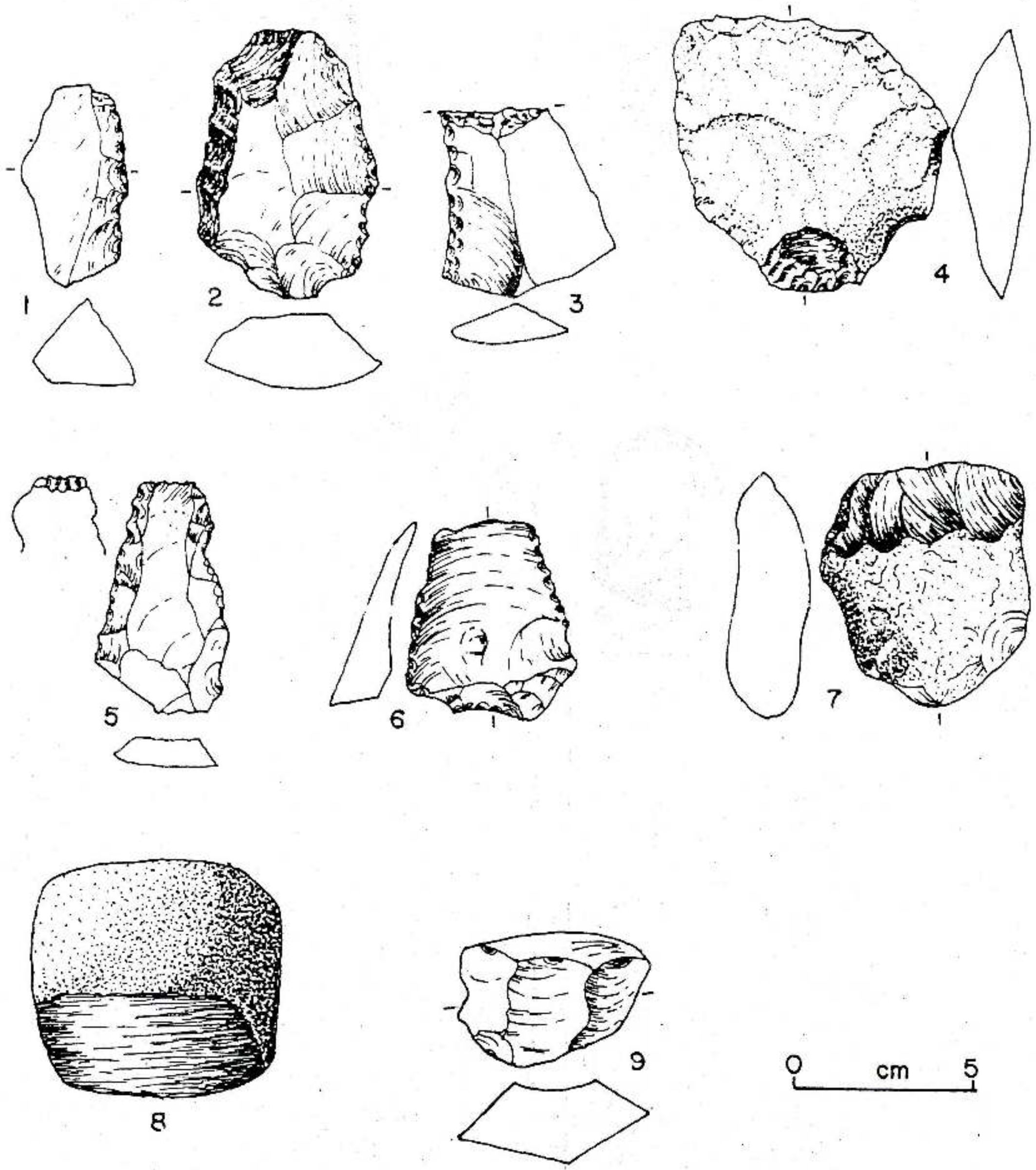



Fig. 15. **Medium-sized stone artefacts from the I Fm**

Type 97b: medium-sized spheroidal nucleus (n=1)
Type 98a: small discoidal nucleus (n=2)
Type 98b: medium-sized discoidal nucleus (n=4)
Type 98c: large discoidal nucleus (n=3)

(*e*) *Small artefacts*
Type 100a: small non-descript nucleus (n=1)

(*f*) *Grindstones*
Fig.23(6): metate with circular concavity
Fig.26(2): mano

Site 30: *vembu* at ca. 70m+msl; ?tectonically elevated

(*a*) *Mousterioid*
Type 98a: small discoidal nucleus (n=2)

(*b*) *Small artefacts*
Type 100a: small non-descript nucleus (n=2)

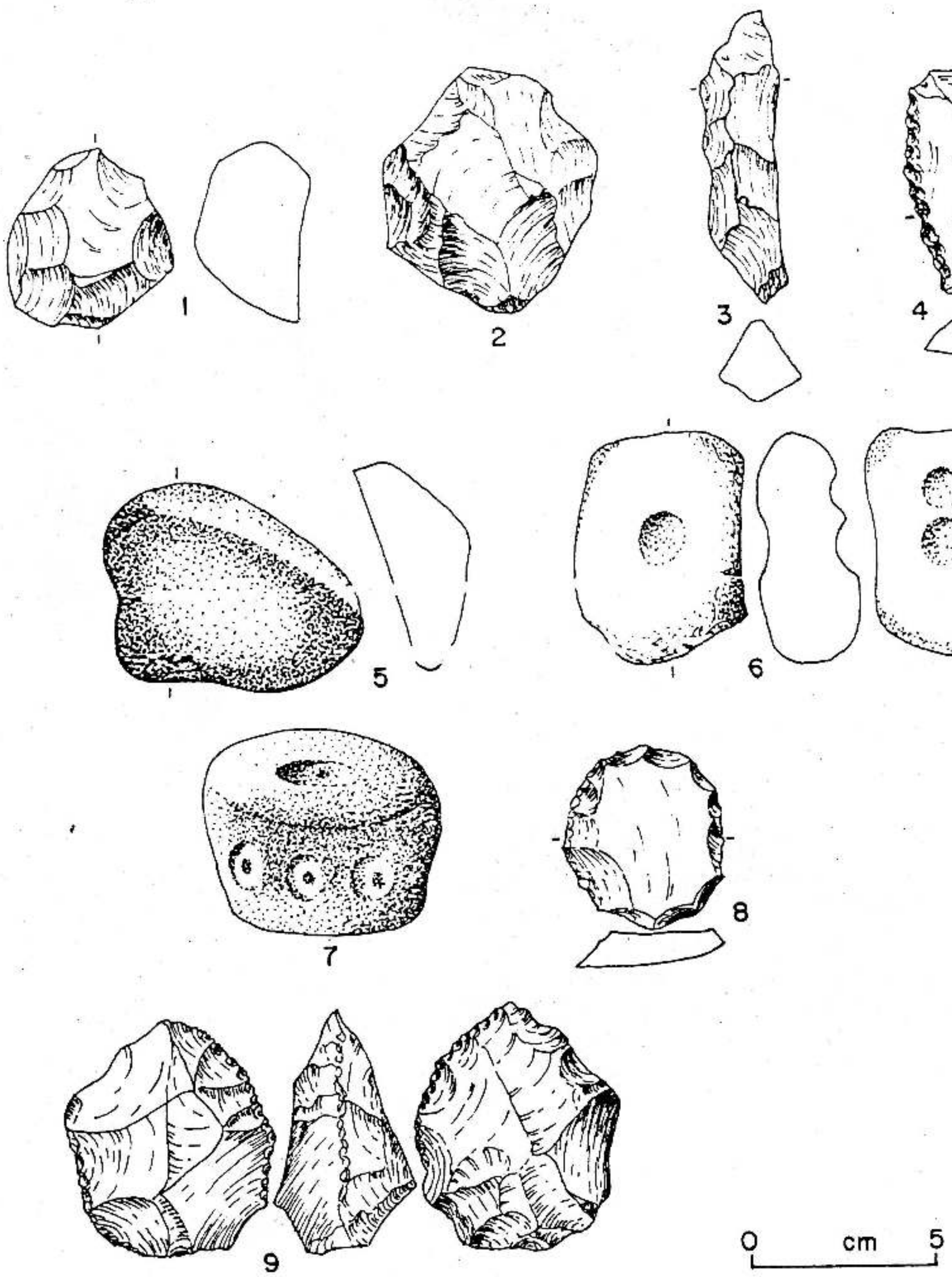



Fig. 16. Medium-sized stone artefacts from the I Fm

Site 29a: *vembu* at ca. 65m + msl

(*a*) *Mousterioid*

Type 98b: medium-sized discoidal nucleus (n=1)

(*b*) *Small artefacts*

Type 100a: small non-descript nucleus (n=1)

Site 11: *vembu* at ca. 63m + msl

(*a*) *Quasi-Acheulean*

Fig.18(3): medium-sized, convex end-chopper; no step-flaking; ?MTA

(*b*) *Bolas*

Fig.17(1)

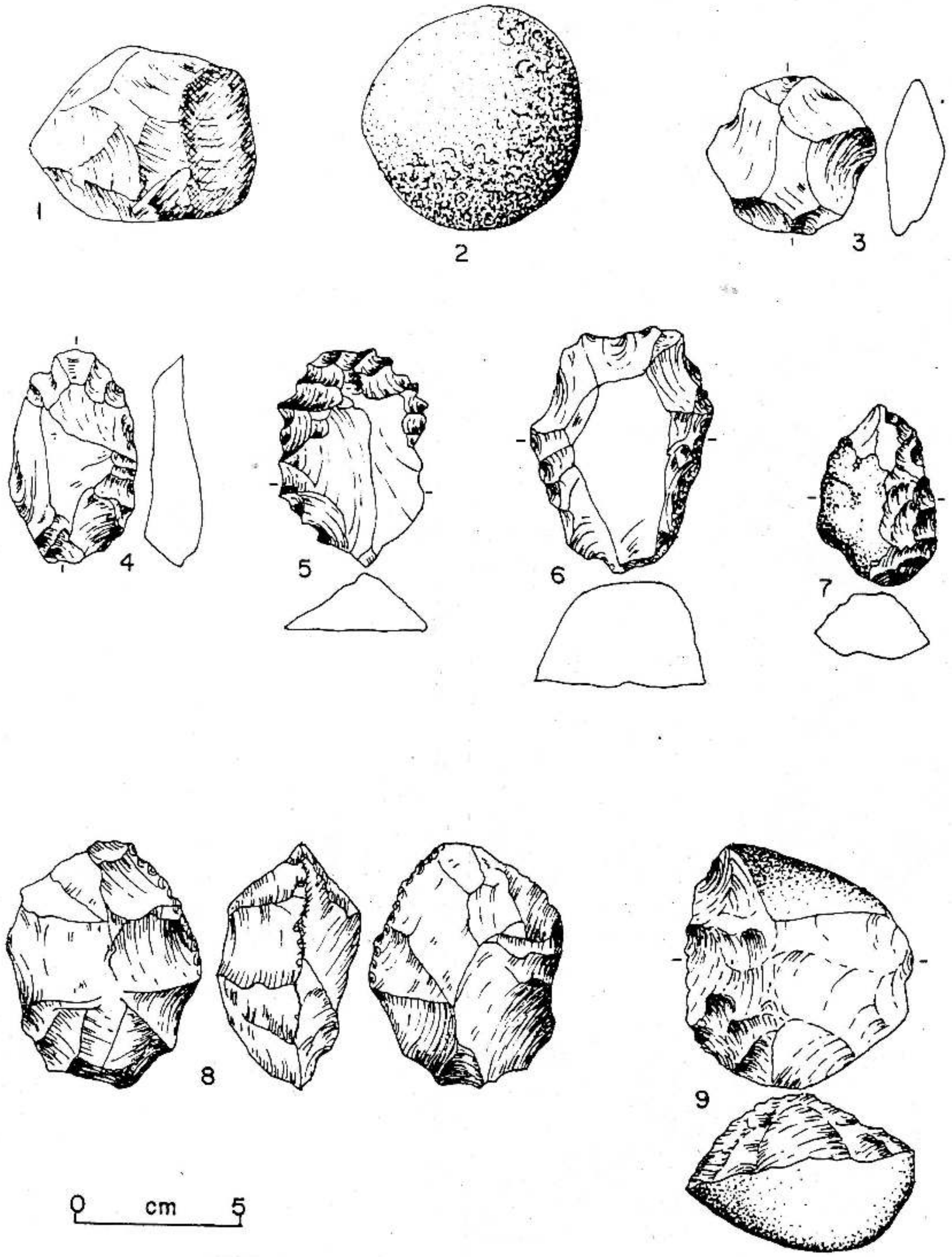



Fig. 17. Medium-sized stone artefacts from the I Fm

(*c*) *Mousterioid*

Fig.20(2): medium-sized side-scraper with stepped edge-trimming
Fig.20(7): scraper on flake derived from prepared spheroidal core
Type 40e: small truncated flake (n=1)
Type 98a: small discoidal nucleus (n=1)
Type 98b: medium-sized discoidal nucleus (n=1)
Type 98c: large discoidal nucleus (n=1)

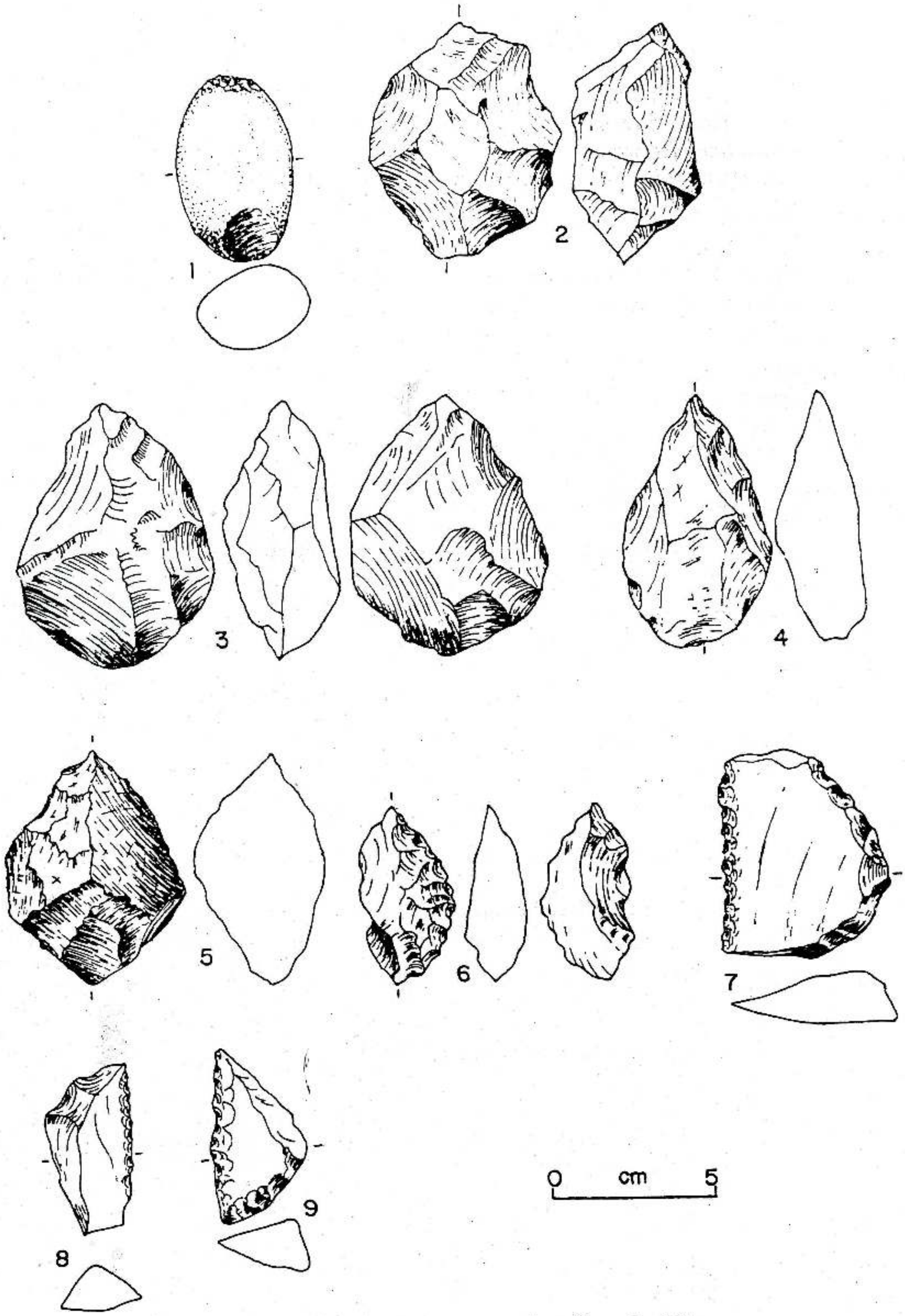



Fig. 18. Medium-sized stone artefacts from the I Fm

(*d*) *Small, finely trimmed*
Fig.13(1): convex scraper with fine edge-trimming
(*e*) *Small artefacts*
Type 100a: small non-descript nucleus (n=1)

Site 12: *vembu* at ca. 60m +msl
(*a*) *Quasi-Acheulean*
Fig.16(9): medium-sized convex chopper on chert; no step-flaking
(*b*) *Mousterioid*
Type 40d: backed small flake (n=1)
(*c*) *Small artefacts*
Fig.11(24): small quartz nucleus
Type 100a: small non-descript nucleus (n=1)
(*d*) *Pitted hammer-stones*
Fig.16(6): medium-sized pitted hammer pebble

Site 20: *vembu* at ca. 57m + msl
(*a*) *Medium-sized choppers*
Fig.15(7): chert chopper, somewhat akin to Mesolithic specimens from Bellan-bandi Palassa (v. S.Deraniyagala 1971*a*).

Site 22: *vembu* at ca. 53m +msl
(*a*) *Mousterioid*
Type 98a: small discoidal nucleus (n = 1)
(*b*) *Small artefacts*
Type 100a: small non-descript nucleus (n = 1)

Site 13: *vembu* at ca. 53m +msl
(*a*) *Mousterioid*
Fig.13(6): medium-sized, backed semi-lunate on quartz

Site 4: *vembu* at ca. 50m +msl
(*a*) *Large choppers*
Fig.22(3): large chopper on granular chert
(*b*) *Bolas*
Fig.25(1): large, crude bolas

Site 33: *vembu* at ca. 50m +msl
(*a*) *Quasi-Acheulean*
Fig.32(6): hemi-lemniscate plan-form; no step-flaking
(*b*) *Mousterioid*
Type 98b: medium-sized discoidal nucleus (n = 1)
(*c*) *Small artefacts*
Type 100a: small non-descript nucleus (n = 2)

Site 19: *vembu* at ca. 50m +msl
(*a*) *Large, crude choppers*
Fig.22(2)
(*b*) *Quasi-Acheulean*
Fig.25(7): large ovate chopper; no step-flaking

Site 37: *vembu* at ca. 48m +msl
(*a*) *Mousterioid*
Type 98a: small discoidal nucleus (n = 1)

Site 5: *vembu* at ca. 47m +msl
(*a*) *Mousterioid*
Fig.21(4): large scraper on chert flake

Site 8: *vembu* at ca. 47m +msl
(*a*) *Mousterioid*
Fig.18(7): medium-sized backed lunate

Site 17: *vembu* at ca. 47m + msl

(*a*) *Rolled artefact*

Fig.22(5): heavily rolled large chopper; possibly coeval with deposition of gravel

(*b*) *Mousterioid*

Type 97b: medium-sized spheroidal prepared nucleus (n = 1)

Site 18: *vembu* at ca. 47m + msl

(*a*) *Bolas*

Fig.25(2): large, regular bolas-stone on granular quartz

Site 18a: Latosol at ca. 49m + msl

(*a*) *Mousterioid*

Type 98b: medium-sized discoidal nucleus (n = 1)

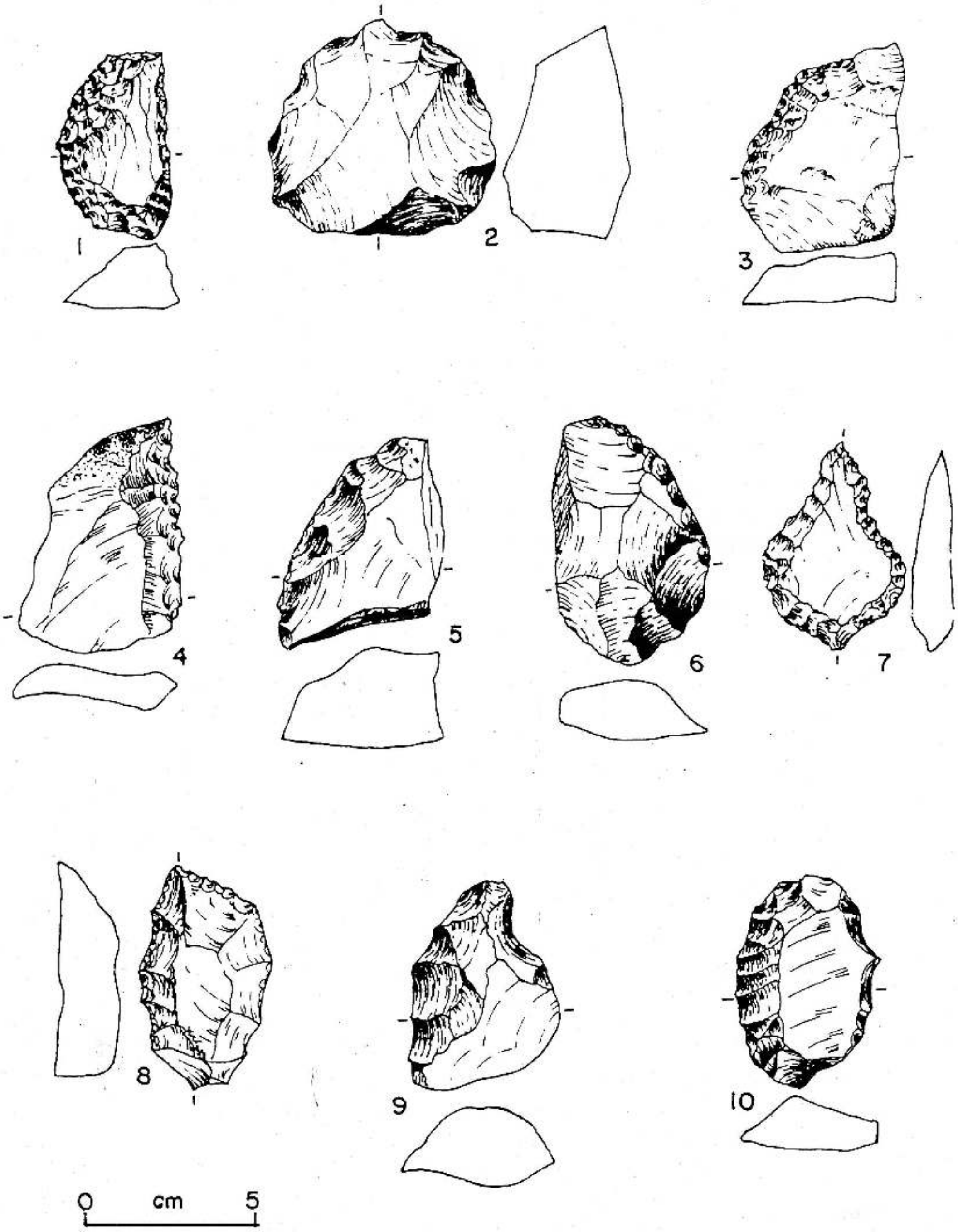



Fig. 19. Medium-sized stone artefacts from the I Fm

(*b*) *Small artefacts*

Type 100a: small non-descript nucleus (n = 1)

Site 18b: basal gravel at ca. 47m + msl

(*a*) *Small artefacts*

Type 100a: small non-descript nucleus (n = 1)

Site 24: *vembu* at ca. 46m + msl; rich in artefacts

(*a*) *Quasi-Acheulean*

Fig.30(1): large cleaver; tranchet technique not employed

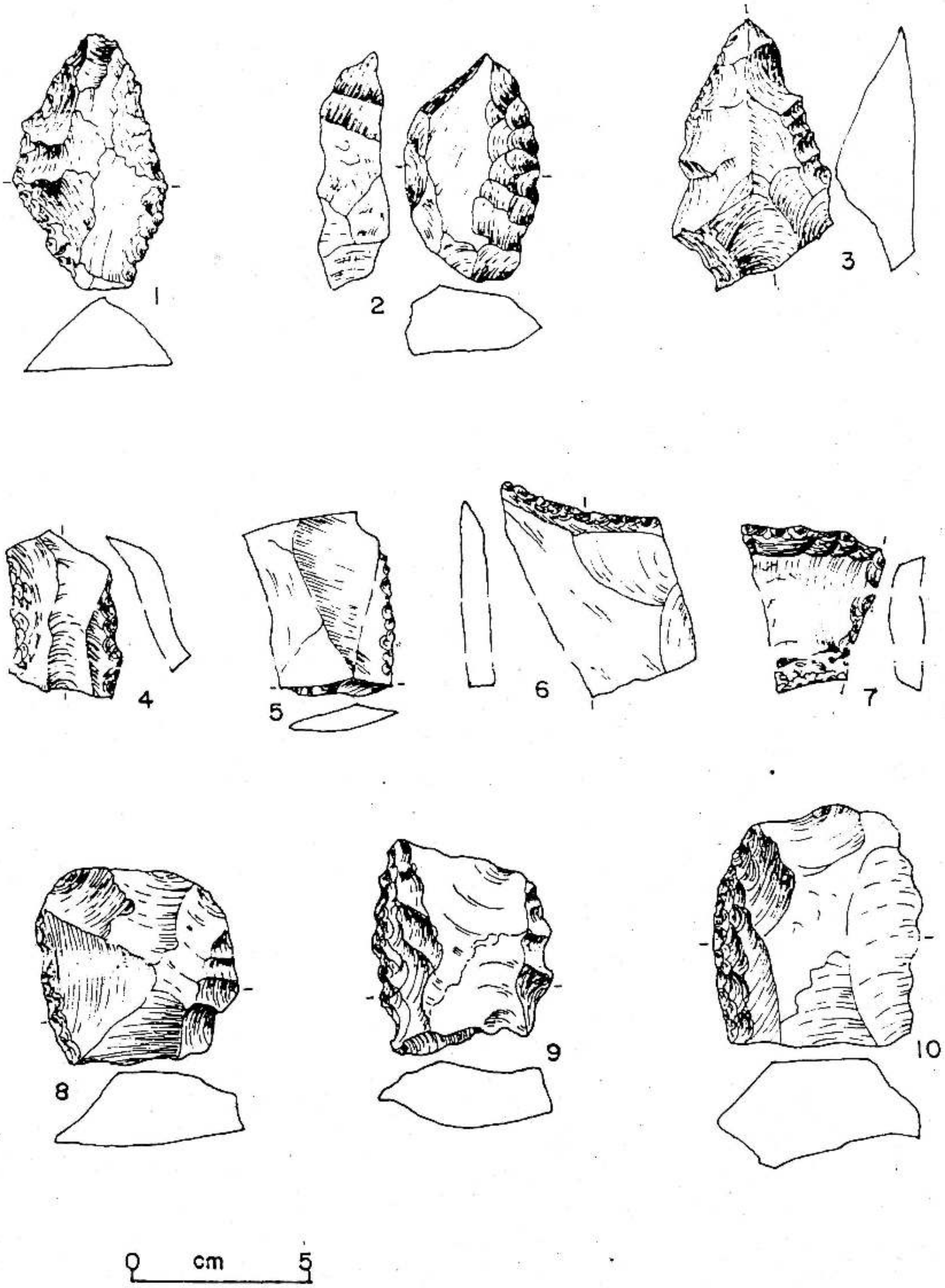



Fig. 20. Medium-sized stone artefacts from the I Fm

(*b*) *Bolas*
Type 87b: large bolas (n = 1)
(*c*) *Mousterioid*
Fig.29(5): large ovate chopper, unifacially trimmed; ?MTA
Fig.30(4): large perimetal scraper on quartz with conspicuously regular, invasive step-trimming.
Type 97b: medium-sized spheroidal nucleus (n = 2)
Type 97c: large spheroidal nucleus (n = 1)
Type 98a: small discoidal nucleus (n = 1)
Type 98b: medium-sized discoidal nucleus (n = 5)
Type 98c: large discoidal nucleus (n = 1)
Type 40d: backed small flake (n = 1)
(*d*) *Small, trimmed artefacts*
Fig.12(6): small, finely trimmed convex scraper on quartz
(*e*) *Small artefacts*
Type 100a: small non-descript nucleus (n = 2)
(*f*) *Medium-sized hammer-stones*
Fig.18(1): used, medium-sized hammer-pebble
(*g*) *Small hammer-stones*
Fig.12(14): used, small hammer-pebble on quartz, similar to specimens from Mesolithic Bellan-bandi Palassa (v. S.Deraniyagala 1971*a*).
(*h*) *Pitted hammer-stones*
Fig.24(4): large, pitted pebble, akin to those found in the Mesolithic of the Wet Zone.
Fig.16(7): medium-sized pitted pebble; multiple pitting

Site 9: *vembu* at ca. 45m + msl
(*a*) *Crude, large implements*
Fig.28(5): crude, large point on granular quartz
(*b*) *Quasi-Acheulean*
Fig.26(4): large, thick chopper
(*c*) *Mousterioid*
Type 40d: backed small flake
(*d*) *Small artefacts*
Type 100a: small non-descript nucleus (n=2)
(*e*) *Microliths*
Fig.13(20): quadrangular microlith; truncated at one end; Type 5e(ii)

Site 36: *vembu* at ca. 45m + msl; ?tectonically elevated
(*a*) *Mousterioid*
Fig.11(4): backed small flake; Type 40b(i)
(*b*) *Small artefacts*
Type 100a: small non-descript nucleus (n=2)

Site 14: *vembu* at ca. 45m + msl
(*a*) *Bolas*
Type 87a: medium-sized bolas (n=1)
(*b*) *Mousterioid*
Fig.16(3): wedge-form trimming flake from spheroidal prepared core; possibly akin to specimen from Indian Middle Palaeolithic.
(*c*) *Bladelets*
Fig.11(25): small blade-nucleus on quartz

Site 21: *vembu* at ca. 43m + msl
(*a*) *Massive artefacts; water-worn; ?coeval with basal gravels*
Fig.30(7): large convex chopper; water-worn
Figs.21(6), 22(6): massive, crude choppers on granular quartz; water-worn

(*b*) *Mousterioid*
Fig.17(8): medium-sized ovate chopper; ?MTA
Type 103a: trimmer from prepared spheroidal nucleus (n=1)

(*c*) *Small, trimmed artefacts*
Fig.12(7): elegantly trimmed small scraper on rock-crystal

Site 7: *vembu* at ca. 42m+msl

(*a*) *Quasi-Levallois*
Fig.21(2): flake with faceted platform and primary trimming on dorsal aspect

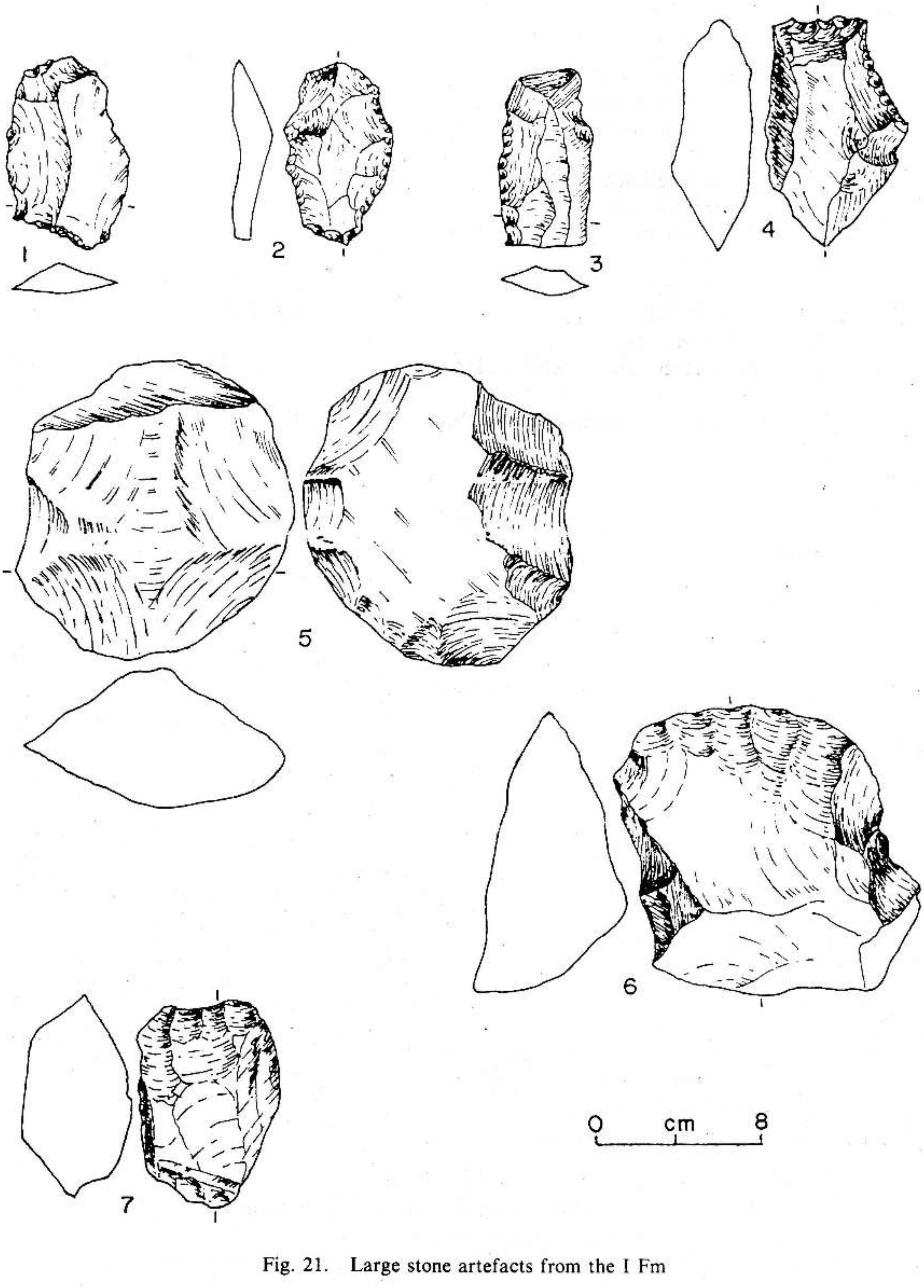



Fig. 21. Large stone artefacts from the I Fm

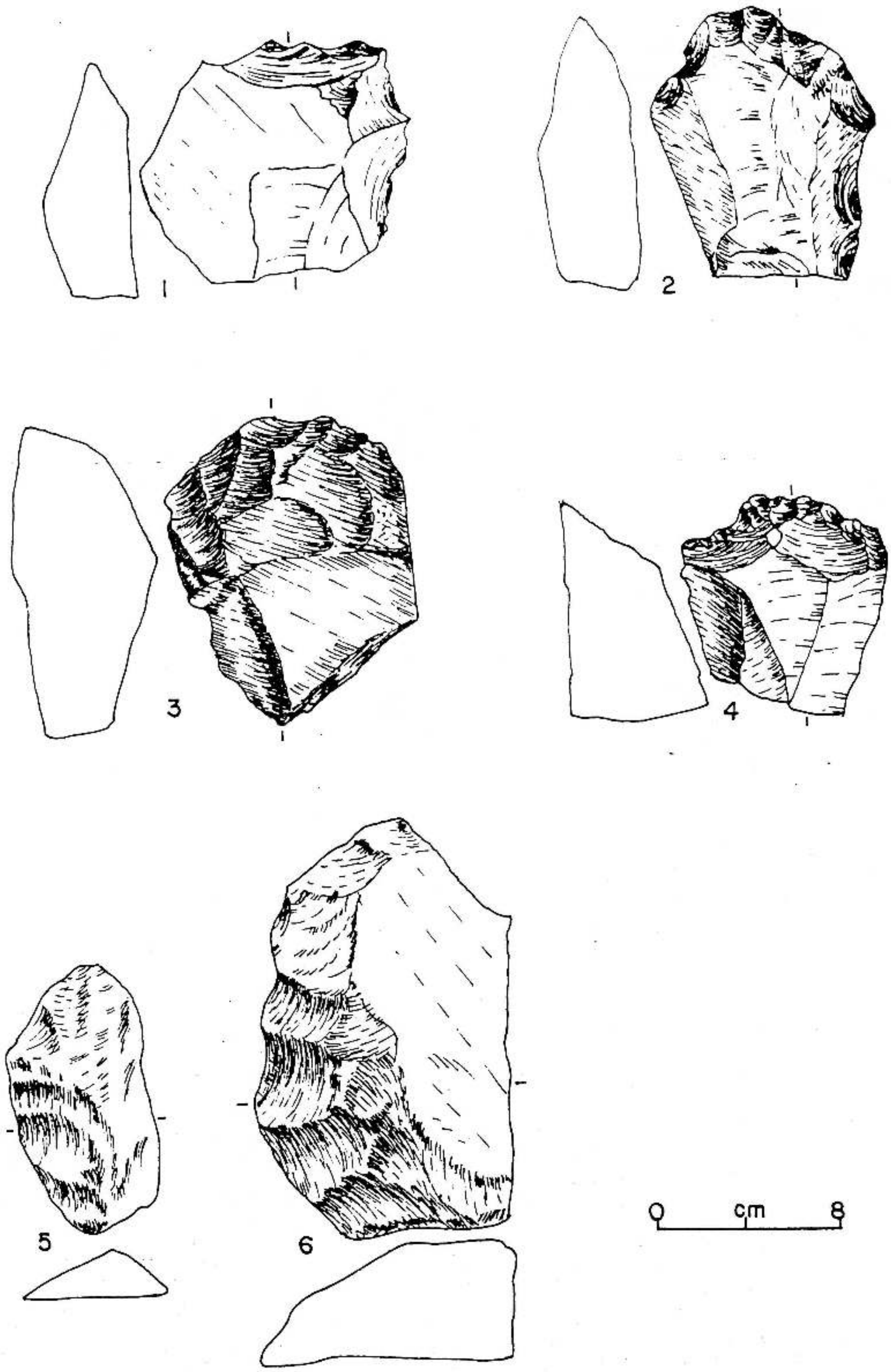



Fig. 22. Large stone artefacts from the I Fm

(*b*) *Mousterioid*
Fig.30(3): wedge-form flake from spheroidal prepared nucleus

(*c*) *Grindstones*
Fig.37(7): large grindstone

(*d*) *Small artefacts*
Type 100a: small non-descript nucleus (n=1)

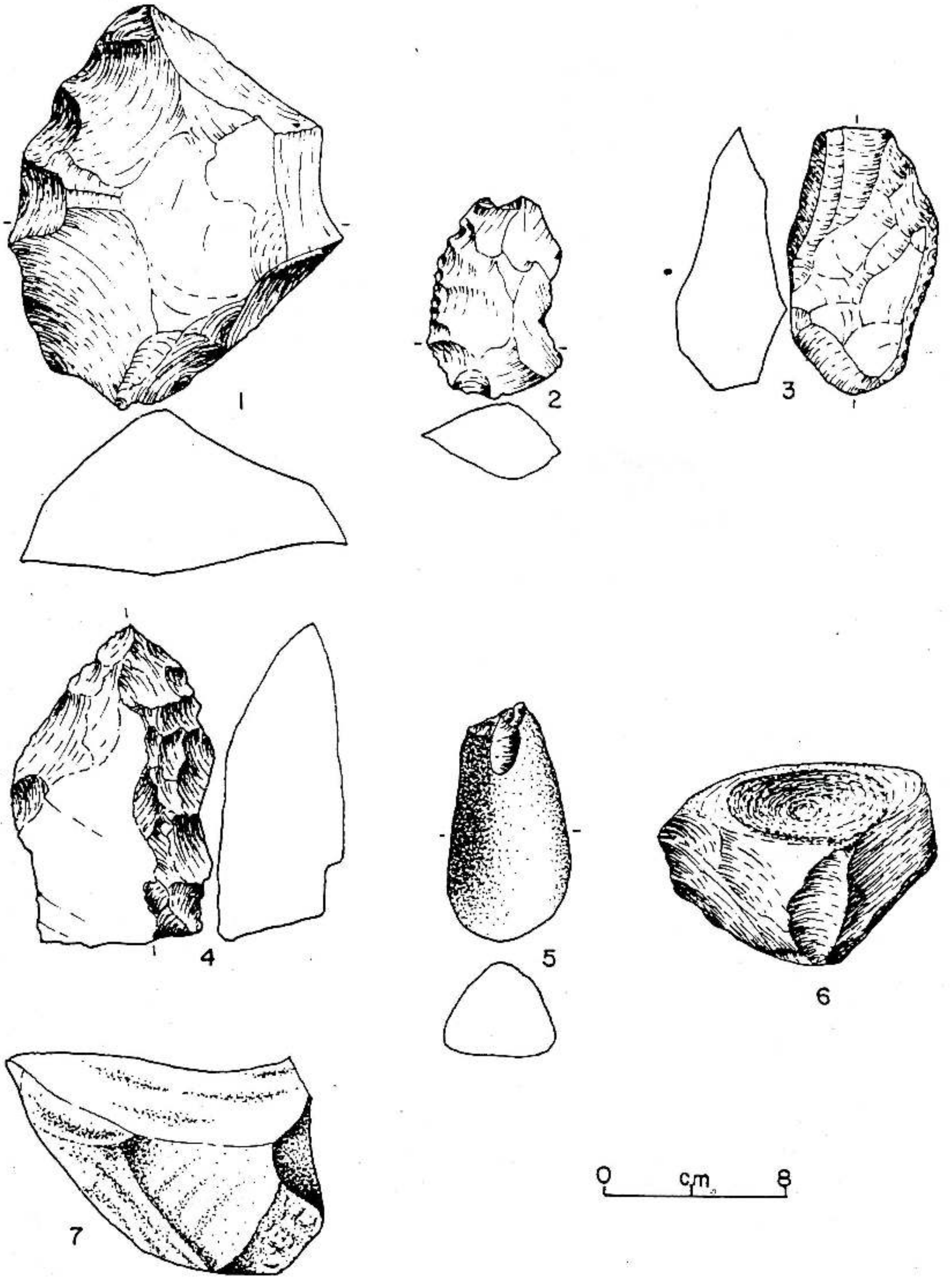



Fig. 23. Large stone artefacts from the I Fm

Site 31: *vembu* at ca. 40m + msl; ?tectonically elevated

(*a*) *Mousterioid*

Fig.18(6): finely trimmed, medium-sized point on chert
Type 98b: medium-sized discoidal nucleus (n=5)

(*b*) *Small artefacts*

Fig.12(15): ovoid, small nucleus
Type 100a: small non-descript nucleus (n=6)

Site 34: *vembu* at ca. 40m + msl; ?tectonically elevated

(*a*) *Mousterioid*

Fig.19(1): medium-sized, step-flaked scraper on chert

Type 97c: large spheroidal nucleus (n=1)
Type 98b: medium-sized discoidal nucleus (n=1)
Type 98c: large discoidal nucleus (n=1)

(*b*) *Small artefacts*
Type 100a: small non-descript nucleus (n=1)

Site 40: *vembus* at ca. 20-40m+msl; very probably ?tectonically elevated; rich in artefacts; this site might represent several marine regressions, possibly from the Holstein onwards.

(*a*) *Crude, massive choppers*
Figs.23(1), 24(5), 25(6): large choppers on chert
Fig.26(1): large, water-worn chopper on granular quartz; ?coeval with a gravel
Fig.21(5): large chopper on chert; re-flaked subsequent to being water-worn

(*b*) *Bolas*
Fig.17(2): finely trimmed bolas on granular quartz

(*c*) *Mousterioid*
Fig.28(2): delicately step-flaked large point on milky quartz; survivals of the Acheulean tradition appear to be evident; ?MTA; Type 70.
Type 40d: small backed flake (n=2)
Type 41a: medium-sized backed flake (n=3)
Type 98a: small discoidal nucleus (n=8)
Type 98c: large discoidal nucleus (n=5)

(*d*) *Small artefacts*
Fig.12(5): small discoidal perimetal scraper
Fig.13(15): small scraper with fine edge-trimming
Fig.11(11): small concave scraper with use marks
Type 100a: small non-descript nucleus (n=4)

(*e*) *Bladelets*
Fig.12(4): bladelet; Type 93a(ii)

Site 40a: Latosol at ca. 40m+msl; probably tectonically elevated

(*a*) *Mousterioid*
Type 98b: medium-sized discoidal nucleus (n=3)

(*b*) *Small artefacts*
Type 100a: small non-descript nucleus (n=1)

Site 3: Latosol at ca. 33m+msl

(*a*) *Mousterioid*
Fig.18(8): wedge-form flake from spheroidal nucleus
Type 98b: medium-sized discoidal nucleus (n=1)

Site 35: *vembu* at ca. 32m+msl; ?tectonically elevated

(*a*) *Red ochre*
Fig.12(1): used specimen of red ochre

(*b*) *Mousterioid*
Type 41a: medium-sized backed flake (n=1)
Type 98a: small discoidal nucleus (n=1)
Type 98c: large discoidal nucleus (n=5)

(*c*) *Small artefacts*
Type 100a: Small non-descript nucleus (n=10)

Site 32: *vembu* at ca. 30m+msl; ?tectonically elevated

(*a*) *Large choppers*
Fig.24(7): large chopper on chert, akin to specimens from Mesolithic Bellan-bandi Palassa (v. S.Deraniyagala 1971*a*).

(*b*) *Mousterioid*
Type 98b: medium-sized discoidal nucleus (n=2)

(*c*) *Small artefacts*
Fig.12(18): small, used concave scraper
Type 100a: small non-descript nucleus (n=1)

Site 45: *vembu* at ca. 25m + msl

(*a*) *Quasi-Acheulean*

Fig.29(3): large pick; no step-flaking

(*b*) *Mousterioid*

Type 98a: small discoidal nucleus (n=8)

Type 98b: medium-sized discoidal nucleus (n=1)

Site 26: *vembu* at ca. 15m+msl

(*a*) *Mousterioid*

Type 98b: medium-sized discoidal nucleus (n=1)

(*b*) *Small artefacts*

Type 100a: small non-descript nucleus (n=1)

Site 38: *vembu* at ca. 15m + msl

(*a*) *Bladelets*

Fig.11(22); bladelet-nucleus on rock-crystal

Site 50: *vembu* at ca. 15m + msl

(*a*) *Mousterioid*

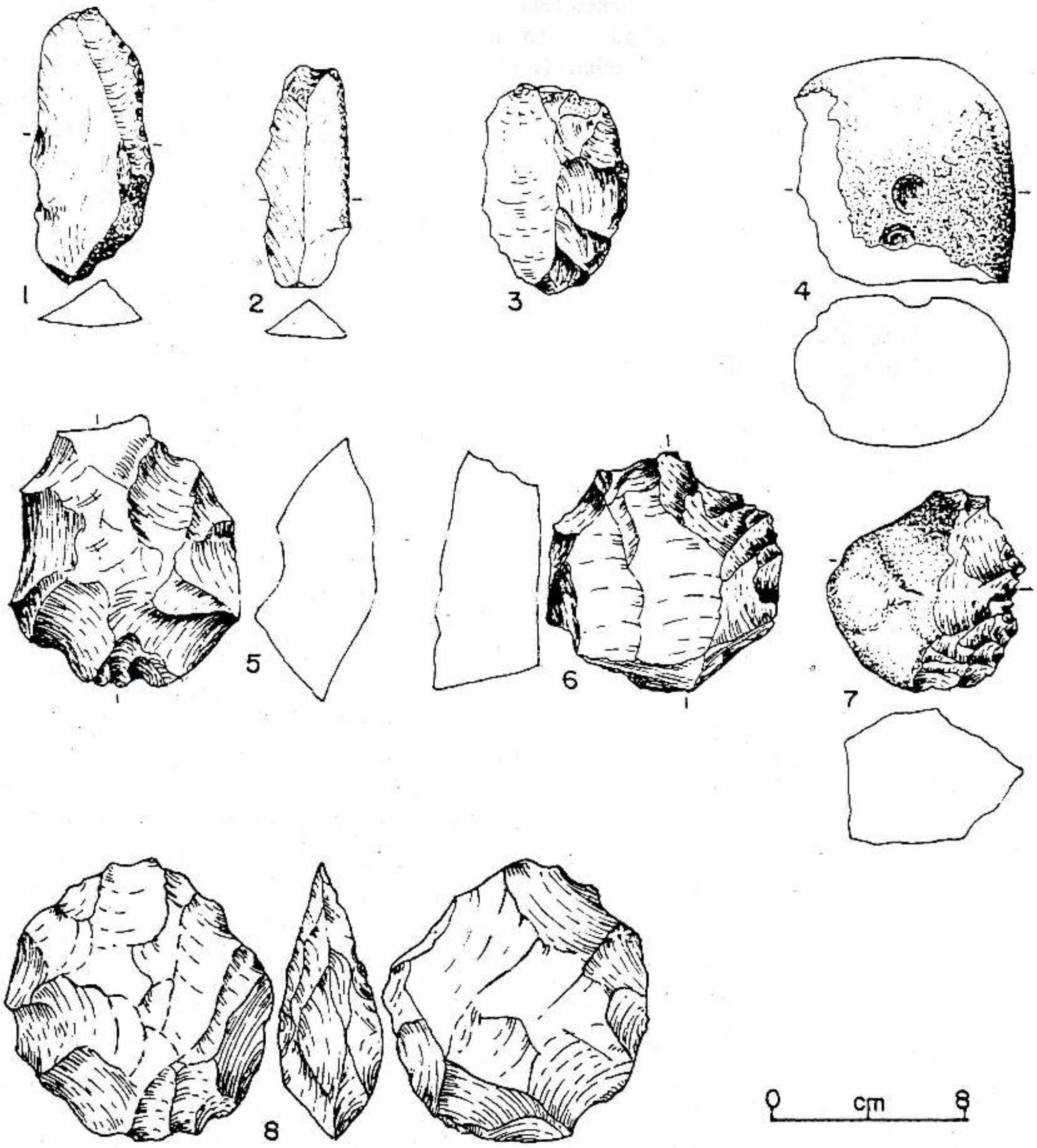



**Fig. 24. Large stone artefacts from the I Fm**

Fig.37(7): large chopper with flat, invasive trimming; ?MTA
Type 41a: medium-sized backed flake (n=1)
Type 98a: small discoidal nucleus (n=2)
Type 98b: medium-sized discoidal nucleus (n=1)
Type 98c: large discoidal nucleus (n=1)

(*b*) *Small artefacts*
Type 100a: small non-descript nucleus (n=4)

(*c*) *Microlithic semi-lanates*
Type 7b: microlithic semi-lunate (n=1)

Site 28: *vembu* at ?10m+msl

(*a*) *Mousterioid*
Type 40: truncated small flake (n=1)

(*b*) *Small artefacts*
Type 100a: small non-descript nucleus (n=5)

Site 39: *vembu* at ca. 10m+msl

(*a*) *Mousterioid*
Type 98a: small discoidal nucleus (n=1)
Type 98c: large discoidal nucleus (n=1)

(*b*) *Bladelets*
Type 91a: used bladelet (n=1)

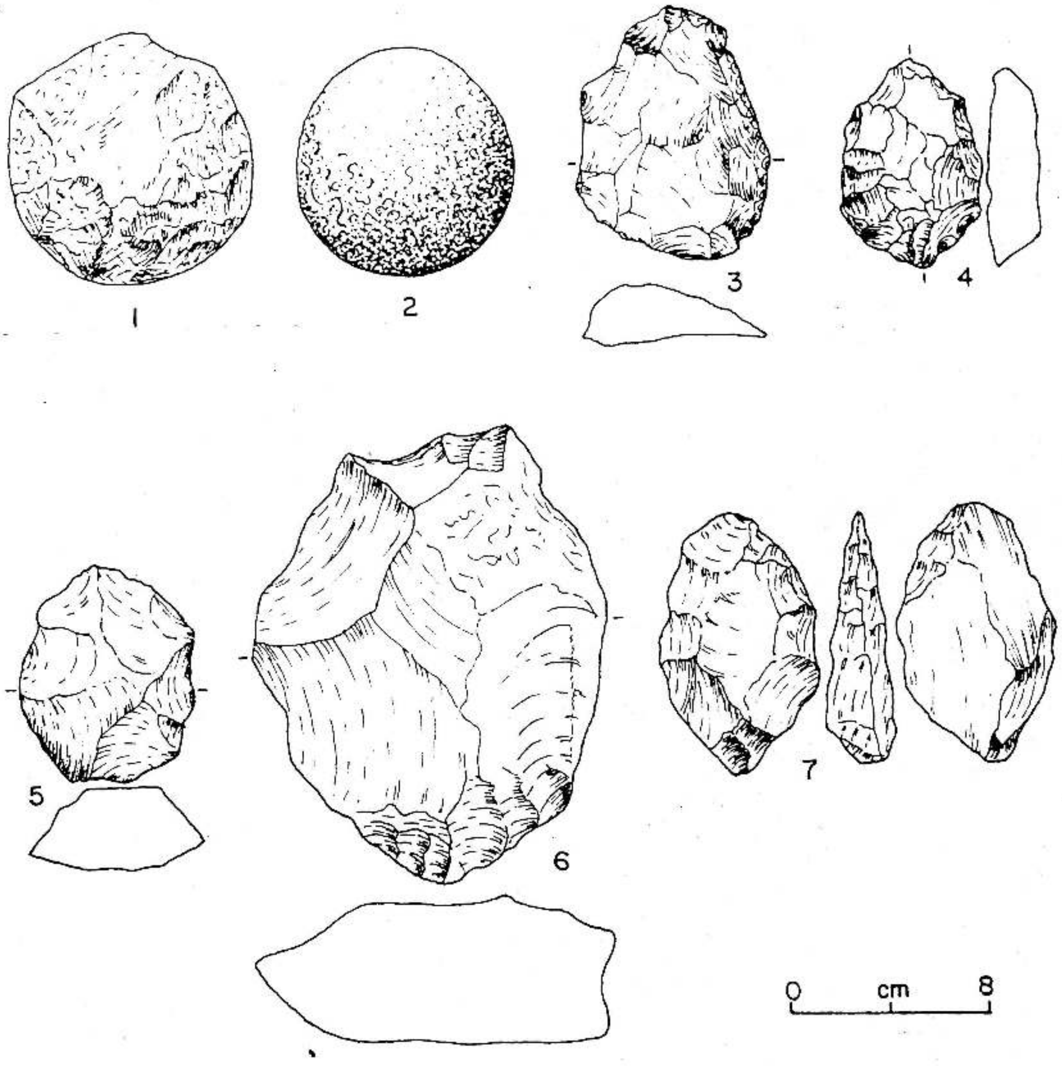



Fig. 25. Large stone artefacts from the I Fm

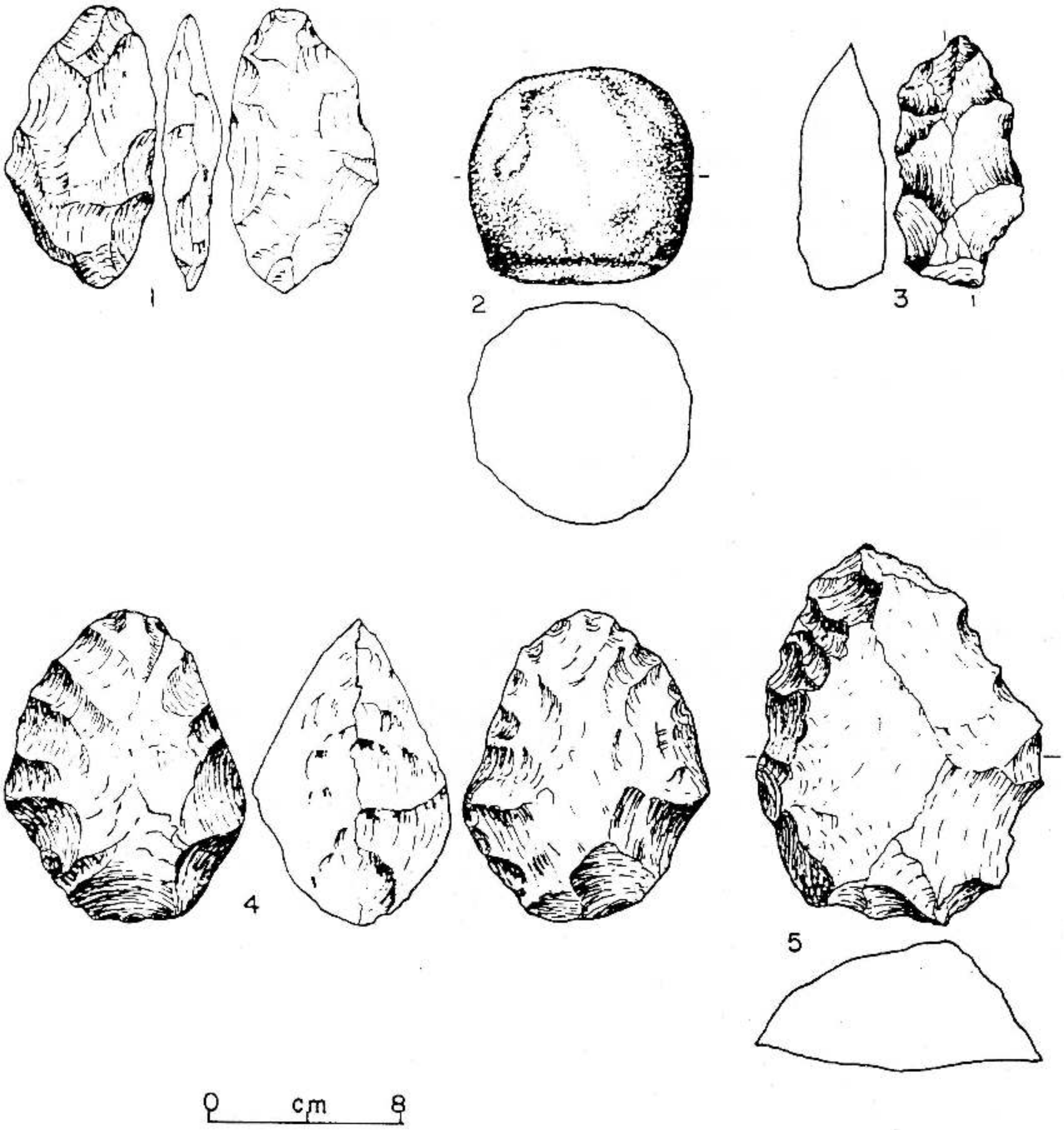



Fig. 26. Large stone artefacts from the I Fm

Site 41: *vembu* at ca. 10m+msl

(*a*) *Mousterioid*

Type 41a: medium-sized backed flake (n=2)
Type 98a: small discoidal nucleus (n=9)
Type 98b: medium-sized discoidal nucleus (n=1)

(*b*) *Small artefacts*

Type 100a: small non-descript nucleus (n=3)

(*c*) *Bladelets*

Type 101a: bladelet waste (n=1)

(*d*) *Geometric microliths*

Fig.13(5): microlithic lunate (Form 13) barb, on quartz, Type 2b(iii)

Site 42: *vembu* at ca.10m+msl

(*a*) *Mousterioid*

Type 98a: small discoidal nucleus (n=2)

Site 48: *vembu* at ca. 10m+msl

(*a*) *Mousterioid*

Type 98a: small discoidal nucleus (n=1)
Type 98b: medium-sized discoidal nucleus (n=1)

(*b*) *Small artefacts*
Type 100a: small non-descript nucleus (n=1)

Site 49: *vembu* at ca. 8m+msl

(*a*) *Mousterioid*
Fig.24(8): large, beautifully form-, edge- and body-trimmed perimetal chopper on granular quartz; shallow step-flaking (not clear on illustration).
Fig.29(1): large flake with form trimming and blunting retouch
Fig.12(9): small, regular, discoidal nucleus on rock-crystal
Fig.12(17): small, backed flake
Fig.11(20): small awl with blunting retouch for edge-trimming; Type 40b(iii)

(*b*) *Small hammer-stones*
Fig.12(13): small, used hammer-pebble, akin to specimens from Mesolithic Bellan-bandi Palassa (v. S.Deraniyagala 1971*a*).

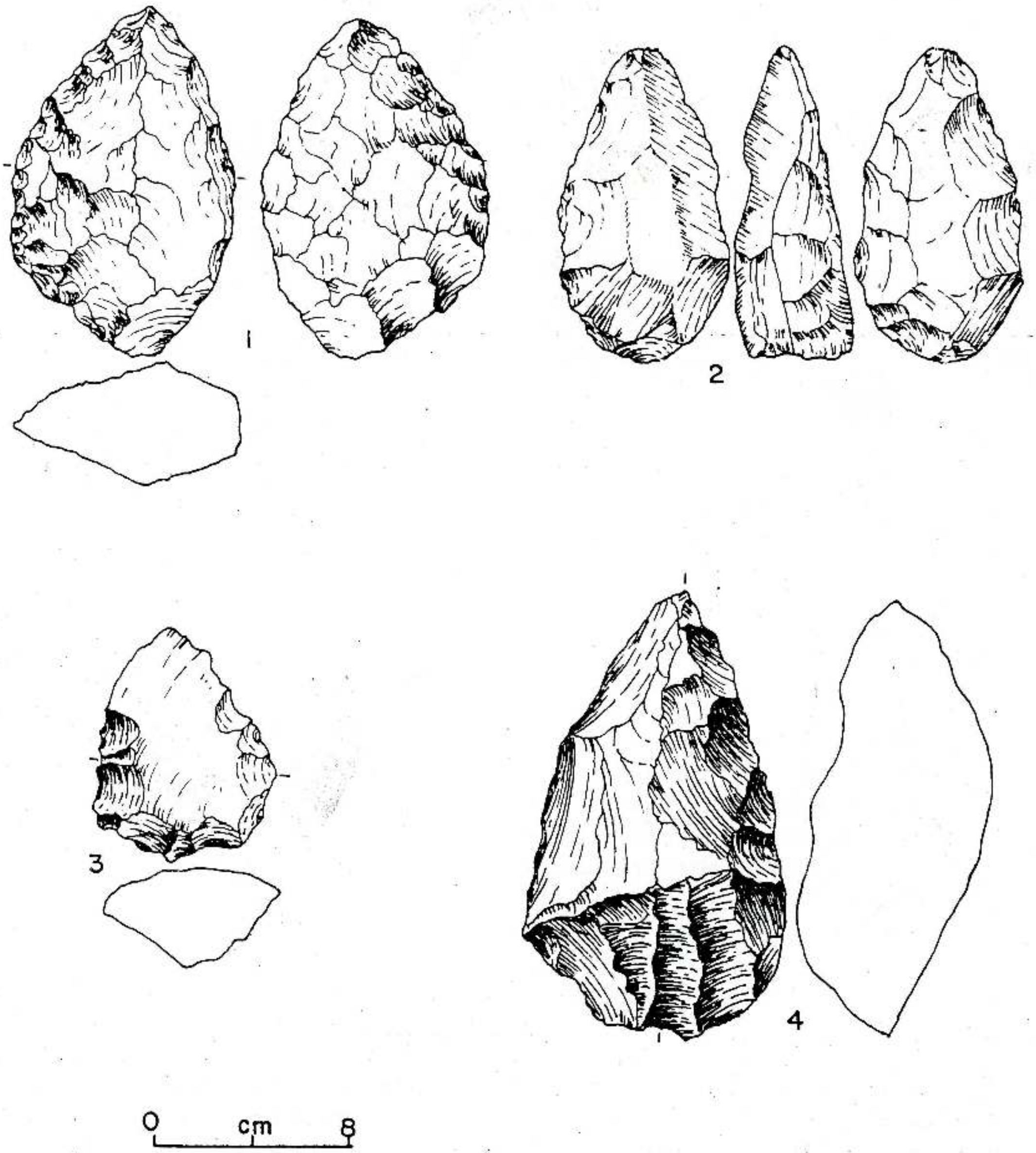



Fig. 27. Large stone artefacts from the I Fm

Site 49a: Latosol at ca. 10m+msl

(*a*) *Bladelets*
Figs.12(2,3): bladelet fragments

Site 25: *vembu* at ca. 8m+msl
(*a*) *Grinder*
Fig.15(8): medium-sized mano, on gneiss
(*b*) *Pitted hammer-stones*
Type 109b: large, pitted hammer-stone (n = 2)

The site data set out above refer in most cases to artefacts found on the *vembus*, which could represent several cultural phases, the earliest specimens being potentially coeval with the gravels exposed in the *vembus*. Water-worn, large choppers were found at Sites 17 (47m), 21 (43m) and 40 (20-40m; ?tectonically

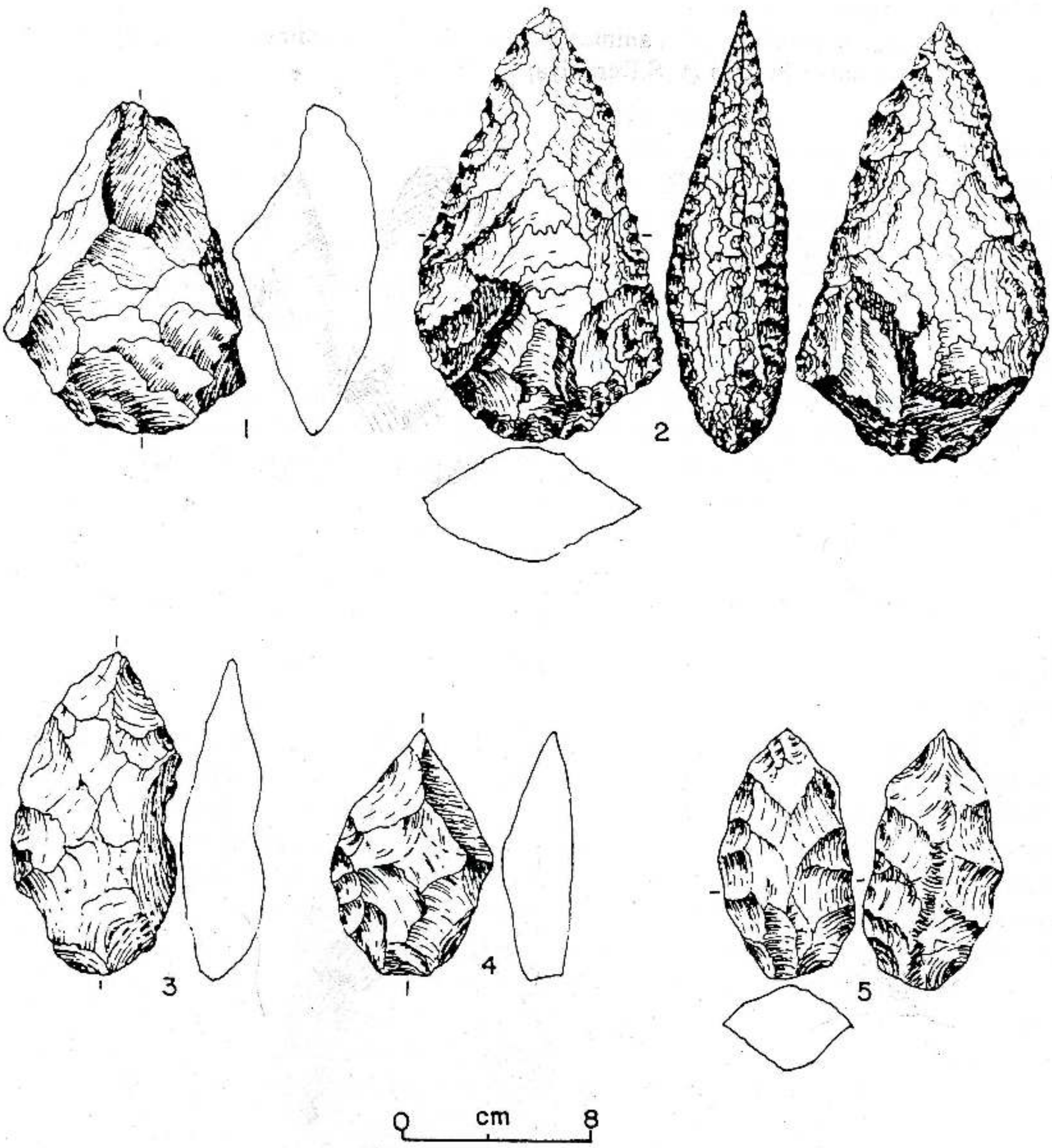



Fig. 28. Large stone artefacts from the I Fm

elevated). While it is probable that the abrasion occurred long after the artefact was manufactured, due to rolling in the *vembus* during the seasonal rains, it is also possible that some of these specimens are indeed coeval with the gravels of the I Fm, which in the case of Sites 17 and 21 could eustatically signify a Holstein age of ca. 300,000 BP – or even a pre-Holstein age if tectonic influences can be discounted. That artefacts once made were at times refashioned, perhaps after a lengthy lapse of time, is instanced at Site 40 with its re-flaked chopper.

Crude, massive choppers were found at Sites 27 (80m; ?tectonically elevated), 4 and 19 (50m), 9 (45m), 21 (43m) and 40 (20-40m; ?tectonically elevated). However this artefact category need not signify great antiquity typologically: Mesolithic Bellan-bandi Palassa (S.Deraniyagala 1971*a*) has yielded some very archaic-looking choppers for which close parallels have been found at Sites 20 (57m) and 32 (30m; ?tectonically elevated). It is quite possible that heavy-duty choppers were manufactured throughout Lanka's Stone Age.

A glance at the illustrations will reveal that the quasi-Acheulean artefacts cannot be interpreted as being "true" Acheulean. Their resemblance to Acheulean types could be entirely spurious; or else it probably represents a survival of Acheulean stylistic traits into the Middle Palaeolithic to produce a local Mousterian in the Acheulean Tradition (MTA), as in the case of Type 70 from Site 40 and the large, cordate, bifacial chopper (Type 75a), with step-flaking, discovered by Biddell from a *vembu* near Iranamadu (Hocart 1928:Pl.93). It is likely that both factors, namely spurious resemblance and survivals of the Acheulean tradition, were in operation and it is impossible to classify a specimen one way or the other. Quasi-Acheulean artefacts were found at Sites 27 (80m; ?tectonically elevated), 11 (63m), 12 (60m), 33 and 19 (50m), 24 (46m) and 9 (45m). It is noteworthy that these occurrences appear to have been associated with pre-Eem gravels (?Cromerian). The quasi-Levallois artefact from Site 7 (42m) can be considered to bear merely a spurious resemblance to this techno-tradition.

Bolas-stones, functionally typified by the gneiss specimen from Site 40, are known from as early as the Upper Acheulean of Olorgesailie in East Africa (Clark 1970:92). These artefacts occur in the *vembus* at 63-43m+msl, a range similar to that of the quasi-Acheulean: Sites 27 (80m; ?tectonically elevated), 11 (63m), 4 (50m), 18 (47m), 24 (46m), 14 (43m) and 40 (20-40m; ?tectonically elevated). It is hence possible that some of these date to the Cromerian or an earlier interglacial, although they could also post-date the *vembu* gravels considerably. A medium-sized bolas-stone was found in the basal gravels of the RBE Fm at Gedige I and a finely finished small specimen has recently been excavated from one of the lower layers of Beli-lena Kitulgala, which is dated to the Upper Pleistocene.

Although the gneiss bolas-stones were probably used as such or as hammers for dressing other artefacts, specimens made of quartz tend to grade into spheroidal prepared nuclei (Type 97). An examination of Indian Middle Palaeolithic material housed at the Deccan College, Poona, revealed several specimens of what are apparently core-trimming flakes with segment-like plan-form, wedge-form cross-section and the arc of the segment displaying core-dressing such as are found on spheroidal prepared nuclei. (Noteworthy is the absence of a cone or bulb of percussion on these trimming flakes, suggesting that bipolar flaking had been employed with the attendant shearing across the bulb (for this technique v. Crabtree 1972:10-1).) It is thus possible to hypothesise that spheroidal prepared nuclei are representative of the Middle Palaeolithic of India, although the lower and upper age boundaries are indeterminate. The presence of Type 97 at Sites 27 (80m; ?tectonically elevated), 11 (63m), 17 (47m), 24 (46m), 14 and 21 (43m), 7 (42m), 34 (40m; ?tectonically elevated) and 3 (33m) could therefore be considered to range from the Cromerian interglacial to the Eem on the basis of eustatic altimetry and typological cross-dating with India.

Step-trimming, which is characteristic of the Upper Acheulean, and even more so of the French Mousterian, is rare among the artefact sample considered. Certain conspicuous examples with step-trimming do turn up occasionally, such as Type 70 from Site 40 and the specimens from Sites 24 (46m), 34 (40m) and 49 (8m); but these cannot be evaluated as to the significance of this techno-trait – apart from the rather nebulous implication that it might represent a Mousterioid tradition. Similarly, there are several artefacts, usually on flakes, that can merely be termed "reminiscent" of Mousterioid categories: for instance from Sites 27 (80m; ?tectonically elevated), 11 (63m), 13 (53m), 5 and 8 (47m) 24 (46m), 21 (43m), 31 (40m; ?tectonically elevated), 40 (20-40m; ?tectonically elevated), 35 (32m; ?tectonically elevated), 50 (15m), 41 (10m) and 49 (8m). The small, finely trimmed specimens from Sites 11 (63m), 24 (46m) and 21 (43m) are typologically almost

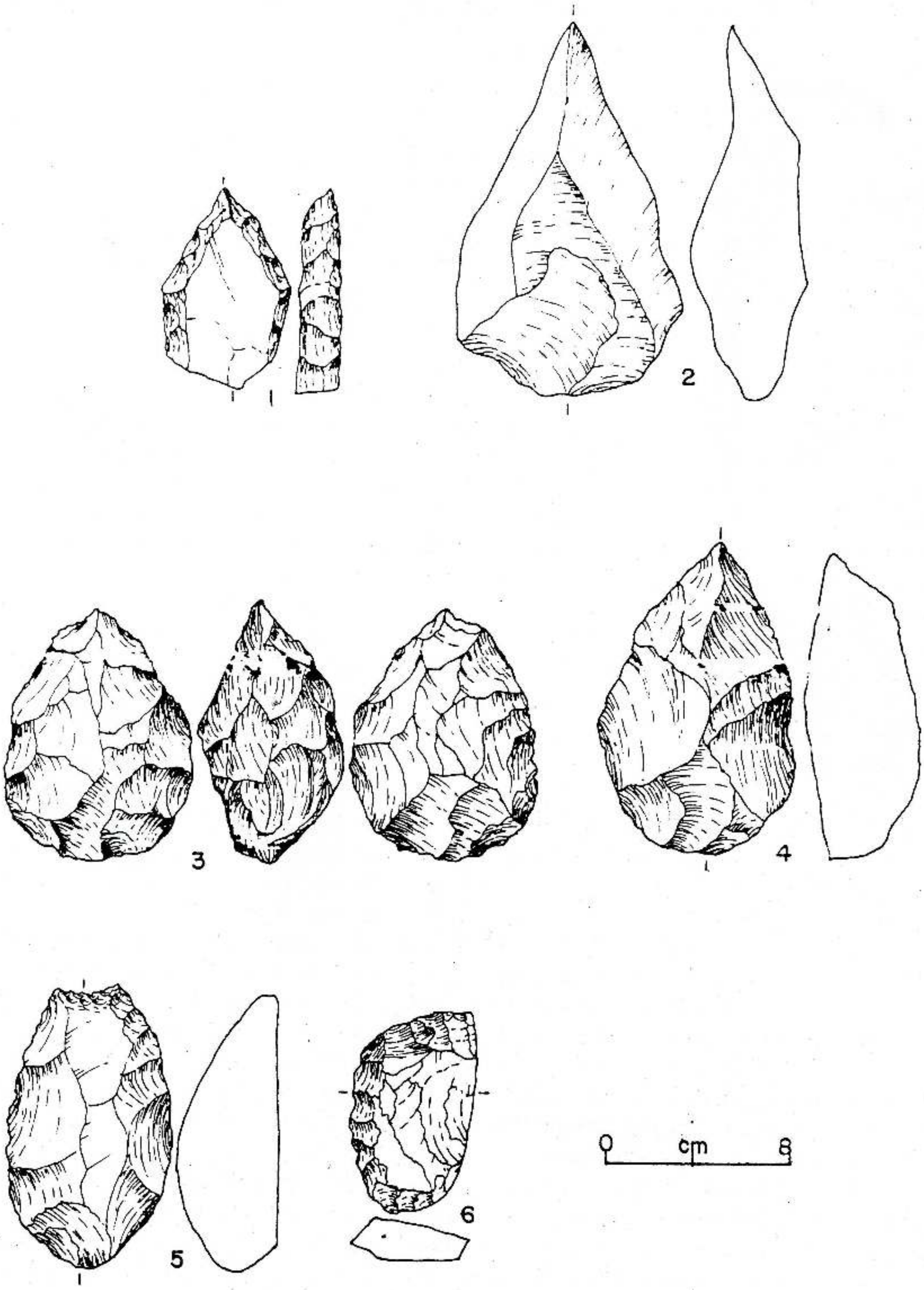



Fig. 29. Large stone artefacts from the I Fm

certainly not pre-Middle Palaeolithic, although they could conceivably be earlier. I have regarded these small, as well as somewhat larger, trimmed flake-tools, as being Mousterioid, pending evidence to the contrary; but conceptually there is nothing to prevent their being post-Middle Palaeolithic or Lower Palaeolithic.

The use of blunting retouch in the form of backing or truncation on small artefacts became prevalent in Europe during the Mousterian at ?ca. 100,000 BP (v. Chap.3.3.6; Bordes 1961*a*:804; 1966:80ff; 1968:102,105; 1972:54; 1973:217; Bordes and de Sonneville-Bordes 1970:63). Hence, by analogy, the specimens from the I Fm can be assigned to a Middle Palaeolithic (or subsequent) industry: specifically those

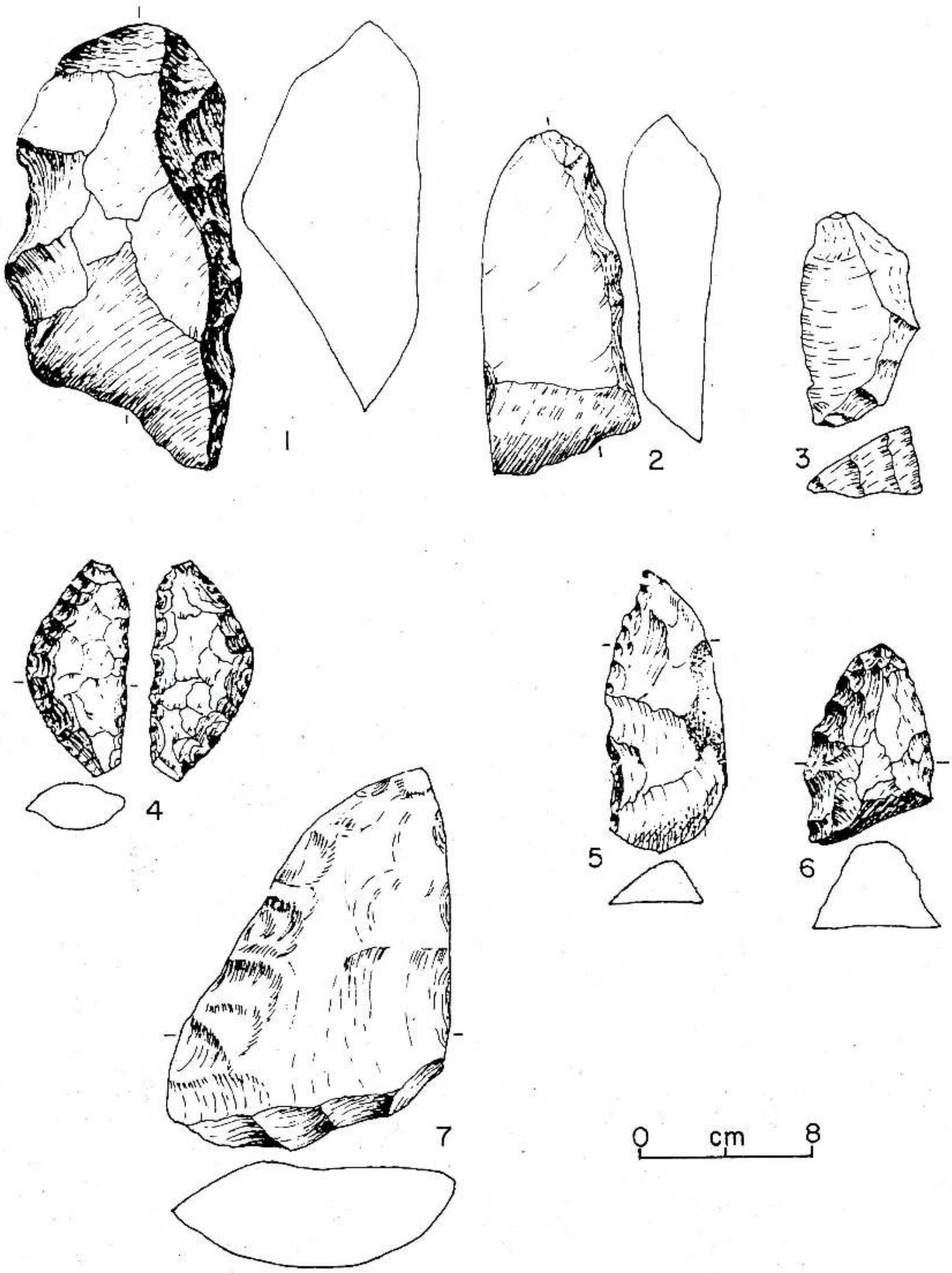



Fig. 30. Large stone artefacts from the I Fm

from Sites 11 (63m), 12 (60m), 24 (46m), 9 (45m), 36 (45m; ?tectonically elevated), 40 (20-40m; ?tectonically elevated), 28 (?10m) and 49 (8m). There is scarcely any doubt that some of these artefacts belong to Mesolithic industries and that they occur on high-level gravels as a result of Mesolithic man exploiting quartz and chert gravels which lie exposed on the *vembus*. Similarly, while discoidal nuclei are very charcteristic of west European Mousterian industries (Coles and Higgs 1969:60; Bordaz 1970:39) their presence in Lanka need not signify Middle

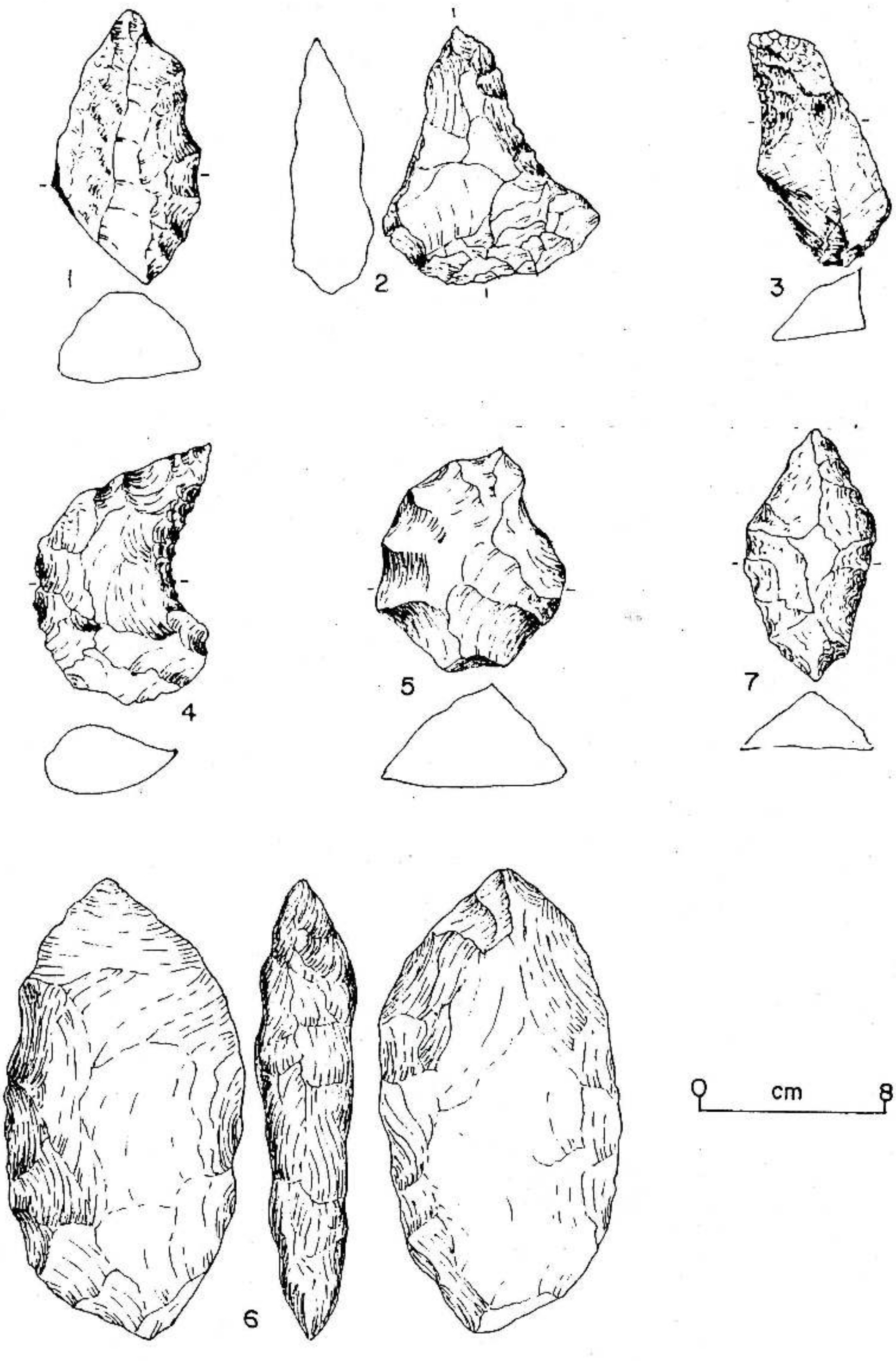



Fig. 31. Large stone artefacts from the I Fm

Palaeolithic chronological associations; they could just as well be Mesolithic. Medium-sized and large discoidal nuclei have been found at Sites 27 (80m; ?tectonically elevated), 29a (65m), 11 (63m), 33 (50m), 24 (46m), 31 and 34 (40m; ?tectonically elevated), 40 (20-40m; ?tectonically elevated), 40a (40m; ?tectonically elevated), 3 (33m), 35 (32m; ?tectonically elevated), 32 (30m; ?tectonically elevated), 45 (25m), 26 and 50 (15m), and 39, 41 and 48 (10m). These discoidal nuclei, if dated by eustatic altimetry, appear to have a wide age range, from the Holstein interglacial or earlier onwards. However their precise age cannot be estimated due, as mentioned earlier, to the stratigraphy of *vembu* artefacts. Small discoidal nuclei, such as are common in Mesolithic assemblages in Lanka, have also been found in a wide assortment of sites: 27 (80m; ?tectonically elevated), 30 (70m; ?tectonically elevated), 11 (63m), 22 (53m), 37 (48m), 24 (46m), 40 (20-40m; ?tectonically elevated), 35 (32m; ?tectonically elevated), 45 (25m), 50 (15m), and 39, 41 42 and 48 (10m). It is very probable that a significant proportion of these specimens belonged to post-Middle Palaeolithic factory-site assemblages, where the exposed *vembu* gravels had been exploited for their raw materials.

The above evidence indicates that discoidal nuclei, particularly the small ones, may not be considered diagnostic of the Middle Palaeolithic in Lanka: they are found in large numbers in the island's Mesolithic – and possibly in the Lower Palaeolithic as well, if such an industry is ever to be isolated in the I Fm.

The presence of small discoidal nuclei does indicate that small (<4.5cm) artefacts were associated with the *vembus* that were sampled. Small, used hammer-pebbles, akin to Mesolithic specimens from Bellan-bandi Palassa (v. S.Deraniyagala 1971*a*) were found at Sites 24 (46m) and 49 (8m); and it is likely that these were used for knapping small artefacts as well as for trimming larger ones.

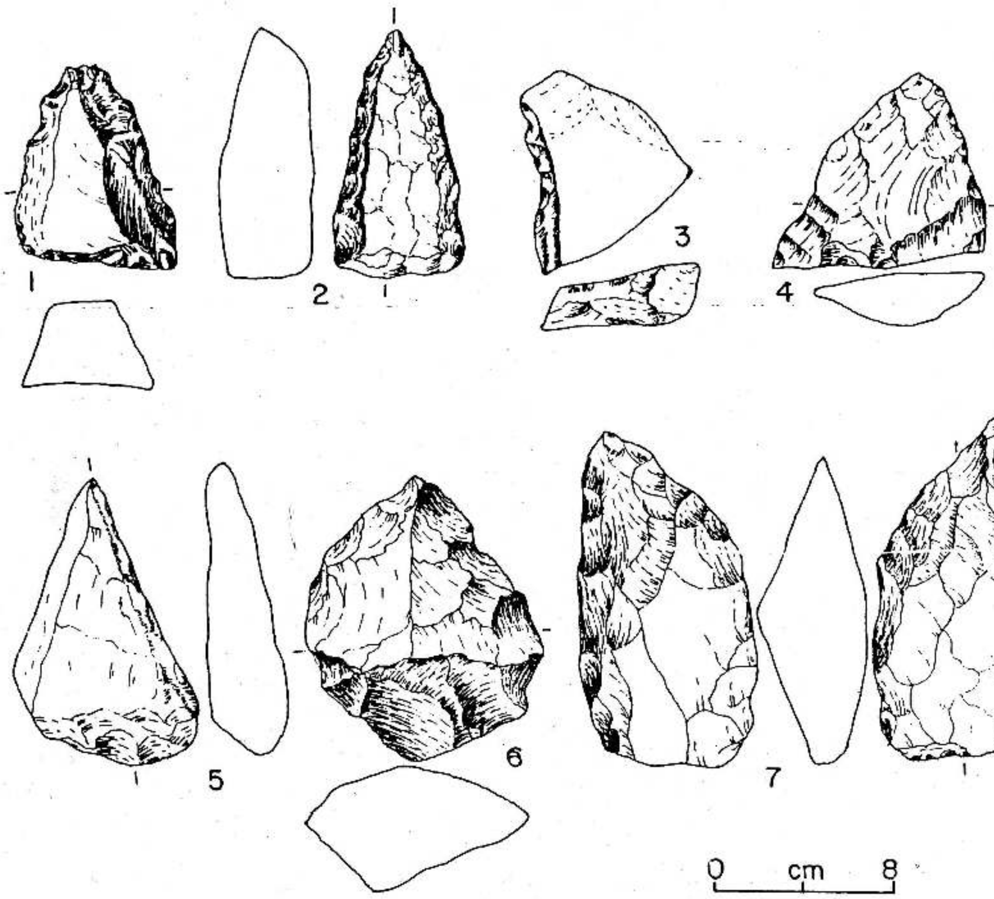



Fig. 32. Large stone artefacts from the I Fm

Evidence of the occurrence of small implements stem from Sites 29a (65m), 12 (60m), 33 (50m) 18b (47m; in gravel), 9 (45m), 36 (45m; ?tectonically elevated), 7 (42m), 31, 34 and 40a (40m; ?tectonically elevated), 32 (30m; ?tectonically elevated), 26 (15m), and 28 (?10m). The presence of small tools within the basal gravel at Site 18b at 47m +msl does indeed sugest that Holstein (and perhaps Cromerian) industries had a component of small implements – which need not cause surprise considering their occurrence in the Oldowan of East Africa (< 3cm, trimmed; Leakey 1971), Verteszöllös and Choukoutien Locality 1. Hence the presence of small tools does not necessarily signify relatively recent (?Mesolithic) industries; they could certainly be Lower Palaeolithic. On the other hand, as with the small discoidal nuclei in the high-level *vembus*, they could also represent factory debris post-dating the deposition of the gravels by a considerable span of time.

Pitted hammer-stones (Type 109) have been found in the lowermost layer at Batadomba-lena, at ca. 28,500 $^{14}$C BP. Specimens of pitted pebbles were found associated with the I Fm at Sites 12 (60m), 24 (46m) and 25 (8m). While it is tempting to construe the Batadomba-lena evidence as indicative of an Upper Pleistocene chronological status for pitted hammer-stones in Lanka, their occurrence in high-level *vembus* could signify a much greater age (note that the Oldowan of East Africa has pitted "anvils" (Leakey 1971) which are akin to Type 109). Similarly mullers from Sites 27 (80m; ?tectonically elevated), and 25 (8m), and grindstones from Sites 27 and 7 (42m) could also represent very early specimens, their age being indeterminate in the *vembus*.

True blade technology, as evinced in bladelets and bladelet-nuclei, was found represented at Sites 14 (43m), 40 (20-40m; ?tectonically elevated), 38 (15m), 39 and 41 (10m) and 49a (8m). In the case of Site 14, and perhaps 38, the bladelets almost certainly constitute a function of the exploitation of exposed gravels, long after their deposition, since it is not readily conceivable that blade technology would have been synchronous with 43m thalasso-static gravels. The same can be considered to apply in the case of the microlithic semi-lunate found at Site 50 (15m), although in this instance it is also likely that it had dropped onto the *vembu* surface from the associated latosolic sands which could post-date the gravels by a considerable length of time. The geometric microlithic barb on a lunate found at Site 41 (10m) can also be accounted for by the same factors as for the semi-lunate at Site 50.

The used red ochre found at Site 35 (32m; ?tectonically elevated) could date from the Holstein interglacial onwards. Red ochre is known to have been used in the Lower Acheulean of Olduvai Upper Bed II, which would place it in the Lower Pleistocene (Cole 1963; Clark 1970), and a Holstein age in Lanka is not an impossibility.

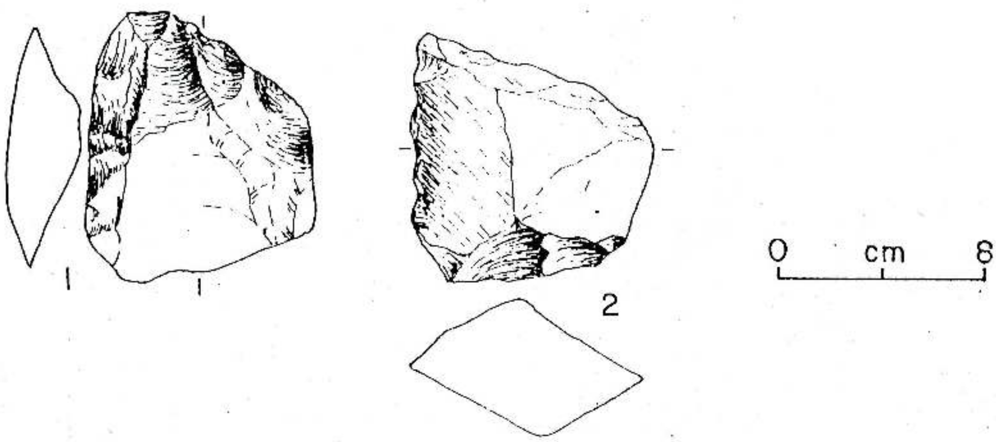



Fig. 33. Large stone artefacts from the I Fm

It is clear from the above discussion that the artefact sample from Stage II of the research design, namely the exploration of sites in the I Fm, comprises a hotch-potch of cultural phases which certainly includes the latter Stone Ages of Lanka, and that there is a likelihood that some of the specimens date from the Lower Palaeolithic of the Holstein or even Cromerian interglacials. The presence of a Middle Palaeolithic technological component is evident; but its chronological implications are far from clear: is it a survival in a later cultural phase or is it Eemian? The shortcomings of techno-chronology are very apparent in this instance: it simply is not possible to employ it as a sole means of dating an industry, an independent dating source being an essential requisite.

Having considered the results of the I Fm survey, it is opportune to examine the cultural material retrieved from the excavations at Sites 45a,b (25m), 50a (15m) and 49b,c (8m) (v. App.III for detailed site data). The artefact sample in these instances can be considered to have much more stratigraphic resolution than in the case of the ones from the surface of the *vembus*. However, I would refer the reader back to Chapter 3.3.3 so that he may be adequately forewarned about simplistic one-to-one correlations between artefact provenance and their contemporaneity with the associated matrix: (*a*) the basal gravels can incorporate much earlier material; (*b*) the surface of the gravels can have artefacts of several phases post-dating the deposition of the gravels, as in the case of gravels exploited for their raw materials or in the lag deposits resulting from the deflation of overlying dunes; (*c*) the I Fm dune sands could contain colluvially derived components; and (*d*) there can be lag deposits (in varying stages of downward movement) within the sands themselves.

*Site 45a*: The stratigraphy of Site 45a (Fig.50) comprises a basal gravel (Stratum II) capped by a colluvial Latosol (Stratum III; v. App.III). The cultural sequence may be delineated as follows (artefact sample, n, = 28,454):

II Basal gravel, ca. 1.5m thick, incorporating a stone-line ranging between levels (1) and (3).

(5) lowermost level, overlying bed-rock. Total artefact sample (n)=3
small discoidal nuclei (n=1)
small artefacts (n=3)

(4) n=21
small artefacts (n=21)

(3) n=216
small discoidal nuclei (n=2)
small artefacts (n=185)
medium-sized artefacts (n=24)
large artefacts (n=7)

(2) n=7,405
microlithic lunates (n=3; Fig.37(13))
microlithic semi-lunates (n=1; Fig.37(7))
small, backed flakes (n=6; Fig.37(3))
bladelets (n=7; Fig.37(6))
small discoidal nuclei (n=73)
medium-sized discoidal nuclei (n=19)
large discoidal nuclei (n=2)
small artefacts (n=7,261)
medium-sized artefacts (n=129; Fig.38(2))
large artefacts (n=15)

(1) top of Stratum II, at ca. 26m +msl, n=9,420
microlithic lunates (n=14)
microlithic triangles (n=1; Fig.37(22))
microlithic semi-lunates (n=2; Fig.37(15))

non-geometric microliths (n=3; Figs.37(18,21))
backed bladelets (n=2; Fig.37(5))
small, backed flakes (n=4)
bladelets (n=4)
bladelet-nuclei (n=1; Fig.37(8))
small discoidal nuclei (n=60)
medium-sized discoidal nuclei (n=21; Fig.38(1))
large discoidal nuclei (n=6)

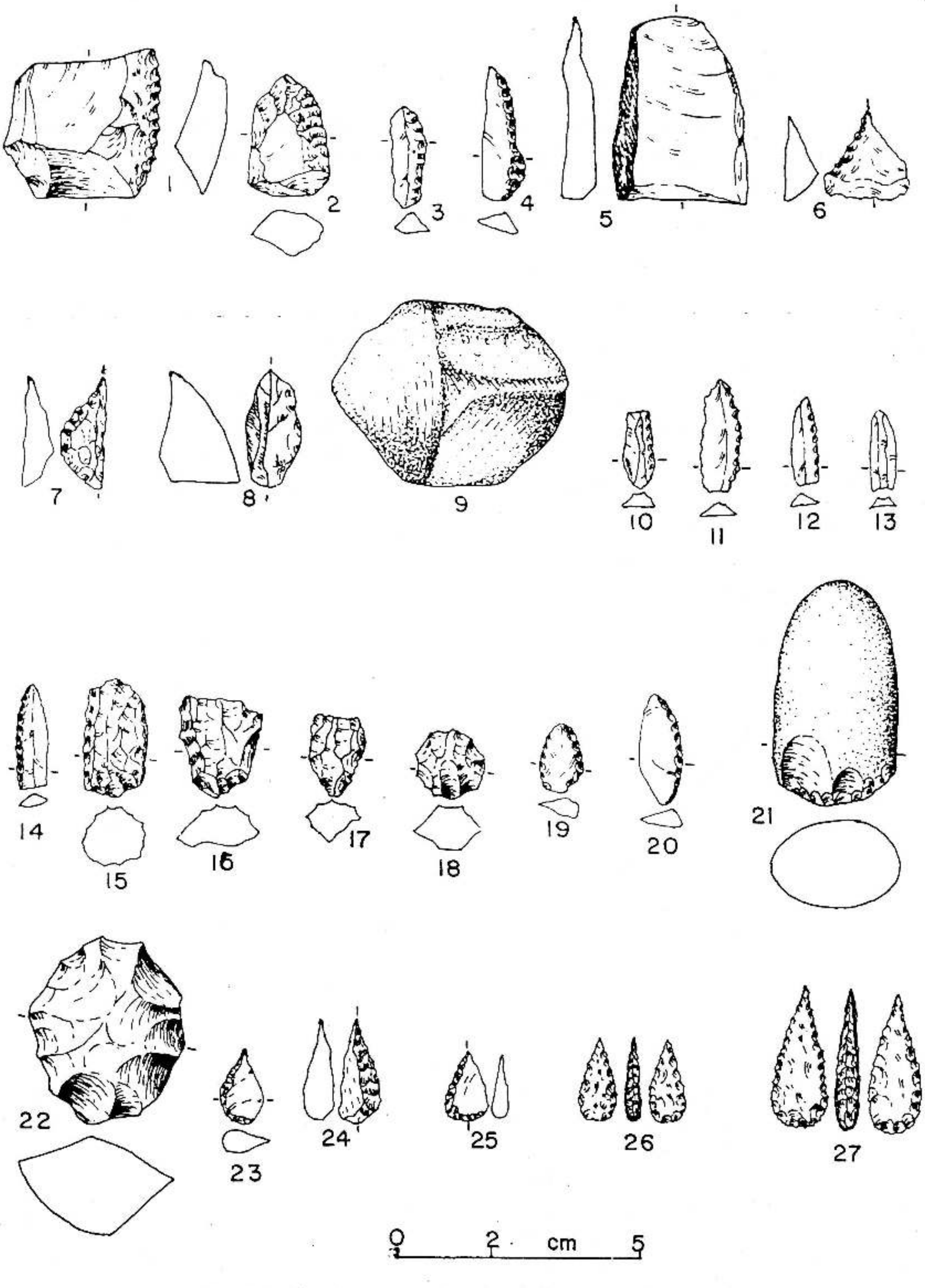



Fig. 34. Small stone artefacts from Sites 43 and 43a

medium-sized pitted pebble (n=1)
small artefacts (n=9,313)
medium-sized artefacts (n=91)
large artefacts (n=14)

III (1) n=897; in view of its disturbed nature, it suffices to mention that this layer contains geometric microliths (n=4; Fig.37(14)).

X Surface lag deposit with little chrono-stratigraphic significance, n=10,492. Noteworthy artefact categories are:
microlithic lunate and semi-lunates (Fig.37(19))
backed bladelets (Fig.37(4))
Balangoda Point (Fig.37(20)); nearly identical with specimen from Batadomba-lena 7b dated to ca. 22,000 $^{14}$C BP.

The distribution of artefacts in Stratum II indicates, rather unequivocally, that they are associated with the stone-line. It is very likely that the latter had been exploited for its raw material and that levels (1)-(3) represent a factory site or sites. The few artefacts secured from levels (4) and (5) may be considered intrusive, pending evidence to the contrary. Hence the artefacts in Stratum II may or may not be coeval with the deposition of the stone-line. What is significant is the Mesolithic technology which distinguishes the assemblages. The stone-line appears to have been overlain by colluvial gravels succeeded by latosolic loams. The stone artefacts in Strata III and X are probably derived from factory components related to the stone-line and would hence be probably contemporaneous with the artefacts in Stratum II. Stratum II(1-3) may be considered to have yielded a representative assemblage of artefacts from the factory site associated with the stone-line. As to whether they represent a single occupation or several in palimpsest is indeterminate, pending a micro-stratigraphic excavation with detailed plotting of floor plans.

*Site 45b*: As with Site 45a, the stratigraphy at 45b (Fig.51) comprises a basal gravel, Stratum II, capped by a colluvial Latosol, Stratum III:

II Basal gravel, ca. 20cm thick
(2) overlying bed-rock; n=82
medium-sized discoidal nuclei (n=6)
large discoidal nuclei (n=2)
small artefacts (n=43)
medium-sized artefacts (n=33)
large artefacts (n=6)

(1) uppermost level of Stratum II; ca. 25m +msl; n=1,292
microlithic semi-lunate (n=1)
large, form-trimmed artefact (n=1; Fig.39(1))
small, truncated flake (n=1)
bladelets (n=2)
bladelet-nuclei (n=2)
small discoidal nuclei (n=5)
medium-sized discoidal nuclei (n=22)
large discoidal nuclei (n=3)
small artefacts (n=1,196)
medium-sized artefacts (n=66)
large artefacts (n=30)

III Latosolic loam; n=111. This stratum being colluvial, it suffices to mention only the more significant artefact categories:
microlithic lunate (n=1)
microlithic semi-lunate (n=1)
small, backed flake (n=1)

The situation at 45b is similar to that at 45a: the basal gravel has been exploited by Mesolithic man for his raw materials and the assemblage from Stratum II(1) can be considered representative of this factory component. The artefacts in II(2) may be intrusive, noting their sparseness, and the specimens in Stratum III are probably derived from II(1). It is noteworthy that there is no lag deposit at the surface of this location due to its being downslope.

It is possible to sum up the technological and stratigraphic evidence from Sites 45a and 45b by stating that a Mesolithic factory facies occurs on the surface of the

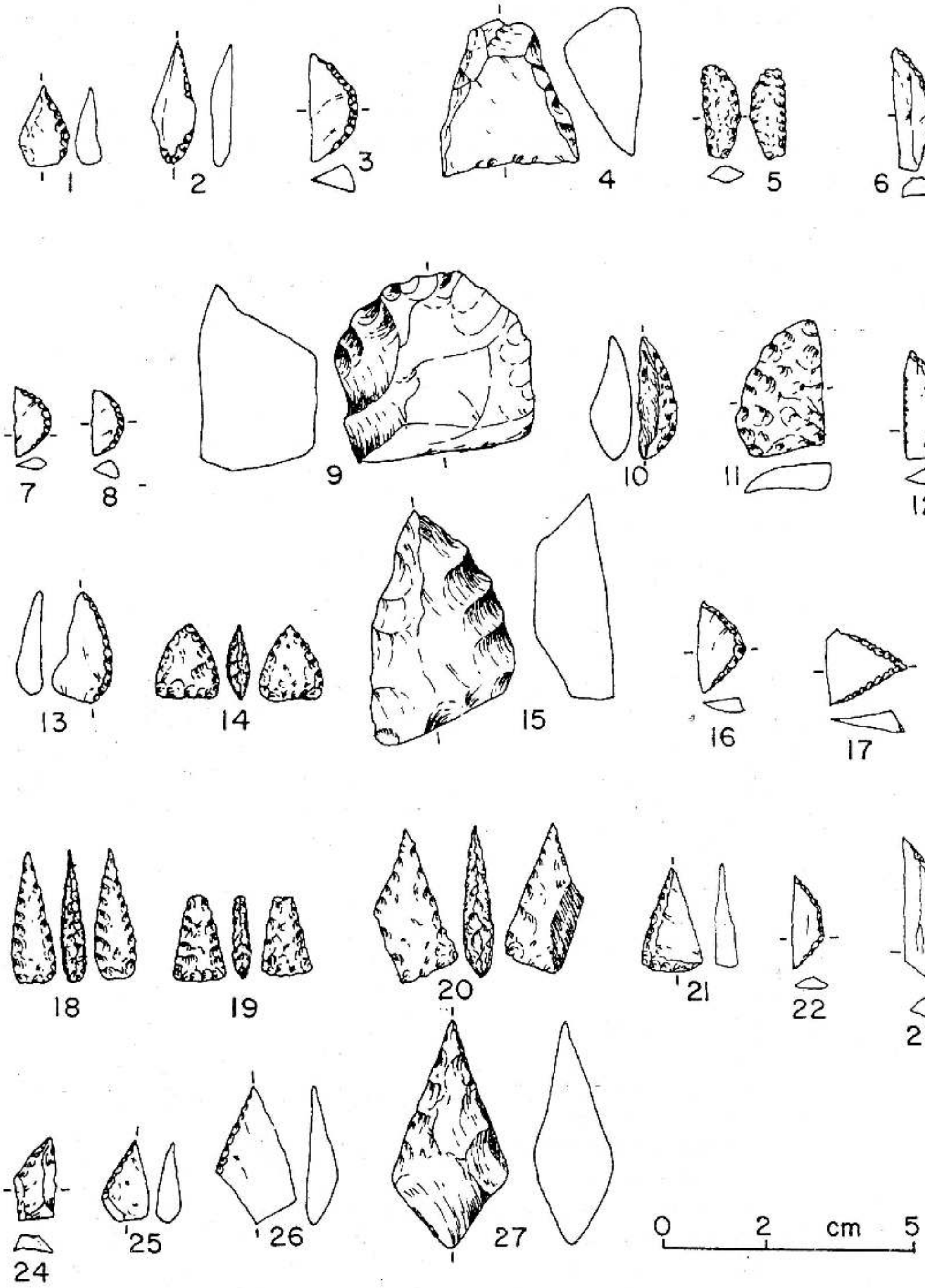



Fig. 35. Small stone artefacts from Sites 43 and 43a

gravels and that there is no firm evidence of artefacts being found *in situ* within the gravels. The latosolic loams overlying the gravels lack analytical utility due to their colluvial origin.

*Site 49b*: The chrono-stratigraphy at Site 49b comprises ca. 1m of basal gravels at ca. 8m +msl (Stratum II) overlying bed-rock and dated to over 38,000 BP by correlation with the 8m shoreline in southeast India or, more plausibly, to the Late Monastirian at ca. 75,000 BP (v. Chap.3.3.4). It is capped by ca. 2m of Red Latosol aeoleanite (Stratum III; Fig.48) dated to ca. 28,000 TL BP (ibid). The basal gravels contain a stone-line (with bifurcations) which includes large, sub-angular boulders of granular quartz.

II (4) lowermost level of the basal gravels overlying bed-rock; most artefacts in Stratum II display signs of being water–worn, and, due to this factor, it is likely that a significant proportion of the small artefacts were not recognised as such, n=4.
medium-sized, backed flake (n=1)
small artefacts (n=2)
medium-sized artefacts (n=2)

(3) n=10
medium-sized discoidal nucleus (n=1)
small artefacts (n=5)
medium-sized artefacts (n=5)

(2) n=648
medium-sized quasi-Levallois nucleus (n=1; Fig.42(6))
medium-sized spheroidal prepared nucleus (n=1)
small discoidal nuclei (n=15)
medium-sized discoidal nuclei (n=7)
large discoidal nuclei (n=3)
small artefacts (n=604)
medium-sized artefacts (n=33)
large artefacts (n=11)

(1) n=221
small discoidal nuclei (n=15)
medium-sized discoidal nuclei (n=5)
large discoidal nucleus (n=1)
small artefacts (n=171)
medium-sized artefacts (n=50)
large artefacts (n=8)

III (6) lowermost Latosol level, directly overlying the basal gravels; n=24
microlithic lunate (n=1; Fig.40(29))

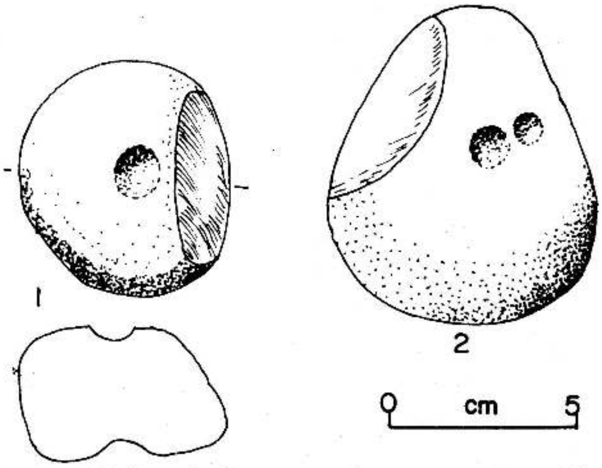



Fig. 36. Medium-sized stone artefacts excavated from Site 43a

small, backed flakes (n=2)
small artefacts (n=17)
medium-sized artefacts (n=6)
large artefact (n=1)

(5) n=38
small artefacts (n=38)

(4) n=99
small artefacts (n=99)

(3) n=948
small discoidal nuclei (n=3)
medium-sized discoidal nucleus (n=1)
large discoidal nuclei (n=2)
small artefacts (n=942)
medium-sized artefact (n=4)
large artefacts (n=2)

(2) n=6,692
microlithic semi-lunate (n=1)
small, backed flakes (n=3)
small discoidal nuclei (n=15)
medium-sized discoidal nuclei (n=3)
small artefacts (n=6,636)
medium-sized artefacts (n=51)
large artefacts (n=5)

(1) n=17,326
microlithic lunates (n=20; Figs.40(30), 41(4))
microlithic isosceles triangle (n=1; Fig.41(20))
microlithic semi-lunates (n=14; Figs.40(27), 41(6,8,9))
non-geometric microlith Type 10c (n=1)
non-geometric microlith Type 17c (n=1)
backed bladelets (n=2; Fig.40(11))
small, backed flakes (n=29; Figs.41(15,23,25))
Balangoda Points, Types 43a,f,h (n=3; Figs.40(26), 41(16))
bladelets (n=10)
bladelet-nuclei (n=8; Figs.40(14,15,16))
small discoidal nuclei (n=74; Fig.40(23))
medium-sized discoidal nuclei (n=12)
red ochre (n=3)
small artefacts (n=17,230)
medium-sized artefacts (n=88)
large artefacts (n=8)

X Surface lag deposit of artefacts (n=38,286) which appear to have been derived almost entirely from a continuation upwards of the archaeological horizon represented in III(1-3), as per the data from the excavation of Site 49c. However, considering that this is a lag deposit, one can only select certain salient artefact categories as representative, primarily, of the archaeological component seen in 49b III(1-3). Of course, some of the elements may post-date this horizon (i.e., III(1-3)).

microlithic lunates (n=32; Figs.40(28), 41(3))
microlithic scalene triangle (n=1; Fig. 41(19))
microlithic sub-triangle, Type 4b (n=1; Fig.41(22))
microlithic sub-trapezoidal, Type 6 (n=1; Fig.41(26))
microlithic semi-lunates (n=5)
non-geometric microlith Types 10c (n=2), 12 (n=1; Fig.41(17)), 14 (n=1), 17c (n=1)
small, backed flakes (n=19; Fig.40(9))
bladelets (n=3)

bladelet-nucleus (n=1)
medium-sized pitted pebble (n=1; Fig.42(3))

The artefacts in the basal gravels display signs of rolling, so that it is possible that as much as 25 per cent of the artefacts were not secured in the sample from this stratum due to many of the rounded flakes of quartz, particularly the small category,

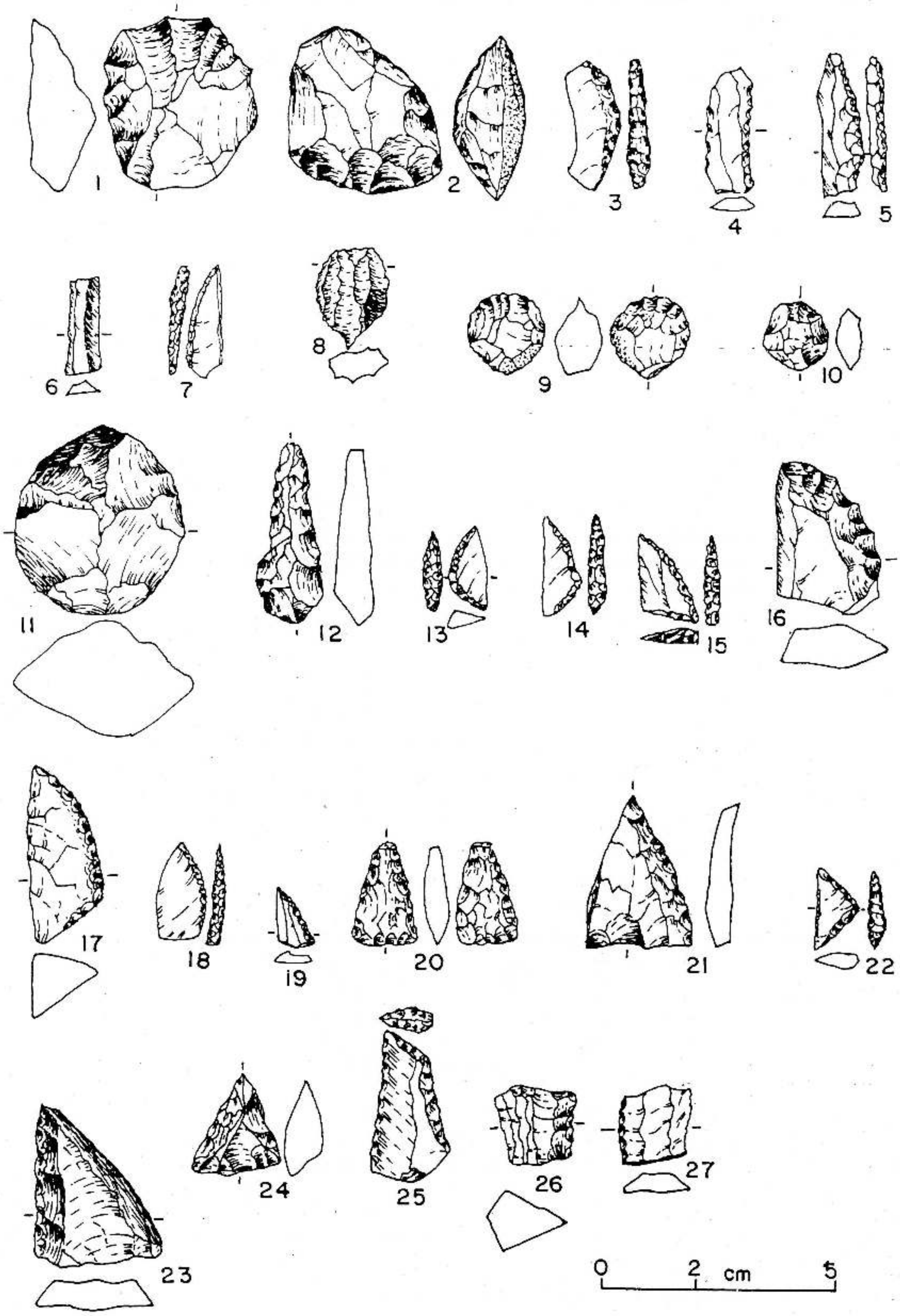



Fig. 37. Small stone artefacts from Site 45

being unrecognisable as artefacts. In comparison, the omissions in Sites 45a II, 45b II and 50a II are not likely to have exceeded 5 per cent, since the artefacts in these instances were in relatively mint condition. Rolled artefacts were also scarce in 43a II. Bearing this situation in mind with regard to 49b II, it is perhaps not surprising that this stratum has yielded a relatively large number of medium-sized and large artefacts. But it is nonetheless significant that 49b II has not produced a single geometric microlith, backed or simple bladelet, or even a backed small flake, suggesting that technologically this stratum is pre-Mesolithic. Whilst it is difficult to conclude on this question, since it is possible to argue that the diagnostic traits of Mesolithic technology, such as geometric microliths, would have been obliterated by water-wear, chrono-stratigraphically the industry ought to be late Middle Palaeolithic.

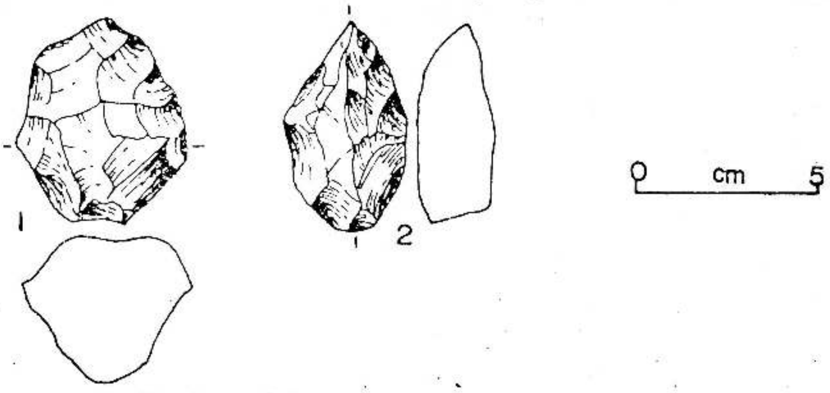



Fig. 38. Medium-sized stone artefacts from Site 45

Although artefacts were found from the basal level of Stratum II upwards, the main archaeological horizon in the basal gravels of 49b appears to be associated with the stone-line in 49b II(1,2). Stone Age man would have exploited the quartz boulders found in the stone-line as well as the veins of granular quartz in the decaying bed-rock. It appears very likely that the artefacts are coeval with the deposition of the gravels at ca. 8m+msl (?final Eem) particularly in view of the high degree of water-wear exhibited by many of the specimens. The presence of a spheroidal prepared nucleus and of a quasi-Levallois nucleus, as well as of some rather Mousterioid-looking medium-sized and large tools in 49b II(2), could imply a Middle Palaeolithic industry. However, as mentioned above, the physical weathering of the artefacts is not conducive to the making of techno-chronological inferences on the basis of this sample.

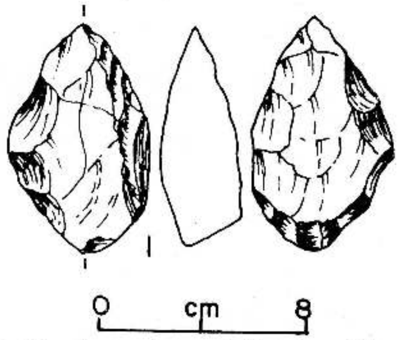



Fig. 39. Large stone artefact from Site 45

As for Stratum III, the Red Latosol aeoleanite dated to ca. 28,000 TL BP (Chap.3.3.4), the presence of geometric microlithic lunates from the basal level upwards designates it technologically Mesolithic. Levels III(1-3) constitute what appears to be a single archaeological horizon, rich in artefacts. The upper part of this horizon has been eroded, leaving behind a lag deposit of artefacts in Stratum X. 49b

III(1-3) are distinguished by geometric microlithic lunates and triangles, Balangoda Points, backed bladelets, bladelet-nuclei and lumps of red ochre which had been used. The pitted pebble in X is also probably derived from an upper level of the occupation represented in III(1-3).

*Site 49c*: It will be recalled (Chap.2.4) that 49c was excavated so as to check on the

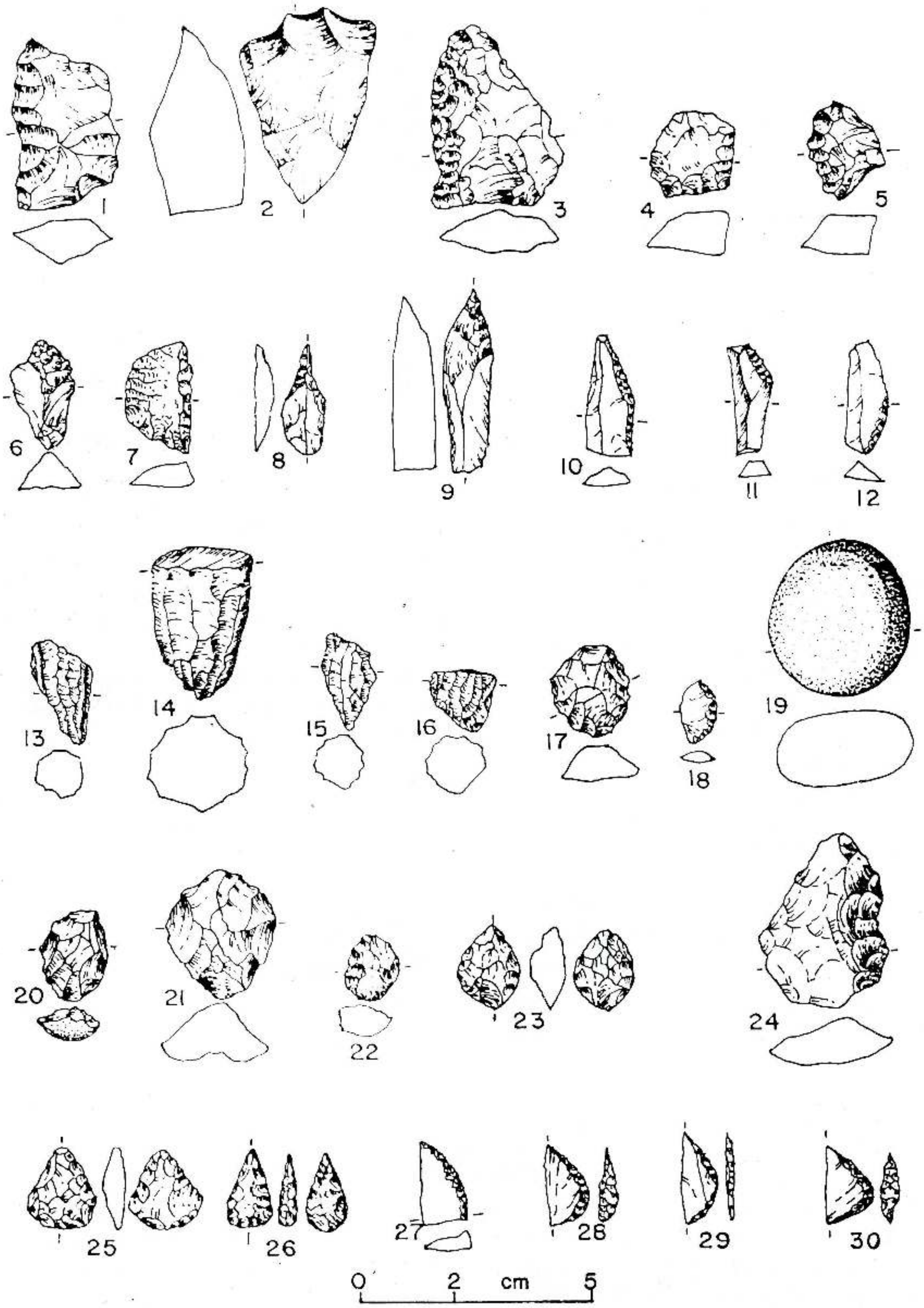



Fig. 40. Small stone artefacts excavated from Site 49

possible sources of the artefacts in the lag deposit of 49b X. The results were positive: it was found that artefact-rich 49c III(5-7) correlated stratigraphically with 49b III(1-3) and X. The stratigraphy of 49c (Fig.52) comprised a vestigial basal gravel at 8m+msl (Stratum II), which did not yield any artefacts, capped by ca. 4m of Red Latosol (Stratum III):

III (13) lowermost level of the Red Latosol, overlying Stratum II; n=10
small, backed flake (n=1)

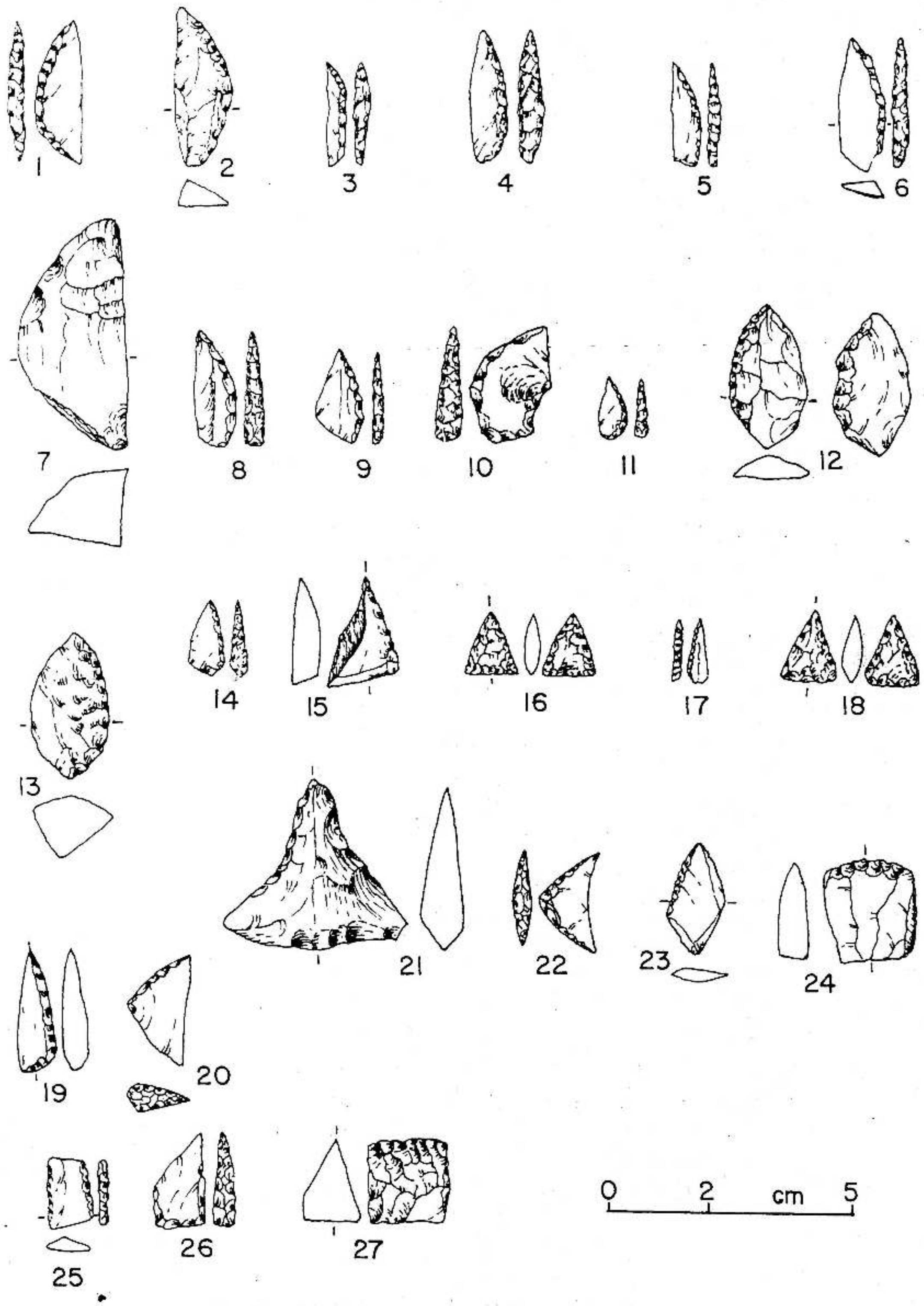



Fig. 41. Small stone artefacts excavated from Site 49

bladelet-nucleus (n=1)
small artefacts (n=8)
medium-sized artefacts (n=2)

(12) sterile

(11) n=1
small artefact (n=1)

(10) sterile

(9) n=304
small artefacts (n=300)
medium-sized artefacts (n=4)

(8) n=56
small discoidal nuclei (n=2)
small artefacts (n=54)
medium-sized artefact (n=1)
large artefact (n=1)

(7) n=2,609
bladelet (n=1)
bladelet-nucleus (n=1)
small discoidal nuclei (n=3)
red ochre (n=2)
small artefacts (n=2,601)
medium-sized artefacts (n=8)

(6) n=7,793
microlithic lunates (n=29; Fig.41(1))
microlithic sub-lunates, Type 2a(ii) (n=1), Type 2b (n=2)
microlithic semi-lunates (n=7; Figs.40(10), 41(5))
microlithic sub-semi-lunate, Type 8a (n=1; Fig.41(10))
non-geometric microliths, Type 9 (n=2; Fig.40(18)), Type 13 (n=1; Fig. 41(11)), Type 17 (n=1; Fig.41(14)).
backed bladelet (n=1; Fig.40(12))
small, backed flakes (n=7; Fig.40(8))
Balangoda Point, Type 43f (n=1; Fig.41(18))
bladelets (n=2)
small discoidal-nuclei (n=28; Figs.40(21,22))
medium-sized nucleus (n=1)
small hammer-pebble (n=1; Fig.40(19))
red ochre (n=4)
small artefacts (n=7,781)
medium-sized artefacts (n=11)
large artefact (n=1)

(5) n=2,228
small, backed flakes (n=3)
bladelet nucleus (n=1); Fig.40(13))
small discoidal nucleus (n=6)
medium-sized discoidal nucleus (n=1)
small hammer-pebble (n=1)
small artefacts (n=2,227)
medium-sized artefact (n=1)

(4) n=11
small artefacts (n=11)

(3) n=26
small artefacts (n=25)
medium-sized artefact (n=1)

(2) n=68
small artefacts (n=68)

(1) sterile

X sterile

The Latosol at 49c yielded much the same archaeological evidence as 49b III, with a major occupation layer occurring at 49c III(5-7) which is in all probability a continuation of 49b III(1-3) as well as of 49b X. Noteworthy techno-traits comprise bladelet-nuclei from the lowermost level upwards, microlithic lunates and semi-lunates in levels (5-7) – adequate evidence for the designating of 49c III as technologically Mesolithic – and the Balangoda Point in 49c III(6). The presence of red ochre in 49c III(5-7), as in 49b III(1-3), suggests a habitation component in addition to the factory facies. The basal gravel of 49c II being vestigial, it is not surprising that no artefacts were forthcoming from it.

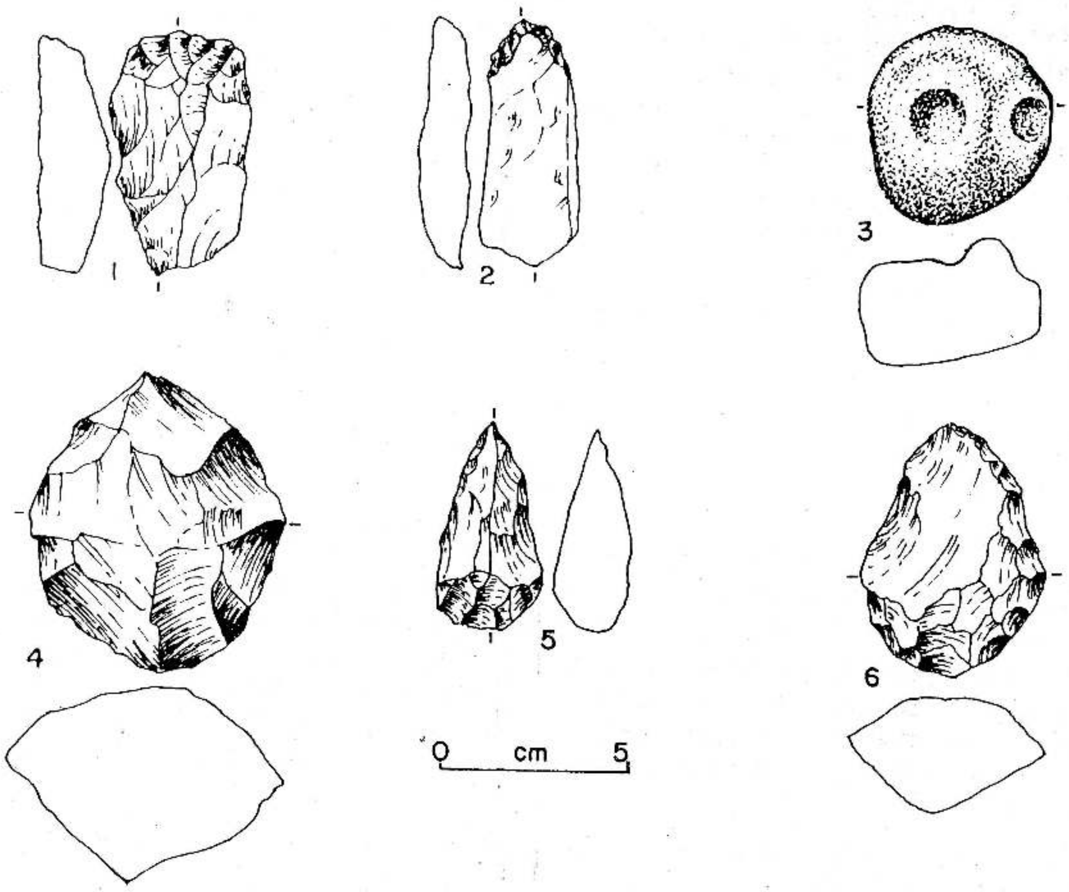



Fig. 42. Medium-sized stone artefacts excavated from Site 49

The above discussion concerning the technological contents of Site 49b can be concluded as evincing that the basal gravels contain water-worn artefacts that are apparently coeval with the deposition of the gravels. One of the main attractions of this location for Stone Age occupation would have been the veins of granular quartz found in the decaying bed-rock, which was apparently used for implement manufacture, as indicated by the relatively high proportion of artefacts on this rather coarse material. Similarly, the bulk of the artefacts in the basal gravels are associated with the stone-line of granular quartz boulders in 49b II(1,2), which once again appears to have been utilised as a source of raw material, thus making the assemblage in 49b II(1,2) primarily a factory facies. The techno-chronology of the industry in the basal gravels is indeterminate due to the obliteration of diagnostic traits (if they existed) by water-wear. The lack of microliths, bladelets and even backed flakes, and the presence of some Mousterioid-looking medium-sized and large implements, do suggest a pre-Mesolithic (?Middle Palaeolithic) technological phase (?75,000 BP; v. Chap.3.3.4). However, this proposition is very speculative in view of the nature of the sampling bias.

The Red Latosol overlying the basal gravels at Site 49, which has been dated to ca 28,000 TL BP, contains an unequivocally Mesolithic industry from the base of the deposit upwards. It is characterised by geometric microliths. The Balangoda Points in the main occupation horizon in 49b III(1-3) and 49c III(5-7) are particularly noteworthy in view of their stylistic specialisation which could serve as a chronological index fossil or index scale. Perhaps with a larger sample of Balangoda Points it will become possible to schematise their stylistic evolution, thus enabling one to assign a fairly detailed chronology to their various stylistic manifestations. The present sample is inadequate for this purpose. The pitted hammer-stone found in 49b X can hypothetically be assigned to the main occupation in the Latosol, from which it is probably derived.

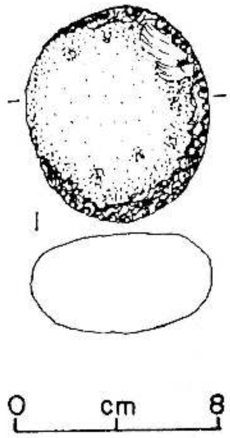



Fig. 43. Large stone artefact excavated from Site 49

*Site 50a*: A thick basal gravel (ca. 1m; Stratum II) overlies the bed-rock, and it is capped by ca. 3m of Red Latosol sands (Stratum III) which are apparently *in situ* (Fig.53). Stratum IV comprises a midden of lagoon molluscs, ca. 0.2m thick, which could be culturally pre- or protohistoric, depending on how the associated radiocarbon date of 5,260 BP (shell) is interpreted (v. Chap.3.3.4). Stratum V consists of ca. 0.7m of colluvial latosolic loam which is akin in its depositional facies to 45 III:

II (4) basal level of the gravels, overlying bed-rock; n=2
small artefact (n=1)
medium-sized artefact (n=1)

(3) n=26
small discoidal nuclei (n=2)
small artefacts (n=19)
medium-sized artefacts (n=7)

(2) n=9,503
non-geometric microlith, Type 11 (n=1; ?Mousterioid)
small discoidal nuclei (n=36)
medium-sized discoidal nuclei (n=61)
large discoidal nuclei (n=15)
large hammer-stone (n=1)
small artefacts (n=8,712)
medium-sized artefacts (n=719)
large artefacts (n=72)

(1) uppermost level of Stratum II; n=2,473
non-geometric microlith,Type 9b (n=1)
large, spheroidal prepared nucleus (n=1)
small discoidal nuclei (n=15)
medium-sized discoidal nuclei (n=31)

large discoidal nuclei (n=8)
small artefacts (n=2,298)
medium-sized artefacts (n=145)
large artefact (n=30)

III (11) lowermost level of Latosol, directly overlying basal gravel; n=2
small artefact (n=1)
large artefact (n=1)

(10) n=16
small artefacts (n=12)
medium-sized artefacts (n=4)

(9) n=105
small artefacts (n=102)
medium-sized artefacts (n=3)

(8) n=29
small artefacts (n=28)
medium-sized artefact (n=1)

(7) n=41
small artefacts (n=40)
medium-sized artefact (n=1)

(6) n=57
bladelet (n=1)
small artefacts (n=53)
medium-sized artefacts (n=4)

(5) n=1,568
backed bladelets (n=2; Fig.44(2))
small, backed flakes (n=3)
bladelet (n=1)
bladelet-nuclei (n=2; Fig.44(3))
small discoidal nuclei (n=16)
small artefacts (n=1,559)
medium-sized artefacts (n=9)
bone artefact: abraded long-bone fragment (n=1)

(4) n=1,219
microlithic lunate (n=1)
small, backed flakes (n=2)
bladelet (n=1)
bladelet-nucleus (n=1)
small discoidal nuclei (n=2)
medium-sized hammer-stone (n=1)
small artefacts (n=1,210)
medium-sized artefacts (n=9)

(3) n=154
small artefacts (n=151)
medium-sized artefacts (n=2)

(2) n=22
small artefacts (n=21)
medium-sized artefacts (n=1)

(1) n=167
small discoidal nucleus (n=1)
small artefacts (n=163)
medium-sized artefacts (n=4)

IV (2) lower level of shell midden, overlying Latosol; n=95
small discoidal nucleus (n=1)
small artefacts (n=94)
medium-sized artefact (n=1)

(1) upper level of shell midden; n=233
small discoidal nucleus (n=1)
large discoidal nucleus (n=1)

small artefacts (n=213)
medium-sized artefacts (n=9)
large artefact (n=1)

V Stratum V is colluvial in origin and not *in situ*. Hence, despite the rather large sample of artefacts secured from this stratum (n=4,035), their analytical utility is limited and only some of the more significant specimens are listed below:

microlithic lunates (n=4)
small, backed flakes (n=5)
bladelets (n=2)
bladelet-nucleus (n=1; Fig.44(4))

The basal gravels (Stratum II) at Site 50a are of considerable thickness and it is noteworthy that artefacts were found from the lowermost level upwards. It is only possible to state that the artefacts from the lower levels are predominantly small and on quartz; the size of the sample is exceedingly small and it does not justify any further comment. It is somewhat unlikely that these specimens had intruded from a higher horizon, since the gravelly matrix is not conducive to such downward movement. It can be hypothesised that the artefacts in II(4-3) are coeval with the deposition of the 15m gravel, possibly during the Eem interglacial (ca. 130,000 BP; >74,000 TL BP). The two small discoidal nuclei in II(3) are perhaps significant as representing Mousterioid technology.

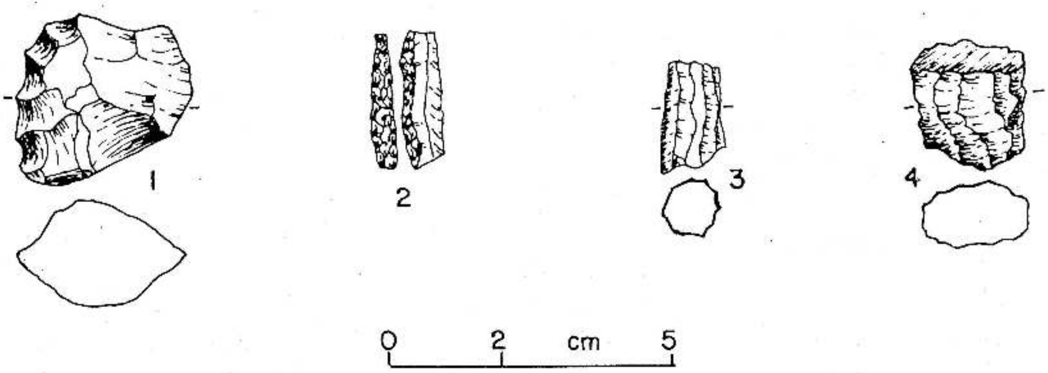



Fig. 44. Small stone artefacts from Site 50a

It is the upper levels, II(2) and II(1), that contain the main archaeological horizon in the basal gravels of Site 50a. Considering that the base of II(2) is ca. 0.4m below the surface of Stratum II, it is possible that these artefacts are also coeval with the deposition of the gravels during Eem; another possibility, however, is the

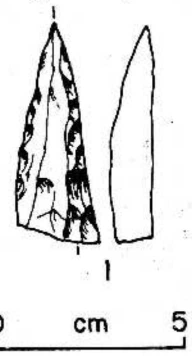



Fig. 45. Medium-sized stone artefact from Site 50a

hypothesis that Stone Age man camped on the gravels and that the artefacts had subsequently become incorporated in the uppermost horizons of Stratum II. Artefactually, II(1) and II(2) may be considered to represent a single assemblage. The absence of geometric microliths and blades is noteworthy. However, the occurrence of non-geometric microliths, a large spheroidal nucleus, and an unusually high proportion of medium-sized artefacts, could signify that this assemblage is Middle Palaeolithic technologically. It is also possible, however, that factory components on the surface of the gravels contain more than one culture phase, perhaps ranging from the Middle Palaeolithic to the Mesolithic, and that further sampling could yield geometric microliths as well. In this latter connection it is noteworthy that the overlying Latosol contains a Mesolithic industry.

The Red Latosol, Stratum III, capping the basal gravels at Site 50a, is technologically Mesolithic, as indicated by the occurrence of geometric microliths and backed bladelets in III(4,5). In this regard, 50a III could correlate with 49b III, as corroborated in the close match between their ages at ca. 28,000 TL BP (Chap.3.3.4). The latter dune deposit occurring at ca. 7m lower than at Site 50a need not signify much, since as mentioned in Chapter 3.3.3 coastal dunes can be blown up

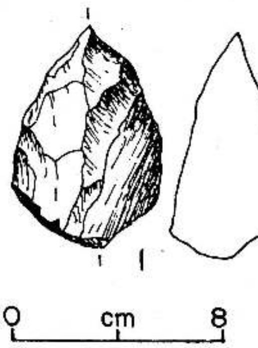



Fig. 46. Large stone artefact from Site 50a

to elevations in excess of 30m above the prevalent sea level. The concentration of artefacts in 50a III(4,5), relative to the levels underneath and above, makes it possible that they contain a single archaeological horizon.

Stratum IV, dated to ca. 5,260 cal BP, can be considered to contain Mesolithic artefacts (despite the absence of diagnostic geometric microliths in the sample) since the underlying and overlying strata yielded geometric microliths. However, since the dating medium was shell, it is not possible to estimate the age of this midden with any confidence. The absence of protohistoric artefacts, such as pottery, in Stratum IV, and the occurrence of several specimens of stone artefacts within it, make it probable that the midden is Mesolithic. Indubitably Mesolithic oyster midens have recently been located on the Mandakal-aru estuary in the far north near Poonakari.

Having considered the data from the excavations in the I Fm on an intra-site basis, it is necessary to view some of the broad categories of techno-traits from an inter-site angle. The data relating to the latter are set out below; the stratigraphic units thus treated from Stage III of the research design are restricted to the horizons identified as possibly representing single occupation components in view of the relatively high concentrations of their respective artefact contents (for identification of these horizons v. site data above):

I Fm survey; Stage II of research design

| *Category* | *Count (n)* | *%* |
|---|---|---|
| Sample | 775 | 100.0 |
| Trimmed, excluding nuclei | 341 | 44.0 |
| Used, non-trimmed, excluding nuclei | 130 | 16.8 |
| Potential tools | 38 | 4.9 |
| Small (< 4.5cm) | 343 | 44.3 |
| Medium-sized (4.5-8cm) | 256 | 33.0 |
| Large (> 8cm) | 176 | 22.7 |

Site 45a II(1-3)

| *Category* | *n* | % |
|---|---|---|
| Sample | 117,041 | 100.0 |
| Form-trimmed | 30 | 00.2 |
| Others, trimmed | 30 | 0.2 |
| Used, non-trimmed | 55 | 0.3 |
| Potential tools | 199 | 1.2 |
| Nuclei | 1,300 | 7.6 |
| Waste | 15,425 | 90.5 |
| Small | 16,761 | 98.4 |
| Medium-sized | 244 | 1.4 |
| Large | 36 | 0.2 |
| Amethyst | 5 | 0.03 |
| Quartz | 17,012 | 99.8 |
| Chert | 24 | 0.1 |

Site 45b II(1)

| *Category* | *n* | % |
|---|---|---|
| Sample | 1,292 | 100.0 |
| Form-trimmed | 2 | 0.2 |
| Others, trimmed | 5 | 0.4 |
| Used, non-trimmed | 7 | 0.5 |
| Potential tools | 23 | 1.9 |
| Nuclei | 163 | 12.6 |
| Waste | 1,092 | 84.5 |
| Small | 1,196 | 92.6 |
| Medium-sized | 66 | 5.1 |
| Large | 30 | 2.3 |
| Quartz | 1,292 | 100.0 |

Site 49b II(1,2)

| *Category* | *n* | % |
|---|---|---|
| Sample | 869 | 100.0 |
| Form-trimmed | 4 | 0.5 |
| Others, trimmed | 24 | 2.8 |
| Used, non-trimmed | 23 | 2.6 |
| Potential tools | 41 | 4.7 |
| Nuclei | 121 | 13.9 |
| Waste | 656 | 75.5 |
| Small | 775 | 89.2 |
| Medium-sized | 83 | 9.6 |
| Large | 19 | 2.2 |
| Quartz | 869 | 100.0 |

Site 49b III(1-3) – 49c III(5-7)

| *Category* | *n* | % |
|---|---|---|
| Sample | 37,596 | 100.0 |
| Form-trimmed | 98 | 0.3 |
| Others, trimmed | 68 | 0.2 |
| Used, non-trimmed | 66 | 0.2 |
| Potential tools | 690 | 1.8 |
| Nuclei | 738 | 2.0 |
| Waste | 35,904 | 95.5 |
| Small | 37,417 | 99.5 |
| Medium-sized | 163 | 0.4 |
| Large | 16 | 0.04 |

| *Category* | *n* | % |
|---|---|---|
| Quartz | 37,397 | 99.5 |
| Chert | 185 | 0.5 |
| Gneiss | 5 | 0.01 |
| Red ochre | 9 | 0.02 |

Site 50a II(1,2)

| *Category* | *n* | % |
|---|---|---|
| Sample | 11,976 | 100.0 |
| Form-trimmed | 7 | 0.06 |
| Others, trimmed | 51 | 0.4 |
| Used, non-trimmed | 23 | 0.2 |
| Potential tools | 302 | 2.5 |
| Nuclei | 761 | 6.4 |
| Waste | 10,790 | 90.1 |
| Small | 11,010 | 91.9 |
| Medium-sized | 864 | 7.2 |
| Large | 102 | 0.9 |
| Quartz | 11,947 | 99.8 |
| Chert | 29 | 0.2 |

Site 50a III(4,5)

| *Category* | *n* | % |
|---|---|---|
| Sample | 2,787 | 100.0 |
| Form-trimmed | 1 | 0.04 |
| Others, trimmed | 18 | 0.6 |
| Used, non-trimmed | 8 | 0.3 |
| Potential tools | 76 | 2.7 |
| Nuclei | 110 | 3.9 |
| Waste | 2,568 | 92.1 |
| Small | 2,769 | 99.4 |
| Medium-sized | 18 | 0.6 |
| Large | 0 | 0.0 |
| Quartz | 2,766 | 99.2 |
| Chert | 21 | 0.8 |

It is very apparent from the above summaries of the data that there has been a considerable bias in the sampling during Stage II of the research design, namely in the I Fm survey, towards trimmed as well as large and medium-sized artefacts. There has also been a bias towards chert artefacts. These biases are explicable on the grounds that (*a*) there was a deliberate selection for trimmed tools, since these are more diagnostic techno-stylistically than non-trimmed artefacts; and (*b*) unconscious selection for large and medium-sized artefacts, and also for chert as a raw material, on the assumption that these traits are characteristically Middle Palaeolithic – as per Wayland's identifications (1919) and by analogy with Indian Middle Palaeolithic assemblages.

The excavated samples indicate that 89.2-99.5 per cent of the artefacts are small, 0.4-9.6 per cent medium-sized and 0.0-2.3 per cent large. Of these, the proportion of medium-sized and large artefacts in the basal gravels is significantly higher than in the overlying Latosols, possibly due (at least in part) to sampling bias caused by water-wear on the artefacts. However, at Site 50a where, unlike at 49b, water-wear (although present at times) is not a significant factor in Stratum II, the artefacts in the basal gravels do indeed appear to be larger than those in the overlying Latosol; and the same could be true of Site 49b which would accord with a hypothetical Middle Palaeolithic status for the artefacts in 49b II. With regard to raw material, in all instances the majority (99.2-100.0%) of the artefacts is on quartz, as opposed to chert (0.0-0.8%), and the high incidence of chert artefacts in the I Fm survey is definitely the result of sampling bias.

What is very noticeable is the extremely low proportion of trimmed artefacts at all the excavated localities (0.4-0.6%, omitting 49b II(1,2) where non-trimmed artefacts were probably frequently omitted in the sample due to their being unidentifiable as artefacts), as against nuclei (2-13.9%, the modal range being probably at the lower end of this spectrum if sampling bias due to water-wear is eliminated) and waste (84.5-95.5%, once again omitting the biased sample from 49b II(1,2)). This is clearly indicative of the presence of a factory facies in these deposits: Stone Age man would have exploited the gravels of the I Fm by camping directly on them or on the adjacent coastal dunes that were later to become Latosols and which accumulated with the regression of the sea. One of the main reasons for the frequency with which Stone Age sites are associated with the I Fm would have been the ready access which would always have been available to quartz and chert gravels suitable for implement manufacture. It is significant that the Jaffna peninsula with its Calcic Latosols and with a potential subsistence base very akin to that of I Fm country has yet to yield prehistoric artefacts. The reason for this anomaly appears to lie in the lack of exploitable gravels on the peninsula. On the other hand, the presence of red ochre in 49b III(1-3) and 49c III(5-7) does indicate that the occupation was not confined to a factory facies and that a more settled base-camp component was also present – which is not surprising in view of the excellent fishing and shellfish collecting that would have been available in the local estuaries and lagoons and the relatively high exploitable biomass of terrestrial fauna in ecozone A.

The incidence of use marks, as apparent to the naked eye, is remarkably low in all instances (0.2-0.5%, omitting 49b II(1,2) due to bias from water-wear). This is ascribable to the durability of quartz as a raw material. Wear-analysis experiments conducted by me using glass, flint and quartz revealed that whereas the two former materials register wear quite readily quartz is extremely obdurate in showing the slightest trace of use. It is likely that a high proportion of the category termed potential tools, which account for 1.2-2.7 per cent of the sample, omitting 49b II(1,2), would indeed display signs of wear if examined under sufficient magnification. With regard to "waste", it is difficult to visualise as to how these artefacts could represent anything but debitage from implement manufacture, and there is very little likelihood of any of it having been used as "tools".

The quantitative data on the traits of size, raw material, trimming, use, nuclei and waste do not suggest significant differences between the assemblages in 45a II(1-3), 45b II(1), 49b II(1,2), 49b III(1-3), 49c III(5-7), 50a II(1,2) and 50a III(4,5), except in that there are hints that the artefacts in the basal gravels are larger, on average, than those in the Latosols. The inter-site agreement in the percentages for the various categories enumerated above is, in fact, remarkable, and it is hypothesised that the behaviour of quartz as a raw material is the primary constraint behind this agreement – a technological, rather than a stylistic or functional, cause.

Summarising the techno-chronology of the sites excavated in the I Fm, Site 45 does not appear to have artefacts that are coeval with the deposition of its basal ?thalasso-static gravels at 25m +msl. Mesolithic man had subsequently exploited these gravels for implement manufacture, and his factory debris and finished artefacts are found associated with the surface of the gravel bed. The overlying latosolic loams are techno-chronologically insignificant due to their colluvial origin.

Site 50a has artefacts throughout its basal gravels at ca. 15m +msl, which makes it likely that they are Eem in age. The majority of the artefacts are concentrated in the upper levels. Technologically, the presence of small, backed flakes in this latter horizon, and the absence of bladelets and geometric microliths, suggest a Middle Palaeolithic phase. The considerable depth of Latosol overlying the basal gravels at Site 50a contains geometric microliths and can hence be termed Mesolithic. The midden of lagoon shells resting on the Latosol is of indeterminate associations as far as lithic technology is concerned. The stone artefacts occurring within it may be derived from an earlier deposit, although the radiocarbon date of ca. 5,260 BP on the shells does not make it improbable that the midden represents the activities of Mesolithic man.

It is noteworthy that the Latosol sands at Site 50 at ca. 28,000 TL BP are much more recent than the hypothetically Eem basal gravels. It is likely that coastal dunes had been blown up on to the gravel terrace during the Paudorf interstadial and that prehistoric man living on these dunes while they were accumulating had exploited exposures of Eem terrace gravels.

At Site 49 the basal gravels at ca. 8m +msl appears to contain a pre-Mesolithic industry – although this view is speculative due to the sampling bias from the obliteration of diagnostic techno-traits from water-wear. Subsequently, Mesolithic man had camped on the coastal dunes, prior to their stabilisation, and exploited the gravel exposures for their raw material. The 8m sea level in South India has been radiocarbon dated to the Paudorf interstadial to. >38,000 BP, although it more probably represents a Late Monastirian shoreline at ca. 75,000 BP (Chap.3.3.4). Stratum III at Site 49 has been dated to ca. 28,000 TL BP thus correlating with a depositional episode of 50a III.

5.2.6 *Reddish Brown Earth Formation.* The geomorphology of the Reddish Brown Earth Formation has been described in Chapter 3.3.3. These sedimentary deposits comprise a basal gravel overlying bed-rock which is often weathered into the Reddish Brown Earth soil category. The gravel is usually in the form of a stone-line, and its genesis is as a lag deposit caused by extensive subaerial denudation. Stone Age man has exploited the raw material of quartz and chert pebbles occurring in the stone-lines, and it is not rare to find his factory sites on the gravels of the RBE Fm. The artefacts have at times been incorporated within the upper horizons of the gravels, although their coevality with the deposition of the gravels is quite probable in certain instances. The basal gravels are often capped by colluvial clayey loams which frequently contain artefacts, such as pottery, of the historical period.

The factors which led to the investigation of the RBE Fm, in connection with the chrono-stratigraphy of the I Fm, have been mentioned in Chapter 2. The first sample to have been secured from the RBE Fm is from quarries at the Rifle Range at Trincomalee (southeast of the town), where Todd found numerous quartz artefacts on a stone-line with rolled pebbles. These, together with the unpublished site data, are housed in the British Museum and await analysis (v. Allchin 1958:188; 1980:62-3). Typologically, a microlithic lunate is illustrated and the industry seems to be Mesolithic. (It is noteworthy that Allchin has mistakenly assigned the provenance of the artefacts to the I Fm; whereas the I Fm does not occur to the south of Pulmoddai which is nearly 50km to the north of Todd's site.)

The next indication of artefacts occurring in the RBE Fm was when Deraniyagala (1946:unpublished notes; 1953*a*:Pl.11(5)) described some hammer-stones and mullers, among which was a large, pitted pebble (Type 109b).These were found associated with a basal gravel along a distance of ca. 0.7km in the cutting of the new canal at Polonnaruva in 1946 (ecozone B). The gravels, ca. 0.7m thick, were capped by 0.7m of loam. Then came the spot survey of sites near Embilipitiya as a part of the I Fm exploration, and the chance discovery of a Mesolithic assemblage within the basal gravels of the RBE Fm in the excavations at Gedige, Anuradhapura (S.Deraniyagala 1972). Finally there was the excavation of

Site 43a in Stage III of the research design (for detailed site data v. App.III).

The salient technological data from the spot survey, Stage II of the research design, may be set out as follows (v. App.III):

Site 42: stone-line in Reddish Brown Earth
- (*a*) *Mousterioid*
  - Type 98a: small discoidal nucleus (n=2)
- (*b*) *Small artefacts* (n=4)

Site 43: surface of stone-line in Reddish Brown Earth
- (*a*) *Geometric microliths*
  - Type 1: lunates (n=30; Fig.35(6))
  - Type 3b: isosceles triangle (n=1; Fig.35(17))
- (*b*) *Non-geometric microliths*
  - Type 9a: plan-form 3 (n=2; Fig.34(19))
  - Type 10: plan-form 6 (n=2; Fig.34(24))
  - Type 13: plan-form 9 (n=2)
- (*c*) *Balangoda Points*
  - Type 43h (n=1)
  - Type 43i (n=1; Fig.35(5))
- (*d*) *Backed bladelets*
  - Type 39a (n=1; Fig.34(10))
- (*e*) *Bladelets*
  - Type 93a (n=1)
- (*f*) *Mousterioid*
  - Type 40: small, backed or truncated flakes (n=20; Figs.34(1), 35(25))
  - Type 98a: small discoidal nuclei (n=6; Fig.37(10))
  - Type 98b: medium-sized discoidal nucleus (n=1)
- (*g*) *Pitted hammer-stone*
  - Type 109a: medium-sized (n=1)

The analysis of the surface finds from the exploration of the RBE Fm indicated that Site 43 contained a Mesolithic component and that the same was probably true of Site 42. The results of the excavations in the RBE Fm at 43a were to amplify this view, with lots of artefactual evidence.

*Site 43a*: Excavations at Site 43a yielded a rich assemblage of artefacts from the stone-line (Stratum II; Fig.48); the overlying Reddish Brown Earth loam (ca. 0.75m), being colluvial, has not much analytical significance:

II Basal gravel; more precisely, a stone-line, overlying bed-rock; n=120,269
- microlithic lunates (n=214; Fig.35(3,10))
- microlithic sub-lunate: plan-form 5 (n=1)
- microlithic triangles (n=8; Figs.35(16,21))
- microlithic trapezoidals (n=2; Fig.35(22))
- microlithic rectilinear (n=16; Fig.35(23))
- microlithic semi-lunates (n=20; Figs.34(4), 35(12,13))
- non-geometric microliths: Type 9 (n=3; Fig.34(20)); Type 10 (n=24; Figs.34(23,25), 35(1) ); Type 12 (n=1; Fig.35(2)); Type 14 (n=3); Type 17 (n=3; Fig.34(14)).
- backed bladelets (n=11; Figs.34(3,11,12))
- small, backed flakes (n=142; Figs.34(6,7), 35(24))
- Balangoda Points (n=6): Type 43a (n=2; Fig.34(26,27)); Type 43b (n=1; Fig.35(20)); Type 43c (n=1; Fig.35(18)); Type 43e (n=1; Fig.35(14)); Type 43g (n=1; Fig.35(19)).
- ?celt: Type 86a (n=1; fragmentary; Fig.34(5))
- bladelets (n=16; Fig.34(13)
- bladelet-nuclei (n=19; Figs.34(15,16,17))

small discoidal nuclei (n=1,283; Figs.34(18,22))
medium-sized discoidal nuclei (n=30)
large discoidal nuclei (n=4)
small, used hammer-stones (n=19)
mullers (n=3)
pitted hammer-stones (n=2; Figs.36(1,2))
red ochre (n=36; Fig.34(9))
graphite (n=27)
small artefacts (n=119,980)
medium-sized artefacts (n=281)
large artefacts (n=8)

There is no doubt whatsoever that 43a II is technologically Mesolithic, with its rich array of geometric microlithic lunates, triangles and trapezoidals, as well as of Balangoda Points. The presence of pitted hammer-pebbles and of what appears to be a fragment of a celt is noteworthy. The red ochre and graphite (?pigments) indicate a habitation facies included within the overall factory component (v. artefact proportions below). Due to the nature of the stratigraphy (v. Chap.3.3.3) it is not possible to state unequivocally that the archaeological horizon in 43a II comprises a single occupation, several chronologically allied occupations in palimpsest, or several chronologically disparate occupations superimposed within a single lag deposit. A subjective assessment is that the archaeological horizon comprises artefacts from a single technological phase, the Mesolithic, although it is impossible to decide whether it contains elements of more than a single occupation. The presence of well-rounded pebbles and a few water-worn artefacts in the deposit indicates an alluvial component as well, and it is probable that the water-worn artefacts are coeval with the deposition of the gravels which are of considerable antiquity in view of the degree of down-cutting the associated stream has undergone since. The occupation of this site appears to have been intimately linked with the exploitation of the gravels for implement manufacture, as with the sites excavated in the I Fm.

The excavation in the citadel of Anuradhapura at Gedige (S.Deraniyagala 1972:62-3) produced a small sample of Mesolithic artefacts, characterised by geometric microlithic lunates, in a basal graval (Stratum I) of the local RBE Fm. The grouped data, as considered for the inter-site comparison effected for the sites in the I Fm, may be set out as follows for Site 43a II, which is assumed to comprise a single occupation, and for Gedige I:

Site 43a II

| *Category* | *n* | % |
|---|---|---|
| Sample | 120,269 | 100.0 |
| Form-trimmed | 109 | 0.1 |
| Others, trimmed | 162 | 0.1 |
| Used, non-trimmed | 113 | 0.1 |
| Potential tools | 1,149 | 1.0 |
| Nuclei | 5,199 | 4.3 |
| Waste | 113,212 | 94.1 |
| Small | 119,980 | 99.8 |
| Medium-sized | 281 | 0.2 |
| Large | 8 | 0.01 |
| Quartz | 119,784 | 99.6 |
| Chert | 412 | 0.3 |
| Gneiss | 10 | 0.01 |
| Red ochre | 36 | 0.03 |
| Graphite | 27 | 0.02 |

Gedige I

| *Category* | *n* | % |
|---|---|---|
| Sample | 380 | 100.0 |
| Form-trimmed | 3 | 0.8 |
| Others, trimmed | 10 | 2.6 |
| Used, non-trimmed | 19 | 5.0 |
| Potential tools | 60 | 15.8 |
| Nuclei | 113 | 29.7 |
| Waste | 168 | 44.5 |
| Small | 320 | 84.2 |
| Medium-sized | 50 | 13.2 |
| Large | 4 | 1.0 |
| Quartz | 380 | 100.0 |

The above data reveals that Gedige has a markedly higher proportion of trimmed tools, used artefacts and potential tools, and a lower percentage of nuclei and waste, suggesting that, compared to 43a II, the factory facies is less prominent than the habitation facies. However, considering the sparseness of the artefact sample from Gedige (n=380), despite the relatively large area excavated (64m$^2$), it is scarcely possible to attach too much significance to this comparison.

What does emerge, however, is the degree of agreement between 43a II on the one hand and the excavated assemblages from the I Fm on the other; namely, 45a II(1-3), 45b II(1), 49b II(1,2), 49b III(1-3)+49c III(5-7), 50a II(1,2) and 50a III(4,5). The high proportion of nuclei and waste in 43a II, as in the sites of the I Fm, leaves little doubt as to the dominance of the factory facies in this assemblage. The presence of pigments suggests the occurrence of a base-camp component as well, as in 49b III(1-3)+49c III(5-7).

Typologically, all the diagnostic elements from 43a II, such as geometric microliths, Balangoda Points, backed bladelets and pitted hammer-pebbles, are found in the Latosols as typified in 49b,c III. Hence it is probable that a certain degree of synchroneity exists between 43a II and 49b,c III, and the thermoluminescence dating of the latter at ca. 28,000 TL BP (Paudorf) could apply to the former on the basis of typological correlation.

As for Gedige, the sample is too small for it to be possible to estimate its age, apart from designating it Mesolithic on the basis of its geometric microlithic lunates. Considering the depositional conditions pertaining to the basal gravels of the RBE Fm, it is not feasible to correlate gravels from different localities on their geomorphology alone, as lag deposits that are widely separated in time can resemble one another closely. A cultural deposit dated to ca. 2,700 BP overlies the Mesolithic horizon of Gedige I (Addendum II).

I have made reference to implementiferous sediments that are transitional in facies between the I Fm, and the RBE Fm: the Hungama Formation (Chap.3.3.3). The small artefact sample secured from the H Fm during the surface survey of the I Fm, notably from Sites 54, 54a, 54b, 55 and 57 (App.III), is suggestive of Mesolithic elements, although clear diagnostic traits were not obtained. Without securing a more representative artefact sample, it is hazardous to speculate on the chrono-typological status of the artefacts in the H Fm. Their chronological range is likely to correspond to that of the I Fm, on the basis of the genesis of these sediments. The main import of the H Fm, so far, lies in its potential for establishing chrono-stratigraphic links between the I Fm and the RBE Fm, particularly with reference to their respective basal gravels.

*5.2.7 Ecozones A-F; Lithics.* The present chapter sub-heading concerns the distribution of the more diagnostic lithic categories, in techno-chronological terms, to have been found in Lanka, so as to observe if there should be any zonal patterning.

Since the primary slant of this work is ecological, it follows that the distribution of the stone artefacts should be viewed against the mosaic of ecozones A-F that have been delineated for the island (v. App.I; Map 1). To start with, there is no need to consider the smaller environmental units, such as climatic or physiographic sub-zones; this requirement would only arise once major zonal patterning can be observed – which is scarcely the case in Lanka, so far.

*Ecozone F*, the "arid" zone in the far north, has not yielded any stone artefacts. The claim that stone tools had been dredged up from the sea off the Jaffna peninsula (Hartley 1913:120) needs to be verified: it is probable that the coast referred to falls, in fact, within ecozone A.

The lack of prehistoric stone artefacts in ecozone F can only be attributed to a corresponding lack of raw materials suitable for implement manufacture in this region. The country-rock is karstic limestone, and no quartz or chert is locally available. The siliceous nodules occurring in the limestone are far too soft for the production of serviceable artefacts.

Of course, it is likely that finished artefacts, if not suitable nuclei, were transported into ecozone F from ecozone A, since otherwise F would have been as habitable as A in terms of food potential. Should this have been the case, it is unlikely that the artefacts will be found in any numerical density, as the debitage component would be minimal. Further investigations are an urgent requirement in ecozone F: artefact assemblages are likely to comprise a high percentage of trimmed specimens.

*Ecozone A* consists primarily of the Iranamadu and Reddish Brown Earth Formations. The typological data pertaining to the former have been set out in the site gazetteer of Appendix III and interpreted in Chapter 5.2.5. Hence there is no need to repeat what has already been said; it suffices to summarise that as far as the I Fm is concerned a rather amorphous range of possibly pre-Mesolithic categories, such as choppers and step-trimmed scrapers, occur. Geometric microlithic lunates, triangles and trapezoidals characterise some of the assemblages as technologically Mesolithic, which is reinforced by the presence of backed bladelets, bladelets and bladelet-nuclei, small backed flakes and small discoidal nuclei. Distinctive elements in these assemblages include Balangoda Points and non-geometric microliths. As in the rest of the Dry Zone, pitted hammer-stones (Type 109) are rare, and nut-stones (Type 111) absent. Grindstones are occasionally found, noteworthy being the mortars with small circular depressions from Site 27 (v. Wayland 1916*a*:Pl.). Red ochre (?pigment) is not rare, as at Site 49b,c III. The excavations at Sites 45, 49 and 50 do not indicate size or raw material differentiation between the Mesolithic assemblages in the I Fm and elsewhere (e.g., Bandarawela) in the island.

The assemblages excavated from the apparent occupation horizons in the gravels and Latosols of Sites 45, 49 and 50 (Chap.5.2.5) display a high degree of quantitative agreement in their typological composition. They indicate an assemblage-type with a predominantly factory facies, with perhaps a slight admixture of base-camp traits as in the occurrence of red ochre pigment; debitage and nuclei preponderate compared, for instance, to the essentially base-camp facies at Gedige I and Bellan-bandi Palassa in ecozone B (v. below) where by-products of implement manufacture constitute a smaller component.

Apart from the I Fm, excavations in 1982 at the ancient sea port of Mantai near Mannar (directed by J. Carswell of the University of Chicago, M.E. Prickett of Harvard and myself) brought to light a Mesolithic habitation in the basal layer representing occupation deposits on the then existing shoreline characterised by a typical assemblage of inter-tidal molluscs. Although only a small area of the site was excavated, it sufficed to indicate a relatively high proportion of finished tools: microlithic lunates and sub-lunates. The nuclei, according with the average size of the pebbles constituting potential nuclei in the region, were very small (<1cm), resulting in exceptionally small tools being made. (This habitation was associated with the exploitation of marine resources, which included dugong and conch shells. The sea level would have averaged ca. 1m above that of the present, as indicated by the elevation of the inter-tidal zone, at ca. 3,800 cal BP (assayed at the British Museum by courtesy of R.Knox).)

Oyster middens associated with small waste flakes on quartz, a few being on chert, occur along the estuary of the Mandakal-aru, just south of Poonakari in the extreme north. Several large nodules of silicified limestone had been brought to the middens for breaking open the oysters. It is hypothesised that these middens are assignable to a Mesolithic techno-tradition. It is noteworthy that the oyster shells do not display any considerable antiquity, judging by their state of preservation.

Other prehistoric sites in ecozone A include the rock-shelter at Tantrimalai (Still 1911:74-105), Ochchapuva-galge cave in Vilpattu (Deraniyagala 1958*b*:E4), Itikala cave in the southeast (S.Deraniyagala in Solheim and S.Deraniyagala 1972) and the Lenama cave complex also in the southeast (Deraniyagala 1948:F7). None of these sites yielded artefacts which are typologically diagnostic of any technological phase.

*Ecozone B* is best represented by Site 43 (v. Chap.5.2.6) in the RBE Fm and by the open-air midden site of Bellan-bandi Palassa. It will be recalled that Site 43 yielded a large number of artefacts, the entire assemblage resembling those of 49b,c III closely: geometric microlithic lunates, triangles and trapezoidals, non-geometric microliths, Balangoda Points, backed bladelets, bladelets and bladelet-nuclei, pitted hammer-stones; namely a typical Mesolithic assortment of artefact types. The assemblage type, as with 49b,c III, is predominantly of a factory facies. In all respects, no lithic artefactual differentiation is observable between ecozone A as represented by Sites 45, 49 and 50 in the I Fm and Site 43 of the RBE Fm in ecozone B. Todd's assemblage from the RBE Fm at Trincomalee and the sample from Gedige I at Anuradhapura also included microlithic lunates (hence Mesolithic) and Deraniyagala found pitted hammer-stones at Polonnaruva (Chap.5.2.6).

Apart, from the RBE Fm, there is Bellan-bandi Palassa in the Valave valley, beneath the Kaltota escarpment (Deraniyagala 1956*a*; 1957*a*; 1957*b*; 1958*a*; 1963*a*; S.Deraniyagala 1971*a*; S.Deraniyagala and Kennedy 1972). This site comprises a Mesolithic base-camp (ca. 6,500 TL BP), apparently single-phase, with lots of artefactual and faunal remains. The Mesolithic stratum has yielded the remains of some twelve humans: Balangoda Man. This stratum, ca. 5-30cm thick, overlies the bed-rock of crystalline limestone (the alkalinity of which has caused the preservation of the bone material) and it appears to have been truncated by the construction of an irrigation dam over it during the Middle Historic period as dated by the associated ceramics, although Mesolithic artefacts derived from the basal stratum have been found incorporated in the dam. Among the artefact categories from the Mesolithic horizon are (S.Deraniyagala 1971*a*; id. and Kennedy 1972): microlithic lunates (n=72), microlithic trapezoidal Type 5c(i) (n=1), non-geometric microlith Types 9a, 10c, 11, 13a and, notably, 20 a tanged point, backed bladelets, bladelets and bladelet-nuclei, small backed flakes, small discoidal nuclei, single specimens of a possible edge-ground celt and of parrot-beaked burin Type 88e, several pitted hammer-stones, nut-stones, small hammer-pebbles, rather archaic-looking choppers (e.g., Type 90b), red ochre and mica. Noteworthy absentees are microlithic triangles and Balangoda Points; but this could be due to the relatively small size of the artefact sample. Red ochre had been ground on some of the nut-stones. Grouped data (cf. those from the I Fm and RBE Fm) from the probe in 1970 comprise the following (S.Deraniyagala and Kennedy 1972):

| *Category* | *n* | % |
|---|---|---|
| Sample | 4,330 | 100.0 |
| Form-trimmed | 18 | 0.4 |
| Others, trimmed | 47 | 1.1 |
| Used, non-trimmed | 105 | 2.4 |
| Potential tools | 1,677 | 38.7 |
| Nuclei | 613 | 14.2 |
| Waste | 1,833 | 42.4 |
| Small | 4,225 | 97.5 |
| Medium-sized | 98 | 2.3 |
| Large | 7 | 0.2 |
| Quartz | 4,259 | 98.4 |
| Chert | 54 | 1.3 |
| Gneiss | 7 | 0.2 |

The proportions of waste and nuclei as opposed to "tools" are similar to those of Gedige I in the RBE Fm and markedly different from those found at Sites 43a II, 45a,b, 49b,c and 50a (v. Chap.5.2.5-6). This is in conformity with Bellan-bandi Palassa having a strong home-base component, as evinced by the food remains and the human skeletons, although implement manufacture had indeed occurred at the site: potential nuclei had been transported from alluvial gravels of the Valave river ca. 3km away, and possibly a quartz outcrop ca. 1km distant from the site had been quarried. Technologically, in terms of knapping, artefact size and raw material, the assemblage is akin to those from Sites 43, 45, 49 III and 50 III.

A few kilometres closer to the Kaltota escarpment, Udupiyan-galge and Lunu-galge caves were probed by Deraniyagala (1940*a*:364-6; 1943:99,101) down to ca. 2m and 1m below the surface respectively. In both instances the excavator affirms that the artefacts in the upper horizons were smaller than those from the lower levels. However this statement needs to be verified and there are doubts as to its reliability. Udupiyan-galge, the type-site for the Mesolithic "Balangoda Culture" of Lanka, yielded pitted hammer-stones and abraded pieces of haematite and graphite. Pitted hammer-stones were also found at Nika-wewa, near Sigiriya (id. 1945:134-5; 1954:120) and at Manda-galge cave near Siyambalanduva (id. 1952*a*:E4; 1953*a*:Pl.11(4)).

*Ecozone C* has been investigated primarily by the Sarasins and the Seligmanns in their quest for Vadda antecedents (v. Chap.1.2). Nilgala cave, stratigraphically excavated by the Sarasins, was tested down to ca. 2m -gl; bed-rock was not reached (Sarasin and Sarasin 1907:189; 1908:11-2; Sarasin1926:77). The main occupation levels, with ashy bands and numerous artefactual and faunal remains, occurred at 0.4-0.8m -gl, and the cultural material is said to have become increasingly scarce (in a ?colluvial yellow loamy matrix) down to ca. 2m -gl. The prehistoric horizon was devoid of ceramics which first appeared in a historical context in the uppermost 0-4cm -gl. A certain degree of stratigraphic admixture has been suspected by the Sarasins who attribute this to the activities of termites, ant-eaters, porcupines and sloth bears. Tool types do not display any vertical differentiation, and significant among them is the occurrence of microlithic lunates, non-geometric microlith Type 14 (n=1), bladelets and small quartz hammer-stones (n=ca. 60): a Mesolithic assemblage.

The lower cave at Bendiya-galge, near Henebedda, was trenched by the Seligmanns (Seligmann 1908:115; Seligmann and Seligmann 1908:162; 1911:22-4). The prehistoric layer was only ca. 60cm thick; it was underlain by bed-rock and overlain by ca. 60cm of deposits of the historical period. No typological data are available, although the assemblage is most probably Mesolithic. The Seligmanns affirm that ca. 3 per cent of the artefacts had been trimmed, which is double that of Bellan-bandi Palassa (1.5%). It is possible that conspicuously "used" tools were categorised as trimmed at Bendiya-galge, which would bring the total close to the Bellan-bandi Palassa percentage of 3.9 for trimmed plus used. However, the meagreness of the Bendiya-galge artefact sample (n=300) limits the significance of this comparison.

*Ecozone E* in the uplands of the Dry Zone is best represented by the artefacts sampled from the grassy hill-tops of Bandarawela (v. Sarasin and Sarasin 1908:17-9; Sarasin 1926:78; Seligmann and Seligmann 1908:157; Hartley 1914*a*; Noone and Noone 1940). Hartley's was the most intensive of these investigations, and in the course of a few weeks he had inspected practically every hill-top within a radius of several kilometres of Bandarawela. He found lots of artefacts, including occasional microliths; but it was only on a cluster of three hills and on one other hill-top that he noted artefacts in any special profusion. In addition to collecting several hundred artefacts from the surface of these four sites, Hartley excavated on the richest of them, Church Hill. The excavation was effected over two seasons and a trench, ca. 28m long by 5m wide, was taken down to bed-rock at ca. 0.3m -gl.

The stratigraphy comprised a homogeneous loam with a gravelly, artefact-rich horizon. The latter (for description of similar horizon v. Mueller-Dombois and Perera 1971:22) appears to comprise the end-product of earthworm activity, as can be adduced by the occurrence of brass cartridge cases and bottle-glass in association with the implements (v. Wayland 1919:88,93; Noone and Noone 1940:1,19), possibly mingled hopelessly with a lag deposit akin to the stone-lines of the RBE Fm in the lowlands of the Dry Zone. In the latter connection it is significant that the *wet patana* grasslands in the uplands of the Wet Zone (ecozone D2) do not have this gravelly horizon (Mueller-Dombois and Perera 1971:22).

Careful sieving (6mm gauge) of the excavated material by Hartley, and subsequent sorting by hand, produced a remarkably large sample (n=4,768) of "worked" (?trimmed) artefacts. The "non-worked" specimens were discarded. Some twenty-five years later, the Noones sampled the same four sites: the resultant collection comprised 2,000 artefacts; and apparently some of these were "extracted" from beneath the surface of the ground. The typologically significant categories in these samples comprise microlithic lunates (n=>264; by far the commonest form-trimmed type), microlithic sub-lunate Types 2a(i), 2a(ii), 2b(i), 2b(ii), microlithic triangles (n=>52; obtuse-angled isosceles and scalene plan-forms, rare), microlithic sub-triangle Type 4b, microlithic trapezoidal Types 5a, 5b, 5c, (n=>8), microlithic semi-lunates, non-geometric microlith Types 9 (n=1), 10c (n=5), 11 (n=1), 12 (n=7), 13c (n=1), 14 (n=2), 15 (n=2), 16 (n=3), 17c (n=4), 18 (n=1; shouldered point), Balangoda Point Type 43k (n=1; poor specimen), small edge-trimmed awls Type 40b(iii) (n=17), large and medium-sized edge-trimmed choppers and scrapers (occasionally), small hammer-pebbles, mullers (rare), red ochre (common), graphite (rare): a characteristically Mesolithic range.

Hartley (1914*a*:66-7) presents quantitative data on the total of 1,081 "worked" artefacts secured during the second season of excavations. However the significance of these data is very limited due to the inadequacies and overlaps in his typology (v. critical review in Chap.1.2). What does emerge is that microlithic lunates predominate among the form-trimmed categories, with the triangles trailing as a poor second and trapezoidals being very rare – as is the case with all of Lanka's Mesolithic assemblages.

Technologically, the Noones (1940:13-5) mention the presence of burinate elements, such as a so-called angle-burin (ibid.:Fig.1(20)). They also mention the possible use of the micro-burin technique of snapping off microlith-blanks from bladelets. However, neither of these propositions can be validated convincingly, and it appears as if the Noones were unduly influenced by concepts of burin and micro-burin technology in Europe. As for size, most of the Bandarawela specimens are small, although, as elsewhere in the island, medium-sized and large specimens are by no means absent.

Ravanalla cave, in the vicinity of Bandarawela, was extensively excavated over five seasons by Deraniyagala (1945:140; 1946*a*:F4; 1949:F4; 1950:E8; 1953*a*:127-30). The excavation was executed metrically in 15cm spits, down to over 1.5m -gl (v. id. 1953*a*:Pl.1(7)). The sediments were generally of loose compaction, and ashy as well as compacted (?shell) bands were observed. The lower strata could not be sampled due to their being cemented. It is unfortunate that this very important site has not been described in any detail by the excavator. A test excavation conducted by me in 1985 revealed that all undisturbed prehistoric cultural deposits had been stripped by P.E.P. Deraniyagala, leaving a sterile bed-rock of consolidated breccia in a fault-plane of the Precambrian country-rock. The breccia appears to be pre-Quaternary in age.

A large sample of artefacts and faunal remains were retrieved from Ravanalla by dry-sieving the excavated material. The artefacts comprise an unusually large proportion on chert, and the number of medium-sized specimens is relatively large. This could be the result of sampling bias; but it is nonetheless significant. Noteworthy is the occasional occurrence of denticulate tools, a category that is absent at other sites. Trimmed artefacts are very rare, and there are no geometric or non-geometric microliths in the sample housed at the Colombo National Museum. A hammer-stone with vestigial dimple pits (?Type 109) and several small quartz hammer-pebbles were secured. Pottery of the late Early Historic period was found, presumably in the topmost levels.

Stripura cavern at Arukvatte (id. 1955*a*:301; 1965*a*:118-20; 1957*a*:8), briefly investigated by Deraniyagala, revealed an antechamber with "travertine" deposits which contain artefacts and faunal remains. These cemented beds are apparently overlain by ca. 1 m of unconsolidated material with artefacts. No typological data are available concerning the small sample of artefacts secured by dynamiting the travertine. The apparent tilting of the latter, possibly associated with subsidence of the karstic formation, suggests considerable antiquity.

The entirety of Lanka's Dry Zone, comprising ecozones F, A, B, C and E, has been considered. The Wet Zone (ecozones D1-3) will now bear examination.

*Ecozone D3*, the highlands, presents sampling difficulties due to its almost impenetrable montane rain-forest and the dense mat of roots in the open grasslands. Artefacts were invariably retrieved from localities where recent clearing activities, such as path construction, have removed these obstacles, and the resultant sample is very small indeed.

A survey of the Horton Plains (S.Deraniyagala 1972*a*) brought some twenty-seven prehistoric sites to light. A $1m^2$ probe at Site 13 (Map 9) down to bed-rock revealed a loam with the typical Red-Yellow Podsolic (variant with prominent A1) soil of this ecozone (for pedology v. de Alwis and Panabokke 1972:50). An artefact-rich horizon was encountered at 30-40cm -gl, and this feature is ascribable to the action of worms, as confirmed by the presence of glass fragments within this horizon elsewhere on the Horton Plains. This stratigraphic picture appears to be typical of the grasslands, and perhaps of the forested area as well. Among the significant categories of artefacts secured were microlithic lunate Types la, le (Site 4, 6; n=2), a microlithic triangle Type 3a(i) (Site 6), and bladelets (Sites 8,27; n=2). These artefacts may be considered Mesolithic, and while the sample is extremely meagre, excavations at Sites 6, 9 and 13 could yield more representative assemblages. References to artefacts sampled from the Horton Plains occur in Pole (1913:23-4), Hartley (1914*a*:66), Sarasin and Sarasin (1908:20) and Sarasin (1926:83,88); but no typological data are afforded.

Pedro Estate, Nuwara-eliya, has yielded a single microlithic sub-triangle (Type 4b; Hartley Collection), and a probe in Bagava-lena cave, near the summit of Adam's Peak, produced a few quartz flakes and some pigment (?red ochre) (Deraniyagala 1963*d*:E37,44).

*Ecozone D2* was investigated primarily by Pole (1913) and Hartley (Hartley Collection). The Maskeliya region has several sites with diagnostic implements: geometric microliths (Scarborough Cave, n=3), microlithic lunates (Gangawatte, n=2), microlithic sub-triangle Type 4a (Scarborough Cave, n=1), microlithic semi-lunate Type 8b (Glenugie Estate, n=1).

Then there are the environs of (*a*) Norwood: microlithic lunate (Gouravilla Estate, n=1), microlithic semi-lunate (Gouravilla Estate, n=1), Balangoda Point Type 43a (Glencairn Estate, n=1); (*b*) Bogavantalava: non-geometric microlith Type 12 (Bogavantalava Estate, n=1), medium-sized pitted hammer-stone (Bogavantalava Estate, n=1, with exceptionally wide pits); and (*c*) Hatton: microlithic sub-triangle Type 4b (Strathdon Estate, n=1), non-geometric microlith Type 12 (Hatton Estate, n=1).

All the above assemblages from ecozone D2 may be considered Mesolithic.

*Ecozone D1* has seen more by way of prehistoric excavations than any other part of Lanka. However, despite the retrieval of large samples of cultural material – particularly by Deraniyagala who tested several caves – none of it has been described in any detail (v. Chap.1.2). Some of the more salient data to have been published may be enumerated as follows.

Beli-galge cave at Bambarabotuva has been excavated by Parsons, Hartley and Deraniyagala (Hartley 1911:198-200; Seligmann and Seligmann 1911:20-2; Sarasin 1926:87; Deraniyagala 1943:110,112). Hartley's data indicate Stone Age deposits at ca. 1-2.5m -gl within the cave, succeeded by material of the historical period at 0-1m -gl. Bed-rock was not reached. A large sample of artefacts has been retrieved from these excavations; but it has not been described with any adequacy, the only noteworthy elements being pitted hammer-stones, nut-stones and pieces of graphite pigment. Hartley (1911:198,200) merely affirms that the implements are cruder than those he secured from Bandarawela – which might be partly a function of the coarse sieve (2.5cm) he employed at Beli-galge.

Batadomba-lena cave at Kuruwita was probed by Deraniyagala down to ca. 1.5m -gl (Deraniyagala 1940*a*:367-8; 1941:F3; 1943:95-6,103-10; 1952*a*:E4; 1953*a*:131; 1965*a*:3). Among the artefacts secured were a mace-head, pitted hammer-stones, nut-stones, two "mortars", red ochre, graphite and "pumice". Subsequent excavations conducted at the site (1980-82) have yielded over 200,000 artefacts. The analysis of the finds has yet to be completed; however, there is firm evidence that geometric microliths comprising excellently formed lunates, triangles and trapezoidals occur from the basal stratum upwards (Figs.54-9). This lowermost Stratum 7c has been dated to ca. 28,500 $^{14}$C BP, and a series of radiocarbon dates are available for the sequence, up to ca. 11,500 cal BP (v. Chap.3.4.1). Pitted hammer-stones occurred from Stratum 7c onwards, and a Balangoda Point was found in 7b which has been dated to ca. 22,000 $^{14}$C BP. Bladelet technology is conspicuously rare and pottery was not found except in the topmost, disturbed levels. The significance of this site cannot be over-emphasised in view of the very early dates it has yielded for Mesolithic technology.

The excavations conducted at Beli-lena-Kitulgala (1978-83) revealed ca. 3m of deposit down to bed-rock, of which the middle horizons have several dates forming a consistent series from ca. 13,000 to 11,000 cal BP (v. Chap.3.4.1). The lower strata are currently being dated on charcoal, and it is likely that they extend back to over 27,000 BP (Addendum I). What is very significant is that this site too has indubitable geometric microliths from the basal layer upwards, thus corroborating the evidence from Batadomba-lena. The analysis of the finds and the excavation report of this site is being prepared by W.H. Wijepala (field director) of the Department of Archaeology, Government of Sri Lanka.

Deraniyagala's test pits in the caves of Yakgiri-lena near Matugama (1953*a*:127), Manela-galge at Gavaragiriya (1962:E15; 1963*d*:E36) down to ca. 2m -gl, Kabara-galge (1955*a*:303; 1965*a*:3) down to ca. 1m -gl, and Gunaratne's (1971) excavation of Beli-lena Athula, all yielded pitted hammer-stones. Nut-stones were also found at these sites except at Yakgiri-lena and Manela-galge. Beli-lena Athula has been dated to ca. 7,900 cal BP (v. Chap.3.4.1) in its uppermost prehistoric level; and although the lower levels are stated to be culturally sterile (Gunaratne 1971:1), this assertion needs checking. Kalukola-deniya cave, near Kegalle, has yielded a surface find of a stone celt, Type 85 (S.Deraniyagala 1972*b*:9).

The Hartley Collection has Balangoda Points from several localities, presumably open-air sites, in ecozone D1: Type 43g from Rye Estate, Balangoda and St. Clive's Estate, Nawalapitiya (n=2); Type 43i from Donside Estate, Nawalapitiya (n=1); and Type 43j from Syston Estate, Ukuvela (n=1). Primrose Hill, Kandy yielded Type 43b (n=1; ibid.). Non-geometric microlith Type 18 in the Hartley Collection is from ca. 30km along the Kandy-Nawalapitiya road.

A large assemblage of pitted hammer-stones and nut-stones has been secured from beneath ca. 6.5m of alluvial silts at Tunmodera, near Labugama (Deraniyagala 1965*b*), and an open-air site with pitted hammer-stones is known to occur beneath ca. 0.5m of silt on the flood-plain of the Kelani river at Collure between Biyagama and Waturupata.

It is apparent from the above account that, with regard to the various ecozones of Lanka, the extant data do not show up any variation, with the exception that pitted hammer-stones appear to occur much more frequently in ecozone D1 than elsewhere and that nut-stones are restricted to D1 except at Bellan-bandi Palassa in ecozone B. It is not possible to explain the high frequency of occurrence of pitted hammer-stones in D1. As for nut-stones, there appears to be a correlation between the distribution of these artefacts and that of the edible nut *Canarium zeylanicum*, both being restricted to ecozone D1. At Bellan-bandi Palassa it is likely that the site's "extended territory" would have included ecozone D1 with these nut-trees, since the distance from one ecozone into the other is not very great.

As for typological change through time, namely vertical evolution, it is conceivable that the basal gravels of the I Fm at Site 50a, and possibly at Site 49b,c, contain pre-geometric-microlithic phases which are followed by Mesolithic assemblages in the overlying latosolic sands. At none of the other sites investigated so far in Lanka is there any indication of typological change through time.

*5.2.8 Lithic Style and Types.* Adequate sampling of the high-level gravels of the Iranamadu Formation is likely to reveal distinctive pre-geometric-microlithic industries which could reach back into the Middle Pleistocene. The Ratnapura Industry provides no typological clues concerning its antiquity or stylistic affiliations. There is so far no vestige of a blade and burin industry: burins are absent except for a few specimens with what is probably a spurious resemblance to this category of artefacts, and blades occur only as bladelets in the Mesolithic. The Acheulean tradition has not been observed to occur in Lanka, although there are hints of a

Mousterian in the Acheulean tradition in the I Fm.

The typological entities that are distinctive among the stone tools of Lanka are geometric microlithic lunates, triangles and trapezoidals, microlithic semi-lunates, various types of non-geometric microliths such as tanged and shouldered points, Balangoda Points, backed bladelets, pitted hammer-stones and nut-stones. The geometric microliths are being considered diagnostic of the Mesolithic technological phase in Lanka, whereas the remaining categories could predate it. I wish to stress again that the term Mesolithic is being employed in this work as representing a technological phase characterised by geometric microliths and that there are no implications as to a post-Pleistocene age or any particular mode of subsistence, contrary to standard procedure in Europe.

With regard to the causative factors behind microlithisation, one could only make a sweeping generalisation that it represents the result of a systemic interaction between (*a*) style, as in the choice of geometric plan-forms, (*b*) function, as represented in a presumed superior utility of composite tools, and (*c*) technology, as in the manipulation of the quartz raw material. It would be foolhardy to attempt to disentangle the different strands of this web of interaction in search of a prime-mover: such an effort would be contrary to the theoretical paradigm adopted in this work with its basis in Systems Theory, modified to suit cultural phenomena (Chap.1.4). It is more realistic to limit one's targets to smaller gains in knowledge employing carefully planned tactics for data retrieval, and perhaps (?in the distant future) a processual "explanation" may then be assayed for the phenomenon of microlithisation in the tropics as exemplified in Lanka during the Upper Pleistocene.

This leads to the problem of sample size. As evinced in the excavations at Sites 43, 45, 49 and 50, form-trimmed tools usually do not account for more than ca. 0.2 per cent of the artefact totals; and it is the form-trimmed tools that are analytically by far the most useful taxon in any typology. Hence, it is abundantly clear that the number of form-trimmed artefacts available for analysis in Lanka is very small indeed – very much fewer than what could be considered adequate for a study of typological variation through space and time. It is futile to apply even such a rudimentary procedure as seriation on such a small sample of form-trimmed tools, a situation that is compounded by the extreme dearth of contextual data from all sites apart from the few excavated after 1969.

The above impasse could change once several thousand, perhaps around five thousand, form-trimmed artefacts are available from stratified contexts. To obtain a sample of five thousand form-trimmed specimens it is estimated that over two million artefacts will have to be sampled and sorted, on the basis of the 0.2 per cent average of form-trimmed artefacts in the assemblage totals. Once an adequate sample has been secured, a detailed intra-type analysis of the categories that at present constitute broad types, such as microlithic lunates, triangles and trapezoidals, Balangoda Points and tanged or shouldered points, will probably reveal patterned variation through space and time. This will involve fine-tuning of the present non-tool-specific classificatory system into a tool-specific scheme. Modal analysis can be employed to supplement information supplied by type-variety analysis, while noting that Lanka's lithic studies are still in their "pioneer" stage and that dispensing with typology is a luxury that cannot be afforded.

*5.2.9 Lithic Technology.* It is not feasible to isolate stylistic traits from those of technology and function readily; hence in the foregoing chapter sub-heading I have considered style within the overall context of artefact types. The present sub-heading will deal only with those traits that can be termed technological and which can be attributed to raw material and modes of artefact manufacture.

The very high percentage of debitage in the prehistoric lithic assemblages from Lanka can be attributed to the nature of the raw material. In Chapter 5.2.5-6, I have presented the data on the relative frequencies of occurrence of the various raw materials used for artefact manufacture in the occupation horizons delineated for the Iranamadu and Reddish Brown Formations. In each instance over 99 per cent of the artefacts have been made on quartz, with less than 1 per cent on chert and even fewer on igneous rocks such as gneiss. The strong selection for quartz can be explained by the ready availability of this material in alluvial gravels and as primary intrusive veins in the country-rock in all parts of the island except on the Jaffna peninsula. In comparison, chert pebbles in alluvial gravels, although widespread, are very rare, and outcrops within the crystallines rarer still. (The cherty siliceous nodules which are common in the Miocene limestone are too soft for implement manufacture.) Gneiss, while ubiquitous except in limestone country (Map 19), is too soft and granular for any form of flaked artefact: its use was almost exclusively confined to hammer-stones, mullers and grindstones, where its special properties of granularity and relative softness were desirable. The modes of occurrence of Lanka's prehistoric raw materials have been set out in some detail by various workers: quartz (v. Parsons 1908:174; Cooray 1967:123-4,191,193); chert (Wayland 1919:94-101; Cooray 1967:180); igneous crystallines, including dolerite (Cooray 1967:245); graphite (ibid.:205-6); mica (ibid.:207); pumice (Wadia 1941*d*) (also v. map of minerals in Cooray 1967:227). A detailed geological account of these occurrences is not relevant in the present context of a treatment of prehistoric technology.

From among the varieties of quartz which had been used, the bulk of the artefacts are on milky quartz. However, rock-crystal, which is relatively scarce, had definitely been the preferred material for small, form-trimmed artefacts such as microliths, Balangoda Points and also bladelets, as already noted by the Noones for Bandarawela (1940:3,16). Rock-crystal nuclei were usually not discarded until completely exhausted – specimens of less than 1cm diameter are common – thus demonstrating the esteem in which this material was held. Outcrops of rock-crystal, as at Site 4 of the I Fm, are very rare, and potential nuclei comprising alluvial pebbles are also scarce. It appears as if rock-crystal has superior flaking properties compared to milky quartz, and it is possible that this is coupled with greater functional durability as well.

There is a tendency for a marked cleavage to occur in Lanka's quartz, both rock-crystal and milky quartz, which makes controlled conchoidal fracture difficult to achieve (v. Parsons 1908:171,173,176). With regard to milky quartz, its granularity makes for a crude fracture akin to an igneous rock such as granite (v. Rosenfeld 1965:44,160; Witthoft 1967:126; 1967*a*:384). Concerning flaking properties and the cleavage of quartz, the Noones (1940:2-3) affirm that

> quite a number of the bulb faces bore one or more faint ridges sometimes running towards the top of the piece and on other pieces askew. These are suggestive of a semi-pyramidal rather than the usual conchoidal fracturing. The schistosity of certain grades of quartz caused angular and flat cleavage, which though too often troublesome could be turned to account...: implements bearing part of such natural cleavage planes are not uncommon. In some cases a subsidiary cross-plane has split off the knife-edge margin along a blade and damaged the tool. Advantage taken of this schistosity and crystalline formation is instanced in (*a*) use as knapping and trimming platforms, (*b*) in producing the larger triangles and heavy scrapers and (*c*) making some of the pyramidal discoids.

Hartley (1913:119) submitted specimens of rock-crystal from Lanka to a professional flint-worker of Brandon in Suffolk. The latter apparently could do "nothing at all" with this material. It should however be borne in mind that within its overall range of hardness and cleavage, the flaking characteristics of rock-crystal tend to differ according to locality due to variation in details of crystal form, and slight variations in hardness are also caused by differences in the crystalline lattice (Witthoft 1967:126; 1967*a*:384). As for milky quartz, when it is flaked "each individual quartz crystal breaks with a conchoidal fracture [*sic*], but the rock as a whole has an irregular fracture . . . single crystals may be flaked successfully. . . ." (Rosenfeld 1965:160).

It is here hypothesised, as per the above evidence concerning the flaking properties of quartz, that it is the intractability of this material that led to the accumulation of vast quantities of debitage at the factory sites as instanced at Sites 45, 49 and 50 in the I Fm and Site 43 in the RBE Fm. It is also known that water-worn pebbles, as opposed to material quarried from primary deposits, incorporate a relatively high proportion of incipient cracks within the mass of the pebble as a result of fluviatile battering (Leakey 1953:32). Since most of Lanka's nuclei occur on pebbles, this could be an added factor leading to numerous debitage.

On percussion, quartz step-fractures along its cleavage (Crabtree 1972:51), and hence the production of true blades is difficult under these conditions. The resultant primary flakes are usually rectilinear (S.Deraniyagala and Kennedy 1972:33) and can readily be converted into geometric microliths. This circumvents the necessity of first producing bladelets and then employing the micro-burin technique of producing microlith blanks (v. Leakey 1953:45; 1958:139) as has frequently been done in the Mesolithic industries of western Europe. The cross-sections on the quartz artefacts from Lanka fall predominantly within the category of "medium" thickness, "thick" being somewhat less common. It is rarely that body-trimming has been used for altering the effective cross-section of a tool.

Allchin (1958) sugggests that fire-shattering had been used for securing flakes from quartz nuclei in Lanka. However, I have not observed any evidence, such as large-scale fire-reddening of quartz, to corroborate this hypothesis. As for heat treatment of nuclei so as to obtain greater control over fracture behaviour (v. Goodwin 1960:316; Crabtree and Butler 1964:1-2; Shepard 1965:28-9; Crabtree 1966:17; 1972:5), once again there is no firm evidence that this technique had been employed: however, further investigations are necessary on this subject.

Apart from rock-crystal and milky quartz, a granular variety of the latter has frequently been used for the manufacture of medium-sized and large artefacts. This material has poor flaking properties due to its granularity, and hence was probably considered unsuitable for small tools requiring fine edges and precise trimming. However, it would have sufficed for crude heavy-duty categories such as choppers. Rose quartz, rutile quartz and amethyst have been employed according to their availability, which is scarce, and there was apparently no selection for any special property, such as their attractive colour; for instance the outcrop of rose quartz at Site 20 on the Horton Plains (S.Deraniyagala 1972*a*:19) does not seem to have been exploited with any particular intensity.

Chert is found in all parts of the island in alluvial gravels or in rocky outcrops, except in the Jaffna peninsula where, as mentioned earlier, the cherty siliceous nodules in the Miocene limestone are too soft to be of any use on implements. (In this connection it is significant that the relatively soft green chert found in the Maskeliya area (Parsons 1907:190) was also not exploited by Stone Age man.) The properties of chert are those of an impure flint, and these properties as well as the modes of origin of cherts are set out in several works (Oakley 1939:278,280,283; Skinner 1956:14-6; Hurst and Kelly 1966:518; Witthoft 1969:498-9,504; Crabtree 1972:4-5). It suffices to mention that chert comprises an intermeshing of crypto-crystalline chalcedony and crystalline quartz with either amorphous opal or water filling the interstices. The impurities which colour the material is thought to occur in the interstices and they do not affect the general texture of the material to any significant extent. As is to be expected, the isotropy in chert is much more pronounced than in quartz.

Chert is very much rarer than quartz in Lanka, which accounts for its proportion of less than 1 per cent in the assemblages where quantitative data are available. Besides it is softer than quartz and hence the relatively frequent occurrence of use marks on artefacts of chert as compared with those on quartz (v. Pole 1913:8). It is noteworthy that chert artefacts have only very rarely been trimmed (v. ibid.; Hartley 1913:120; 1914*a*:63). This material, being softer than quartz, was probably considered not worth the effort of trimming, when the resultant artefact became blunt or otherwise exhausted almost as soon as it was made. Concerning the properties of Lanka's cherts, Wayland (1919:94) affirms that "the chert varies in quality from an opaque splintery substance, little used by Stone Age peoples, to a stone with a fine conchoidal fracture, closely resembling European flint and often translucent in thin flakes". When Deraniyagala (1945:124,127; 1950:E4) affirms that fossilised wood was employed by prehistoric man in Vilpattu, he was probably mistakenly referring to fibrous cherts, since I have not seen any fossilised wood in this area. Translucent chert, jasper and chalcedony, have been used according to their availability, and with no apparent selection for any special properties they might have, although further investigations might reveal that translucent chert was preferred for artefacts requiring delicate trimming.

There is no adequate explanation as to why chert, particularly the flint-like translucent varieties, was not used for blade production in conformity with the Upper Palaeolithic blade tradition of peninsular India. The finer grades of chert in Lanka are not unsuited for this purpose. In view of their isotropy, a much greater degree of control over fracture behaviour is feasible than is the case with quartz. It can only be hypothesised that since the main production trend was set by quartz technology, it was not altered to suit a scarce material such as fine-grained chert. It should also be borne in mind that Lanka's chert is usually much coarser than the crypto-crystalline silicas such as agate which have been used extensively for bladelet production in the Mesolithic of India, or even the lydianite employed in its Upper Palaeolithic assemblages. Perhaps, on an average, Lanka's chert was just too coarse as to be acceptable for large-scale blade and bladelet production.

As for the absence of the Acheulean techno-tradition in Lanka, it is noteworthy that by far the majority of the Indian assemblages are on sedimentary quartzites, although specimens on chert or quartz are not unknown. Despite the proposition that style is largely independent of raw material (Leakey 1953:30-1) and that flaking techniques may be adjusted for this purpose with changes in raw material (Bordes and Crabtree 1969:3), the absence of quartzite in Lanka appears to have been a major constraint against the production of Acheulean bifaces on the island. Quartz does not seem to have been considered a suitable substitute, presumably due to its intractability. To this might be added other factors, such as the non-savanna, rain-forest environment, which in both Africa and India seems to have inhibited the expression of the Acheulean techno-tradition.

What has been considered in the foregoing discussion is the role of raw material in Lanka's prehistoric lithic technology. As for the procedure of manufacturing the implements themselves, I have alluded to the possibility that bipolar flaking had been employed on spheroidal prepared nuclei (Type 97) as represented in the segments of sector-form flakes in the I Fm (v. Chap.5.2.5; for technique v. Crabtree 1972:10-1). Similar specimens occur in India's Middle Palaeolithic. The Levallois tradition of prepared nuclei can be considered lacking in Lanka, despite the occurrence of a few specimens which probably bear a spurious resemblance to Levallois nuclei. It is noteworthy that the Levallois tradition is not conspicuously in evidence in most of peninsular India either, except perhaps in Rajasthan's Middle Palaeolithic, and hence raw material is unlikely to have been the main factor influencing its absence in Lanka.

With regard to blade technology, as mentioned earlier, it is very scarce in Lanka: only a few bladelet-nuclei have been found so far, and these are from Mesolithic contexts. Primary guide flakes (*lame à crête*; v. Bordes and Crabtree 1969:7,15; Crabtree 1972; also Allchin and Allchin 1974:52) have not been found in Lanka, although the appearance of this technique in Europe is as early as in the Evolved Perigordian of France (Bordes 1969:11). In fact this special aspect of blade technology first occurs in India during its Chalcolithic phase, and it is conspicuously absent in the Indian Upper Palaeolithic and Mesolithic assemblages. However, core-trimming tablets (Type 101a) have been found in Lanka, such as the specimen from Bellan-bandi Palassa (S.Deraniyagala 1971*a*:77).

By far the majority of the nuclei found in Lanka are non-distinctive, grading into discoidal nuclei where discoidal pebbles had been utilised. It can hence be concluded that core preparation did not represent a specialised field of lithic technology.

The quartz artefacts from Lanka rarely display prominent cones or bulbs of percussion due to the fracture pattern being determined to a large extent by the cleavage. There has been a marked preference for gneiss for the hammer-stones, and the frequent occurrence of heavy battering on these indicate their use for direct percussion. It is known that a relatively soft material (vs. quartz) for the hammer enhances the diffusion of the lines of force in the nucleus, which tends to reduce shattering (v. Crabtree and Swanson 1968:50), and this probably explains the choice of gneiss for the heavier hammer-stones. The smaller hammer-stones are frequently on quartz pebbles, and these were probably used for secondary trimming as well as for the dressing of nuclei. (The very small (<1cm) nuclei frequently found in Lanka's Mesolithic could only have been flaked by indirect percussion coupled perhaps with pressure flaking.) It has been experimentally observed that hammers weighing 0.2-1.5kg and up to ca. 8cm in diameter are optimal for primary flaking, whereas smaller ones of ca. 60-85g are suitable for secondary work (ibid.; Baden-Powell 1949:38; Leakey 1953:40; Coles and Higgs 1969:56). It would be interesting to observe if these two size/weight categories apply to Lanka's prehistoric hammer-stones. The measuring and weighing of a large sample of hammer-stones and the graphic presentation of the results could be revealing in this respect.

The retouch on most artefacts examined from Lanka is of the feathering variety. Step-trimming is rare and is most in evidence on certain artefacts from the higher (?older) levels of the I Fm, thereby suggesting a Mousterioid tradition. Fluting and long, invasive retouch have not been observed.

The invasive, shallow trimming on Balangoda Points has almost certainly been executed through pressure-flaking – thus dating the use of this technique at Site 49b to ca. 28,000 TL BP and at Batadomba-lena to ca. 22,000 cal BP, which is early compared to its advent in Europe. Some of the blunting retouch on the very small microliths seems to be the result of rasping against an abrasive surface: specimens are known from Maskeliya, Bandarawela, Bellan-bandi Palassa and the Horton Plains (Pole 1913:31; Noone and Noone 1940:3; S.Deraniyagala 1972*a*:22; S.Deraniyagala and Kennedy (1972:36). It is noteworthy that adequate core preparation has at times provided the backing for microlithic lunates, thereby eliminating the necessity for secondary blunting trimming. This is possibly an extension of the proposed bipolar flaking tradition associated with spheroidal prepared nuclei.

A classification of retouch has yet to be effected for Lanka (cf. Sankalia 1964:41; Movius et al. 1968:6,8; Crabtree 1972:87; Bricker 1973:229,232,235-43,288-90, 293,297).

With regard to artefact size, it seems to have been influenced to a certain degree by the size of the nuclei available for knapping. At Site 40 of the I Fm this situation is clearly exemplified: factory loci associated with large potential nuclei had larger artefacts on an average than those with smaller nuclei. At Mantai where the potential nuclei were very small indeed the resultant artefacts are exceptionally small. However, this is not to deny that there would have been an overall tendency to produce progressively smaller tools, microlithisation, during the Upper Pleistocene in Lanka, although concrete evidence is still lacking to support this hypothesis. This tendency could represent a clear instance of cultural choice, as opposed to its being a function of the average size of the available potential nuclei. By analogy with microlithic industries in Europe, Africa and Australia, it can be hypothesised that the microliths in Lanka were frequently hafted into composite tools; in fact, some specimens of microliths bear traces of what appear to be hafting scars.

The spheroidal bolas-stones found in Lanka could have been made by bouncing stone upon stone (cf. Clark 1970:92). The absence of celts in Lanka, apart from the somewhat dubious specimens from Bellan-bandi Palassa, Site 43a of the RBE Fm and Kalukola-deniya cave, can partly be attributed to the scarcity of fine-grained igneous rocks on the island (e.g., dolerite). This is in marked contrast to the situation in the Deccan of India where Neolithic polished celts are of frequent occurrence, presumably due primarily to the ready availability of fine-grained crystallines. The above mentioned specimens from Lanka appear to have been ground; but none of them bears any vestige of polishing.

The pits on the pitted hammer-stones and nut-stones tend to be conical, and striations suggest their having been produced by a rotary action, perhaps of a fire-drill. The same technique might have been employed to perforate the mace-head found at Batadomba-lena. Cylindrical drilling with a hollow core (*BBC* 1964:3) is unknown from Lanka.

*5.2.10 Lithic Function.* Having considered style and technology, it is function that remains to be examined. It will be recalled (Chap.5.2.2) that function has been classified in my taxonomic system solely on the basis of macro-morphological traits and hence designated "apparent" function. There has been no attempt to hypothesise that apparent function equated in any manner with "real" function: for instance, a cutter has been designated as such since its edge-angle is less than 40°, with no implication that it was not in fact used as a scraper or transverse arrow-head. (Perhaps, with regard to edge- and point-tools, the only exception is the category of used concave scrapers which could only have been used as such (v. Allchin 1958: 199).) As for micro-wear, experimental comparison between the behaviour of glass, chert and quartz, as conducted by me in 1974, indicated that too many independent variables are involved to be able to usefully isolate the manner and purpose for which an artefact had in fact been used. This may sound simplistic, and I have no doubt that intensive micro-wear investigations could indeed be productive in a highly specific context; but I have yet to be convinced as to the general utility of such studies, particularly in a situation as in Lanka which is still in the "pioneering" stage.

Bearing the above qualifications concerning apparent function in mind, it is possible to affirm that cutters and scrapers predominate in Lanka's assemblages, whereas points and awls constitute a distinct minority. Choppers and adzes are rare, and burins (with typical spall removals) practically non-existent apart from a few stray specimens which probably bear a mere spurious resemblance to this category of tools (e.g., the busked burin from Ladiyagala (S.Deraniyagala in Solheim and S.Deraniyagala 1972:27,Fig.3a)). Combination tools, such as scraper *cum* cutter, do occur (v. Noone and Noone 1940:4), although not very frequently. Denticulates are conspicuously scarce (cf. rare occurrences at Ravanalla cave). The extreme rarity of celts, despite the occasional availability of dolerite, suggests that functionally they were not esential for the subsistence economy: probably that the felling of trees and the digging of the ground (Fagan 1974:201) were not vital operations such as would have been the case in a Neolithic subsistence economy. Sickle gloss has not been observed (v. Witthoft 1967*a*:383-5; Hole and Heizer 1973:19) on any of the artefacts, which suggests that grasses were not being harvested extensively with stone tools.

Occasionally, artefacts have been reflaked to produce fresh functional edges, as evinced by the trimming of already water-worn or patinated specimens (e.g., in I Fm; also v. Hartley 1913:121). As mentioned earlier, waste predominates in all the assemblages and it is likely that this category, as well as nuclei, hammer-stones, mullers, grindstones and pigments have been correctly identified in terms of their "real" function.

Mullers, pestles, grindstones and mortars frequently bear traces of red ochre, as at Batadomba-lena, and Beli-lena at Kitulgala (Deraniyagala 1943:96, 107-9,Fig.8,Pl.8(4,5); 1965*a*:3). It is however likely that these had multiple uses in that food and perhaps medicinal materials would also have been processed with them. It is also possible that the grooved "mortar" from Batadomba-lena was used to grind down bone and antler tools. The abrasion on the grindstones indicates both linear and rotary action: the former is represented at Kabara-galge (id. 1955*a*:Pl.7; 1965*a*:3) and at Batadomba-lena (id. 1941:F3) and the latter at Bellan-bandi Palassa; but they are not mutually exclusive. It has been hypothesised that the nut-stones, with their distinctive dimple pits, were primarily used as anvils for cracking nuts of *Canarium zeylanicum* (v. id. 1943:107); but they have frequently been used as grindstones as well and many bear smears of red ochre (e.g., at Bellan-bandi Palassa and Batadomba-lena; ibid.:103,107; 1958:82; 1958*a*:256; 1965*a*:3). Nut-stones akin to those from Lanka have been used by the Australian aborigines for cracking macadamia nuts, the pits functioning as anvils while a heavy slab of rock crushes the nuts (J.Kamminga 1979:pers. comm.). As for the pits on the hammer-stones of Type 109, their function is indeterminate. They could have been produced by a fire-drill, assisted in the hafting or served as anvils for knapping stone tools. The striations occurring within the pits however indicate that they were formed by a rotary action. This supports the fire-drill (for technique v. Hiller and Furness ?1902:36) hypothesis, as postulated by Fujimori for similar pitted stones from Japan where the vertical wooden element revolving in a horizontal piece of wood is thought to have been steadied from above with a pitted stone (Kidder 1968:32). The occurrence of the pits on the lateral sides of some specimens appear to confirm this hypothesis. The action is likely to have been that of a bow-drill, and it is the fine wood dust that resulted that would have smouldered and caught fire. The wide range of distribution of pitted pebbles in various parts of the world (v. Chap.5.2.13) does indeed suggest a very basic function such as that of fire-making. The discovery of a pitted stone of Type 109 in a late Early Historic context at the port of Mantai during the 1984 season of excavation appears to corroborate this proposition, as it is unlikely to have been related to any function associated with prehistoric lithic technology. There is also the possibility that the pits on nut-stones served a similar function, although this time as the lower component of the fire-drill assemblage; the striations in the pits, once again, imply this. That most of the pitted stones had also been used as hammers is attested by the presence of battering on them, while some display abrasion facets and others bear smears of red ochre (e.g., at Batadomba-lena; Deraniyagala 1941:F3; 1943:96).

As mentioned earlier, bolas-stones could represent prepared nuclei (v. Hole and Heizer 1965:197), missiles or fabricators used for dressing artefacts. The gneiss specimens, as from Site 17 of the I Fm, are unlikely to have served as nuclei. The occurrence of bolas-stones exclusively in the Dry Zone, as in the *vembus*, suggests that they were indeed used as missiles in the relatively open terrain.

Abraded pieces of red ochre have frequently been found; for instance at Bandarawela (Noone and Noone 1940:18), Batadomba-lena (Deraniyagala 1940*a*:368; 1941:F3), Bellan-bandi Palassa (S.Deraniyagala and Kennedy 1972:36), Udupiyan-galge (Deraniyagala 1943:101), Beli-lena Kitulgala, Site 43a II in the RBE Fm and Site 49b,c III of the I Fm. These were most probably used for pigment, as suggested by the reddened human frontal bone from Ravanalla cave (id. 1953*a*:128) and the red ochre-coated fractional interment of humans excavated in 1986 at Fa Hien cave (W.H.Wijepala 1986:pers. comm.). Although less frequently, graphite also seems to have been used as a pigment, as at Bandarawela (Noone and Noone 1940:19), Batadomba-lena (Deraniyagala 1941:F3; 1943:95), Udupiyan-galge (id. 1943:101), Bambaragala (ibid.:102), Beli-galge Bambarabotuva (ibid.:110), Beli-lena Athula (Gunaratne 1971:3) and Site 43a II of the RBE Fm. A chalky evaporate from the roof of the cave has been ground, presumably as a pigment, on grindstones in Batadomba-lena. Graphite-like molybdenite (*sic*) is supposed to have been found at Kabara-galge (Deraniyagala 1955*b*:E16) and at Bellan-bandi Palassa (id. 1957*a*:11). The mica and biotite discovered at various sites could either be natural deposits derived from the country-rock or else they could represent manuports for ?ornamental purposes: these materials have been found at Batadomba-lena, Bambaragala and Bellan-bandi Palassa (id. 1943:96,102; S.Deraniyagala and Kennedy 1972:36). The pumice from Batadomba-lena, if indeed it is pumice, poses a mystery as to its function: it is scarcely possible that Balangoda Man was that cosmetic minded as to use it to scrub himself with, as suggested by Deraniyagala (1943:95-6). In this context, the Vaddas, who are the cultural descendants of Balangoda Man, are known to have been most unconcerned about the layers of dirt that they carried on their persons.

With regard to the functional aspect of the assemblages (for treatment of assemblage-types v. Mason 1967:740; Collins 1969:267-8), I have delineated in Chapter 5.2.5-6 the basis for the interpretation of the occupation horizons at Sites 43, 45, 49 and 50 of the RBE Fm and I Fm as being primarily factory sites characterised by an exceptionally high proportion of nuclei and debitage. On the other hand, Gedige I and Bellan-bandi Palassa, with a higher proportion of trimmed artefacts relative to nuclei and debitage, appear to have a stronger base-camp component, although the factory facies is also present (Chap.5.2.7). It is very likely that with adequate sampling a continuum will be observed between essentially base-camp and extraction facies, perhaps in a multi-modal configuration as to the frequency of occurrence of the relative proportions of these two facies on a site by site basis. These proportions could in large measure have depended on the distance from camp to the sources of lithic raw material for instance, which in turn would have been determined by the settlement pattern with specific reference to the site-territory as governed by the overall subsistence economy: the closer the base-camp to a source of raw material, the larger the factory component, due to increased facility in transporting raw materials back to camp. The site-territory itself, as far as Lanka is concerned, is likely to have been determined primarily by the availability of food resources, raw materials being but a secondary factor due to their occurrence in profusion (e.g., quartz) in most parts of the island.

*5.2.11 Bone, Antler and Shell Artefacts.* The abraded fragment of cervid cannon bone found in the ancient dune sands of Site 50a III(4) of the I Fm (App.III) constitutes evidence of a bone artefact in Lanka at ca. 28,000 TL BP. Then there are the specimens of bone and antler tools from Beli-lena Kitulgala and Batadomba-lena caves. The Beli-lena artefacts have been dated to ca. 13,000 cal BP, whereas the Batadomba-lena specimens range from ca. 28,500 to 11,500 $^{14}$C BP (Figs.54-9; also v. Deraniyagala 1943:110,Pl.9(4); 1953*a*:Pl.8(1)).

The bone and antler tools at Beli-lena and Batadomba-lena comprise elongate single points (ca. 2-12cm long by 0.4-0.7cm thick), elongate rhomboidal double points (ca. 1.5-4cm by 0.4cm; from ca. 28,500 BP onwards at Batadomba-lena), edge-ground bone picks, also made of antler tines ($\leqslant$15cm) and edge-ground spatulae ($\leqslant$10cm). Unique to Beli-lena Kitulgala are form-ground spatulae with nicks cut into the lateral edges to produce a serrated appearance (fragments ca. 3-5 cm long by 1.5cm wide by 0.5cm thick) and barrel-beads on segmented long-bones (ca. 2cm long by 1.5cm diameter). Batadomba-lena has yielded a shell-bead at ca. 28,500 BP (Fig.59); at ca. 16,000 $^{14}$C BP there are small, flat disc-beads of mother of pearl from the freshwater bivalve *Unio anodontina* (ca. 0.5cm diameter) with tiny serrations cut into the perimeter (Fig.56); and there is the (unaltered) barbed spine of a marine ray (ca. 3cm long) at ca. 17,000 $^{14}$C BP which resembles a very small harpoon (Fig.57). At both sites it is not improbable that the spurs of the jungle fowl *Gallus lafayetti* (set naturally in the shank) and canines *in situ* in the mandibular rami of, for instance, monkeys, had been used as awls (v. id. 1943:110). Numerous specimens of the arboreal snail *Acavus* with a large perforation in the body-whorl (v. id. 1940*a*:368) may represent "beads"; but this feature could just as well be associated with a specific method of winkling out the meat of the molluscs for consumption. Perhaps the aperture served both these functions. Fragments of large marine molluscs found at Beli-lena Kitulgala, and at Batadomba-lena (ca. 13,500 $^{14}$C BP) probably represent debitage from the manufacture of shell artefacts.

Bellan-bandi Palassa, dated to ca. 6,500 TL BP, has also yielded a relatively large sample of bone and antler artefacts (id. 1956*a*:119; 1957*a*:12; 1958:79; 1958*a*:231,240-3; 1960*a*:98-101; 1963*a*:100,Pl.3). (The faunal remains at this site appear to have been preserved by the alkalinity of the underlying limestone bed-rock, as opposed to the situation at the other open-air sites investigated so far.) Among the artefacts from Bellan-bandi Palassa are small rhomboidal double points, small single points, bone and antler picks, bone and antler spatulae (noteworthy being a large (ca. 20cm) specimen on elephant bone), a potential awl on the canine of a civet's mandible, a *Muntiacus* antler with two notches cut into its bezel (?for attachment), a pestle on a sambhur brow-tine, and a perforated shell of a marine *Cypraea* (cowrie) shell.

The prehistoric deposit of Ravanalla cave yielded small rhomboidal double points, small single points, elongate single points (ca. 6cm), elongate pieces of bone with single and double cross-incisions along their length (n=3), potential awls on spurs of jungle fowl and on longitudinally split monkey canines, bone spatulae and perforated marine shells (n=2) (id. 1949:F4; 1950:E8; 1953*a*:127,130,Pl.2-4,8(2-4); 1955*a*:Pl.5; 1957*a*:Pl.8). Particularly noteworthy is the discovery of a human frontal bone that had apparently been drilled (but not perforated) bifacially (id. 1953*a*:128). The rough sutural edges have been chamfered off and the bone smeared with red ochre on its cerebral aspect.

Excavations at other cave sites have also produced artefacts of bone and antler: (*a*) Alu-galge, Telulla (id. 1955*a*:299; 1957*a*:Pl.8 (3,4)) small rhomboidal double points, small single points, spatula on sambhur antler; (*b*) Udupiyan-galge (id. 1940*a*:366; 1943:100), small rhomboidal double points, small single points;

(*c*) Beli-galge, Bambarabotuva (Hartley 1911:198,200; Sarasin 1926:87; Deraniyagala 1943:110), bone points, pierced *Acavus* shells; (*d*) Nilgala cave (Sarasin and Sarasin 1908), cross-incised pieces of bone as at Ravanalla, bone and antler pieces with wide cross-grooves (possibly representing process of cutting across for segmenting), carapace fragments of hard-shelled terrapin which had been smoothed along sections of rough edges, bone spatulae, bone "polisher" (for hide working), hollowed out antler with both ends truncated, heel-bone of deer with deep hollow drilled longitudinally into it, pierced *Acavus* shells, shells of *Unio thwaitesii* and *U. corrugatus* with edges blunted by use. There is a possibility that some of the above mentioned "tools" merely bear the tooth marks of rodents such as porcupines giving them the semblance of artefacts, and some caution is required on this score.

A basic typology has yet to be systematically formulated for the bone, antler and shell artefacts of Lanka's Stone Age, all of which appear to belong to the Mesolithic phase of lithic technology. It is hoped that the analysis of the finds from Beli-lena Kitulgala and Batadomba-lena, currently being assayed, will lead to a preliminary classification which can later be amplified as per the questions being probed. A major obstacle to the formulation of an adequate typology is the meagreness of the sample. As with form-trimmed stone tools, it will be yet a while before this situation can be rectified. However, the extant data seem to suggest a widespread use of small rhomboidal double points from ca. 28,500 BP onwards and, of course, single points of all sizes, as well as of larger picks and spatulae. Specialised categories comprise the serrated-edge spatulae and barrel-beads from Beli-lena, the small serrated disc-beads from Batadomba-lena and the cross-incised elongate bones from Ravanalla and Nilgala caves. Perforated marine shells occurred at Bellan-bandi Palassa and Ravanalla, and perforated *Acavus* shells were frequently found in profusion at all the Wet Zone sites and also at Bellan-bandi Palassa, Alu-galge (Telulla) and Nilgala cave, where they were probably introduced as items of trade. In the case of Bellan-bandi Palassa, there is also the possibility that, as with the nut-stones and the hypothetical processing of *C. zeylanicum* nuts, the *Acavus* molluscs were harvested in the neighbouring Wet Zone.

It is clear that the above mentioned degree of differentiation cannot be interpreted on a regional or ecozonal basis with any degree of validity, considering the extremely small size of the sample. Hence, for the time being, the bone, antler and shell industry of Lanka may be regarded as typologically homogeneous throughout the island, pending the accumulation of an adequately large sample for testing this hypothesis.

Having thus considered the formal stylistic aspect of the bone, antler and shell artefacts from Lanka, an examination of the technological traits follows. The smaller points have been made by longitudinally splitting long-bones or antler and then grinding their ends to a point, as indicated by the presence of longitudinal and transverse striations. Certain bones reveal cut-marks: stone knives appear to have been used for primary excision and the shaping of the resultant slivers. Fracturing by percussion, possibly with hammer and wedge, seems also to have been employed. Granular crystallines, for instance gneiss, might have been used for sawing through bone and antler, such crystallines being more efficient than vitreous crypto-crystallines (v. Crabtree 1972:8). So far, there is no evidence to indicate that the groove and splinter technique characterising European Upper Palaeolithic bone and antler technology, where the burin apparently played such an important role (Movius 1968*a*:314-5), had been employed in Lanka – although Deraniyagala (1963*a*:100,Pl.3(10)) illustrates a cannon bone from which a splinter had been excised, presumably with a graving tool. It will be recalled that burins do not constitute a distinct category among Lanka's types, unlike in the European Upper

Palaeolithic industries.

The so-called grooved mortar from Batadomba-lena (id. 1943:Pl.8(4)) might have been used for abrading bone and antler tools into shape. The large spatula on elephant bone from Bellan-bandi Palassa appears to have had its periosteal surface chiselled or adzed into shape with a hammer and stone chisel prior to being finished with edge-grinding. The drilling in the human frontal bone from Ravanalla seems to have been effected with a solid core (?fire-drill). As for raw materials, an evaluation of selection for bone versus antler with regard to specific implement categories has yet to be effected.

In terms of function, that of the beads is obvious. The bone points could have been used as projectile points (?arrow-heads; ?blow-pipe darts) and/or as awls. (For hafting of rhomboidal double points resembling those from Lanka, cf. wooden fish-spear from Oenpalli, Australia (Mulvaney 1975:105), although the Australian specimens are larger.) Small bone points might also have been used to winkle out the meat of molluscs. It is noteworthy that three small rhomboidal points were found associated with the neck of a human, and another with a pelvis, at Bellan-bandi Palassa (Deraniyagala 1958*a*:231; 1979:51), which could imply their use as poison carriers, despite the absence of a tradition of using poison for such purposes in the ethnographic data from Lanka.

The picks, particulary those on antler tines, were probably used as such, and the more pointed specimens could also have been employed as awls. These picks probably supplemented digging sticks and stone picks functionally. The shanks of jungle fowl with their spurs, canines in mandibles and split canines could all have served as awls, and perhaps even as fish-hooks. It is difficult to assess the functions of the spatulate tools: the processing of hides and of certain vegetable products are possibilities. The serrated-edge spatulae from Beli-lena Kitulgala constitute a mystery as to their function, as do the cross-incised elongate bones from Ravanalla and Nilgala caves. The Sarasins (1908:63) suggest that the incisions on the latter were memory aids, or that they were "messenger sticks" serving as passports between bands as recorded for the Vaddas who used wood instead. With regard to molluscs, the blunted valves of *Unio* were most probably used as scrapers or cutters. The perforated *Acavus* shells are thought by the Sarasins (ibid.:67) to have served as spokeshaves, by analogy with ethnographic data from the Bororo of Brazil and from Queensland, Australia. However, the occurrence of perforated *Acavus* shells in the Dry Zone of Lanka (e.g., Alu-galge, Bellan-bandi Palassa, Nilgala) suggests that they were brought in from the Wet Zone as ornaments or other items of trade, as would also have been the case with imports of perforated marine molluscs. (Cf. the perforated shells thought to have been used as ornaments in the Upper Palaeolithic of Czechoslovakia (Le Gros Clark 1965:147).) The heel-bone of a deer, with a hole drilled in it, found at Nilgala cave has been tentatively identified as a whistle by the Sarasins (1908:65), although I feel that this is somewhat far-fetched. The human frontal bone from Ravanalla probably served some ritualistic purpose, or it could have been used to steady a fire-drill, much as the Vaddas used an animal skull.

Finally, as with stone artefacts, there are the potential tools. The numerous bone and antler splinters and fragments occurring in the cave deposits could readily have been used as point-tools; and some might deliberately have been broken in a particular manner so as to be serviceable. At Alu-galge, for instance, "the astragali and the heads of long-bones of some of the larger mammals such as the sambhur and buffalo . . . appear to have been sliced [or broken] on two sides to form a triangular point, with a rounded grip" (Deraniyagala 1955*a*:299). The form- and edge-ground artefacts stand out clearly as implements to be classified; it takes greater acuity to identify the tools fashioned by cutting and flaking alone. As for unaltered potential tools, the ray's spine from Batadomba-lena, resembling a barbed harpoon, constitutes a prime example.

The bone, antler and shell industry of prehistoric Lanka can pride itself in its antiquity of at least 28,500 $^{14}C$ years BP at Batadomba-lena. However, the sample secured thus far is numerically meagre in the extreme and it is essential to rectify this situation by further excavation in sites with good preservation of organic materials so as to be in a position to formulate a reasonably comprehensive typology to be used as a starting point for evaluating space-time relationships between Lanka's various assemblages.

*5.2.12 India and Further Afield.* The Mesolithic stone tool technology of Lanka would have formed an integral part of the Indian Mesolithic tradition. There is no question about it since, as demonstrated in Chapter 4.5.3, the two countries would have been connected physically as recently as ca. 7,000 years ago as a result of eustatic fluctuations in sea level. Hence it is very relevant to any study of Lanka's prehistoric technology to compare it with that of India, and thence further afield.

The Lower and Middle Palaeolithic industries of India, as they relate to Lanka's prehistory, have been dealt with in Chapter 3.2.4 in connection with the dating of the Ratnapura Fauna. It suffices to mention that Lanka has yet to reveal the existence of a Lower Palaeolithic industry: for instance, not one Acheulean biface has been found so far. As for the Middle Palaeolithic which is widespread in India, it is possible that some of the lithic assemblages in the gravels of the Iranamadu Formation are assignable to this technological as well as chronological phase – and indeed it is even conceivable that some of the high-level gravels contain Lower Palaeolithic assemblages of Cromerian interglacial age. Sites 50a II and 49b II have provided hints concerning the former (Chap.5.2.5.), but much more evidence is required before firm conclusions can be drawn.

Then there is the Upper Palaeolithic techno-complex of India, which has only recently been defined with any precision. This industry is apparently characterised by true blades and blade-nuclei. The occurrence of an indubitable burin component is somewhat debatable and primary guide flakes from the nuclei have yet to be discovered. Stratigraphically, the Upper Palaeolithic of India is said to succeed the Middle Palaeolithic horizons and precede those of the Mesolithic, as in the deposits on the Belan river. Three radiocarbon dates (on shell) are available for this industry: 19,160±330 BP (TF-1245) and 25,070 $\pm\,^{810}_{730}$ BP (PRL-86) for the Belan (G.R.Sharma in Mujumdar and Rao 1970:97; Agrawal and Kusumgar 1975: 220) and ca. 25,000 BP for Patne (Joshi 1975:13). However, considering the much earlier age of the Mesolithic in Lanka at ca. 28,500 BP, and since shell is not reliable as a dating medium, these dates cannot be considered accurate and may for the present be disregarded (v. Addendum IV).

As mentioned in Chapter 3.2.4, peninsular India has a (?somewhat idealised) four-fold aggradation scheme for its Quaternary fluviatile deposits. The Upper Palaeolithic assemblages have been found associated with Gravel III of this scheme, as in the Belan valley and in the Kurnool District (de Terra and Paterson 1939:319-20; Thimma Reddy 1970:233; Rajaguru and Hegde 1972:72). Possibly the finest of these sequences is on the Belan (Mujumdar and Rajaguru 1970:97,100,102; Allchin 1973:46; Sankalia 1974:38,40,180-1,224,238). At this locality there is apparently a complete sequence from the Lower Palaeolithic to a microlith-using ceramic phase. The sequence, commencing at its base, comprises a basal laterite overlain by Gravel I+Acheulean; Silt I, sterile; Gravel II+three phases of a Middle Palaeolithic which become progressively smaller in artefact size and which sees the gradual replacement of quartzite with chert as the dominant raw material+*Bos* *namadicus*; Silt II + Middle Palaeolithic in the lower horizons, but Upper Palaeolithic elements appear in the upper levels; Gravel III + Upper Palaeolithic with fluted blade-nuclei and true blades of ca. 6cm in length; Silt III+Upper Palaeolithic in lower horizons, and there is apparently progressive microlithisation (as with the Middle Palaeolithic of Gravel II) culminating in a non-geometric microlithic industry in the upper horizons; aeolean Silt IV + Mesolithic geometric microliths; Silt V + geometric microliths and pottery which has recently been dated to ca. 8,000 TL (?$^{14}$C) BP (B.K.Thapar 1984:pers. comm.).

The other important site is Patne, on the Tapti river of Maharashtra (Sankalia 1974:225-8). This site has been excavated and the sequence, from base upwards, comprises: bed-rock; 1.5m silty gravel+Middle Palaeolithic; 1.3m silt+Upper Palaeolithic (A) which has more "blade-like" artefacts than the Middle Palaeolithic; 1m gravel capped by silt+Upper Palaeolithic (B) with more long, thick "blades" than in phase (A) and with fluted nuclei and backed blades; 1.5m fine gravel overlain by silt+Upper Palaeolithic (C), the silt being particularly rich in artefacts which include fluted nuclei and backed "pen-knife" blades, and there has apparently been a major shift in the raw materials from jasper, which predominated from the Middle Palaeolithic to the Upper Palaeolithic (B) to chalcedony in the Upper Palaeolithic (C)+beads on ostrich shell with a criss-cross pattern and ostrich shell fragments (n= >100) suggestive of dry interpluvial conditions possibly during one of the Würm pleniglacials (?lower); 2m fine gravel capped by implement-rich silt+Upper Palaeolithic (D) which has a few geometric forms (?microliths) and a refinement over (C) in its backed "pen-knife" blades; 1m fine gravel+Mesolithic (A) characterised by smaller artefacts than in the Upper Palaeolithic (D) and by geometric microliths; 0.5m sterile loam; 1.5m clay+Mesolithic (B) with exceptionally small microliths of "poor quality".

The above sequences from the Belan valley and Patne appear almost too perfect to be true and investigations being conducted by J.D. Clark at Belan should shed light as to the reliability of G.R. Sharma's assertions. Meanwhile, assuming that they are acceptable, there seem to be evidence of Middle and Upper Palaeolithic industries evolving locally from one into the other, each industry evolving progressively smaller artefacts within itself, leading consecutively into non-geometric microlithic (i.e., devoid of triangles and trapezoidals), geometric microlithic and geometric microlithic with pottery phases respectively, the last having been dated to ca. 8,000 BP. The process of diminution of average artefact size appears to have occurred within the Mesolithic itself at Patne.

There are several other sites occurring in alluvia, which provide a composite picture which in detail may turn out to be akin to the sequence as presented above (for distribution of sites v. Sankalia 1974:208):

(*a*) Hunsgi Nulla, Karnataka (ibid.:219,222,246; Paddayya 1970:187): Gravel I+Lower Palaeolithic; Gravel II+Middle Palaeolithic; Gravel III+"Upper Palaeolithic" on chert (although I have failed to note any true blades in the illustrations); surface of Silt III+Mesolithic.

(*b*) Singhbhum District, southern Bihar (Sankalia 1974:46-7,180,223): Gravel I, sterile; Silt I, sterile; Gravel II+Acheulean; Gravel II surface+Middle Palaeolithic; Silt II+Upper Palaeolithic (9% of flakes being blades); ground surface+Mesolithic.

(*c*) Midnapore District, Chota Nagpur Plateau, West Bengal (ibid.:51,178,180,224): Gravel I+Acheulean; Silt I+Middle Palaeolithic; Gravel II+Upper Palaeolithic with blade tools; loam.

(*d*) West Khandesh on Tapti, Maharashtra (ibid.:75): Silt I+Acheulean; gravel+Upper Palaeolithic blades; silt+Mesolithic.

(*e*) Ranka Nulla on Tapti (ibid.:155): gravel+three factory assemblages of the Upper Palaeolithic.

(*f*) Gonda, near Bhadne on Tapti (ibid.:226): Gravel II+Upper Palaeolithic

(*g*) Terrace 4, West Punjab (Movius 1949:342): Evolved Sohan, conceivably Upper Palaeolithic, although no blade tools have been observed.

With regard to aeolean sediments, dunes assigned to the Würm glaciation in central Rajasthan and Gujarat are said to contain Upper Palaeolithic assemblages:

(*a*) Budha Pushkar, central Rajasthan (Allchin, Hegde and Goudie 1972:364; Goudie et al. 1973:249-52; Allchin and Goudie 1974*a*:546): The dune is suspected of having contained an Upper Palaeolithic horizon within it, although no artefacts have as yet been found *in situ*. The distinction between the Mesolithic and so-called Upper Palaeolithic artefacts is that the former are thought to average ca. 1.5cm in length, whereas the latter are said to be ca. 2.5cm. One wonders as to the validity of this rather arbitrary division.

(*b*) Pavagarh Hill, near Baroda, Gujarat (Goudie et al. 1973:251,253): An Upper Palaeolithic industry is said to occur at 1-2m -gl in the dune, whereas Mesolithic artefacts are found on the surface.

(*c*) Visadi Dune, Gujarat (ibid.:253; Allchin, Hegde and Goudie 1970:24-5; Allchin and Goudie 1971:260-1; Allchin 1973:47): A blade and burin industry has apparently been observed on erosional surfaces and the original provenance of these artefacts is thought to have been at ca. 1-2m -gl. However, geometric microliths were also found in the so-called blade and burin industry which in any case comprised a very small sample (n=340).

The above data indicate that so far there is a lack of conclusive evidence as to the occurrence of an indubitably Upper Palaeolithic horizon in the Würm dunes of central Rajasthan and Gujarat. It is probable that B. Allchin's investigations will shed further light on this question.

There is a strong likelihood that cave sites will produce clear sequences spanning the Upper Palaeolithic and Mesolithic technological phases of India. The present evidence is sparse, but it nonetheless deserves to be set out:

(*a*) Billa Surgam cave, Kurnool District, Andhra Pradesh (Foote 1884; 1884*a*; 1885): This cave was probed by Foote, and it has yielded a large assemblage of faunal remains which included a rhinoceros. No stone artefacts are recorded; but several bone points and so-called harpoons as well as pendants on teeth were found. The latter have been assigned Upper Palaeolithic status by the excavator, presumably by analogy with the bone and antler industries of Europe.

(*b*) Muchchatla Chintamanu Gavi cave, near Billa Surgam (Murty 1975:136): Excavations yielded extensive faunal remains, which once again included rhinoceros, and some of the bones are suspected of being tools fashioned by employing the groove and splinter technique. None of these so-called artefacts display signs of grinding and there is some doubt as to their artefactual status. However, the lithic component included some rather crude blades, and it is probable that these do represent an Upper Palaeolithic technological phase, although the artefact sample is very small (n=220).

(*c*) Bhimbetka Shelter IIIF-23, near Bhopal, Madhya Pradesh (Sankalia 1974:224-6; Misra 1976:43): Excavations have revealed ca. 1.5m of archaeological deposit which apparently contains the following sequence, from the base upwards: Acheulean; Middle Palaeolithic; Upper Palaeolithic on quartzite with thick blades, burins and "Aurignacian end-scrapers"; Mesolithic on chalcedony. It is difficult to conceive of such a sequence occurring within a mere 1.5m of deposit, and some caution is required in the interpretation of its context.

(*d*) Parkho-darra cave, Sangao valley, near Peshawar (Allchin, Hegde and Goudie 1970:24-5; Allchin 1973:43-5; Sankalia 1974:196): This cave was excavated by Dani and it is suspected of having yielded an Upper Palaeolithic blade industry in the lower levels, which progressively became "microlithised" so as to result in a Mesolithic industry in the upper horizons.

As stated at the outset, the evidence from cave sites on the Indian sub-continent is meagre and there is considerable nebulosity regarding the antecedents of Mesolithic technology at these sites. Not much reliance can be placed on the available cave "sequences".

There are several miscellaneous open-air sites in India which purport to have Upper Palaeolithic associations, and some of these may be enumerated:

(*a*) Bangaltota, near Sangankallu, Bellary District, Andhra Pradesh: (Sankalia 1969:3,16-36; 1974:167,171,174,245-6): Excavations revealed a gravelly "murram" of iron-stone nodules overlain by a loam containing a Mesolithic industry. The "murram" is said to have been associated with blade-nuclei and backed lunates which were larger than the typical Mesolithic specimens. There is a possibility that the latter assemblage represents an Upper Palaeolithic phase, although it is just as probable that the raw material employed, namely basalt, quartzite and quartz, played a significant role in differentiating artefact size and that the lower assemblage in the "murram" was none other than a technological variant of the Mesolithic.

(*b*) There are several surface scatters of artefacts in Andhra Pradesh which include both Upper Palaeolithic and Mesolithic typological categories. The former are invariably on fine-grained quartzite or lydianite (Murty 1968:89) and artefacts include blades up to 10 cm in length, although the mean is ca. 4cm, backed blades, and macro-lunates of 2-3cm length (a large version of the typical Mesolithic lunates). The Mesolithic elements are said to be almost invariably made on agate, chert, chalcedony or quartz (ibid.), and they comprise the standard range of microlithic lunates, triangles and trapezoidals that characterise the Indian Mesolithic. Representative of this situation are the sites on the Rallakalava river, such as Renigunta Locality 6 of south-eastern Andhra Pradesh, and the Markapur region of central Andhra Pradesh (ibid.; Paddayya 1970:186; Allchin 1973:45; Sankalia 1974:208-13,241). The Series III assemblages from Nandi-Kanama pass of Andhra Pradesh is another such occurrence (Gordon 1958:11,22).

In all the above mentioned cases of open-air sites, there is more than a hint of doubt that the so-called Upper Palaeolithic elements constitute technological variants, without chronological implications, on Mesolithic categories, and that variations in raw material dictated the size differences in the artefacts. The quartzite specimens are usually larger than the ones on crypto-crystalline silicas such as agate, thus giving a semblance of chrono-cultural variation (Upper Palaeolithic vs. Mesolithic) which probably is not represented in these assemblages. On the other hand, sampling from well-defined contexts could indeed produce evidence of the existence of an Upper Palaeolithic phase preceding the Mesolithic at sites as in the case of Andhra Pradesh; but this has yet to be effected convincingly. Of course, it is not infrequently the case that so-called Middle Palaeolithic tool types occur in association with Upper Palaeolithic categories, as at the factory sites of Salvadgi and Meralbhair in the Shorapur doab of northern Karnataka (Paddayya 1970:166-7). This is not unexpected as it is readily conceivable that Middle Palaeolithic elements, which are non-specialised in any case, would have survived into the Upper Palaeolithic technological phase, as on the Belan.

Having established that there are indications of an Upper Palaeolithic technological phase in India, however ill-sampled, which preceded the Mesolithic phase and which appears to have formed a stylistic and technological continuum with the latter, attention may now be focused on the internal evolution of the Mesolithic itself in India. With regard to this subject the following claims have been made:

(*a*) A non-geometric phase, namely with microlithic lunates but without triangles or trapezoidals, precedes the geometric phase with the latter elements; for example on the Belan and at Lekhahia (G.R. Sharma in Misra 1965:77; Ghosh 1967:39,51-2; Sankalia 1974:40,180-1,224,237-8; Misra 1976:41-2), certain caves and shelters of the Kaimur range and on the lake shores of the Ganges valley, Uttar Pradesh (Misra

1976:51), and Pachad cave in the Konkan (Joshi and Bopadikar 1972:53). However, considering the presence of microlithic triangles and trapezoidals in the Mesolithic of Lanka at ca. 2,500 BP and also in the Upper Palaeolithic (D) of Patne, it is likely that the non-geometric phase of Mesolithic stone tool technology is simply a function of sample inadequacy at the above mentioned sites. It should be borne in mind that microlithic triangles and trapezoidals are rare compared to lunates, and unless the artefact sample is large the triangles and trapezoidals could be missed in the assemblage retrieved.

(*b*) There is said to be a progressive decrease in the average size of the artefacts in the Mesolithic, as at Patne. This is a trend which has been postulated for the Middle Palaeolithic (e.g., Belan) as well as for the Upper Palaeolithic (Patne). The final, ultra-microlithic, phase of the Mesolithic is at times associated with the occurrence of pottery (e.g., Morhana Pahar, Mirzapur, M. P. (R. K. Varma in Misra 1965:74; Misra 1976:41)).

(*c*) A final microlithic phase with pottery has been observed at sites such as the Belan where it has been dated to ca. 8,000 BP, Bagor II of ca. 4,750 $^{14}C$ BP (charred bone), and several other localities in Madhya Pradesh (Misra 1976:46). There is a likelihood that, at least on some sites, the occurrence of pottery is accompanied by the appearance of Neolithic subsistence traits, although a pre-Neolithic ceramic tradition may not be discounted.

(*d*) Technogically, the boundary between the final Mesolithic and the Neolithic/Chalcolithic of India is blurred (Sankalia 1974:279), there being a typological continuum in the lithic tradition (Allchin and Allchin 1974:55). The tradition of manufacturing geometric microliths continues into the latter cultural phase, as at Kalibangan's Pre-Harappan, the basal mature Harappan of Allahdino near Karachchi and at Navdatoli (Sankalia 1974:345,462; Hoffman and Shaffer 1976:103,105). The main distiction between the Mesolithic and Neolithic/Chalcolithic lithic technologies appears to lie in the production of finer bladelets in the latter, which appears to be linked with the introduction of the primary guide flake (*lame à crête*; crested guiding ridge) technique, presumably from a source outside the sub-continent (?West Asia). There is also, apparently, a trend towards a decreasing proportion of trimmed artefacts to occur in the Neolithic/Chalcolithic compared with the Mesolithic (Misra 1965:67; Allchin and Allchin 1968:257; Allchin and Allchin 1974:57). In fact the higher the degree of urbanisation manifested at a site, the smaller the trimmed tool component tends to be, as demonstrated progressively at the sites of Adamgarh, Barasimla, Krishna Bridge, Birbhanpur, Langhnaj, Chandoli, Prakash, Maski, Navdatoli and Piklihal (Allchin and Allchin 1974:61). This feature is probably related to the production of increasingly fine bladelets and blades with the advent of the primary guide flake technique in progressively urbanised contexts, which reduced the necessity for the alteration of blanks by trimming. Long distance trade in high quality raw material at the more urbanised sites would have been an added factor leading up to a higher standard of workmanship (and craft specialisation) which resulted in the production of correspondingly superior blades (v. ibid.:65).

The above situation has been summarised thus: "There is no marked difference between the [Mesolithic and the Neolithic/Chalcolithic stone tools in India], and indeed the Neolithic/Chalcolithic settlement with the lowest percentage of unworked blades, Chandoli, yields almost identical proportions of blades, backed blades and composite points and barbs [geometric microliths] to Langhnaj, the Stone Age site with the highest. However, the difference between the extreme samples at either end of the chart is wide . . ." (ibid.:62). Modifying this general view, the Allchins (1974*a*:74) affirm that "the stone blade industry of the southern Neolithic has more in common with the preceding Mesolithic culture of the region than with that of contemporary settled cultures on its margins, which suggests a continuity of populations and technology within the region".

Of the four points (*a*)-(*d*) which I have raised above, concerning the internal evolution of Mesolithic stone technology in India, (*a*) and (*b*) are somewhat doubtful: for instance, no typological change has been observed in the lithics of Bagor I through III spanning over 5,000 years from ca. 7,000 $^{14}$C BP to the early Iron Age (Sankalia 1974:262). On the other hand, (*c*) and (*d*) appear to be valid: geometric microliths occur in association with pottery in certain assemblages, and in general the Neolithic/Chalcolithic phases have fewer trimmed tools, such as geometric microliths, than is the case with typical Mesolithic assemblages.

With regard to the role of raw material in India's Mesolithic, I have already mentioned the so-called shift in the predominance of quartzite to that of chert in the transition from the Lower Palaeolithic to the Middle Palaeolithic in peninsular India (Chap.3.2.4). In the Upper Palaeolithic, the earlier phases are said to have been dominated by quartzite and lydianite whereas the final phases witnessed the emergence of crypto-crystallines such as chalcedony as the chief raw material. This sequence is said to be represented at Belan and at Patne. The dominance of crypto-crystallines continued to be the hallmark of the Mesolithic assemblages wherever these materials were available. In India, nearly all of the Mesolithic assemblages showing refined bladelet technology are on crypto-crystallines such as agate and chalcedony. In Bagor I, the tools on chert display finer secondary work than those on quartz (Sankalia 1974:262-4) and in Gujarat, in general, there has been a distinct preference for crypto-crystallines (Allchin, Hegde and Goudie 1970:27). Another instance is Salvadgi in Bijapur District of Karnataka (Sankalia 1974:166), where the Mesolithic is primarily on agate and chalcedony as opposed to the predominance of cruder chert during the Middle Palaeolithic. Areas where quartz is the only suitable material available for implement manufacture are exceedingly poor in their blade component. This dichotomy is best illustrated in bladelet-dominated western and central India where crypto-crystallines are readily available in the country-rock (trap), while the region to the south of southern Karnataka is quartz country (e.g., Calicut in Malabar, Tinnevelly) and the Mesolithic assemblages contain very few blade elements (Aiyappan 1945:149; Allchin 1966:102,115,119; Allchin and Allchin 1968:76,93-4; Allchin and Allchin 1974:50,57). I have already referred to this aspect of the influence of raw material on blade vs. flake technology in Chapter 5.2.9.

Having postulated that there is a blade vs. flake dichotomy in India's Mesolithic, it is significant that, in general, the former assemblages exhibit a higher proportion of trimmed tools, particularly of finely form-trimmed specimens, than is the case with the flake-dominated quartz assemblages. In this regard, the presence of microlithic scalene triangles at certain sites, such as Bagor I (ca. 7,000 BP; Misra 1970:222; 1976:37) and their conspicuous absence in the quartz assemblages is most probably related to the workability of crypto-crystallines as opposed to quartz. As far as Lanka is concerned, it is hence futile to consider effecting a stylistic comparison between its Mesolithic quartz industry with India's assemblages on crypto-crystalline silicas such as agate or chalcedony, or even chert. The influence of raw material on style is an imponderable which destroys the validity of any such comparison. It is only possible to compare Lanka's assemblages with their quartz counterparts in India.

A glance at the published data on Indian Mesolithic tool categories would highlight the direct comparability that exits between the Mesolithic assemblages of the Iranamadu Formation, as at Sites 49 and 50, and the assemblages from the *teris* of south-eastern India (Aiyappan 1945:154; Allchin 1966:115; Allchin and Allchin 1968:94). There is a very strong likelihood of a chrono-stratigraphic correlation between the 8m *teris* of Tinnevelly District and Site 49, and it is significant that Site 49b,c III and the 8m *teris* have both yielded microlithic lunates, triangles and trapezoidals, as well as Balangoda Points. In the whole of India, the last category has only been found in association with the *teris*, and its correlation with Lanka is indeed worthy of note. As for the remaining data on the quartz assemblages in India, there is little of use for the interpreting of Lankan typological evidence and this situation must perforce rest at that pending further work in India.

A few random comparisons between certain stone tool categories of Lanka and India (and beyond) may be set down as follows. Their intrinsic merit lies not so much in any immediate inferences that would result as in their potential for providing a basis for formulating future research strategy directed towards explaining certain negative or positive correlations. (For provenance in Lanka of certain categories, mostly Mesolithic, v. App.II.)

(*a*) Trimmed artefacts (percentage)

*Lanka*: 0.5-1.5%; more reliably ca. 0.5%

*India*: Birbhanpur Trench 1, 4.70% out of 2,647 artefacts; Langhnaj 1.38% out of 1,300 artefacts (Misra 1967:120).

(*b*) Bladelets

*Lanka*: very rare

*India*: common in regions with ready availability of crypto-crystalline silicas, but rare in quartz-dominated areas. High standard of technology in Neolithic/Chalcolithic.

(*c*) Primary guide flake technique of blade production

*Lanka*: absent

*India*: first appearance with the Neolithic/Chalcolithic, as at Navdatoli (id. 1965:67; Allchin and Allchin 1968:90; 1974:55; Sankalia 1974:464). Claims of its occurrence in Mesolithic horizons, as at Mirzapur (Sankalia 1974:238) need to be verified. Absent, for instance, in the Mesolithic of Langhnaj (id. 1965*a*:68).

*France*: present as early as in the Evolved Perigordian (Bordes 1969:11)

(*d*) Burins

*Lanka*: absent

*India*: absent in Mesolithic (Gordon 1958:24-5); possibly absent in Upper Palaeolithic, but needs verification.

(*e*) Micro-burins

*Lanka*: absent

*India*: absent; bladelets segmented by simple snapping as in several regions of Africa (Subbarao 1958:77; Allchin and Allchin 1974:56).

*Central Europe*: absent in the Mesolithic, e.g., Ostromer Group (J.K.Kozlowski 1973).

(*f*) Levallois

*Lanka*: absent

*India*: absent in the Mesolithic; recorded from the Lower Palaeolithic of Wainganga on the Godavari (Allchin and Allchin 1968:65) and from the Middle Palaeolithic of Rajasthan and on the Sohan (de Terra, Movius and Colbert 1943:376; Sankalia 1964:59).

(*g*) Balangoda Points

*Lanka*: present (rare) in the Mesolithic

*India*: occur only in the 8m *teris* of Tinnevelly (Zeuner and Allchin 1956:19). The foliate points of the Pre-Harappan Chalcolithic of Pakistan and Afghanistan at Kot-Diji I, Periano Ghundai I and Mundigak II (v. Khan 1959:16; Allchin and Allchin 1968:106, 111,118; Sankalia 1974:338-9) do not bear a stylistic resemblance to Balangoda Points.

*Australia*: the small bifacial points of the microlithic phase of ca. 5,000-2,000 BP are very similar to Balangoda Points, particularly the smaller specimens (e.g., from Ingaladdi); the unifacial Pirri Points are closely akin (e.g., from Kenniff Cave, ca. 5,000 BP (Mulvaney 1969:117-22)).

*Southern Africa*: the bifacial foliates of the Umguzan Complex of ca. 30,000-15,000 $^{14}$C BP (Sampson 1974:Fig.86(7)) are somewhat similar to Balangoda Points.

(*h*) Tanged points (microlithic)

*Lanka*: very rare

*India*: absent

(*i*) Shouldered, hollow-based points

*Lanka*: very rare

*India*: absent

(*j*) Scalene triangles (microlithic)

*Lanka*: very rare; absent as well defined type

*India*: common in certain Mesolithic assemblages, as at Langhnaj, Bagor I, Sarai Nahar Rai, Adamgarh and Bhimbetka IIIF-32 (Misra 1970:222; 1976:31,37,50; Sankalia 1974:258,262-4).

(*k*) Rhomboid (microlithic)

*Lanka*: absent

*India*: present (e.g., Bagor I; Sankalia 1974:262-4).

(*l*) Drill-bits, laterally blunted

*Lanka*: absent

*India*: present at Bhimbetka IIF-23 (Misra 1976:44)

(*m*) Polished stone celts

*Lanka*: doubtful; except for a few possibly edge-ground specimens

*India*: very rare, e.g., Langhnaj I (n=2; ca. 3,875 $^{14}$C BP; Sankalia 1965*a*:40); common in the Neolithic centred on the Deccan, down to the Kaveri river.

*Australia* and *Japan*: occur as early as ca. 20,000 BP (Bordaz 1970:93)

(*n*) Mace-heads

*Lanka*: very rare (n=1; Batadomba-lena)

*India*: rare; scattered occurrences noted from Langhnaj I (Misra 1965:64; Sankalia 1974:254), Salsette Island, Bombay, with microliths (Sankalia 1974:247), Hunsgi Nulla surface, Karnataka (ibid.:246), Vedullucheruvu and Nallagundhu surface, Chittor (Mesolithic or Upper Palaeolithic; ibid.:210,241), Neolithic/Chalcolithic of peninsular India, such as Bagor II and Navadatoli (ibid.:470; Thapar 1965:90-1).

*Iran*: drilled stone pendants found in the Upper Palaeolithic (Hole and Flannery 1967:160).

*Central Europe*: perforated stone objects found in the Upper Palaeolithic of Brno II of Würm II and at Predmosti (ca. 30,000 BP; Jelinek 1969:484-5).

(*o*) Bolas-stones

*Lanka*: present in lowland Dry Zone

*India*: present in the Acheulean assemblage of Chirki on the Godavari, Maharashtra (dolerite, quartz; Sankalia 1974:88), in the Mesolithic of Bagor I and Tilwara, Rajasthan (ibid.:270; Misra 1976:34) and in the Chalcolithic of Kot Diji I (Sankalia 1974:339)

*Miscellaneous*: bolas-stones are known from the Upper Acheulean of Olorgesailie (Bordes 1968:65), the Fauresmith and Pietersburg Complexes of southern Africa (ibid.:125; Clark et al. 1968:106), the Kabuh Beds of Java, the Fenho Complex of

China (Bordes 1968:86-7) and in numerous other post-Acheulean contexts in the Old World.

(*p*) Nut-stones

*Lanka*: fairly common in ecozone D1

*India*: absent

*East Africa*: present in a Wilton/Tshitolian context akin to Kenya's Wilton (B) at Gashiha in Rwanda (Nenquin 1967:Pl.9). Pitted anvils have been found in Olduvai Bed IV in an Upper Acheulean context (Leakey 1975:485), although their similarity to Lanka's nut-stones has not been established.

*Australia*: present in Victoria (Mitchell 1949:159)

*Japan*: present in Middle Jomon, ca. 5,000-4,500 BP (Kidder 1968:32,Pl.5b)

*North America*: common in Ohio and New York States; occasionally found in Susquehanna and Delaware basins (Witthoft 1969:32).

(*q*) Pitted hammer-stones

*Lanka*: common in ecozone D1; rare in Dry Zone

*India*: rare; e.g., Bagor (V.N.Misra 1969:pers. comm.), Allahabad and Kaimur plateau (Mitra 1927:225-7), Birbhanpur, West Bengal (Fairservis 1971:90), Nandi-Kanam Pass, Andhra Pradesh (Sankalia 1974:207), Neolithic and Chalcolithic contexts, as in Bellary, the Kolar gold mines, Tekkalakota and Navdatoli (Dalton 1926; Deraniyagala 1945:135; Nagarajarao and Malhotra 1965:68) it being noteworthy that in certain instances, as at Mirzapur, Banda and T. Narsipur (Ghosh 1962:54; Allchin and Allchin 1968:172), stone celts have dimple pits on them, Neolithic Assam (T.C.Sharma 1969:pers. comm.), and Early Historic horizons at Bhir Mound and Sirkap in Taxila (Deraniyagala 1960*e*:E30) and Brahmagiri (Wheeler 1948:254).

*Iraq*: Jarmo, Neolithic ca. 8,700 BP (Braidwood 1967:119); Tepe Gawra X-XI, Uruk period ca. 5,300 BP (Tobler 1950:Pl.42(12); Porada 1965:177).

*Egypt*: Fayum B Complex, Neolithic (Deraniyagala 1948*a*:13; 1951*a*:2)

*East Africa*: Olduvai middle and upper Bed II, Lower Pleistocene, "anvil-stones" possibly akin to the pitted hammer-stones of Lanka (v. Leakey et al. 1971:81,114,218,Pl.17); Wilton and Smithfield Complexes (Deraniyagala 1948*a*:13).

*Southern Africa*: Pietersburg Complex, ?80,000-?50,000 BP (Mason 1967:748); Bambata Complex ?50,000-30,000 BP (A.L.Smith 1972:190-1); Smithfield Complex (Sampson 1974:380-1,Fig.139).

*Congo*: present (Deraniyagala 1965)

*Rumania*: Veterani Terasa and Icoana, Mesolithic, 8,000-7,500 BP (Boroneant 1973:21,31).

*Yugoslavia*: Padina, Mesolithic (Jovanovic 1960:Fig.17)

*Great Britain*: Bog Culture Complex (Evans 1897:238-43)

*Borneo*: Niah Cave, 5cm -gl (Peabody Museum, Harvard)

*Vietnam*: Hoabinhian and Bacsonian Industries (Matthews 1966:93)

*New Guinea*: present (Deraniyagala 1965)

*Australia*: Victoria (Mitchell 1949:159; Cooper 1961; Deraniyagala 1963*a*:97)

*Japan*: Middle Jomon, ca. 5,000-4,500 BP (Fujimori in Kidder 1968:32; Deraniyagala 1958*b*:E13).

*North America*: present, and frequently common (Witthoft 1969:31) e.g., Copena Village Complex, Pickwick Basin, Tennessee (Webb and Jarnette 1942), La Plata, Pueblo II Complex, 600-800 AD (Deraniyagala 1945:139).

*Central America*: Couri Complex, Haiti, 0-700 AD (Rouse 1966*a*:Fig.15(8)); Cayo Redondo Complex, Cuba, 0-1,500 AD (ibid.:Fig.15(9)).

It is clear from the widespread distribution of pitted pebbles that their function would have been linked to a general purpose – which, as postulated in Chapter 5.2.10, is likely to have been to steady the bow-drill used in fire-making. Some of the pitting, as at Olduvai Bed II, might be the result of use as an anvil in implement manufacture; but these would not display striations from rotary action.

(*r*) Grindstones

*Lanka*: common

*India*: Bagor I

(*s*) Large stone artefacts

*Lanka*: not common in the Mesolithic

*India*: apparently very rare in the Mesolithic

(*t*) Pottery

*Lanka*: absent in the Mesolithic

*India*: known to occur in association with geometric microliths, which at Belan has been dated to ca. 8,000 BP. Other instances of this combination of pottery with microliths occur at Langhnaj I and Lekhahia (Sankalia 1974:224,237-8,255).

*Northern Thailand*: present, ca. 8,000 BP, at Spirit Cave (Solheim 1971:37)

*Japan*: present at ca. 12,000 BP (id. 1972*a*:56)

(*u*) Bone, antler and shell artefacts

*Lanka*: common in Mesolithic, from at least as early as ca. 28,500 $^{14}$C BP at Batadomba-lena.

*India*: very little data available, probably due to poor preservation at many of the sites. Langhnaj yielded beads on tusk-shell (***Dentalium***) (Misra 1965:70-1; Sankalia 1965*a*:Pl.14), and the Neolithic of peninsular India had bone points and edge-ground scrapers as well as beads and pendants on shell (Paddayya 1975:333).

*Iran*: bone awls occur in the Upper Palaeolithic assemblages (Hole and Flannery 1967:160).

(*v*) Red ochre

*Lanka*: common

*India*: ?common; e.g., Bagor I, Langhnaj I, Lekhahia with human burials, Bhimbetka IIIF-23 (Sankalia 1965*a*:36; G.R.Sharma in Misra 1965:78; Misra 1976:44).

*Iran*: present, smeared on grindstones of the Upper Palaeolithic (Hole and Flannery 1967:160).

The above comparison is essentially between the material cultures of India and Lanka with regard to the Mesolithic technological phase. As stated at the outset, there is little that can be interpreted constructively from the respective correlations – apart from what has already been said concerning raw material, blade production and the possible influence of blade technology on certain stylistic traits. The extent to which raw material has determined the relative proportions of trimmed artefacts in the various assemblages is well worthy of further enquiry – although it is unlikely that this will ever be assessed with any degree of precision due to the modifications resulting from the nature of the site function ranging from base- to extraction-camp.

One salient feature to emerge from the Indo-Lanka comparison is the direct correlation between the Indian *teris* and the Iranamadu Formation of Lanka, both technologically and chrono-stratigraphically. Employing the *teris* as a starting point, it should be possible to extend this correlation further into the sub-continent.

With regard to India, it is possible to conclude tentatively that there has been a continuous evolution, technologically and stylistically, from the Middle Palaeolithic to the Mesolithic. There is, apparently, some stratigraphic evidence to support this view, as at Belan and Patne. According to this hypothesis, at its most basic level, there are (*a*) progressive diminution of artefact size, "microlithisation"; (*b*) shifts in raw material from quartzite (Lower Palaeolithic) to chert (Middle Palaeolithic), and then fine-grained quartzite and lydianite (Upper Palaeolithic) to fine crypto-crystallines such as agate (Mesolithic); (*c*) the introduction of blade technology with the Upper Palaeolithic, and its progressive "microlithisation" leading up to the production of bladelets as best represented in regions with a ready availability of crypto-crystalline silicas, whereas the quartz-dominant areas "microlithised" flake technology; (*d*) the appearance of geometric forms, such as backed lunates, triangles and trapezoidals, in the late Upper Palaeolithic, which became microlithised to constitute the typical techno-trait of the Mesolithic phase as geometric microliths (there being insufficient evidence for a non-geometric microlithic phase preceding the geometric phase); (*e*) the introduction of pottery into otherwise Mesolithic assemblages at ca. 8,000 BP; (*f*) the introduction of the primary guide flake technique of blade production (?from West Asia) during the Neolithic/Chalcolithic in India, which led to the production of finer blades and bladelets than those which characterised the Mesolithic; and (*g*) the diminishing of the geometric microlithic component during the Neolithic/Chalcolithic phase in favour of an increase in the proportion of unretouched blades and bladelets – apparently in direct proportion to the degree of urbanisation evinced in the latter horizons.

There is obviously, as in many parts of the Old World, an acceleration in technological change from the Lower Palaeolithic to the Neolithic in India: "typologically and technologically the [Mesolithic] culture differs more markedly from its predecessor... than the latter differs from its own predecessor..." (Misra 1967:206). Assuming that the Indian evidence of a continuous progression, technologically and stylistically, from the Lower Palaeolithic to the Mesolithic is acceptable, the question arises as to whether this evolution occurred as a phenomenon that was entirely independent of external influences. The answer appears to be a categorical negative. It is scarcely conceivable, for instance, that India's Acheulean had no phylogenetic links with the Acheulean of West Asia and further afield in Africa and Europe. With the progressive increase in mobility postulated for the Middle Palaeolithic, Upper Palaeolithic and Mesolithic technological phases, it would be unreasonable to adopt the stance that India has been impervious to external influences during these cultural phases, particularly from the west whence most of the historically documented impulses are known to have come.

Having postulated that the evolution of India's Stone Age cannot be considered in isolation from extra-Indian cultural phenomena, particularly those of West Asia, it is necessary to qualify this statement by adding that local technological determinants, such as those of raw material, and local stylistic trends (linear evolutionary as well as stochastic (for concept of random walk v. Isaac 1969; 1972*b*)) would have modified the original trajectories of these impulses. India, after all, is almost a continent and such a postulate requires no further elaboration in its defence.

What then could have been the impulse that led to the appearance of blade technology in India? While it is possible to argue that external influences were not solely responsible for this phenomenon, it is necessary to look at the evidence of early blade technology in West Asia and further afield so as to be able to assess India's position in the overall canvas. As in India, there is evidence of the occurrence of blade technology already in the Middle Palaeolithic of eastern West Asia and in Soviet Central Asia: Bisitun in Iran (Coon 1951), Hazar Merd in Iraq (Garrod 1930) and Teshik Tash and Amir Temir in Uzbekistan (Movius 1953). The Middle Palaeolithic of Kunji cave in south-western Iran, in its lower levels, has a radiocarbon date of >40,000 BP (Hole and Flannery 1967) and in Shanidar cave of Iraq its terminal phase has been dated to 50,600±3,000 and 46,900±1,500 $^{14}$C BP (Solecki 1966). These dates, being at the lower limits of the radiocarbon dating range, probably represent calendrical dates that are very much older, and hence not much reliance can be placed on them. Then come the full-fledged Upper Palaeolithic blade industries of West Asia. In Afghanistan, Kara Kamar, with true blades and bladelets akin to the Baradostian of Iran, has been dated to ca. 32,000 $^{14}$C BP (Dupree

1973:261) with the lower levels being >34,000 $^{14}$C BP (Coon 1957:245-8; Dupree 1972); and Aq Kupruk has the Kuprukian industry divided stratigraphically into phases A and B, both being characterised by fine blades and bladelets (2-10cm) and non-geometric microliths (?with lunates). Phase B of Aq Kupruk, which saw an increase in the proportion of microliths, has been dated to 16,615±215 $^{14}$C BP (Dupree 1972; 1973:258,261) and it possibly represents a variant of Mesolithic microlithic technology in this region. The Mesolithic at Kara Kamar has a radiocarbon date of 10,580±720 BP (Coon 1957).

Moving further to the west, there is the distinctive Baradostian Upper Palaeolithic blade industry of Iran, which has eleven radiocarbon dates from Yafteh cave in Khorramabad (Hole and Flannery 1967:157-8,161). These represent the lower-middle horizon of the Baradostian and they cluster from ca. 38,000 to 29,000 BP although extreme dates of >40,000 and 21,000 BP occur. By extrapolation with reference to the rate of sedimentation at this site, the Baradostian is thought to have been succeeded by the Mesolithic at ca. 25,000 BP (Howell and Clark 1963:160; Hole and Flannery 1967:158). Technologically, progressive microlithisation has been observed within the Baradostian (Hole and Flannery 1967:158) and geometric microliths appeared already in the late Baradostian (as did drilled pendants) (Howell and Clark 1963:160). The Mesolithic in the succeeding cultural horizon witnessed a marked increase in the proportion of geometric microliths. Hence, the evidence from Khorramabad tallies with that from India: the transition from the late Upper Palaeolithic to a fully fledged Mesolithic with a pronounced geometric microlithic component appears to have been gradual, as instanced at Pa Sangar and also at Warwasi (Braidwood, Howe and Reed 1961; Hole and Flannery 1967:153,159). The Iranian Mesolithic (Zarzian) in its late phase has been dated to ca. 12,000 $^{14}$C BP (Hole and Flannery, 1967:151): Ali Tappeh cave, 12,400-10,800 $^{14}$C BP (McBurney 1969); Belt cave, 12,275±825, 10,560±610 $^{14}$C BP (ibid.; Coon 1951:31). Typologically, the Zarzian has a prominent component of microlithic scalene triangles (Hole and Flannery 1967:159), which has also a parallel in the western Indian Mesolithic. The occurrence of tusk-shell in the Zarzian of Iran (ibid. 1967:160), which has also been found in the Mesolithic of Gujarat in India, need not be suggestive of a link between the two regions.

Moving still further west into Iraq, there is Shanidar cave (Solecki 1966; Smith 1971). At this site the Baradostian has been radiocarbon dated to ca. 35,050 BP in its lower levels, ca. 34,300 BP in the middle levels and ca. 28,650 BP in the upper horizon which is succeeded by a Mesolithic level with a single date of ca. 12,000 $^{14}$C BP which might represent one of the later phases. As in Khorramabad, it is noteworthy that microliths occur already in the Baradostian, and they rise into prominence during the Mesolithic (possibly around 25,000 BP).

The evidence from eastern West Asia suffices to indicate that it follows the pattern found on the Belan and at Patne in India, where the Middle Palaeolithic develops gradually into the Upper Palaeolithic and thence into the Mesolithic without any abrupt technological shifts. The radiocarbon dates suggest that the Upper Palaeolithic Baradostian industry of West Asia is at least 40,000 years old, if not considerably older, and in its late horizons geometric microliths appeared in the artefact assemblages until finally succeeded at an estimated 25,000 BP by a full-fledged Mesolithic technological phase characterised by a high proportion of geometric microliths. The latter date, of course, accords exceedingly well with the age of ca. 28,500 BP obtained for the Mesolithic of Lanka, and it can certainly be assumed that it is only a matter of further investigation before India produces comparable dates for its own Mesolithic, particularly in view of the chrono-stratigraphic correlation between the 8m *teris* of south-eastern India and the

Iranamadu Formation of Lanka with its Mesolithic industry. The Indian Upper Palaeolithic is likely to extend back from >25,000 to well over 40,000 BP by analogy with the Baradostian of West Asia. Perhaps the latter in its turn may profitably be linked with the very early (?ca. 65,000-60,000 BP) blade traditions in North Africa, as at Haua Fteah. In this connection it is noteworthy that in southern Africa the Pietersburg Complex is said to have blades and blade-nuclei, although crude, at ca. ?80,000-?50,000 BP, with more refined blades, some of them backed, appearing in the succeeding Bambata Complex at ca. ?50,000-30,000 $^{14}$C BP (Sampson 1974:chronology chart,154-64,186,208,Fig.67(19)).

The African dates for its geometric microliths are in conformity with the age of ca. 28,000 $^{14}$C, TL BP for the early horizons in Lanka and the estimated date of ca. 25,000 BP for the lower Mesolithic of Iran. In much of North Africa the Oranian industry with geometric microliths has been dated to as far back as ca. 15,000 BP, and similar dates have been arrived at for geometric microlithic industries in the Nile valley of Nubia where, as in Egypt, a progressive microlithisation is apparently evident through the Würm glaciation (Butzer 1971:587). It is possible that this date will be extended back further to match the evidence from Zaire, where geometric microliths have been found in Matupi Cave at ca. 170-175cm -gl which may be dated by inference from the age of the sealing layers to ca. 28,000 $^{14}$C BP on charcoal (van Noten 1977:36,39,40), and where at Gombe Point such microliths are thought to be older than ca. 43,000 $^{14}$C BP according to D. Cahen (ibid.). Zambia was fully microlithic by ca. 16,000 BP (Sampson 1974:366) and there are indications (van Noten 1983:pers. comm.) that dates comparable to those from Zaire have recently been arrived at. Corroborative data from southern Africa comprise the following (for chronology v. chart in Sampson 1974: $^{14}$C dates):

(*a*) Strong evidence of progressive microlithisation from the Bambata Complex (?50,000-30,000 BP) to the Umguzan (30,000-15,000 BP). There has apparently been no change in the raw materials employed. The Umguzan has a very strong microlithic component from its earliest levels onwards, e.g., microlithic lunates (ibid.:208,240-3,257).

(*b*) Backed bladelets occur in the the Bambata (?50,000-30,000 BP) and Howiesonspoort (30,000-20,000 BP) Complexes. Long blades have been found in latter, some of them backed (ibid.:238,242,Fig.67(19)).

(*c*) Backed semi-lunates (ca. 5cm) in the Pietersburg Complex (?80,000-?50,000 BP) (ibid.: Fig.54(5)).

(*d*) Microlithic lunates in the Bambata (ibid.:Fig.67(17)), Howiesonspoort (ibid.: Fig.84(1,4,5)) and Umguzan (ibid.:243,257,Fig.86(3,4)) Complexes.

(*e*) Microlithic trapezoidals in the Bambata (ibid.:Fig.67(18)) and Howiesonspoort (ibid.:Fig.84(3)) Complexes.

(*f*) Microlithic triangles appear late, namely in the Matopan Industry commencing ca. 7,600 $^{14}$C BP and elsewhere in the Wilton Complex (ibid.:336, Fig.121(3-5),124(10)). (Triangles are found at ca. 28,500 BP at Batadomba-lena.)

(*g*) Bifacial foliate points, somewhat akin to Balangoda points, in the Umguzan Complex (ca. 3cm; ibid.:Fig.86(7)). Note that larger foliate points occur in the Howiesonspoort (ibid.:Fig.84(10)) and in the Angolan Lupembo-Tshitolian (ibid.:Fig.90(3,4)) Complexes.

It is further noteworthy that pitted hammer-pebbles have been found in the Bambata Complex (ibid.:Fig.67(3)), and that bone points and pendants of pierced shells occur in the Oakhurst Complex (15,000-6,000 BP; ibid:277).

Finally, Europe deserves a rapid scanning since it has in many ways served as the model for the interpretation of Stone Age sequences elsewhere in the Old World. The European Middle Palaeolithic industries seem to have been approximately contemporaneous with those of West Asia and by inference, India. Data from several sites in the Perigord of France (Mellars 1970) seem to indicate a gradual process of evolution with n the Mousterian itself into the Upper Palaeolithic, as in India and West Asia: the French sequence comprises the Ferrassie sub-facies, through the Quina into the Mousterian of the Acheulean Tradition (A) and finally the Mousterian of the Acheulean Tradition (B) which evolves imperceptibly into the Upper Palaeolithic Lower Perigordian at ca. 35,000 BP.

The Lower Perigordian had its backed "pen-knife" blades, the morphological forerunners of the Mesolithic semi-lunates (v. de Sonneville-Bordes 1966:133; Delporte in Valoch 1968:371; Coles and Higgs 1969:223; Bordes and de Sonneville-Bordes 1970:64). Microlithic trapezoidals occur in the Upper Perigordian Vb (Bordes 1969:16) and scalene triangles first appear in the Magdalenian II of Gare de Couze and Laugerie Haute at ca. 16,000 BP (ibid.; Bordes and Fitte 1964; Bordes 1968:163,223; 1969:16). The full range of geometric microliths, namely lunates, triangles and trapezoidals, as well as microlithic semi-lunates, occur in the Magdalenian VI at ca. 12,000 BP (Bordes 1968:164,166,222-3) which at several sites is overlain by the Azilian industry (ca. 11,000 BP ) with its prominent component of microlithic lunates (de Sonneville-Bordes 1966:138; Butzer 1971:536).

The full-fledged Mesolithic industries of western and central Europe commence at ca. 10,000 BP, giving rise to a remarkably homogeneous techno-complex, the Mesolithic, in a very extensive region of Europe: Britain to Poland; Norway and Denmark to the Netherlands, France and Switzerland; and Czechoslovakia, Austria and Hungary in Central Europe (v. Gulder 1953; Vertes 1962; Vencl 1966; Valoch 1968; Tringham 1971; Dobosi 1972; J.K.Kozlowski 1973; Newell 1973; Peterson 1973). At all these localities the Mesolithic appears to post-date 11,000 BP: Netherlands ≤10,000 BP (Newell 1973:408); Denmark ≤10,000 BP (trapezoidals ca. 8,000 BP; Petersen 1973:83,122-7,Fig.5); Austria ≤9,500 BP (Gulder 1953:19,30; Tringham 1971:44); Hungary ≤9,000 BP (Dobosi 1972:41; J.K.Kozlowski 1973:320-1) – however there are indications that the Ostromer Group of eastern Austria, west Hungary, Slovakia, Moravia and Bohemia had geometric microlithic assemblages as early as 10,400 BP. Hence it appears as if microlithic technology manifested itself relatively late in Europe, and within Europe itself the southern sites as in France appear to be older than those in the north.

As for the Caucasus and the Crimea, despite evidence that there has been a gradual transition from the Middle Palaeolithic to the Upper Palaeolithic, as at Siuren I, the Mesolithic does not appear to have established itself until ca. 11,500 BP (Sulimirski 1970:16,31). Further to the north, in the Ukrainian steppe of southern Russia, microlithic trapezoidals first occur at ca. 7,000 BP, while lunates and triangles are lacking, and yet further to the north geometric microliths are quite absent, the Swiderian elements of Polish affinities being dominant (Valoch 1968:36; Dolukhanov 1973:28-54).

It is evident from the above rather cursory glance at the data concerning the advent of geometric microlithic technology in Europe that at less than 16,000 years BP it is late compared to the evidence from Africa, West Asia and Lanka. Hence, at the present juncture, the Mesolithic of Europe cannot be considered as being within the mainstream of relevance to a study of Lanka's Mesolithic. Similarly, the microlithic industries of Southeast Asia and Australia are relatively recent in comparison: Celebes, pre-Toalean dated to >5,800 $^{14}$C BP (Glover 1973:61) and Toalean of ca. 5,800-3,000 $^{14}$C BP (Mulvaney 1975:231); Australia, ≤ 6,700 $^{14}$C BP (Lampert 1971:67-70; Mulvaney 1975:230,289-91). Hence it is West Asia and Africa, and above all India, that deserve careful monitoring with respect to advances in knowledge concerning the origins of their Mesolithic industries.

The present evidence indicates unequivocally that the age of Lanka's early Mesolithic at ca. 28,500 BP is not anomalous when compared with the chronology of microlithic industries from West Asia and Africa. What is now required is the accumulation of dates, dates and more dates – the building blocks of archaeology – so as to fill the chronometric voids that exist between Africa, West Asia and Lanka.

*5.2.13 Conclusions.* The Ratnapura Industry, which occurs in the alluvial Ratnapura Beds, has on faunistic grounds been tentatively assigned Middle and Upper Pleistocene components, while the admixture of more recent elements due to depositional factors complicates the issue. The stone tools are typologically amorphous and at present not much can be inferred as regards the age and stylistic, technological and functional traits of the Ratnapura Industry. Systematic sampling is required before the chrono-stratigraphy and typological characteristics of this "industry" can be assessed with so much as minimal adequacy. The first step in this direction has perforce to be a careful delineation of the stratigraphy of the Ratnapura Beds, perhaps through an analysis of drill cores from the strike valleys since fluviatile terraces are lacking.

The Acheulean techno-tradition has not been observed to have manifested itself in Lanka. Indeed it does not appear to have extended south of the Kaveri river in South India. It may be hypothesised that one of the major determinants of this negative phenomenon is the lack of sedimentary quartzite in this region, since this was by far the most preferred material for biface manufacture in India as in the Madras industry. Handaxes on chert, quartz and even basalt have occasionally been found in India, but it seems as if these were mere excrescences off the main quartzite tradition and that where quartzite was lacking the Acheulean tradition of biface manufacture did not take root.

Another negative influence, as far as the absence of the Acheulean is concerned, appears to be that of the prevailing vegetation. It has been noted in Africa that the Acheulean tradition is usually lacking in the heavily forested regions, as in central and western Africa, and that there had been a marked selection for savanna country (Collins 1969:279; Clark 1970:94). In India, a parallel situation appears to have prevailed; the rain-forests in the Western Ghats of Kerala are devoid of traces of the Acheulean tradition and the same factor would have applied to the Wet Zone of Lanka.

The present evidence indicates that the Dry Zone of Lanka and south-eastern India, south of the Kaveri, would have been much more open country during certain Pleistocene altithermals such as the Eem or even the Holstein (Chap.4.2.3). Hence, it can be hypothesised that in this instance it was the distribution of the sedimentary quartzites that constituted the primary determinant for the differential occurrence of the Acheulean in South India and for its absence in Lanka's Dry Zone, while the presence of equatorial rain-forest in Kerala and Lanka's Wet Zone acted as an added disincentive for its prevalence in these regions. It is also probable that during altithermals such as the Holstein or Eem "Acheulean man" could not cross over from India to Lanka's hypothesised monsoon-forests due to the high sea levels that would have been prevalent; whereas the Series A, B and C forests of lesser altithermals (such as at present) and of glacial episodes, when a land link could have existed, would have been a barrier against such a diffusion.

The Levallois techno-tradition is also lacking in Lanka, despite the occurrence of a few artefacts which resemble Levallois nuclei, probably spuriously. In India it is said to occur in certain Lower Palaeolithic assemblages, as at Wainganga, and in the Middle Palaeolithic of Rajasthan; but it does not appear to have persisted as a technique of flake production into the Mesolithic of the sub-continent.

The tradition of manufacturing blades never appears to have caught on prominently in quartz-dominated Lanka and South India, due to the fracture behaviour of this material. Traces of blade technology, although devoid of the primary guide flake technique, occur in the bladelets and bladelet-nuclei of Lanka's Mesolithic; but, quantitatively, this element is very small indeed, which is in marked contrast to certain regions of India, such as the Deccan, where crypto-crystalline silicas (e.g., chalcedony, agate) are readily available for the manufacture of high quality bladelets in the Mesolithic.

The high-level thalasso-static gravels of the Iranamadu Formation could contain Lower Palaeolithic industries and there are typologically Mousterioid elements with hints of Acheulean traits; but this needs to be established by dating the sediments through eustatic altimetry coupled with thermoluminescence dating of the associated aeoleanites representing ancient coastal dunes, and by endeavouring to secure artefact samples from these sediments. The excavations at Sites 50 and 49 of the I Fm suggest that the basal gravels of these two sites are of Eem age, the former being older than the latter. The basal gravels at Site 50 at ca. 15m +msl are datable to over 74,000-64,000 TL BP on the basis of the dating of the overlying Latosol, which would place their deposition in the Eem (ca. 130,000 BP; Main Monastirian). Typologically, the artefacts from 50a II are non-distinctive, despite their being in a relatively unworn condition. However, two non-geometric microliths were found near the upper boundary of this stratum, and these could represent a post-Eem lag deposit which became incorporated in the gravels, or else a Mousteriod microlithic phase. The artefacts in 50a II are predominently small, suggesting a general trend towards microlithisation.

The stone tools from the basal gravels of Site 49 at ca. 8m +msl are too water-worn as to be diagnostic chronologically or stylistically. It is probable that they represent a late Eem industry (ca. 75,000 BP; Late Monastirian): the dating of the 8m sea level in south-eastern India to over 38,000 $^{14}$C BP, which is at the unreliable limits of the radiocarbon dating technique, could be interpreted as supporting this proposition.

The above views on the techno-chronology and chrono-stratigraphy of the basal gravels of the I Fm supersede those expressed by me after the initial analysis of the cultural finds (v. S.Deraniyagala 1981:143-56). The preliminary study mistakenly attributed a Mesolithic component to the basal gravels of the I Fm. This mistake was due to the assumption that the geometric microliths found associated with the basal gravels of Site 45a were in fact coeval with the deposition of these gravels. Subsequent contextual studies (Chap.3.3.3) have indicated that the artefacts were deposited on the surface of the gravels and that they are by no means coeval with the latter.

The excavations in the fossil coastal dunes (Latosols) at Sites 50 and 49 of the I Fm have yielded microlithic lunates in the former, and microlithic lunates, triangles and trapezoidals as well as Balangoda Points in the latter. The Latosol at Site 49 has been dated to ca. 28,000 TL BP, which is in agreement with the radiocarbon dating of aeoleanites overlying the 8m coastline in south-eastern India. The upper horizon of the Latosol at Site 50, with microlithic lunates, has a similar antiquity, whereas a lower horizon has been dated to the final Eem at ca. 74,000-64,000 BP. The artefactual associations of this latter horizon have yet to be established unequivocally.

A stone tool assemblage almost identical to that of the Latosol at Site 49 of the I Fm has been excavated at Site 43 of the Reddish Brown Earth Formation; however this site has not been dated due to lack of suitable materials for assaying, although artefactual cross-dating could assign an age of >20,000 BP to Site 43. On the other hand, excavations at the cave of Batadomba-lena in the Wet Zone of Lanka have produced yet another assemblage which is almost identical in its components with that of the Latosol at Site 49: namely, geometric microlithic lunates, triangles and trapezoidals as well as Balangoda Points. A series of radiocarbon dates on charcoal is available for this site, and they have turned out to be consistent. The lowermost horizon with the full complement of geometric microliths (lunates, triangles and trapezoidals) has been dated to ca. 28,500 BP, which is in remarkable agreement with the thermoluminescence date for the Latosol at Site 49. The stratum from which the Balangoda Point was excavated has been dated to ca. 22,000 $^{14}$C BP. Evidence confirming the validity of the dates from Batadomba-lena has been forthcoming from the numerous radiocarbon dates from Beli-lena cave at Kitulgala, also in the Wet Zone (three laboratories). Once again there were geometric microliths from the lowermost stratum onwards, although Balangoda Points were not found. The middle strata have been dated to ca. 13,000 cal BP and the lower levels comprising some 2m of sediments, have yielded several dates ranging from over 27,000 $^{14}$C BP to ca. 13,500 BP (Addendum I). The lowermost context, IIIa(1), has as yet to be dated reliably, the charcoal sample secured having been inadequate.

So far, only one clear-cut technological phase is discernible in Lanka's Stone Age: the Mesolithic, although amorphous flake industries appear to precede it. I must stress again that the term Mesolithic is being employed in this work in a purely technological sense in that it designates as such any assemblage with geometric microliths, and there are absolutely no implications as to modes of subsistence or settlement. Within this Mesolithic technological phase in Lanka, there is insufficient evidence at present to suggest that there has been any stylistic, technological or functional evolution. Nor is there clear evidence of regional differentiation, apart from the concentration of pitted hammer-stones in ecozone D1, and the effective absence of nut-stones in the Dry Zone and of bolas-stones in the Wet Zone.

As regards assemblage-types, those excavated in the I Fm at Sites 45, 49 and 50 and in the RBE Fm at Site 43 represent habitations of a predominantly factory facies which was probably linked to the exploitation of the gravels for their raw material for implement manufacture. The proportion of debitage is exceedingly high at these sites, which appears to be directly related to the intractability of quartz as a raw material for knapping. Conversely, the percentage of the trimmed artefact component tends to average around 0.5. Sites such as Bellan-bandi Palassa and Gedige I, on the other hand, display a stronger base-camp component with a higher proportion of trimmed artefacts, although the factory element is still very prominent. Further investigations will undoubtedly reveal a range of assemblage-types, nodal points within an overall continuum. Similarly, tool-specific analyses could be employed to assess the typological evolution among and within the stone tool industries of Lanka.

The Neolithic/Chalcolithic technological tradition of peninsular India, with its characteristic polished stone celts and ceramics, and bladelets produced by the primary guide flake technique, is completely lacking in Lanka (and once again in southernmost India as well). The absence of the celts and fine bladelets can be explained, at least in part, by the rarity of dolerite for the former and the absence of ultra-fine-grained crypto-crystallines such as agate for the latter. Even if a Neolithic subsistence pattern should be discovered in Lanka at some future stage of investigation, the lithic component in the material culture is likely to be indistinguishable from that of the Mesolithic as known in Lanka's Balangoda Culture; perhaps the only tell-tale clue would be the presence of sickle gloss on some of the cutters, although this has not been observed so far on a single artefact in Lanka. Pottery has yet to be discovered in a Stone Age context on the island, despite suspicions that it would indeed occur in association with stone tools at sites that are transitional between prehistory and the historical period in Lanka (?in refuge areas).

Technologically, Lanka's prehistoric phase, represented by the Mesolithic

Balangoda Culture, appears to have leaped directly into the Iron Age of the protohistoric phase with its affiliations to that of peninsular India. This has been demonstrated in the lower levels of the citadel at Anuradhapura (S.Deraniyagala 1972). So far there is no evidence of a transitional or overlap phase between the prehistoric and protohistoric episodes. It has been inferred, on the basis of literary evidence – as corroborated by the several radiocarbon dates from Anuradhapura and the yet to be evaluated radiocarbon dates from Kandarodai in the Jaffna peninsula – that the Iron Age of Lanka commenced at ca. 2,800 BP. This latter proto-historic phase appears to have ended around 2,500 BP with the arrival of cultural impulses originating in the Gangetic plains of northern India which introduced writing to the island and thus heralded the historical period (Addendum II). Within a few centuries of the latter episode, Lanka had exploded into the blossoming of its irrigated agriculture-based urban civilisation, the mature Early Historic period as represented in the chronicles and, materially, in Gedige IV of Anuradhapura (ibid.). Prehistoric technology might have survived for some centuries after the advent of the protohistoric period, most probably among the Vadda aborigines who formed a cultural and physical continuum with Mesolithic Balangoda Man. Archaeological evidence is lacking on this score, and it is likely that the Stone Age of Lanka took a steep dive into oblivion with the dawn of the historical period with possible survivals in the Wet Zone rain-forests.

So much for the internal evidence concerning prehistoric technology in Lanka. As to its external links, it is obvious that India takes prime place due to its geographical location. But unfortunately the extant data on the Upper Palaeolithic and Mesolithic technological phases of India are woefully inadequate in every respect, even at the level of basic chronology. Hence looking further afield, Iran's Mesolithic Zarzian seems to have had its beginnings at ca. 25,000 BP, the North African Oranian at least as early as ca. 15,000 BP and geometric microlithic industries in Zaire at ca. 28,000 probably represent a late phase of a tradition of making geometric microliths at over 40,000 years ago. Zambia appears to have comparable dates for its geometric microliths and the Umguzan Complex of southern Africa was fully microlithic at 30,000-15,000 BP. All of these data seem to indicate that the apparently very early dates assigned to the Mesolithic in Lanka at ca. 28,000 BP are not anomalous at all. They are indeed anomalous compared to the few dates available for India's Mesolithic, which are all Holocene, and the age of the initial appearance of geometric microlithic technology in Europe. The former appears to be a function of inadequate investigation and the latter region, at least in the higher latitudes, seems to have been a backwater as far as microlithic technology was concerned and is of no direct relevance to an evaluation of the chronology of Lanka's Mesolithic. It is hypothesised that the chronological lacuna in India will be filled once an adequate density of radiometric dates has been achieved for the sub-continent. A corollary to this hypothesis is that the pre-Mesolithic Upper Palaeolithic blade industry of India is of middle Würm age in its lower horizons and that its affiliations are with the Baradostian of Iran at > 40,000-25,000 BP. Although geometric microliths have been found in the Andaman Islands, the Bandung Plateau of Java, the caves of southern and central Sumatra, Sulawesi and Australia (Glover 1973; Mulvaney 1975), these assemblages, on present evidence, appear to be of Holocene age and, as with Europe, are peripheral in their relevance to a study of the origins of geometric microlithic technology in Lanka (v. Addendum IV).

Lowering the centre of gravity to a broader a level of enquiry, there is the phenomenon of progressive microlithisation, as exemplified in the sequences from the Middle Palaeolithic to the Mesolithic of Europe, Africa, Iraq, Iran and India, which culminated in the Mesolithic technological phase as represented in Lanka. There is scarcely any doubt that this is not a matter of a trend set by stylistic idiosyncrasy: it is too widespread for that. There must have been functional or technological advantages accruing from this line of development. Functionally, there might have been a strong link between an increasing predominance of composite tools, particularly in the later cultural phases, and microlithisation. Technologically there was the progressive increase in efficiency in the utlilisation of raw materials from the Acheulean biface to the bladelet, via Mousterian flake and Upper Palaeolithic blade, in terms of length of functional edge produced per unit volume of raw material in the potential nucleus (for this thesis v. Howell 1965:113; Bordes and Crabtree 1969:5; Bordaz 1970:6,57,93; Crabtree 1972:85). Geometric microlithic technology, with hafting into composite tools, would have had the further advantages of morphological flexibility in terms of functional edge-length and edge-curvature, edge-angle optimisation and relative robusticity of the segmented bladelet or flake, ready replaceability of functional edge by substitution of segments, resilience of the composite tools against snapping in the middle, and lightness of the final artefact thus facilitating its transport (Semenov 1964:203; Rosenfeld 1965:158; Bordaz 1970:93; Tringham 1971:40-1). It is very probable that stylistic elements in geometric microliths were interwoven systemically into the practical advantages accruing from microlithisation; some of the standardised geometric forms in Mesolithic industries undoubtedly have this trait, although it is difficult to isolate these elements from technology and function.

It can be concluded that the causative factors of microlithisation were sufficiently compelling as to result in a general upwelling of industries characterised by geometric microliths in much of Africa, West Asia and in Lanka at around 30,000 BP, with antecendents possibly extending as far back as 50,000 BP. Further investigations in West Asia and India are likely to fill the geographical lacunae in this scheme. And then it will be opportune to consider the formulation of macro-hypotheses, models if you will, which in their testing would bring resolution to the question of the rise of microlithic, both geometric and non-geometric, industries in large expanses of the Old World. I am not convinced that ideas do not have wings: stimulus diffusion at minimum. But this is speculation, which must perforce be brought down to earth and tested with careful formulation of research design.

## 5.3 SUBSISTENCE AND SETTLEMENT

*5.3.1 Introduction.* The information that is extant concerning prehistoric subsistence and settlement in Lanka is limited. The main contributions in this field have been made by the Sarasins and Deraniyagala (Chap.1.2), supplemented by as yet unpublished (some of it not fully analysed) material from recent surface surveys and excavations, notably in the Iranamadu Formation and the caves of Beli-lena Kitulgala and Batadomba-lena. The data are primarily qualitative, the quantitative aspects being far from adequate.

The site and zonal data will be dealt with on an intra-ecozone basis, followed by an inter-ecozonal assessment, and the conclusions compared with the evidence from India and further afield. The "non-core" traits such as mortuary practices will be subsumed in their treatment within the topics of prehistoric subsistence or settlement, and the physical anthropology of Lanka's prehistoric humans will merely be touched upon within the context of settlement since this aspect of anthropology falls well outside the scope of the present work.

*5.3.2 Ecozone F.* In the Dry Zone, the relatively arid ecozone F has not yielded any evidence of prehistoric settlement so far. This appears to point to the fact that even if prehistoric humans did occupy this ecozone the density of these settlements would have been low, thus leaving mere vestiges which are not readily recognisable without intensive scrutiny. The present human population in much of ecozone F, as on the Jaffna peninsula, is very dense and any prehistoric cultural remains that might have been found would probably have been brought to the notice of the Archaeological Department.

The earliest evidence of human settlement in the Jaffna peninsula comprises the Iron Age occupation at Kandarodai dated to ca. 400 $^{14}$C BC (Chap.5.4.2.). It can be hypothesised that ecozone F was not favoured for settlement by Stone Age man due to (*a*) the lack of raw material deposits for stone tool manufacture, which would have neccessitated the logistically inconvenient measure of transporting (?ready-made) artefacts from ecozone A (Chap.5.2.7); and (*b*) the inaccessibility of fresh water, since groundwater occurs deep in the karstic Jaffna Limestone and it is unlikely that prehistoric man had the technology to exploit it. The food potential of ecozone F is likely to have been akin to that of the coastal facies of ecozone A, with extensive resources of shellfish, fish and marine mammals. The terrestial resources are difficult to estimate in the absence of natural forest in this region today. The latter might well have been a somewhat drier version of vegetation Series A, approaching the category termed monsoon-forests (syn. tropical deciduous forest) which characterise regions with a relatively high total annual rainfall punctuated by a marked dry season (v. Ollier 1974:337). If this was the case the relatively higher proportion of deciduous species would have resulted in a more open type of forest than in Series A, which could in turn have supported a somewhat higher exploitable faunal biomass than ecozone A. However, the scarcity of fresh water is likely to have been a major constraint on the faunal population as well, which would probably have offset the advantages of the open forest.

The islands off the Jaffna peninsula, also falling within ecozone F, would undoubtedly have served as "stepping stones" for people crossing the Palk Strait during phases of high sea level when the land connection between India and Lanka would have been severed, as it is today, with the springboards for such migration being the Tinnevelly coast of south-eastern India and the north-western seaboard of Lanka. These islands have yet to be surveyed; but they are likely to yield significant evidence of prehistoric traffic between India and Lanka. Since seafaring was technologically feasible for the settling of Australia by crossing over 100km of ocean at ca. 50,000 BP (Calaby 1971:80; Golson 1977:2-3), there is no reason to be sceptical about the ability of early man in South India and Lanka to perform likewise.

*5.3.3 Ecozone A.* Apart from ecozone F, traces of prehistoric occupation occur throughout Lanka. In ecozone A the most noteworthy occurrences are those associated with the Iranamadu Formation (I Fm). The dry dolines (*vembus*) of this formation are invariably implementiferous. The sites located on Map 11 constitute a mere fraction of the total potential. There are literally hundreds of such sites awaiting survey. Many of these are hopelessly concealed within the Latosol sands which form a blanket; particularly in the extreme northeast around Mullaitivu where exposures of basal gravels are seldom encountered – which in its turn would have discouraged prehistoric settlement due to the non-accessibility of raw materials for implement manufacture as in ecozone F. It is noteworthy that Wayland (1919) remarks on the scarcity of artefacts in the northeast. Apart from the Latosol blanket, the Series A vegetation of this ecozone effectively obscures any sporadic exposures of cultural material that may exist in the Latosols, with the exception of the vegetation-free *vembus* where artefacts are easily observable.

Stone Age man appears to have camped along the shoreline of ecozone A, on beach dunes, exploiting the marine (particularly lagoonal) and estuarine food resources that characterise the prograding coasts of this ecozone (App.I; Arudpragasam 1974:71). In addition to these aquatic resources, the terrestrial exploitable faunal biomass is likely to have been the highest for the island (as it is today) for much of the Quaternary. A further attraction for prehistoric man would have been the quartz- and chert-rich basal gravels of the I Fm, which appear to have been extensively exploited as evinced at Sites 45, 49 and 50. The occurrence of artefacts within the basal gravels (e.g., the presence of artefacts with considerable water-wear at Site 49a) suggests that man had been camping on the gravel exposures while they were in the process of being deposited. On the other hand, it is almost certain that camps were being established on gravel exposures of the I Fm until the termination of the Stone Age in Lanka, for the purpose of extracting quartz and chert raw materials: many of the sites in the *vembus* could conceivably post-date the deposition of the I Fm by considerable periods of time.

The constraint which could have affected human settlement most in the I Fm terrain is the factor of accessible fresh water. In general, the water-table in the Latosols is known to occur at depths of over 30-50m below the surface (Panabokke 1967:34; de Alwis and Panabokke 1972:33), which would have been well beyond the capacity of Stone Age man to reach. However, while groundwater (for definition v. Sirimanne 1967:69) in the hinterland of the I Fm would thus have been inaccessible, lenses of rain-fed fresh water, floating on a denser saline sub-stratum, are known to occur in the unconsolidated Sandy Regosols bordering the coastline in ecozone A. The latter sediments meet the prerequisites for the maintenance of a freshwater lens in beach sediments, which are (Thomas 1963:27): "(1) permeability, so that fresh water infiltrates rapidly, yet not so great as to allow free mixture of fresh and salt water; (2) small tidal and seasonal fluctuations in the groundwater level, thereby reducing mixing; and (3) sufficient rainfall to add more fresh water to the lens than is lost through evaporation, transpiration, mixing and lateral seepage". Such lenses are being exploited today by fisherfolk in Latosol country, as at Site 50 and at Panama-modera-gala to the north of Site 39. These wells into the Regosols are usually shallow (< 2m in depth) and, given the loose compaction of beach sands, would have been within Stone Age man's technological means to exploit. It is thus possible to hypothesise that the dense human settlements on the I Fm were confined to the shore region and that except under very special circumstances, such as the occurrence of freshwater dolines in Vilpattu, or during the rainy season, the hinterland of Latosol country was not intensively occupied due to the scarcity of water.

No direct information has been forthcoming as regards the subsistence economy of prehistoric man in the I Fm. This is due to the non-preservation of organic materials in the latosolic sands and in the basal gravels. Equatorial conditions and the high permeability of the sands have ensured the leaching out of most organic matter from the Latosols (steady infiltration rate ca. 46cm per hour for Latosol as opposed to ca. 3cm per hour for Reddish Brown Earth according to experiments by W.D. Joshua (de Alwis 1971:23); for carbon and nitrogen content of Latosols v. de Alwis 1971:143). However, it will be recalled (App.III) that the stratum of lagoon shells that overlay the Latosol at Site 50a has been partially leached and that the dissolved calcium carbonate has recrystallised as caliche nodules within the main Latosol profile (for process v. Butzer 1975:31). Should such a Latosol be denuded by subaerial weathering, the caliche nodules will form a lag deposit on the underlying basal gravels. This is precisely what appears to have taken place, as per the evidence from several *vembus* (e.g., at Kudremalai) where nodules of caliche form semi-ovate heaps on the *vembu* floor. It can be hypothesised that these heaps represent recrystallised lag deposits originating in shell middens once incorporated within latosolic sands, thus providing indirect pointers to the subsistence activities of prehistoric man living on the coastal dunes that constitute the I Fm's upper member.

With regard to the settlement components in the I Fm, as with most open-air sites – particularly in dune environments where lag deposits form easily – it is very difficult to estimate the extent of an occupation area at any one point in time. Sites tend to spread laterally, amoeba-like, and superimposed lag deposits can result in palimpsests with blurred boundaries giving the appearance of a continuum (for statigraphy of I Fm v. Chap.3.3.3). This is undoubtedly true of several sites in the *vembus*, as exemplified at Site 40 where rows of conjoined sites occur (v. Deraniyagala 1961:155). Moreover, *in situ* occupation horizons in the Latosols, as at Site 49b,c, have not been excavated adequately extensively for them to reveal the extents of the settlements. However, a rapid examination of the artefact concentrations occurring in the *vembus* suggests a tendency for them to cluster within an area of ca. $50m^2$, with occupation sub-units appearing within the main periphery, representing various activity facies. However, further investigations are likely to reveal settlement configurations that differ considerably from the mode hinted at above, but no data are as yet on hand to support this proposition (cf. Newell 1973 for a range of settlement types for Mesolithic sites in northern Europe). Prominent among the activity units are small clusters of stone nuclei and debitage, where artefacts would have been knapped (e.g., Site 40 which interestingly displays a direct correlation between artefact size and quartz pebble size in the immediate vicinity of the knapping locality). In addition to the quartz and chert pebbles occurring in the basal gravels, veins of rock-crystal (Site 4), granular quartz (Sites 9,49) and outcrops of chert (Sites 27,40) have clearly been exploited for artefact manufacture. The clusters representing knapping activities are frequently not more than $0.75\text{-}3m^2$ in extent, which suggest that only a few individuals were engaged on the task at any given time.

The apparent modal extent of ca. $50m^2$ for the settlements in the I Fm does not suggest a unit of more than one, or at most two, nuclear families as occupants of a site. Moreover, had large groups been exploiting shellfish at these settlements, it is likely that the middens would have been sufficiently deep as to neutralise the leaching action of percolating acids, thus ensuring the preservation of the shells. Both these points, while suggesting a hypothetically small settlement group, are founded on a very limited data base, and they merely serve to provide direction for future work on this subject. In conclusion, it scarcely needs stating that obstacles to adequate sampling, and the lack of fine chronological resolution, make it impossible to estimate prehistoric population density in the I Fm terrain on the basis of direct archaeological data.

The shell midden (Stratum IV) overlying the Latosol (Stratum III) at Site 50a has been assigned to the Mesolithic on the basis of its association with an aceramic lithic assemblage and the radiocarbon date of ca. 3,310 BC (shell). The midden certainly post-dates the deposition of the I Fm dune sands at this location and hence cannot be considered integral to the I Fm. Its extent appears to exceed $300m^2$, judging from a few tell-tale erosional exposures and the depth of the deposit is ca. 0.35m in the excavation. The midden comprises shells of inter-tidal forms, predominantly the bivalve *Meretrix casta* which is still eaten by the coastal inhabitants of Lanka's Dry Zone. In a very small minority (ca. 0.005%) are the bivalves of the genus *Arca*, the apple snail *Pila globosa*, (both forms being considered edible today), *Littorina* sp., and *Potamides cingulatus* which appears to have been dredged up with the other molluscs. The size-range of *Meretrix* in 50a IV does not suggest selective harvesting – there is no obvious selection for large specimens. (Note that my initial hypothesis, based on a preliminary appraisal of the shell remains, that this shelly stratum is of natural origin (S.Deraniyagala 1976:20; 1981:152) is no longer tenable in view of the depositional environment proposed for Stratum III, which, under normal circumstances, rules out the possibility of a lagoon deposit overlying it.

A deposit akin to that of 50a IV, although perhaps not as extensive, has been observed at Site 56 on a Red Latosol, and the assemblage of *Meretrix* shells at Weliwala, 400m to the east of Uda Pottana lagoon (Deraniyagala 1961:153), is also apparently a midden, although its cultural associations are indeterminate. The midden of *Arca* bivalves on the summit of Site 30 in the morthwest has been dated to ca. 997 BC, and once again its cultural associations are not known (v. Addendum I).

Far to the north of the island, a series of oyster middens occur along the south bank of the Mandakal-aru estuary, near Poonakari (ca. 1km to the west of the main Mannar-Poonakari road; first observed by P.E.P. Deraniyagala 1968:pers. comm.). The oysters are of the edible estuarine variety (*Ostrea madrasensis*) and untrimmed nodules of siliceous limestone derived from the country-rock of Jaffna Limestone have been employed to batter open the valves. A few small chips of quartz waste (and fewer still of chert) were found in association. The latter are techno-chronologically indeterminate; but the relatively good state of preservation of the oyster shells suggests a Holocene age. No ceramics were found at these middens. Nodules of caliche, recrystallised (as at Site 50a) from the leached middens, were observed on certain aspects of the shell mounds.

The middens along the Mandakal-aru are situated at 8-20m from the present waterline and ca. 50m to the fore of a bluff comprising Yellow Latosols. Eight sites were noted along a stretch of ca. 100m. The widths of the middens approximate ca. 8m, whereas their length along the estuarine shore varies up to ca. 15m. The depth of deposit ranges from a few centimetres to ca. 1.5m, in proportion to the overall extent of the particular midden, and the spacing between the sites is 10-20m. Comparing these sites with those in the *vembus*, the ca. 8m width is significant in that it could represent the maximum linear dimension of a single occupation, whereas the variable length of the middens can reflect lateral shifting of the occupation through time to form palimpsests. But this is mere speculation, and only careful stratigraphic dissection of these sites can test the above proposition.

To the north of Mandakal-aru, on the Kalmunai promontery, shell middens have apparently been noted by P. Ragupathy (History Department, University of Jaffna; 1982:pers. comm.). This is not at all surprising in view of the rich food resources that the Jaffna lagoon can offer. Further investigations are necessary before it is possible to place these sites in their cultural contexts: note the occurrence of recent shell middens at Arippu in the northwest, and the consumption of lagoonal shells (e.g., *Arca*) at Illankaiturai on the east coast south of Trincomalee was observed by me to be a very conspicuous feature of the local subsistence strategy (1970).

Excavations at the historical port of Mantai (Matota) (BC 500-1,200 AD, according to literary evidence) in 1980 by J. Carswell (Oriental Institute, University of Chicago), M.E. Prickett (Peabody Museum, Harvard) and myself revealed a basal occupation horizon, overlying sterile sands, with geometric microliths (very small lunates) in the upper levels of this stratum. In association with the microliths were the bones of a dugong (*Dugong dugon*). It is probable that this large marine mammal had been captured in the shallow sea off Mantai, or else that a carcass had been scavenged. A rib of the dugong had been employed to extract the meat of a large chank (*Turbinella pyrum*; for habitat in Tinnevelly coast at 3-5m -msl v. Pate

1917:22,234), and it was found stuck through the thick shell of this mollusc. In association with the dugong were found numerous shells of inter-tidal habitat molluscs, for instance *Arca*, which seem to represent food remains of Mesolithic man at this site. Charcoal, found with inter-tidal molluscs directly beneath (probably a lower horizon) this deposit, has been radiocarbon dated at the British Museum to ca. 3,800 BP (by courtesy of R.Knox).

So much for coastal settlement and the exploitation of marine and estuarine resources in ecozone A. It is significant that the terrestrial vertebrate component in the middens is negligible, despite conditions suitable for their preservation in the alkaline shelly matrices. This indicates that the middens are almost exclusively representative of shellfish exploitation, perhaps on a seasonal basis which complemented movements linked to the exploitation of the terrestrial fauna of the hinterland. The extents and depths of the shell middens do not in any instance denote intensive, settled harvesting of molluscan resources; and the camps, as with the earlier settlements in the I Fm, appear to have been occupied by not more than a single, perhaps two, nuclear families at a time.

As regards cave sites in ecozone A, there is no dearth of spacious, well-lit, and otherwise eminently habitable caves in this ecozone. These are located in rocky outcrops of the Vijayan Series and are easily accessible from the lowland plains. Probes have been conducted at these sites since the Sarasins (1908:6-8) initiated systematic prehistoric investigations in Lanka with the excavation of Galge in the south. However, many of these probes failed to yield prehistoric occupation deposits: for instance, investigations in the large caves at Nachchiyar-vellachchi-male in the northeast and at Itikala, Bambaragastalava and Kudumbigala-Yodalena in the southeast (S.Deraniyagala in Solheim and S.Deraniyagala 1972:6-7,17,19,30-1) proved to be prehistorically sterile. Testing by other workers in caves of ecozone A has at best yielded very few prehistoric artefacts: Galge (Sarasin and Sarasin 1908:6-8), Tantrimalai (Still 1911:74-5), Kirinda (Hocart 1928:164), Lenama cave complex (Lewis 1915:128; Deraniyagala 1948:F7), Otchappuva-galge in Vilpattu (Deraniyagala 1958*b*:E4).

This situation, where habitable caves, often with access to fresh water, should not have been occupied intensively, while open-air sites rich in artefacts abound (e.g., Site 39 near Itikala cave), has defied explanation. The caves, their origin being associated with jointing in Ordovician basement crystallines, would certainly have been in existence when man camped on the coastal dunes of the I Fm. One explanation for this anomaly is that the Buddhist monks who occupied most of these caves from Early Historic times had cleared them of prehistoric deposits prior to settling in (v. Sarasin and Sarasin 1908:2). But this would have resulted in tell-tale talus deposits outside the caves, and I have not observed this to be the case at any of the Dry Zone caves (e.g., the very large Dambulla main cave in ecozone B). Besides, it is scarcely conceivable that every cave would have been swept clean of its prehistoric strata, particularly since caves in the Wet Zone have revealed the existence of rich prehistoric deposits beneath Early Historic horizons, as at Beli-lena Kitulgala and Alu-lena Attanagoda, indicating that the monks who appear to have inhabited these caves were really not too concerned about living on top of prehistoric cultural deposits. Another explanation for the sparseness of prehistoric occupation of caves in ecozone A, and indeed in the rest of the lowland Dry Zone, is that Stone Age man had a competitor for such choice habitations: the sloth bear. This temperamental animal can turn out to be very nasty and aggressive on the slightest provocation, and is more than a match for an adult human, The sloth bear, which is restricted in its range of distribution to the lowlands of the Dry Zone (i.e., co-extensive with the prehistorically sparsely occupied caves), could well have discouraged the small family units of Lanka's Stone Age man from risking confrontation by competing for the same habitations. It is probable that the latter gave the bears a wide berth and left them to occupy the caves; whereas in the ecozones outside the habitat of sloth bears, most caves display signs of prehistoric human habitation. With the advent of iron technology, hunter-gatherer Vaddas have resorted to using their all purpose *keteriya* light axe to defend themselves against attacks from bears; but still the rather horrific scars carried by some Vaddas and Sinhalese forest villagers in the Dry Zone constitute ample testimony to the ferocity of sloth bear attacks, and one cannot accuse Stone Age man of cowardice if he preferred to avoid the animals! The apparently now extinct (19th century) sun-bear *Helarctos inornatus* (related to species in Southeast Asia and known as a fossil in India) is said to have been even more ferocious and moved around in packs (Gray 1884:677-709; Nevill 1887*c*; Parker 1887; Deraniyagala 1955*e*; 1965). These bears once again were restricted to the Dry Zone's lowlands. (There is said to have been a specimen collected from Lanka in the Museum of Natural History in Paris (ibid.), and it was distinguished from the sloth bear in possessing six upper incisors as opposed to four.) Another, and perhaps much more valid, reason for the non-occupation of Dry Zone caves would have been that open-air camps afford much more flexibility in adapting to resource fluctuations than caves do, and that hence preference was given to the open-air camps, particularly as continuous rains are rare in the Dry Zone and the shelter of caves is thereby not an imperative.

*5.3.4 Ecozone B.* The coastal tract of ecozone B, prograding and geomorphologically akin to that of ecozone A, would have supported a prehistoric subsistence economy similar to that of the latter ecozone as described above: primarily, exploitation of shellfish and shallow-water vertebrates in lagoonal and estuarine habitats. There is archaeological evidence on this score from Site 57 (Map 15), associated with a Grumusol and the Hungama Formation. As with 50a IV, a shallow deposit of *Meretrix* shells (with a few specimens of *Arca* and *Potamides cingulatus*; dated on shell to ca. 1,240 BC) occurs at this site. The discovery of a sambhur molar in this deposit suggests that it is a midden. Stone artefacts were found above this layer; however, further sampling would probably yield artefacts from within the midden itself.

In the hinterland of ecozone B, there is the Reddish Brown Earth Formation. The basal gravels of this formation appear to have been exploited as a source of raw material for implement manufacture, in much the same manner as the gravels of the I Fm. This has been clearly demonstrated in the analysis of the stone artefacts secured from the excavations at Site 43 (Map 11; Chap.5.2.6). The extent of this site is difficult to estimate: bulldozer cuttings suggest at least one dimension in excess of 20m. Once again, it is impossible to affirm whether this comprises a single occupation or a palimpsest of a series of settlements.

Sites associated with the basal gravels or stone-lines of the RBE Fm appear to occur throughout the range of distribution of this formation as a function of the availability of quartz and chert pebbles suitable for implement manufacture in the gravels. Sites have been observed in the RBE Fm at Gedige in Anuradhapura (S.Deraniyagala 1972:64,159-60), Site 42 in Map 11, and Trincomalee (Todd in Allchin 1980). At Polonnaruva artefacts have been observed to occur on the stone-line of the RBE Fm for a distance of ca. 600m along the cutting of an irrigation canal and it is probable that several sites are represented at this locality (Deraniyagala 1946: unpublished notes; 1953*a*:Pl.11(5)). There are undoubtedly many more sites awaiting discovery in the RBE Fm; but investigations have been hampered by the blanket of colluvial Reddish Brown Earths capping the basal gravels, the dense Series B vegetation of this ecozone and the lack of dry dolines with gravel exposures (unlike in the I Fm). The resultant sampling inadequacy poses a severe obstacle to even remotely estimating the density of prehistoric sites in the RBE Fm. The ready availability of potable water and raw materials for artefact manufacture in the basal gravels and in numerous outcrops of vein-quartz as in the exposure at ca. 2km from Bellan-bandi Palassa (v. S.Deraniyagala 1971*a*:52)), and the relatively high exploitable faunal biomass of this ecozone, would have been attractive for prehistoric human settlement.

None of the sites in the RBE Fm has yielded organic cultural remains which could be used for assessing the nature of prehistoric subsistence practices. Tropical weathering has succeeded in leaching out all traces of bone and shell. However, de Alwis (1972:pers. comm.) has observed ovate heaps of caliche nodules in what has been termed the Kuttigala Series of the Valave basin, and it is possible that they represent prehistoric middens which have suffered recrystallisation. These heaps are said to be 8-10m in diameter, which conforms to the modal dimensions of Lanka's prehistoric sites as observed, for instance, in the uplands of ecozone D2.

Bellan-bandi Palassa (in RBE Fm terrain but not within the formation) is exceptional in that organic materials have survived at an open-air site. The cause for the preservation of bone at this site is in the composition of the bed-rock which immediately underlies the prehistoric (Mesolithic) stratum. Bed-rock comprises crystalline limestone, and it has apparently served to neutralise the acids which would otherwise have leached out organic materials. Corroborating this hypothesis is the occurrence of numerous caliche nodules in the main Mesolithic stratum, and these nodules seem to be the result of lime-rich water moving up the profile by capillary action and depositing the carbonates derived from the bed-rock. The excavations in this habitation yielded a very large quantity of faunal remains from the Mesolithic horizon, and the following forms have been identified (Deraniyagala 1956*a*:119; 1957*a*:12; 1958*a*:257; 1963*a*:88; S.Deraniyagala and Kennedy 1972:37): aquatic bivalve *Unio*, aquatic snail *Paludomus*, land snail *Cyclophorus* (possibly lived in midden), arboreal snails *Acavus roseolabiatus* and *A. prosperus* (rare, probably trade items), hard-shelled terrapin, soft-shelled terrapin, star tortoise, python, land monitor lizard, jungle fowl, water buffalo or gaur, indeterminate bovids, elephant, wild boar, sambhur, spotted deer, barking deer, mouse-deer, sloth bear, black-naped hare, pangolin, porcupine, toque monkey, grey langur, giant squirrel, Ceylon jackal (possibly dog), civet cat and pole cat.

The above list makes it abundantly clear that a wide range of animals were being exploited for food, including carnivores. The elephant is represented by teeth of juveniles, suggesting there was selection for young animals. As for the large bovids, these could be water buffalo, gaur or both. The habitat of the latter could have overlapped with that of the former (v. Deraniyagala 1958:145-6; Simoons and Simoons 1965:16,19-20). Some of the bovid remains secured by Kennedy and myself in 1970 could belong to a smaller animal: this subject requires close scrutiny in the light of the discovery of *Bos* fossils in the Ratnapura Beds, Beli-lena Kitulgala and at Collure. There is a possibility that a form ancestral to *Bos indicus* lived in a wild state in Lanka in prehistoric times (cf. Zeuner 1963, Allchin and Allchin 1974*a*:71 for similar postulate for India). The canid found at Bellan-bandi Palassa could well be a jackal; but a domestic dog cannot be ruled out since the site is only 6,500 (TL) years old. Deraniyagala (1957*a*:12) notes the conspicuous absence of fish and crocodile remains at this site, despite the crocodile infested Valave river being only 3km distant. This probably reflects sample deficiency, although cultural constraints cannot be discounted entirely.

Deraniyagala has not provided any quantitative data on the faunal remains at Bellan-bandi Palassa, apart from affirming that bones of porcupines were very frequently encountered. The small assemblage (n=75) of identifiable faunal remains excavated by Kennedy and the present writer from the Mesolithic Stratum 6 at the site has provided the following percentages (S.Deraniyagala and Kennedy 1972:37): bovid

13%, pig 3%, cervid 1%, bear 1%, monkey 40%, porcupine 15%. There is not much that can be concluded from these figures except that the smaller mammals are more frequently represented than the larger forms. It is important to note that the counts do not refer to the number of individuals, but to the number of bones that have been identified, which greatly reduces the value of these data.

The heavy attrition apparent on the molars of several humans excavated from Bellan-bandi Palassa (Deraniyagala 1963*a*:97) suggests that their diet was high in grit content, possibly due to the grindstones being of poor quality. It is noteworthy that the premolars and molars of the females tend to display more wear than in the case of the males (Kennedy 1965:169), which seems to indicate a higher vegetable component in the diet of the former or else some daily chore that the women had to perform which was heavy on the rear teeth. The absence of evidence of caries or dental abscesses (ibid.:171) and the robusticity of the bones in general (ibid.:157-67) suggest a reasonably well balanced diet. It is likely that one of the functions of the numerous grindstones found at the site was to process food plants. Among them are the nut-stones (S.Deraniyagala 1971*a*:88) which could have been used for cracking *kekuna* nuts brought in from the Wet Zone. Sampling by flotation will undoubtedly produce a more complete picture as to the nature of floral exploitation in ecozone B.

The extent of the site at Bellan-bandi Palassa is indicated by the main bluff created by the seasonal stream that has eroded away a large part of the occupation deposit. This indicates a long axis of ca. 15m.

It is noteworthy that the remains of at least twelve humans have been secured from Bellan-bandi Palassa. These interments were located exclusively in the Mesolithic stratum, which rarely exceeded 30cm in thickness, directly overlying the limestone bed-rock (Deraniyagala 1958:65; 1958*a*:230-2; 1963*a*:104). Many of the skeletons were fragmentary: isolated skulls and calvaria were found in association with more complete skeletons, which is suggestive of fractional (?ritualistic) interment of the former. Some of the latter also lacked their mandibles, and they invariably occurred in a flexed posture with the knees drawn up and the arms either fully or partially flexed (id. 1957*b*:E4; 1958*a*:230-5,Pl.12,257; Kennedy 1965:140). The orientation of the head has been usually towards the east or southeast, with the general position supine or on one side. Deraniyagala (1958*a*:257) claims that the skeletons were often found in pairs and that there were indications at times of a large stone slab having been placed over the head or chest causing its weight to crush the underlying bones (id. 1963*a*:104). There is no mention of any burial pits having been observed, although the tilt of the skull in some instances (id. 1958*a*:Pl.12) seems to suggest that the remains had been interred in a cramped space. The coarse, gravelly texture of the burial stratum appears to have made pit delineation difficult, and the frequent incorporation of faunal remains in the fill (e.g., monkey, bear, porcupine (Kennedy 1965:140-1)) probably served to add to the difficulties of resolving the stratigraphy. Some slight superimposition in the interment of separate individuals has apparently been observed (Deraniyagala 1958*a*:257; 1963*a*:90-1). The remains have been assigned to both sexes and several have been aged at 18-35 years, although a sub-adult (<18 years) and elderly individuals have been noted (Kennedy 1965:146-9).

Functionally, the site at Bellan-bandi Palassa appears to have been a base-camp where people lived perennially. Had the camp been seasonal, it is unlikely that the bone material would have survived the predations of jackals and the gnawing of porcupines. The interment of human remains within the occupation area has been common practice in Lanka's Mesolithic, parallels being found at Beli-lena Kitulgala and Batadomba-lena. It appears as if secondary fractional burial had been performed, namely interment of selected skeletal parts after exposure. However, Deraniyagala has opined that cannibalism could have played a role in the disposition of the human remains, particularly since some of the bones have been found among the food debris with (apparently) longitudinal cracking, and a femur was found with an incision thought to have been made during the stripping of flesh. The discovery of a bone point in direct association with a pelvis, and of three others in contact with the mastoid bone of a skull, have been interpreted by Deraniyagala (1979:51) as evidence of these individuals having been deliberately killed. I have already hinted that some of the fractional burials found in association with more complete skeletons might have had a ritualistic import.

About 2km from the open-air site at Bellan-bandi Palassa, a small but very habitable cave was examined by me. As with caves in the rest of the lowland Dry Zone, this site was found to be remarkably deficient in prehistoric remains, leaving little doubt that there was some factor which weighted for the selection of open-air locations for settlement. Further instances that may be enumerated to highlight the paucity of prehistoric remains in caves situated in ecozone B are as follows:

(*a*) Udupiyan-galge, near Tanjan-tenne in the Kaltota escarpment ca. 10 km to the north of Bellan-bandi Palassa (id. 1940*a*:361; 1940*c*:F7; 1943:96,99,100; for environment v. Domrös 1974:161). The test excavation produced very few artefacts.

(*b*) Bambaragala, near Tanjama in the Kaltota escarpment (Deraniyagala 1943:101-2)

(*c*) Lunu-galge, near Panane in the Kaltota escarpment (id. 1940*a*:364)

(*d*) Alu-galge, Telulla (id. 1955*a*:295-301; 1955*b*:E4; 1957*a*:8-9; 1963*a*:90)

(*e*) Manda-galge, near Siyambalanduva (id. 1953*a*:127)

(*f*) Mullegama-galge, and Balawala-bokka caves in the Eastern Province; sterile of prehistoric remains (Sarasin and Sarasin 1908:75,79,82; Seligmann and Seligmann 1908:163).

(*g*) Sunkankulli cave; sterile (Solheim and S.Deraniyagala 1972:5,20)

(*h*) Nachchiyar-vellachchi-male near Nilaveli; sterile (ibid.:17,19)

(*i*) The Dimbulagala and Dambulla cave complexes have yet to be probed; but the talus deposits outside these very large caves do not suggest the occurrence of rich prehistoric deposits within the caves. The large cave termed Lanka-lena at Ritigala; sterile (1991).

All of these caves are situated within relatively easy access to perennial supplies of water; but the prehistoric deposits are very sparse or lacking in them, compared to cave sites in the Wet Zone. Subsistence data are available primarily from Udupiyan-galge and Alu-galge Telulla. The former (Deraniyagala 1940*a*:366) yielded remains of *Acavus* tree snails (?trade item), *Cyclophorus* land snails (?lived in occupation debris), 3 species of *Paludomus* aquatic snails (*P. solidus, P. nodulosus, P. loricatus*), *Unio* aquatic lamellibranch, freshwater crabs, star tortoise, water monitor lizard, *Ratoufa macroura* giant squirrels, toque monkey, a small (?barking) deer and several other mammals and birds. The bones of the larger mammals were apparently calcined and bore cut-marks. A cist-like arrangement of stones has been considered a hearth (id. 1943:99). Most of the occupation deposit was noted to occur at the front of the cave, as with the other sites along the Kaltota escarpment (id. 1940*a*:364).

The probe at Alu-galge Telulla yielded (id. 1955*a*:299,300) *Cyclophorus* and *Aulopoma* land snails, two species of *Paludomus, Pila globosa* swamp snails, star tortoise, soft-shelled terrapin, land monitor lizard, giant squirrel, porcupine, langur, sambhur and water buffalo. A single human skeleton was found, lying on its side in a flexed position, within the occupation debris. The orientation of the latter was east-west, as at Bellan-bandi Palassa. Apparently this interment was found covered by a pile of stones (id. 1955*b*:E4; 1957*a*:8); no burial pit, however, was discerned. The last molar of this human is well worn, suggesting, once again, a diet with a high grit content (id. 1955*a*:301).

The subsistence and settlement data from ecozone B indicate the exploitation of a faunal spectrum ranging from aquatic molluscs to juvenile elephants and water buffaloes. There is no hint of selection for any particular form or group of forms such as ungulates, although porcupine and monkey remains have been observed to predominate at Bellan-bandi Palassa. The occupation of caves has been very sparse, as in ecozone A. Natural reservoirs of rain-water in the crevices of rocky outcrops appear to have been frequented by Stone Age man, as evinced by the occurrence of quartz chips at such locations (Still 1925:400). It is likely that the hunters awaited their prey at these "water holes" during the dry season (e.g., at Galge). None of the sites, be it cave or in the open air, suggests occupation by more than a couple of nuclear families at a time, with the possible exception of Bellan-bandi Palassa. The numerous human interments at this latter site probably reflect a ritualistic significance attached to this location.

*5.3.5 Ecozone C.* The investigations by the Sarasins in the Vadda country (Bintenne) have supplied nearly all of the data on prehistoric subsistence in ecozone C. As in the rest of the lowland Dry Zone, the cave sites were not found to be rich in prehistoric occupation deposits (e.g., Bendiya-galge (Seligmann and Seligmann 1911:22-4)), and some of the habitable caves had none at all (e.g., Maha-oya, Omuna, Bisokotuwa-galge and at Kallodai (Sarasin and Sarasin 1908:2-3,14)). The Sarasins' excavation at Nilgala cave (ibid:64-88,Pl.9,10) yielded the following fauna: *Acavus phoenix* and *A. prosperus* aboreal snails (?trade items), *Cyclophorus involvulus* land snail, *Paludomus loricata* and *P. neritoides* aquatic snails, *Unio thwaitesi* and *U. corrugatus* aquatic bivalves (common), soft-shelled terrapin, hard-shelled terrapin, land monitor lizard, pangolin, palm squirrel, hare, porcupine, toque monkey, langur, wild boar (rare), sloth bear, water buffalo or gaur, sambhur, spotted deer, barking deer, jackal or domestic dog (1 specimen) and bird remains. The majority of the bones belonged to cervids (ibid:78): mostly spotted deer, sambhur being less frequently represented and barking deer being the least common; both adult and juvenile animals had been killed. It is noteworthy that a canid suspected of having been a domestic dog was found in the Mesolithic layer at Nilgala cave, although, apparently, there is some possibility of its having being a jackal (ibid:76-7). Remains of fish were found to be notably absent (as at Bellan-bandi Palassa), despite the ready availability of fish in the Gal-oya river at no great distance from the site; other conspicuous absentees included snakes, fruit-bats and mouse-deer (ibid:83,88). Many of the bones have revealed traces of slight burning, particularly on the smaller pieces (ibid:59-62). The larger ones do not show signs of burning and the Sarasins have interpreted this phenomenon as being due to the stripping of the flesh from the larger bones prior to preparation or preservation for eventual consumption. Many of the latter display cut-marks. A calcified piece of bark found in the prehistoric layer at Nilgala cave has, apparently, been deliberately excised from a tree and is thought to have been linked to the eating of the cambium (ibid:87). The variety of tree from which the latter had been excised has not been identified.

Most of the occupation deposit at Nilgala cave is said to have been found towards the entrance of the cave (ibid:11-2), as has already been noted in the case of the caves along the Kaltota escarpment. The cultural material found outside Nilgala cave could represent an open-air habitation or a talus deposit. The stratification at this site has revealed sterile bands interleaving the cultural deposits, which is suggestive of seasonal occupation of the site – possibly during the rainy seasons, by analogy with Vadda practice in this region.

Fragmentary remains of four humans were found in the Mesolithic deposit of Nilgala cave (ibid:90-1). The molars were heavily worn, presumably due to a gritty diet. Cranial fragments of a baby were among the remains.

As is evident from the above account, not much data have been forthcoming from ecozone C concerning prehistoric subsistence and settlement. The caves have been but sparsely dwelt in and no major open-air sites have as yet been discovered. Characteristic of certain parts of this ecozone, notably the Vadda country, is the savanna vegetation considered by Holmes (1951) to be the result of periodic firing by man, while de Rosayro (1945; 1946; 1946*a*; 1946*b*) believes the vegetation to represent a climax type (v. Mueller-Dombois and Perera 1971:3). This discrepancy in viewpoints cannot be resolved until pollen studies are undertaken from dated prehistoric contexts: but Mueller-Dombois and Perera (ibid:34-5) do not favour de Rosayro's hypothesis on the grounds that:

> savannas controlled by climate are found in areas of much lower rainfall, about 500mm per year. ... But it is not necessary to assume a former continuous forest cover... elephant, buffalo, sambhur and axis deer... are capable of enlarging grass cover at the expense of wooded areas by their feeding activities in a climate with a dry season in which an upset in the natural balance of factors can easily lead to grass cover. ... Population changes in animals that are equally adapted to browsing and grazing, like the elephant, may cause retreat or advance of woody versus grass cover vegetation.

If Holmes should be correct, it would be interesting to observe if prehistoric man would have been reponsible for inaugurating the process of periodic firing. Technologically, he probably had the means to do so, for instance by ring-barking the trees and burning the dead stands during the February drought. Note that hunter-gatherers in New Zealand are thought to have transformed the landscape by firing, causing the forest to be replaced by grass and scrub (Cumberland 1963:191), as was apparently also the case in Belgium, the Netherlands and northwest Germany at ca. 11,000 BP (Butzer 1971:482-3).

*5.3.6 Ecozone E.* The intermediate dry uplands constitute the last ecozone in the Dry Zone remaining to be considered before moving on to a treatment of the Wet Zone. Large-scale excavations conducted by Deraniyagala in Ravanalla cave have yielded a considerable quantity of cultural remains (Deraniyagala 1946*a*:F4; 1953*a*:127-9; 1955*a*:301). The site can unequivocally be stated to have been as rich in prehistoric deposits as any cave in the Wet Zone. However, none of the finds have been described in any detail. The extensive samples of stone tools and faunal remains stored in the Colombo National Museum await analysis. At first glance the faunal assemblage contains the usual range of forms typically encountered in Lanka's prehistoric cave deposits, with a predominance of small mammals, particularly monkeys. However, pending closer scrutiny, nothing further can be affirmed regarding the composition of this assemblage.

A human molar found at Ravanalla displays considerable wear (id. 1953*a*:138), as is often the case in Lanka's prehistoric humans. As regards subsistence, some fifty seeds of Job's tears (*Coix lachryma jobi*) are said to have occurred in the prehistoric deposit (id.1950:E8). I am not convinced that these specimens came from the prehistoric strata, as they probably would not have survived except in a carbonised state. Further examination is required to clarify this point. *Coix lachryma*, cultivated by hill tribes in India, is thought to be naturalised in the rice fields of Lanka (Trimen and Hodder 1900:192-3; Alston 1931:329). There is said to be a morphological continuum between *C. lachryma* and the indigenous *C. gigantea* (Trimen and Hodder 1900:191-3), and hence the finds from Ravanalla deserve to be further checked for their identification as to which species, or where in the species transitional scale, they belong and interpreted accordingly. The edible nests (comprising dried agglutinative saliva and moss) of the swift *Collocalia brevirostris unicolor* are found in profusion within the recesses of the cave, and it is possible that prehistoric man harvested these for their eggs and swiftlets, although the Chinese tradition of eating the nests themselves has not, until recent times, obtained in Lanka.

Ravanalla cave is strategically located at the head-waters of the Kirindi-oya river, within the main pass leading from the lowlands of southern ecozone A into the hill-country. (It was this route that was used in historical times to transport salt from the salterns of the south into the Kandyan kingdom.) Hence, it is probable that this pass was traversed by prehistoric man in his seasonal movements from the lowland plains into the Uva basin and further into the uplands and highlands, and Ravanalla cave could have had the potential to yield very significant data on interaction between prehistoric groups from several ecozones. A preliminary indication of the validity of this proposition comprises the discovery of two perforated marine shells from a prehistoric context in the cave (Deraniyagala 1949:F4; 1950:E8). Unfortunately, excavations undertaken by me at this site in 1985 revealed that the entire prehistoric deposit has been "cleaned out" in the previous seasons' excavations by Deraniyagala, leaving a thin veneer of mixed back-filling containing tantalising pieces of Early Historic Black and Red Ware in association with artefacts of quartz and chert. Here, perhaps, was a site that held data on the transitional phase from prehistoric to historical periods in Lanka, and perhaps a detailed scrutiny of the site-notes in combination with the collection of finds in the Colombo National Museum would shed light on this elusive episode.

A discovery of some significance from within the prehistoric horizon of Ravanalla is a human frontal bone which seems to have had ritualistic connotations. The cerebral surface has been smeared with red ochre, a biconical hole drilled at one point (although not sufficiently as to perforate the bone), and the rough sutural edges and one zygomatic prominence chamfered off (id. 1953*a*:128; 1958*a*:257). This object is supposed to have been covered by three overlapping slabs of rock. The bone has been assigned to a male of ca. 30 years in age, which agrees with the age at death of many of the Bellan-bandi Palassa specimens (v. above).

The only other cave to have been investigated in ecozone E is Stripura, a very large subterranean cavern at Arukwatte (id. 1955*a*:301; 1956*a*:117-9,120; 1957*a*:8; 1958:29). The unlit interior of this cavern (with a deep lake) was almost totally devoid of signs of prehistoric habitation, apart from the discovery of two hammer-stones. However, the antechamber to the main cavern bore traces of prehistoric occupation: quartz flakes, charcoal, two species of *Paludomus* snails, an *Acavus* species, gaur or water buffalo, spotted deer, sambhur and grey langur (id. 1956*a*:118). Some of these deposits had been cemented with calcium carbonate. (This cavern is now submerged in the Randenigala reservoir of the Mahaweli Project.)

There is yet another Stripura cavern near Uda Pussellawa (id. 1958:29) which I found to be totally lacking in prehistoric remains. Not unnaturally, man did not relish the damp, dark, suffocating interiors of caverns and preferred the light and air of caves and rock-shelters. Nor is there evidence of caverns having had any particular ritualistic significance – unlike in the French Magdalenian. The hills of Bandarawela are situated ca. 10km to the southwest of Ravanalla. These, first noted by the Sarasins (1908:16-7), were intensively explored, within a radius of several kilometres of Bandarawela town, by Hartley (1914*a*:57) and subsequently by the Noones (1940:1). They found traces of prehistoric occupation on practically every hill-top. However, Hartley (1913:122) observed that it was at only four locations – three sites in a cluster and the other ca. 3km away – that there was evidence of intensive occupation in the form of a dense artefact scatter. Hartley's investigations at these four sites yielded the large assemblages of artefacts described by him. These being open-air sites, on hill-tops or hill-saddles, none of the organic remains had survived. Hence, apart from the discovery of grinders (Noone and Noone 1940:7) suggestive of food processing, no information is available as to the subsistence practices of the prehistoric inhabitants of these sites. Among the stone artefacts are hollow scrapers with a significantly small radius to the concavity, which suggests that they might have been used as spokeshaves on arrow-shafts (Allchin 1958: 199).

The Bandarawela sites are preferentially located on hill-saddles (Hartley 1914*a*:58; Noone and Noone 1940:1-2) that constitute interfluves at ca. $\leqslant$ 150m above perennial streams. The latter are usually to be found within a distance of a kilometre from the camp sites. Hartley (1914*a*:57) observes that outcrops of rock are scarce on the hills and that the bulk of the material used for implement manufacture had consisted of pebbles which had been transported up to the camps from the fluviatile gravels in the ravines. The occupation deposits are usually located on the eastern aspect of the hills (ibid.:59; Noone and Noone 1940:1), presumably to receive the morning sun against the chill of the Bandarawela uplands and also to minimise the impact of the westerly summer *Foehn* winds which can be very strong in July and August. At a few spots, artefacts have been found within a circumscribed area (Noone and Noone 1940:1): many of these occurrences have an extent of ca. 50m$^2$, as I have also noted in explorations of eighteen sites in the hilly *dry patana* grasslands around Diyatalawa, Boralanda, Ohiya and Welimada in ecozone E (S.Deraniyagala i.p.*a*). However, Hartley's (1914*a*:58) excavation on Church Hill ridge is said to have measured ca. 30m in length by ca. 5m in width (150m$^2$), down to a depth of ca. 15cm below the surface. This could signify an unusually large site or a palimpsest of several occupations. The activities of worms resulting in the formation of lag horizons in the Bandarawela soils have tended to complicate the interpretation of these shallow deposits.

Hartley (ibid.:60) was unable to infer the logic in the location of the four prime sites he describes:

> I am quite unable to suggest reasons for these four hills being selected as manufactories in preference to any others in the neighbourhood. None of them contain material in any shape. . . . The first two [Church Hill and Bungalow Hill] are large, commanding, and defensible; the last two [Dhoby Hillock and Ambalam Hill] are insignificant in size overlooked by higher elevations. The conditions of the four are so mutually contradictory, that I incline to believe that the occupants changed their ground according to seasonal or other vicissitudes.

It is noteworthy that "a higher proportion of finished [implements] was found on the hill-tops, but a larger number of flakes and chips per square yard was found a little way down the slopes – presumably the waste material thrown away by the workmen on top of the hill" (Allchin 1958:189 commenting on Hartley 1914*a*:59).

The selection of hill-tops and saddles for their open-air settlements by prehistoric man in ecozone E is very evident. This is rather strange, since access to water would have been much easier had he lived in the valleys, unless this advantage was more than offset by the clear visibility (and leech-free conditions, v. Noone 1945:264) afforded by the hill-tops. The latter proposition implies that the *dry patana* grasslands of ecozone E were in existence in prehistoric times. The only method of testing this hypothesis is to conduct palynological studies in the swamps associated with some of the springs (e.g., at Bandarawela), although these do not appear to hold deposits of any depth, and in prehistoric cave sediments datable by radiocarbon. The burnt quartz artefacts that one frequently encounters on the hill sites (Noone and Noone 1940:1) can be assayed for their thermoluminescence; but many of these could have been burnt by the annual grass fires of recent times.

Then, as with the savannas of ecozone C, there is the controversy among plant ecologists as to whether the *dry patana* grasslands of ecozone E represent a climax vegetation (de Rosayro 1945; 1946; 1946*a*; 1946*b*; 1950) or whether it is anthropogenic from periodic firing (Holmes 1951). Mueller-Dombois and Perera (1971:34-5), having considered the pros and cons of this debate, favour the latter hypothesis: "there seems little doubt that a natural woody vegetation has had a certain position in the Uva Basin at an earlier time. Documentary accounts from the early 19th century seem to support this also. . . . De Rosayro's idea that the Uva grass cover may have evolved from a swampy vegetation because of its high amount of sedges in the grass cover does not seem very likely". However, this argument cannot be resolved even if it should be possible to demonstrate that the grasslands were in existence during the late Upper Pleistocene, since man could have had an influence on their genesis ever since he acquired the technology to make fire at least as early as the early Middle Pleistocene: Choukoutien Locality 1, and the Acheulean horizons at Terra Amata in France, Ambrona and Torralba in Spain and Kalambo Falls in Zambia (Howell 1965:79-80; Clark 1970:95; Isaac 1975:884).

Having thus considered the extant data on prehistoric subsistence and settlement in Lanka's Dry Zone, the Wet Zone will now be examined, commencing with the wet lowlands of ecozone D1.

*5.3.7 Ecozone D1.* The alluvial Ratnapura Beds in and around Getahetta, Ratnapura and Kalawana of the Ratnapura District (Chap.3.2; App.I.3.2) have not yielded any faunal or floral evidence which can be linked with prehistoric human subsistence activities; nor have there been any discoveries of cultural deposits which can even vaguely be defined as *in situ* occupations. However, two sites have been observed in the silts of the Kelani basin (to the west of the estimated range of distribution of the Ratnapura Beds), which are in a more convincing stratigraphic context. Tun-modera on the Vak-oya, west of the Labugama reservoir, has yielded pitted hammer-pebbles and nut-stones in alluvial silts over a stretch of some 3km (Deraniyagala 1965:184-5). It is likely that a series of open-air habitation sites are represented in this locality, since the artefacts are too large to have been transported by the elements that deposited the silts. The second site comprises a scatter of quartz and chert artefacts, as well as some pitted pebbles, at ca. 0.5m -gl in a silt at Collure near Biyagama. In this latter instance it is possible that seasonal flooding has translocated some of the artefacts from their original positions in a habitation site. A probe at Collure yielded several specimens of charred *kekuna* nut-shells, indicating that this nut had been exploited from the neighbouring forests.

Moving southwards into the Kalutara District, Yakgiri-lena cave near Matugama was probed by Deraniyagala (1953*a*:127,Pl.11(3)). No data are provided concerning the faunal remains found at this site, except that among them were some marine shells. Lewis (1912:142-3) tested Urumutta cave in Matara District, which yielded cultural remains; but he only observes that the quartz would have been transported from several kilometres away since local deposits of this raw material were not evident.

By far the bulk of the information on prehistoric subsistence in the Wet Zone, and indeed pertaining to the entire island, stem from the investigations in the numerous caves of the Ratnapura District. Once again, the data are qualitative, the quantitative aspects being assayed only recently (P.B.Karunaratne:under preparation for Beli-lena Kitulgala and Batadomba-lena). The following listing of results from the various probes undertaken in this region should suffice to delineate the main features of prehistoric subsistence in the Ratnapura District:

(*a*) Neravana-gallena cave, near Kukulegama (Deraniyagala 1945:140; 1947:22): fragments of elephant molars were found with pitted hammer-stones, nut-stones and flakes of quartz and chert at ca. 0.6m -gl.

(*b*) Kabara-galge cave, above Kakule at Hangamuva (id. 1955*a*:300; 1955*b*:E4,E16): ca. 10cm of prehistoric deposit were found to be rich in vertebrate remains. This was succeeded by ca. 0.6m of molluscan deposit with stone tools; and this in turn was capped by ca. 0.3m of sterile earth which formed a surface fill. The vertebrate remains have not been described in any detail, except that they included bones of fish, reptiles, birds and mammals. However, the molluscs are said to have comprised *Pila*, two species of *Acavus*, three species of *Paludomus* (*P. loricata, P. neritoides, P. sulcata*) and a *Cyclophorus* species. Noteworthy is the discovery of two valves of a large marine mollusc at ca. 60cm -gl and also a cowrie. Pitted hammer-pebbles and nut-stones were found in association. It is not possible to interpret the vertebrate-rich stratum *vis à vis* the molluscan deposit in terms of shifts in subsistence strategy: it is very likely that the latter represents a localised shelly deposit with no broader connotations.

(*c*) Beli-galge, Bambarabotuva (Hartley 1911:197-200; 1914*a*:64; Seligmann and Seligmann 1911:21; Sarasin 1926:87; Deraniyagala 1943:110; Allchin 1958:186): the aceramic prehistoric deposit was observed to occur in the excavation at ca. 1-2.5m -gl (bed-rock was not reached). This yielded a great abundance of *Acavus phoenix* and *Paludomus* (2 spp.) shells. Specimens of *Pila, Aulopoma* and the aquatic snail *Tanalia* were also found. The vertebrate remains have been assigned to small and medium-sized forms, notably the mouse-deer and the purple-faced leaf monkey. Bones of larger forms such as pig and deer were apparently lacking, as were those of fish, reptiles and birds. Parts of a human cranium and bits of long-bones were found within the occupation deposit at ca. 2.75m -gl. A large outcrop of quartz situated near the cave is thought to have been used as a source of raw material, and hill-tops in the area are said to have a moderate scatter of quartz flakes.

(*d*) Batadomba-lena cave, near Kuruwita (Deraniyagala 1940*a*:367-8; 1941:F3; 1943:96, 102-3,107; 1953*a*:129; 1958*b*:E16): this cave was probed very briefly by Deraniyagala who states that he found remains of *kekuna* nuts (and nut-stones), an abundance of *Acavus* and *Paludomus* snails, a few bones of the mahsier fish *Tor longispinis*, maxillary bones of python (?artefactual), lots of bird bones including those of the jungle fowl *Gallus lafayetti*, and mandibles of monkeys and of other small mammals (common). Although bones of cervids and pig were frequently encountered, their jaws and teeth are said to have been scarce – presumably because the heads of these larger animals were left behind at the kill sites after having been divested of their edible parts. The occasional boar tusks that were found were probably used as implements. An assortment of human remains, in a very fragmentary state, was excavated from within the occupation deposits (id. 1953*a*:129). Most of these apparently represent adults.

My own rather extensive excavations in Batadomba-lena have yielded a very large quantity of excellently preserved faunal and floral (carbonised) remains from ca. 28,500 to 22,000 and 16,000 to 11,500 $^{14}$C BP respectively. These are currently being analysed (P.B.Karunaratne: under preparation; M.D.Kajale: under preparation) and it is premature to attempt to evaluate these finds. It suffices to mention that a very large quantity of molluscan remains (*Acavus* and *Paludomus*) were found and that most of the vertebrates represented are of small and medium-sized forms such as giant squirrels, porcupines and monkeys (occasionally the golden civet). Pig and sambhur remains are rare, and elephant is absent. Despite the possibility that the rhinoceros, and perhaps the hippopotamus, were extant in the area at ca. 28,500 BP (the former is thought to have lived in Maharashtra, India, at ca. 3,000 BP (Dhavalikar 1975:15,Pl.45)) their bones do not occur in the deposits at Batadomba-lena. There is some possibility that a large bovine (?gaur) is represented in at least one instance at this site. The discovery of a fragment of a large marine shell in Stratum 5 of ca. 13,500 $^{14}$C BP and of a ray's spine in Stratum 7a of ca. 17,000 $^{14}$C BP indicate communication with the littoral some 50km away. The numerous grindstones found at the site, several with red ochre (and some with white chalk) smears, could have also been used for processing plants for food. The flotation samples of carbonised plant remains do not appear to include any cereals. Remains of lion have been identified from contexts dated to ca. 13,000 BP.

As in Deraniyagala's probe, fragments of human skeletal material were found among the occupation debris and faunal remains. It is difficult to interpret this phenomenon, as to whether the fragments denote cannibalism or accidental incorporation from disturbed inhumations. Of special significance is the discovery of two semi-complete human skeletons in a flexed position and of one fractional interment of a human cranium. All three sets of finds occurred in Stratum 6 dated to ca. 16,000 $^{14}$C BP, and they appear to have been interred in shallow pits or hollows within the occupation strata; and the discovery of human remains which do not belong to the main individuals, but in direct association with them, complicates the interpretation of the mortuary practices involved. There are no indications of well-defined graves having been dug or of their having been filled with any special type of earth, the fill being identical with the charcoal-rich loam which constitutes the rest of Stratum 6. The human remains from Batadomba-lena are currently being studied by a team at Cornell University under the direction of K.A.R. Kennedy and the results should greatly amplify the bald picture presented above (v. Kennedy et al. 1986).

Kegalle District in ecozone D1, to the north of Ratnapura District, has several prehistoric cave sites, of which only three have so far been investigated: the probe at Beli-lena Athula, the full-scale excavation at Beli-lena Kitulgala, and the probe, down to bed-rock, at Alu-lena Attanagoda. Beli-lena Athula on Orukanda Estate, Maniyangama, yielded charred *kekuna* nut-shells, *Acavus* and *Paludomus* snails, and bones of small mammals such as monkey and porcupine (Gunaratne 1971:3,Pl.2c). As appears to be usual in Lanka's prehistoric cave deposits, fragmentary human remains (parts of an occipital and of a parietal) were discovered among the food remains at ca. 30cm -gl (ibid.:3,Pl.3a,b). Several nut-stones were found in this excavation which, however, was not carried through to any conclusion.

With regard to Alu-lena Attanagoda (ca. 9,700 $^{14}$C BP), the prehistoric food remains have yet to be analysed, but it was observed that several specimens of *Acavus* shells were included among them.

The excavations in the very large cave of Beli-lena Kitulgala (ca. 40m wide by 20m long) have yielded an enormous quantity of food remains, both faunal and floral, in an excellent state of preservation as at Batadomba-lena. The faunal remains are currently being analysed by P.B. Karunaratne. The preliminary results indicate the presence of a large component of small mammals, notably giant squirrel, porcupine, flying squirrel, and small rodents. These are supplemented by larger forms such as pig and sambhur. Of considerable significance is the presence of a bovine, which could be gaur or an ancestral form of *Bos indicus*, and this topic deserves detailed scrutiny. In this regard it is necessary to recall the discovery of bovines smaller than the gaur or water buffalo among the Ratnapura Fauna and of a similar fossilised tooth in an alluvium at Collure (Chap.3.2.4). There is a possibility of a phylogenetic link between the small bovines found in Lanka's prehistoric deposits and the local breed of *Bos indicus* which became extinct in the 1930s.

Very large concentrations of molluscan shells formed mini-middens within the stratigraphic sequence at Beli-lena Kitulgala. Most of the shells belonged to *Paludomus* spp., but a significant number were of *Acavus roseolabiatus* and *A. prosperus*. There is no doubt that molluscs constituted an important source of proteins for prehistoric man at Beli-lena. But it must not be overlooked that the sheer volume of shell remains tends to distort the impression of the actual meat weight that it represents: a very large quantity of *Paludomus* or *Acavus* is required to obtain, for instance, 250g of meat, although the discarded shells, in a heap, appear to represent a much larger quantity of meat.

Among the plant remains found in a carbonised state at Beli-lena Kitulgala are seeds of Lanka's wild banana *Musa paradisica* (S. *ati-kehel*), as identified by M.D. Kajale of the Deccan College in Poona, and the nut-shells of *kekuna*. What posed a particular challenge was the identification of a charred granular substance which occurs in concentrated deposits from the lowermost levels upwards (>25,000 – <10,500 $^{14}$C BP). Specimens of these granules were sent to A.H.M. Jayasuriya, Research Officer at the Division of Systematic Botany, Botanic Gardens, Peradeniya. He compared the material with *Eleusine coracana, E. indica, Echinochloa colonum, E. frumentacea, Panicum miliaceum, P. miliare, Pennisetum glaucum* and *Setaria italica*, and concluded that "the size and the shape of the grains are comparable with those of *E. coracana* [finger millet] and *E. frumentacea* [sanwa millet]" (1979:pers. comm.). Subsequently, samples of the granules were intensively examined for their cereal status by Vishnu-Mittre of the Birbal Sahni Institute of Palaeobotany in Lucknow (1981:pers. comm.), G. Kauss of the Römisch-Germanisches Zentralmuseum in Mainz (1981:pers. comm.), T. Watabe of Kyoto University (1981:pers. comm.), P.A. Hyppio of the L.H.

Bailey Hortatorium, Cornell University (1982:pers. comm.), L. Costantini of Museo Nazionale d'Arte Orientale, Rome (1982:pers. comm.), J.R. Harlan and K.W. Hilu of the University of Illinois, Urbana-Champaign (1982:pers. comm.), and F. Hueber of the Smithsonian Institution, Washington D.C. (1982:pers. comm.). None of these investigators was able to identify the plant to which the suspected "grain" belonged: most were convinced that it was not finger millet, and some thought it unlikely that a cereal was represented. Thus the matter rested until M.D. Kajale of the Deccan College, Poona, collaborated with me in trying to narrow down the range of potential candidates by surveying the present-day flora in the vicinity of the site, with particular reference to edible forms. Having compiled a corpus of edible wild plants found in Lanka (App.IV), I was in a position to isolate some of the possibilities and thence to submit them to Kajale's specialist examination. Within a fortnight of such investigations, we were able to conclude that the so-called grain of Beli-lena Kitulgala, which superficially resembles charred finger millet, was none other than the granules from the charred epicarp of the wild breadfruit of Lanka, *Artocarpus nobilis*. Kajale (1983) states thus:

> Ancient carbonised plant assemblage has been recovered by subjecting the habitational soil samples to flotation technique. The laboratory studies have just been initiated and the preliminary observations indicate presence of burnt remains of prickly epicarp of fruit belonging to family Moraceae and has been found to be comparable to wild edible species of *Artocarpus*. The carbonised fruit walls have been found to be in smashed condition, as a result of which fractured granular bodies have been formed. These peculiar structures were thought by earlier workers to be poorly preserved grains of millets, however, author's observations have shown that they do not belong to the category of grains as such. Their grain-like appearance is deceptive and essentially because of the peculiar preservational conditions. Carbonised seeds comparable to those of *Artocarpus* sp. have also been noted. In addition, there are remains of carbonised nut-shells assignable to *Canarium* sp. (*Canarium* sp. cf. *zeylanicum*) belonging to family Burseraceae. This is the first evidence of plant exploitation during the Mesolithic period in Indian sub-continent and detailed work will be reported in due course of time.

Finally, Kajale's identification of the granules as belonging to wild breadfruit has been confirmed by F.R. Fosberg of the Smithsonian Institution (1985:pers. comm):

> Now I have received, from Dr Magdon Jayasuriya, of Peradeniya, excellent specimens of *Artocarpus nobilis*, an endemic species of *Artocarpus* in Ceylon. After studying the fruit of this, I am ready to concur that at least the greater part of the prehistoric material sent belongs to *A. nobilis*. The individual disks of the syncarp of this species have exactly the convex or almost hemispherical shape that bothered me in the fossil material. The individual particles are not seeds, but might probably represent the waste portion, or external skin or rind of the fleshy fruit, which internal fleshy part would be the part eaten.

The wild breadfruit is a very large tree, at times over 30m high and 20m in crown diameter. It occurs in mixed assemblages of rain-forest trees, and never in homogeneous stands. The fruiting is in summer and the seeds and aril are eaten boiled or fried. Prehistoric man at Beli-lena appears to have baked the fruits under hot ashes, as indicated by the remnants of charred epicarp in association with hearths and other ashy deposits, and then eaten the seeds and aril which are exceedingly starchy. The seeds are also rich in fats: an edible oil is extracted by boiling them in water and then skimming off the resultant fat. (Herbivores and pigs tend to attain their sleekest condition during the fruiting season of the wild breadfruit.) Since the edible parts of the wild breadfruit can be preserved after drying, they could have served as a vegetable staple in prehistoric diet, supplemented by wild dioscorea yams (seasonal, and carbohydrate-rich) and *kekuna* nuts (seasonal, fat- and protein-rich). The dioscoreas have not been identified so far. The wild banana, seeds of which have been found in the prehistoric deposit at Beli-lena, yields a very sweet juice on squeezing the fruit, which is customarily served to Buddhist monks. P.B. Karunaratne affirms that numerous nut-shells of *Elaeocarpus subvillosus* (S. *gal-veralu*) occur among the food remains from Beli-lena. The kernels of this nut are apparently eaten by the forest villagers of the remote Sinharaja forest.

Several hearths were excavated at Beli-lena Kitulgala, and the dimensions of some of them can be ascertained from the extent of the zone of reddening of the yellowish clayey loam underlying the charcoal-rich horizon dated to ca. 13,000 cal BP. These hearths range between 1/2 and 1m in diameter, which suggests that they probably would not have serviced a group of people much larger than a nuclear family. This aspect of interpretation of group size needs further investigation on the basis of ethnographic analogy. The hearths appear definitely to have been used for preparing food, as demonstrated in the baking of breadfruit and in the roasting (and possibly the drying) of meat. In addition, it is probable that they served to keep out insects as well as marauding animals.

A discovery of some considerable significance is the partial exposure of a single-course rubble wall in the stratum dated to ca. 13,000 cal BP. The plan-form of this feature appears to have been ovate or apsidal, and it probably served as a footing for a shelter built of plant materials although no post-holes were observed. The fitting and levelling of the stones have been executed with a degree of attention that qualifies this feature to be termed a structure, as opposed to a "circle of stones". A detailed description of this feature will appear in the final site report for Beli-lena (under preparation).

A shell of the marine gastropod *Potamides cingulatus* was found in one of the lowermost horizons of Beli-lena Kitulgala, which can be assigned an age of >18,000 $^{14}$C BP on the basis of the dating of the overlying strata. This mollusc lives in the inter-tidal zone and, being very common (found in millions on lagoon flats) and inconspicuous, there could have been only one mechanism by which it could have reached Beli-lena: namely, as an inclusion within rock-salt brought in from evaporates located along the coast in ecozone A. There is ample evidence that this could indeed have been the case, since the rock-salt being traded today has often been observed to have inclusions of this mollusc. Prehistoric man at Beli-lena appears to have had access to salt from ecozone A at a date antecedent to ca. 18,000 $^{14}$C BP, which suggests a widespread exchange network in view of the considerable distances (>80 km) involved. It is very likely that the salt requirements of prehistoric man in every part of the island during this period and afterwards were met in similar fashion (e.g., Horton Plains from Hambantota via Ravanalla).

With regard to human remains from Beli-lena Kitulgala, miscellaneous fragments of bones were found among the food debris comprising faunal remains in various prehistoric strata from ca. 13,000 BP onwards. This conforms with the nature of their occurrence in Batadomba-lena (v. above). Of particular significance are two fractional interments within the stratum dated to ca. 13,000 cal BP. These are being analysed by K.A.R. Kennedy of Cornell University (v. Kennedy et al. 1986): my initial observation concerning one specimen, prior to plaster-jacketing, suggested a juvenile of ca. 10 years age, with unusually large teeth. In terms of mortuary practice, it is significant that these fractional burials have their counterpart in at least one specimen from Batadomba-lena at ca. 16,000 $^{14}$C BP. As at the latter site, no obvious grave goods were noted; nor were there any signs of the graves having been capped by rock slabs or mounds of earth: the human remains of the two interments were found within lenticles of charcoal and food debris, filling hollows in the underlying strata.

A survey of prehistoric sites was conducted within a radius of ca. 8km from Beli-lena. The resultant report is under preparation by W.H. Wijepala of the

Archaeological Department. It suffices to mention that no open-air sites were encountered, apart from a thin scatter of quartz artefacts from within a circumscribed area on a hill-saddle adjoining Beli-lena. It is not possible to relate these two sites functionally until their temporal association is established. Several shelters and caves were observed to occur within the area surveyed. Although many of these revealed traces of prehistoric occupation (e.g., Tumba-lena), none was rich enough to warrant an immediate probe. In size, habitability and access to water, Beli-lena was far superior to the other sites examined, and this probably accounts for its correspondingly richer prehistoric deposits.

To the north and east of Kegalle District, namely in ecozone D1 of Kandy, Matale and Nuwara-Eliya Districts, several prehistoric sites have been located by early workers (Sarasin and Sarasin 1908:19-20; Pole 1913:2; Hartley Collection). However, no site data are available – not even to the extent of indicating whether a cave or an open-air site is involved. Balangoda Points, dated to ca. 22,000 $^{14}$C BP at Batadomba-lena and ca. 28,000 TL BP at Site 49 of the I Fm, have been found on Primrose Hill in Kandy (S.Deraniyagala 1972*c*), Syston Estate in Ukuvela near Matale, and on Donside and St. Clive Estates near Nawalapitiya (Hartley Collection). The Sarasins (1908:19) observe that stone artefacts are rare, compared to Bandarawela, in this region and Pole (1913:2) states that although chert deposits are common on Clodagh Estate in Matale District artefacts are lacking. A few superficial layers with artefacts were noted in and around Peradeniya Botanic Gardens and on Bahirava-kanda by the Sarasins (1908:19-20). I rather suspect that this paucity of finds around Kandy and Matale is a function of the relative lack of visibility in the *wet patana* grasslands of this region, and that investigations in caves are likely to yield much more evidence of prehistoric settlements.

In conclusion, open-air sites are not frequently encountered in ecozone D1, although I have noted a few on hill-saddles as at Murakele-watte in Miyanapalave near Vaddagala and on Gonnamulla Estate at Olugala; and there is Hartley's discovery of a Balangoda Point on Rye Estate at Balangoda. This apparent sparsity of open-air sites can probably be ascribed to their being hidden from view by colluvial deposits. In fact, the open-air sites mentioned above occur in situations where the colluvial caps have been denuded as an indirect result of agriculture. As for caves, nearly every site in ecozone D1 displays traces of prehistoric occupation, unlike in the Dry Zone. It is very rarely that a sterile cave, such as the small site near Kudawe in the Sinharaja forest (Malpas 1939:F12), is encountered. It appears as if the heavy and persistent rainfall in this ecozone necessitated the use of caves more than in the Dry Zone. It is further possible that the absence of competition from sloth bears for these sites made them more conducive to human occupation. As in the caverns of ecozone E, the subterranean passages in the caverns of Vavul-lena near Kosgala (Deraniyagala 1943:98-9; 1958:29) and Stripura at Batatota in Kuruwita (id. 1940*a*:368) do not display traces of prehistoric human activity: at most, it is only the platforms at the entrances to such sites that yield a few quartz flakes.

The subsistence economy of prehistoric man in ecozone D1 had involved the exploitation of a wide faunal (and perhaps floral) spectrum, with no special emphasis on any particular group or category of animals. This probably reflects the diversity of the then (as today) exploitable biomass, there being no gregarious herds of ungulates or stands of a single type of edible plant. An extensive network of exchange is suggested by the finds of marine molluscs deep in the hinterland, as in the occurrence of *Potamides cingulatus* at Beli-lena Kitulgala.

*5.3.8 Ecozone D2.* The wet uplands of ecozone D2 at ca. 900-1,500m +msl border ecozone D1 particularly to the north of Ratnapura District and to the east of Kegalle

District. Once again, it is the early workers who have recorded most of the prehistoric finds in this region, and yet again the site data are woefully inadequate, there being merely a listing of location spots of surface finds of microliths and other artefacts (App. II): Maskeliya area (Scarborough cave on Scarborough Estate, Gangewatte, Maskeliya and Glenugie Estates (Pole 1913)), Gouravila and Glencairn Estates at Norwood (ibid.; Hartley Collection), Strathdon and Hatton Estates at Hatton (Hartley Collection), sites at Dimbula and Dick-oya (Pole 1913:30), Green's finds on Eton Estate in Pundalu-oya (ibid.:24; Sarasin and Sarasin 1908:20), Bogavanna and Bogavantalava Estates at Bogavantalava (Hartley Collection), G.B. Gardner's finds from a hill-top at Belihul-oya (Parker 1909:64) and Deraniyagala's (1963*d*:E36) quartz and chert artefacts (in these instances from test pits) in eight caves at Butkanda, Ittakanda and Bulutota in the Rakwana massif.

Pole (1913:28) observes that the sites around Maskeliya are "found on every available point of vantage, on the ridges principally". Then again he states (ibid.:27-8):

> I opine that these hunters watched the ridges where the tracks of the game crossed them, for water; stunned the game with ordinary stones, or, wounding them, ran them down and killed them with heavy sticks, perhaps using a chipped stone as a "misericordia"! In fact, the idea strikes one that they worked in concert, in numbers (the heaps of chippings from their implements suggest this), that they camped on the ridges to intercept game crossing them for water, and at a given signal combined for a running hunt; it is very difficult to imagine any other manner, for the only examples of arrow-heads we have found are of so uncouth a character that I strongly doubt if these men counted much on their aid. Mr Thos. Farr, our modern "Nimrod" writes: "What I cannot understand is how any implements or arrow-head made of quartz could be heavy enough and sharp enough to penetrate the skin of a living deer." Doubtless they were of use for birds and small game only. As year by year the same spots were visited at the change of the Monsoons when the game shifted their feeding grounds, so these hunters followed, choosing very much the same spots for their leafy shelters, "something that no animal would take notice of" (Dr Sarasin), manufactured their implements when required, on the same spots, and dropped them on the same grounds. This might account for so many being found on the ridges. They sought their food on these ridges and carried the stone, manufacturing their requirements on the spot.
>
> I am not of opinion that the material was found on the ridges. Nor do I imagine that the stones they made use of as missiles were "worked" in any degree, though they may have *selected* them from the nearest stream. I take it that distance was of no moment; if only game was abundant, there they carried their outfit, probably a "favourite" proved-hard-stone, for flaking; and a few cutting stones, for immediate necessity, to be thrown aside when that particular season was over.

Pole (ibid.:2) further notes that chert flakes in the Maskeliya area occur mostly along the central chain of hills running through Bargany, Alton, Gouravilla and Maskeliya Estates.

As in ecozone D1, a blanket of colluvial loam tends to conceal prehistoric sites in ecozone D2. Where forests were cleared for planting tea, artefacts were exposed on hill summits (ibid.:29; Still 1925:396) where the colluvial cap was absent. The extents of the sites around Maskeliya appear to have been restricted: "The people must have lived in cordons of single families, for they must have occupied the vantage points of every spur of our mountains. Not many flakes are found in the flats" (quoted from Pole in *Ceylon Observer* of 8th August 1907 by Parker 1909:63). My own explorations (1979) in the plateaux of Handapan-ella and Tangamalai, situated in the Rakwana massif, confirm Pole's impression: of the twenty-one sites observed (S.Deraniyagala i.p.*a.*), most had an extent of ca. 50m$^2$ (thus conforming with the mode for many parts of the island).

The *wet patana* grasslands in ecozone D2 are not as extensive as the grasslands in D3 and E, the forest cover being predominant. The origin of these grasslands are once again a matter of debate, whether edaphic or artificial, and it is only pollen analysis that can resolve this problem. However, as mentioned above, sites do occur on hill-tops under virgin forest and it is interesting to note Still's (1925:398) hypothesis that prehistoric man would have used elephant tracks for their travel. He observes that such tracks ususally follow the ridges, and not the valleys, and that since lithic artefact scatters coincide with these tracks in their distribution prehistoric man would probably have utilised elephant paths. In this context it is noteworthy that Butzer (1971:525) cites Tasmanian ethnographic evidence of trails being kept open in dense rain-forest by burning them at regular intervals.

It is very apparent from the above account that the prehistory of ecozone D2 is very much in need of further investigation. As in D1, the colluvial blanket on open-air sites necessitates a focus on cave sites. Besides, the high rainfall in this ecozone would have made prehistoric man select for cave settlements rather than open-air camps, and the absence of bears (v. above for their possible influence on settlement in the Dry Zone) would have been a further "non disincentive".

Data on the subsistence economy of Stone Age man in ecozone D2 are lacking. Presumably it would have approximated closely to that of D1, although perhaps the exploitable biomass (on present-day evidence) is likely to have been slightly lower.

*5.3.9 Ecozone D3.* The central highlands constituting ecozone D3 have long been known to have been inhabited by prehistoric man (Sarasin and Sarasin 1908:20-1; Hartley 1913:122). However, it was the explorations of the Horton Plains in 1970 that placed the facts on a relatively firm footing (S.Deraniyagala 1972*a*). The density of vegetation (close montane forest, with dense bamboo and *Strobilanthes* in open glades, and grassland with their root-mat) tended to channel the explorations along recently cleared areas – for cultivations, roads and constructions. More intensive surveys were conducted on knolls and hill-saddles where, by analogy with the hills of Bandarawela, the occurrence of sites could (potentially) be predicted (*sic*).

The result of five days of survey on the Horton Plains was the location of twenty-five prehistoric sites (Map 9), among which were Site 6 with geometric microliths and Site 13 which was probed with a $1m^2$ test pit down to bed-rock. As with the *dry patana* grasslands of ecozone E, the habitation sites on the Horton Plains were preferentially situated on hill-saddles (Sites 6,21,25,26). A few occur on hill-tops (e.g., Sites 18,28) and on promonteries jutting out of the main plateau (Site 17). There are some indications that the ecotone between forest and *wet patana* grassland was preferred (e.g., Site 13), which could signify that the grasslands were in existence when prehistoric man occupied such sites. The sites are concentrated along the flanks of the head-waters of the Kiriketi-oya river; there is a blank in the west towards Kirigalpoththa and in the east-north-east towards Ohiya, despite surveys which however were not pursued into the northern and north-western regions. Since water is abundant throughout the Horton Plains, and since there has been a marked absence of indigenous fish in the river, the attraction of the riverine environment for prehistoric settlement cannot be explained, apart from the highly speculative hypothesis that mobility was significantly dependent on water transport.

The extents of the sites could not be estimated due to the vegetational cover, but the indications in recent cuttings and erosional exposures were that they, once again, had a modal extent of ca. $50m^2$. Sites 21 and 26, and perhaps 9 and 13, almost certainly conformed to this approximate dimension. These sites appear to represent occupation by not more than a nuclear family (one must acknowledge Pole's intuitive concurrence on this estimate (v. above) with regard to ecozone D2).

Site 20 appears to have been a prehistoric quarry where an outcrop of intrusive quartz was exploited. None of the artefacts found at this site was noted to possess use marks or trimming, suggesting that these tasks were performed elsewhere. The primary flaking from the rock matrix was probably effected with the large sub-angular pebbles which occur in the neighbouring stream. Localised rose quartz was observed within the main mass – this point could conceivably be employed to establish the source of rose quartz if found elsewhere in a cultural context on the Horton Plains. It is very likely that fluviatile pebbles of quartz provided another source of raw material for implement manufacture. Chert artefacts are very rare, contrary to the assemblages from Bandarawela, presumably due to the non-availability of this material on the Horton Plains.

The Stone Age sites on the Horton Plains probably represent seasonal camps (also v. Sarasin and Sarasin 1908:20), when man moved up into the hills during the February drought to fire the grasslands and thus drive game. In this regard the location of Site 26 on the edge of the precipitous escarpment (ca. 1,500m) at Little World's End, with its panoramic view onto the second and lowermost peneplains below, could be of significance. It is possible that this location was used to monitor movements of groups during their seasonal migrations (?smoke signals). Site 17 could have served a similar function. Site 26 could also have been a killing site with game being driven over the precipice. The absence of habitable caves on the Horton Plains is noteworthy: (*a*) this makes it unlikely that a habitation deposit of any depth will ever become available for investigation; and (*b*) Stone Age man probably did not relish occupying open-air sites in this cold, damp region with its low exploitable biomass compared to the rest of the island, except perhaps on a seasonal basis during the dry months of January and February. It is possible that grass thatching (I am not aware of a bark substitute in ecozone D3) was used for protection against the weather.

The Horton Plains constitute only one of the plateaux in the highlands. There are the Moon, Wilson, Kandapola and Sita-eliya Plains in adjoining regions, which, with the exception of the Wilson Plains, were briefly surveyed by me in 1980. These explorations were unproductive, only a few thin scatters of artefacts having been noted, and investigations on Pidurutalagala mountain itself yielded no sites at all, although the Hartley Collection has a geometric microlith (Type 4b) from Pedro Estate in the vicinity. The Ambewela area, surveyed at the same time, was also unproductive, and in this regard Mueller-Dombois and Perera's (1971:7) observation that terrestrial leeches abound in the *wet patanas* (of Sita-eliya, Ambewela etc.) at below ca. 2,100m elevation could be significant. Had the grasslands been in existence during prehistoric times, the presence of leeches could have been a strong disincentive for human settlement at below 2,100m +msl. The relatively high frequency of occurrence of ground-frosts at above 2,100m is thought to be the primary determinant for the absence of leeches on the Horton Plains (ibid.).

With regard to the grasslands comprising *Arundinella villosa* in ecozone D3, there is general agreement among workers that it constitutes a secondary vegetation caused by fire (de Rosayro 1950:119). Mueller-Dombois and Perera (1971:36) states:

> Its floristic source probably came in part from the non-extreme *deniyas*, for example, *Chrysopogon zeylanicus* and *Arundinella villosa*. . . . *That fires can spread through the* grass cover of even the marshy depressional habitats with *Chimono bambusa* was demonstrated during our time of observation. This is possible in this humid climate, because of its short dry season in February.
>
> However, the fire caused by man, must be an old factor in this environment because of the absence of woody remnants in the black *patana* soil. The rate of decomposition should be studied, but it is certainly slow. [Furthermore, the differences between the forest and grassland soils in ecozone D3 (Moormann and Panabokke 1961:16-21; de Alwis and Panabokke 1972:50) point to a considerable antiquity for the

> latter.] It is also probable that fire and gradual expansion of the grass cover at the expense of the mossy forest has caused an almost irreversible change on the lower slope habitats. [Also v. Ollier 1974:340, who affirms that leaf litter provides the bulk of the nutrients to plants in a rain-forest. Once this source is removed, the vegetation stabilises as grasses and will not regenerate easily back to forest. Matters are aggravated by the loss of water-retaining spongy soil structure of rain-forests when these are cleared.] Frost is definitely a factor in the black *patana* zone. . . . It is well known that trees have difficulties getting established in frost locked habitats, and frost frequency and duration are likely to be increased by the presence of the surrounding remnant forest stands.

Apart from the firing, extensive rooting by wild pigs is thought to contribute to the persistence and continuation of the *Chrysopogon zeylanicus* grass cover at the expense of woody forms (Mueller-Dombois and Perera 1971:20).

Still (1925:397) and B.A. Abeywickrama (in Cumberland 1963:205) suggest that the firing was effected by prehistoric man. "The use of fire in game drives doubtless initiated the transformation of forest cover [in the tropics] to scrub and savanna [and grassland] even before the advent of slash and burn agriculture" (Murdock 1963:150). Since fire had been in use at Batadomba-lena cave at ca. 28,500 $^{14}$C BP (Chap.3.4.1), there is a likelihood that the burning of the forests on the Horton Plains (and elsewhere) commenced at least as early as this. Apart from the driving of game, it is possible that prehistoric man in Lanka burned the forests in ecozone D3 simply because these were too dense for habitation: it is estimated that on an average these montane forests carry over 7,500 stems per hectare (Fernando 1967:64-5). Finally, one might refer to the impressive array of evidence for horticulture in the highlands of New Guinea during the early Holocene (Allen et al. 1977). The present environment of these highlands appears to resemble that of the Horton Plains to a considerable degree and the analogy is worth testing. Meanwhile, as with the grasslands in ecozones C, D2 and E, it is vital to analyse pollen cores for securing data on past vegetational shifts – there are suitable ombrogenic swamps on the Horton Plains which could conceivably be radiocarbon dated so as to secure a chronological framework.

*5.3.10 Inter-Zonal.* The site and zonal data on subsistence presented above consistently point to a non-specialised exploitation strategy of a very broad spectrum of fauna. Technological limitations appear to have biased the strategy towards the exploitation of the smaller vertebrates such as monkeys and squirrels, although birds and larger forms such as pig and sambhur were by no means beyond reach (in the latter cases, perhaps at times by scavenging). Invertebrates were also gathered extensively: aquatic and arboreal snails, freshwater crabs, and perhaps forms such as worms and slugs which would leave no overt traces in the archaeological record. The shell middens found along the coastal tracts of the Dry Zone need not signify a specialised overall subsistence strategy: rather, they are probably localised representations of a seasonal activity within the annual food procurement cycle. Similarly, the shelly heaps occurring within prehistoric cave deposits in the Wet Zone seem merely to represent refuse dumps for molluscan remains, as opposed to any wider connotations with regard to dietary selection. The pattern of floral exploitation is also likely to have been very broad-based; although, apart from the instances of Beli-lena Kitulgala and Batadomba-lena, there is a great dearth of data on this aspect of prehistoric subsistence.

As for the technology of hunting and gathering in prehistoric Lanka, nothing substantive is known about the types of tools used for this purpose; some of the hollow scrapers from Bandarawela look suspiciously as though they were used for planing arrow-shafts, and the bone points found closely associated with human remains at Bellan-bandi Palassa could signify that poison had been employed; birds and small mammals were probably trapped; but all this is speculative.

So far there have been no indications that plant or animal domesticates had been exploited by Stone Age man in Lanka. The Job's tears found at Ravanalla are probably not prehistoric at all, and the carbonised granules from Beli-lena Kitulgala, which were initially thought to be grains of finger millet, have been identified as being the wild breadfruit of Lanka (granules from the charred epicarp of the edible fruit). Moreover, I have not observed a single instance of silica gloss occurring on any of the hundreds of thousands of quartz and chert artefacts that I have examined over the last two decades. Such a gloss should normally accompany the intensive harvesting of cereals, whether wild or domesticated, and of bamboos. It is noteworthy that grindstones can develop silica gloss if used for processing cereal epiderms containing opal (Witthoft 1967*a*:386-7) and that pestles and mortars employed in the processing of palms for their sago (and knives used on palm leaves for mat-making) can also acquire a similar gloss (I.Glover 1974:pers. comm.; J.Kamminga 1978:pers. comm.).

The discovery of a canid at Nilgala cave and another at Bellan-bandi Palassa from Mesolithic contexts opens up the possibility that these were indeed domestic dogs, as opposed to jackals. This identification needs to be pursued, although the problems for the taxonomist are considerable. (Note that a mandible of a suspected dhole has been found in a mixed context (?Mesolithic) at Beli-lena Kitulgala (P.B.Karunaratne 1986:pers. comm.) thus compounding the problems of identification.) Deraniyagala (1965:187,193) has compared the living Sinhala hounds of Lanka with the Bassenji of the Congo, the Australian dingo and the "singing dogs" of New Guinea and suggested a phylogenetic link between these widely dispersed forms, possibly through their association with prehistoric human migrations.

Some of the bovines found in prehistoric contexts in Lanka could represent an archaic (?wild) form of *Bos indicus*. If so, it is possible to hypothesise that in later prehistory domestication of *Bos indicus* could have taken place in Lanka as has been suggested for India (cf. Zeuner 1963; Allchin and Allchin 1974*a*:71). It is not known as to when the domestication of the water buffalo first occurred on the island. Until quite recently (ca. 15 years ago) wild buffaloes were being noosed and tamed, as for instance in the Vilpattu area. None of the prehistoric sites have yielded any evidence of bovines having been selectively culled; indeed bovine remains are so rare that it is most unlikely that they represent domesticates. It is noteworthy that the ancient chronicle of Lanka, the *Mahavamsa*, mentions the domestic dog at ca. 500 BC in a context associated with the Stone Age ancestors of the Vaddas, the Yakkas (v. Chap.5.4), whereas domestic cattle are certainly not referred to.

Having thus concluded on the overall subsistence strategy of prehistoric man in Lanka, since at least 28,500 BP as per the faunal remains from Batadomba-lena, it is scarcely possible to evaluate inter-zonal differences within this strategy in the absence of quantitative data. Of course it is clear, for instance, that the spotted deer *Axis axis* and the star tortoise *Testudo elegans* were exploited in the lowland Dry Zone and not in the Wet Zone for the simple reason that these forms do not occur in the latter zone, and hence such distinctions do not necessarily have any cultural significance. The same causative factor, namely the lack of adequate quantitative data, vitiates any attempt at delineating any broad-based evolutionary shifts in prehistoric subsistence strategy in Lanka. Such an assay has to await extensive controlled sampling so as to secure the requisite data base.

Sampling, once again, is a prime determinant of the picture that prevails concerning the distribution of prehistoric sites in Lanka. Where visibility is good, as in the *vembus* of the I Fm or on the eroded hill-tops of the *dry patanas* in ecozone E, there is no difficulty in locating the sites with their conspicuous scatter of quartz artefacts gleaming white. However, much of the island is blanketed by rain-forests and their variants with a superficial network of roots (e.g., Series D1), *wet patana* grasslands (e.g., ecozone D3), colluvial caps of loam (e.g., most of the Wet Zone) or ancient dune sands (I Fm). In such situations sites may be visible, occasionally, in erosional exposures or artificial cuttings, but only very rarely otherwise. One depositional facies which presents less difficulty is the cave sites. In the Wet Zone most of these bear traces of prehistoric occupation, and except in rare circumstances (as in the larger uninhabited forest reserves such as the Sinharaja and Adam's Peak wilderness) discreet enquiries from local villagers frequently serve to locate such caves. However, it can be affirmed at a general level that adequate sampling of prehistoric sites by surface surveys can scarcely be envisaged in Lanka and that this will always be the major obstacle to evaluating Stone Age settlement configurations on the island.

Within the bounds of the sampling constraints enumerated above, on the other hand, a rudimentary view may be assembled concerning prehistoric settlement in Lanka. Apart from the Jaffna peninsula, Stone Age artefacts are ubiquitous on the island. The salient groups of locations for these findings comprise the following:

(*a*) The coastal tracts of ecozone A in the I Fm. Several hundred sites are likely to be present in and on the basal gravels and overlying beach dunes, and these are very visible in the *vembus*.

(*b*) The stone-lines of the RBE Fm in the hinterland of ecozones A and B. These sites are rarely encountered due to the scarcity of suitable erosional exposures in the Reddish Brown Earth colluvial cap.

(*c*) Cave sites in the Dry Zone lowlands of ecozones A, B and C. My investigations reveal that traces of prehistoric occupation at these sites are usually vestigial or absent, despite their habitability. However, open-air sites do occur in their vicinity, and I have suggested that competition for caves from bears (absent in ecozones D and E) could have been one of the determinants of this anomaly, a stronger factor being that open-air camps would have afforded greater flexibility for subsistence activities.

(*d*) Open-air sites on hill-tops and saddles in the *dry patana* grasslands of ecozone E. There are not many caves known from this ecozone, but these do bear relatively rich assemblages of prehistoric cultural remains: caves with hearths would have afforded welcome warmth in this cool environment, and there were no bears.

(*e*) Cave sites in ecozone D1, of which there are several. These are very rich in prehistoric deposits. The volume and distribution of rain in this ecozone would have been a major factor responsible for the intensive occupation of caves.

(*f*) Due to the root-mat and colluvial earth cap in ecozone D1, open-air sites are rarely encountered in this zone, except on exposed and eroded hill-tops and saddles of the *wet patana* grasslands, or in artificial clearings with a secondary growth of bracken. The general environment, with its high and frequent rainfall, is not conducive to open-air settlement.

(*g*) Ecozone D2 appears to represent a somewhat less extreme version of ecozone D1; but this is probably ascribable to the former not having been surveyed as much as the latter, particularly with regard to the caves.

(*h*) Ecozone D3 has numerous open-air sites on the Horton Plains above 2,100m + msl (the leech-free zone). These sites are presumably seasonal camps associated with the firing of grasslands and driving of game during the February droughts. Once again the dense montane forest and the thick mat of grass roots make location of sites very difficult indeed, and the ones I have noted usually happened to have been exposed by recent clearing activities, with the exception of a few on eroded terrain. Sites are very rare in this ecozone at below 2,100m + msl (leech country). I have not observed any caves in this region; but they probably do occur in the main escarpment off the Horton Plains.

The above outline of settlement distribution indicates that there is insufficient data on which a zonal differentiation of settlement intensity and configuration can be based. The only significant point is that in the lowlands of the Dry Zone caves appear to have been avoided by prehistoric man, whereas the converse is true of the Dry Zone uplands in Uva and in the Wet Zone. One explanation for this dichotomy is that the relatively dry climate of the lowland Dry Zone enabled prehistoric man to maximise food procurement efficiency by flexibly selecting suitable open-air camp sites, rather than being forced into the straight-jacket of living in caves which might not be well situated for food procurement. Subterranean caverns were not favoured for occupation, presumably due to the lack of light, dryness and ventilation.

As for the size of the sites, the habitation areas in the caves are naturally circumscribed by the area available in terms of light, ventilation and terrain. In the case of the open-air sites, it is difficult to estimate site area due to the possibility of occupation phases overlapping each other in palimpsest without any obvious stratigraphic breaks. However, it is noteworthy that, on rare occasions, the site boundaries can be assessed. The modal extent of artefact scatters in base-camps appears to be ca. $50m^2$. This dimension does not suggest occupation by more than a single nuclear family, a hypothesis corroborated by the modal size of the hearths exposed in Beli-lena Kitulgala. It needs scarcely be added that smaller extraction camps, where knapping had been performed, are to be encountered fairly frequently. So far, I have not seen a single site which could be considered to represent the synchronous activities of more than five nuclear families at most, and this limitation is likely to have been imposed by the exploitable biomass within the respective site-territories.

Concerning the site-territory of prehistoric settlements in Lanka, the three surveys conducted by me in the Horton Plains (ecozone D3), Ohiya-Welimada (ecozone E) and the Handapan-ella and Tangamalai Plains (ecozone D2) revealed that on an average about 20 sites occurred within each survey area. The latter comprised a radius of 6-8 hours' walking time from our base-camp, the distances involved being variable according to terrain. One wonders whether this count of ca. 20 sites for each of the surveyed areas has any significance in terms of (?similar) prehistoric population densities in ecozones D2, D3 and E – which poses the problem of establishing the time relationship between the sites, whether diachronous or synchronous, a problem without a ready solution.

Apart from the procurement of food, the exploitation of raw material resources for implement manufacture would have constituted an important consideration in the selection of localities for settlement by prehistoric man. Nearly all of the identifiable tools found in Lanka are made of quartz, with a small minority on chert and the non-flaked categories such as hammers and grindstones on gneiss. The absence of vestiges of prehistoric sites in the Jaffna peninsula can be ascribe to the local lack of suitable raw material for implement manufacture. However, the rest of the island is richly endowed with alluvial and primary exposures of quartz and chert (for quartz v. Parsons 1908:171-4; Cooray 1967:123-4,191,193,227,; for chert v. Wayland 1919:94-6, 100-1; Cooray 1967:180).

Sites where raw materials have been quarried for implement manufacture are not rare, as at Site 40 in the I Fm (chert) and Site 20 in the Horton Plains. Alluvial gravels with quartz and chert pebbles, as excellently represented in the basal gravels of the I Fm, were also extensively exploited and possibly preferred to the primary deposits. So far, there is no evidence of raw materials (e.g., quartzite or agate) having been imported from India; nor are there any clear indications that certain varieties of material were gathered from particular quarries in the island which would suggest specialisation in raw material extraction leading up to a barter system (cf. Allchin 1958:198). On the contrary, it is rather remarkable that high-grade outcrops of primary chert, for instance, such as those found at Aparekka in the eastern part of the Ambalangoda area (ecozone D1; Cooray 1967:180) and of vein-quartz at Alpitiya near Godakewela have not been exploited at all. It is also significant that the acid dolerites associated with the margins of dykes found occasionally in various parts of the island (Pattiarachchi 1961:26) have not been utilised for the manufacture of stone celts, contrary to practice in the Neolithic of peninsular India. (Perhaps the subsistence opportunities in Lanka and the resultant strategy did not necessitate the use of celts on a large scale.) Hence, there does not seem to have been any considerable urgency associated with the procurement of raw materals for tool manufacture and thus it can be concluded that the influence of this activity on settlement locations would not have been anywhere nearly as pronounced as that generated by the search for food. It appears likely that stone raw material was frequently "casually collected by the people as they moved about the countryside" (Allchin 1958:198), rather than exploited from any zealously guarded preserves. That some of the sites, as on the I Fm where quartz gravel exposures are common, have a more pronounced knapping component than others is only to be expected; but no specialised extraction camps on a large scale have so far come to light, and it cannot be affirmed that there is any noticeable inter-ecozonal variation in this regard.

The lack of marked seasons, apart from the wet/dry alternations, in Lanka (App.I) has resulted in a corresponding lack of pronounced ungulate migrations – contrary, for instance, to the situations prevalent in semi-arid regions (e.g., sub-Saharan Africa) and high latitudes (cf. Harris 1969:8; Clark 1975:647). This, together with the general year-long clemency of the climate, would probably have meant that movements of prehistoric humans on a seasonal basis were also limited. It is possible, however, to hypothesise that they did occupy the High Plains seasonally, due to the relative inhospitableness of the environment. Inter-ecozonal movements of a restricted nature probably took place via the valleys, such as the Ratnapura-Pelmadulla-Embilipitiya-Hambantota route between ecozones D1, C, B and A, and via passes, for instance the Ella pass linking ecozones A, B, C, E, and D3. The microlithic tool range of Lanka's Stone Age man (at least from the Upper Pleistocene onwards) would have facilitated his movements, although apparently not adequately for him to occupy the Jaffna peninsula with any degree of intensity. Heavy items, such as grindstones, were probably left behind at camp sites as permanent fixtures (v. Leonard 1973:22). Further survey is likely to reveal a patterned configuration of sites along these hypothesised routes. The relatively even distribution of rainfall throughout the year in the Wet Zone would have resulted in caves and rock-shelters being perennially occupied.

Inter-ecozonal trade, presumably rudimentary exchange, would have existed at over 18,000 BP, as per the evidence from Beli-lena Kitulgala where a shell of *Potamides cingulatus* suggests its having been incorporated in salt brought in from coastal ecozone A from at least 80km away, the nearest locality with natural salt evaporates being around Puttalam. Fragments of large marine shells (?debitage from manufacture of ornaments) were also found at Beli-lena in unstratified contexts, and a single specimen was excavated fom Batadomba-lena Stratum 5 dated to ca. 13,500 BP. The spine of a marine ray (?mini-harpoon) was discovered in Stratum 7a (dated on charcoal to ca. 17,000 BP) from the same site. Other sites to have yielded marine molluscan remains are (*a*) Ravanalla cave: perforated marine shells (n=2; Deraniyagala 1949:F4; 1950:E8); (*b*) Bellan-bandi Palassa:cowrie, ca. 6,500 TL BP (n=1; id. 1958:82; 1958*a*:256); (*c*) Kabara-galge, Hangamuva: large marine bivalve at ca. 0.6m -gl (n=2) and a cowrie (n=1; id. 1955*b*:E4,E16); and (*d*) Yakgiri-lena near Matugama: bivalves (id. 1953*a*:127). Deraniyagala's (1943:96) claim that pumice was discovered at Batadomba-lena requires checking, but if correct suggests a link with the east and south coasts where this substance is washed up, for instance near Bagure (id. 1961:150). Wayland (in Wadia 1941*d*:21-2) mentions littoral accumulations of pumice between Chundikkulam and Kokkilai in the northeast, which is thought to have been detached and then washed up from a submerged reef.

Honey and dried meat could have been important items of exchange between the Wet and Dry Zones, the latter being richer in both categories during the summer months. The remains of a sloth bear found in a prehistoric context at Kabara-galge (Deraniyagala 1955*a*:300) in the heart of non-bear country (ecozone D1) suggests that it was brought in with dried meat or with a pelt.

Just as the sloth bear is found only in the lowland Dry Zone, the arboreal mollusc *Acavus* is restricted to the Wet Zone. However, certain sites in the Dry Zone have yielded this form in prehistoric contexts: (*a*) Udupiyan-galge (n=6), Bambaragala shelter (2 spp.), Bellan-bandi Palassa and Alu-galge Telulla, all in ecozone B (id. 1940*a*:366; 1943:102; 1955*a*:300; 1958:71); (*b*) Nilgala cave in ecozone C (*A. phoenix* and *A. prosperus*; numerous; Sarasin and Sarasin 1908:Pl.9); and (*c*) Stripura-galge Arukwatte in ecozone E (1 sp.; Deraniyagala 1956*a*:118). Many of these specimens, as at Nilgala cave, bear perforations through the body-whorl which could signify that these shells were strung as "beads" for ornament and/or currency, and in view of their being found outside their present range of distribution in association with typical Dry Zone forms such as spotted deer, it is very likely that they represent items of trade. Some of the specimens from Bellan-bandi Palassa have been identified as *A. roseolabiatus* (R.Ratnapala 1980:pers. comm.), a species that is today restricted to a very circumscribed area around Kitulgala on the right bank of the Kelani river. Should this identification be correct, it would point to a clear instance of extra-ecozonal importation from a known source. (Note that the land snail *Pomatas olivierri*, found in the early Mesolithic of Belt Cave at ca. 11,500 $^{14}$C BP is known to have been used both as an ornament and as currency in recent times in Iran (Coon 1951; 1957; McBurney 1969). I have also found two specimens of a small *Acavus* species on the surface of Yellow Latosols at Site 35 and between Sites 45 and 47 of the I Fm in the northwest and south respectively. Since these loci are in ecozone A, the shells could only have reached these areas through a human agency, presumably during prehistoric times, although I cannot explain their preservation in the absence of an alkaline matrix. Indeed, there are said to be specimens of *Acavus* in South Indian collections, which could represent trade items found in Indian prehistoric sites as this genus does not occur in India today.

As mentioned above in the context of raw material procurement for stone implement manufacture, there would have been no necessity for inter-zonal trade in quartz or chert due to the ubiquity of these materials on the island, except on the Jaffna peninsula. Red ochre, graphite and mica, in descending order of frequency of occurrence, are the other minerals often encountered in prehistoric deposits (App.II). It is possible that these were used as pigments for ornamental *cum* ritualistic purposes, and hence were in general demand. Red ochre, once again, is ubiquitous on the island, and it is roughly co-extensive with quartz and chert deposits. The major occurrences of graphite, however, are confined to the south-western sector of Lanka (Cooray 1967:205-6,227), although it is likely to be present in association with quartz veins elsewhere. Mica too has a wide range of distribution in association with veins of pegmatites and crystalline limestones (ibid.:207,227). Hence, it can be hypothesised that red ochre, graphite and mica were not significant items of inter-ecozonal trade during prehistoric times, unlike (perhaps) pumice, and certainly salt and other marine products.

*5.3.11 Art, Ornament and Ritual.* It is significant that very little of what can be interpreted as having been of ritualistic import has been found in a prehistoric context in Lanka. The barrel-beads on bone from Beli-lena Kitulgala and the radially incised disc-beads from Batadomba-lena (Fig.56), and also the perforated marine and arboreal *Acavus* shells from the sites enumerated above could have been purely ornamental in function. The serrated bone spatulae from an unstratified context at Beli-lena and the cross-notched slivers of bone from Nilgala and Ravanalla caves could have had a significance beyond that of simple ornament, although not necessarily ritualistic. The two items that seems to have had ritualistic associations are the human frontal bone from Ravanalla, with its rough excrescences smoothed, biconical drilling and the smearing of red ochre, and the red ochre coated human burial (fractional) excavated at Fa Hien cave (W.H.Wijepala 1987:pers. comm.). As to what other purposes the ubiquitous red ochre had been used for is a matter of conjecture.

The excavations at Batadomba-lena (1986) have produced grindstones smeared with a white chalk, and Fa Hien cave had one with graphite, probably as pigments.

There is no rock art which could unequivocally be assigned to the Stone Age: it all seems to be the handiwork of the Vaddas during historical (?post-Anuradhapura period) times (for catalogue v. Nandadeva 1986). However, there is a slight possibility that the symbols and representations of animals pecked into the walls of the prehistoric cave at Doravaka-kanda near Kegalle (Browning 1919) are of the Stone Age, although it is also likely that they were executed by people of the protohistoric Iron Age as with the figure of a deity holding a *bo* sapling in association with non-Brahmi symbols, once again pecked into the rock forming the floor of a small cave above the present temple at Dimbulagala (L.A.Adithiya 1969:pers. comm.). This latter could be a Vadda representation of the formal introduction of Buddhism at ca. 200 BC. An excavation at Doravaka-kanda could reveal whether the prehistoric strata (over 3m of it according to a core) abut against the "art" work, thereby establishing the prehistoric versus protohistoric or historical status of the latter. None of the subterranean caverns have overt indications of ritualistic activity, although the occurrence of a few artefacts in the gloom of the antechamber at Stripura Arukwatte could have had some such significance.

*5.3.12 Mortuary Practice.* The prehistoric human remains discovered so far in Lanka – Nilgala Cave (Mesolithic), Beli-galge, Batadomba-lena (Mesolithic), Ravanalla, Alu-galge Telulla, Bellan-bandi Palassa (Mesolithic), Beli-lena Athula, Beli-lena Kitulgala (Mesolithic), Fa Hien cave – have been found in undifferentiated occupation debris comprising charcoal, ash, faunal remains and artefacts. Bellan-bandi Palassa, Beli-lena Kitulgala and Batadomba-lena have yielded isolated fragments of human bone (without any peripheral material) in ashy deposits with food remains, which suggests no interment at all. It is probable that such occurrences are the products of cannibalism or the result of burials being disturbed and isolated elements of human remains becoming secondarily incorporated in subsequent deposits. Wherever more complete assemblages of human bones have been found, these appear to have been placed within hollows of the living floor and covered with more occupation debris (e.g., Bellan-bandi Palassa, Beli-lena Kitulgala and Batadomba-lena). Some of these "interments" are definitely fractional, as per the evidence from the above-mentioned sites, particularly the red ochre coated assemblage from Fa Hien cave. The more complete skeletons have been found invariably in a flexed position (Alu-lena Telulla, Bellan-bandi Palassa, Batadomba-lena) and they seem to represent secondary burials, as suggested by the frequent lack of relatively robust skeletal parts, although some of these (e.g., at Bellan-bandi Palassa) could conceivably be primary interments.

In general, it can be affirmed that in ecozones B, C and D1, the locations where prehistoric human skeletal remains have been discovered so far, there does not appear to be any visible differences in mortuary practice. With the exception of the Fa Hien cave burial, the interments do not suggest any elaborate death ritual; rather, they point to a relatively "uncomplicated" attitude towards the dead, whereby they were casually buried in shallow hollows in the ground (flexed, hence minimal digging involved) and covered over with occupation debris. These appear to have been disturbed at times, the interments being shallow, resulting in redeposition of isolated skeletal parts in succeeding strata. The possibility of cannibalism being responsible for some of the occurrences of human remains among the food debris cannot be ruled out.

*5.3.13 Physical Anthropology.* Human remains have been found in prehistoric contexts at Nilgala cave, Beli-galge, Batadomba-lena, Ravanalla, Alu-galge Telulla and Bellan-bandi Palassa. The more recent discoveries have been at Beli-lena Athula, Beli-lena Kitulgala, Batadomba-lena and at Fa Hien cave. Of less secure taxonomic status is the so-called *Homopithecus* first upper incisor (very large) from the gravels of the Ratnapura Beds at Karangoda near Ratnapura (Deraniyagala 1960:3-6; 1963*e*:30-1) which Deraniyagala has tentatively correlated with *Gigantopithecus*, thus assigning it hominoid status; and the *Homopithecus* upper left molar from a similar alluvial deposit nearby (id. 1963:20) may possibly be attributed to a hominid on the basis of the rounding of the cusps. Bio-stratigraphically, both these "hominoids" could date back to the Middle Pleistocene, but the chronological imprecision associated with the Ratnapura Beds constitutes a major stumbling block in this regard. A fossil human calva is supposed to have been found at Ellavala from the Ratnapura Beds (id. 1958*a*:239); but although some of its dimensions are provided, no further details are available. The "heavily mineralised" left supra-orbital ridge of a "Neanderthaloid" from the gravels of the Ratnapura Beds, also near Ratnapura (id. 1960:2-3; 1963*e*:31), deserves careful scrutiny before deciding on its status.

The human remains from Nilgala cave (Sarasin and Sarasin 1908:90-2) appear to have a Mesolithic technological context. They represent parts of four individuals, two of whom are only known by single teeth or small jaw pieces. The third is represented by maxillary and cranial fragments of a juvenile, with prominent alveolar prognathism. The fourth is an adult with heavily worn teeth, alveolar prognathism and robust cranial fragments up to 9mm thick. There were apparently several other pieces of long-bone and a phalange of a right big toe which could have belonged to the adult or to another individual.

The human cranial parts and bits of long-bones excavated from ca. 1.7m -gl at Beli-galge Bambarabotuva (Seligmann and Seligmann 1911:21) are also probably from a Mesolithic technological context; but no further data are available. The upper layers at Batadomba-lena are said to have yielded fragmentary remains of several individuals, once again presumably from a Mesolithic context (Deraniyagala 1940*a*:367-8; 1953*a*:129; 1958*b*:E16). Most of these have been assigned to adults, apart from a few deciduous teeth from one or more juveniles. Of some significance is the iliac crest of an adult, and Deraniyagala's observation that some of the cranial fragments display exceptional thickness. Some of the bones apparently display greater loss of organic matter than others, suggesting differences in antiquity among the various components of this assemblage. These remains from Batadomba-lena were despatched to B.S. Guha, an Indian physical anthropologist (Harvard trained) for comment; but none was forthcoming due to the extremely fragmentary nature of the sample.

The first intimation of the physical appearance of Lanka's Stone Age man came from the human frontal bone excavated at Ravanalla (id. 1953*a*:128). This individual has been aged at ca. 30 years, and the bone is conspicuously thick; but what is very prominent apparently are the heavy supraorbital ridges, the thick frontal crest and the weakly developed concavities for the anterior prominences of the frontal lobes. The glabella is said to be well filled-in and the zygomatic process strongly developed. This specimen constitutes the holotype for Balangoda Man (so-called *Homo sapiens balangodensis*, now regarded as *H. s. sapiens* (Kennedy 1974*a*:202)). A third left upper molar, well worn, was also found from these excavations at ca. 0.8m -gl.

The next prehistoric human skeleton to have been found is a poorly preserved, carbonate-encrusted, fragmentary individual from Alu-galge Telulla, possibly from a Mesolithic context (Deraniyagala 1955*a*:296-8,301). Although the skull bones are said to be not as thick as in the frontal from Ravanalla, the supra-orbital ridges are apparently heavily developed and the last molar well worn as in the Ravanalla specimens. The right inominate bone has been interpreted as representing a relatively small pelvis, and the mandible is gracile with a small but well-defined mental tubercle. The temporal lines are prominent, and it is thought that the sex of this individual is male. Deraniyagala (ibid.:301) affirms that the humans from Ravanalla and Alu-galge Telulla possess strong Australoid affinities, on the basis of their respective cranial morphology; he also concludes that they were the direct ancestors of the Vadda hunting and gathering tribes of Lanka in historical times.

1956 saw the initial season of excavation at the open-air midden site of Bellan-bandi Palassa, in the dry lowlands directly beneath the Kaltota escarpment with its series of caves described earlier. This site was excavated on a 6ft by 6ft grid over five short seasons, averaging a fortnight or less each, from 1956 to 1961. The results, particularly those pertaining to physical anthropology, have been published in considerable detail, producing what is perhaps the best reported site of Lanka's Stone Age (id. 1956*a*:119; 1957*a*:8,9; 1957*b*:E4; 1958:66-82; 1958*a*; 1960*a*; 1963*a*; Kennedy 1965). The Noones (1940:21) had stated: "The Sarasins believed that the people who-lived in the rock-shelters and made stone implements were the ancestors of the Veddahs, but without skeletal evidence there is nothing to support such a conclusion". The human skeletal material from Nilgala cave, Beli-galge, Batadomba-lena, Ravanalla, and Alu-galge Telulla was too meagre and fragmentary to provide even a partial answer. Here, at last, at Bellan-bandi Palassa was a somewhat more adequate sample representing the remains of at least twelve individuals, which could be studied as an assemblage – although, it must be stressed, this sample in itself is far from adequate (v. below). Deraniyagala's preliminary reports, in which he did see the Vaddas as deriving directly from Balangoda Man (1958*a*:258; 1960*a*:108), created considerable interest among physical anthropologists. Coon (1962:424-5) who saw some of the material in the Colombo Museum, as well as a single specimen loaned to the American Museum of Natural History, touched briefly upon the subject, considering these humans primitive Caucasoids akin to the Vaddas; and K.A.R. Kennedy wrote his Ph.D. dissertation for the University of California, Berkeley, on material made available to him by Deraniyagala and K.P. Oakley of the British Museum (1962). This latter study, published in its edited form as a British Museum monograph (Kennedy 1965), represents a considerable advance in the application of anthropological method to the prehistory of Lanka, involving metrical/morphological anthropometric examination, radiographic analysis, biochemical and radiometric assays, amino-acid chromatography, and palaeo-serological studies (v. id. 1974:100).

As a consequence of the analyses by Deraniyagala and Kennedy, the physical traits of the individuals (Balangoda Man) as represented in the Bellan-bandi Palassa series may be summarised as follows:

(*a*) Estimated stature: male, 1.74m; female, 1.66m; hence somewhat taller than the average for modern Sinhalese and Tamil populations of Lanka and certainly taller than the Vaddas. However, the vertebrae are disproportionately small for this estimated stature (Kennedy 1965:190).

(*b*) Skull

i. Cranial capacity, variable. A male's could be as much as 1,589.72cc, and a female's as low as 919.66cc (ibid.:151).

ii. General conformation, dolichocephalic (Deraniyagala 1958*a*:255; Kennedy 1965:150).

iii. Vault, low and flat (Deraniyagala 1958*a*:255)

iv. Forehead, sometimes markedly receding, paticularly in males (ibid.). The temporal lines are prominent on the frontal bone, but not on the parietals (Kennedy 1965:153).

v. Occipital curvature, pronounced; about one-third of the occipital bone is visible in norma verticalis (Deraniyagala 1958*a*:255). The occipital torus is very prominent at times (Kennedy 1965:153).

vi. Skull bones, very thick at times (ibid.:151)

vii. Malar bones, thick and wide (Deraniyagala 1958*a*:255). The face would have been wide (id. 1963*a*:97).

viii. The skull is narrow anteriorly relative to its widest region which is located towards the posterior part of the parietals (ibid.:95). The post-orbital constriction is marked (Kennedy 1965:151).

ix. Supra-orbital ridges, divided and very thick at times (ibid.)

x. Orbits, sub-rectangular and larger than in modern Sinhalese and Tamils (Deraniyagala 1963*a*:97; Kennedy 1965:188).

xi. Nasal bones, concave dorsally, with depressed nasal notch (Deraniyagala 1963*a*:97; Kennedy 1965:153). Nasal aperture, wide, short and piriform (Kennedy 1965:188). One specimen had a leptorrhine nose which caused Coon (1962:424-5) to classify it as Caucasoid.

xii. In some adult males the distance from the lower margin of the nasal aperture to the base of the upper incisors (nariale-prosthion) is conspicuously great, being as much as 33mm (Deraniyagala 1963*a*:93,97). The lower margin of the nasal aperture has no ridge, unlike in the Sinhalese and Tamils, but slopes directly onto the maxillo-premaxillary area (ibid.). The premaxillary bones are well fused, but occasionally poorly fused to the maxillae (ibid.:92; 1958*a*:255). The canine fossa is ill-defined, giving the maxillae a filled in appearance (id. 1963*a*:97).

xiii. Alveolar prognathism evident in most adult males (Kennedy 1965:153)

xiv. Palate, larger, wider (Deraniyagala 1958:66) and at times noticeably deeper than in the Vaddas (Kennedy 1965:154,189).

xv. Mandible, more powerful than in the Vaddas (ibid.:189). The gonial prominence anchoring the masseter muscle is sometimes very prominent (Deraniyagala 1958*a*:255). Sigmoid notch, shallow (id. 1963*a*:93). Ascending ramus, higher than in the Vaddas (Kennedy 1965:189) and wide (Deraniyagala 1958*a*:255). The base of the mandible, wide (ibid.). Corpus, deeper than in the Vaddas (Kennedy 1965:189).

xvi. Chin, pointed but better developed than in the Vaddas (Deraniyagala 1958*a*:255)

xvii. Line of occlusion between the jaws, as in the Vaddas, at a relatively steeper angle than in the Sinhalese and Tamils (ibid.:231).

xviii. Mastoid process, robust; stronger than in the Vaddas (Kennedy 1965:186)

(*c*) Dentition

i. Dental arch, rectilinear in some males (Deraniyagala 1965*b*:299), probably due to post-mortem distortion, since considerable warping has been observed on some of the material (Kennedy 1965:144).

ii. Teeth, usually large (ibid.:165)

iii. Attrition, pronounced, even in the third molars (Deraniyagala 1957*a*:10)

iv. Third molar, often as large as the second (id. 1958*a*:255)

v. Pulp cavities tend to be large, although variable in size (id. 1963*a*:92; Kennedy 1965:173).

vi Cusp and groove pattern, highly variable (Kennedy 1965:194); pronounced wrinkling in the patterns (ibid.:167; Deraniyagala 1963*a*:92). The fifth cusp of the molars is well developed (Deraniyagala 1958:66).

vii. Canines smaller, and the premolars larger, than in the Vaddas (Kennedy 1965:193-4). Incisors, smaller than in the Sinhalese (Deraniyagala 1963*a*:97), shovel-shaped in some females and project outwards (ibid.:93; Kennedy 1965:171).

viii. Bite, edge-to-edge (Deraniyagala 1958*a*:255), although over-bite is evident in some (Kennedy 1965:201).

(*d*) Long-bones

i. Humerus, longer and more robust than in Vaddas (ibid.:160)

ii. Radius and ulna, more robust than in Vaddas (ibid.:191)

iii. Femur, thick with pronounced musculature (ibid.:160)

iv. Tibia, straight and heavy, with only moderate musculature (ibid.:162,192)

(*e*) Pelvis, thick and massive, more robust than in the Vaddas; resembles Australian pelvis (ibid.:164,193).

(*f*) Vertebrae

i. Pre-lumbar, small (ibid.:157); the axis vertebra and its odontoid process, remarkably short (Deraniyagala 1963*a*:95).

ii. Lumbar, robust (Kennedy 1965:190)

(*g*) Miscellaneous

i. Calcaneum, shorter, deeper and more rounded than in the Sinhalese and Tamils (ibid.:163; Deraniyagala 1958*a*:255).

ii. Scapula, more robust than in the Vaddas (Kennedy 1965:191)

iii. Hands, larger than in the Vaddas (ibid.:160,192). Terminal phalange of thumb, very strong (Deraniyagala 1958*a*:236).

iv. Glenoid cavity, larger than in the Sinhalese and Tamils (id. 1958:66)

v. Blood group, AB in one sample; note that the A gene is said to be absent in the Vaddas (Kennedy 1965:182).

vi. Sexual dimorphism, high (Deraniyagala 1965:188)

vii. Phenotypic variability, high (id. 1957*a*:11; Kennedy 1965:183)

viii. General categorisation, Australoid (Deraniyagala 1958*a*:255; 1963*a*:93)

The traits of Balangoda Man are said to survive in varying degrees among the living populations of Lanka (Deraniyagala 1963*b*; Kennedy 1965). The comparison of the physical traits of Balangoda Man with those of various post-Pleistocene South Asian populations – from Brahmagiri, Adichanallur, Nevasa, Chandoli, Maski, Piklihal, Lothal, Raigir, Ruangarh, Langhnaj, Nal, Bayana, Sialkot, Harappa, Niah, Talgai, Keilor, Wadjak, and the Vaddas – has indicated that "the Veddas of Ceylon most closely resemble the Balangodese in their physical anthropology" (Kennedy 1965:183), while the links with certain tribal peoples of India are also considered to be strong. The latter investigator employed standard bivariate metrical indices and, more particularly (due to the fragmentary nature of the material), the incidence of certain discrete morphological traits to support these propositions: "It must be emphasised that the fragmentary nature of the Balangodese skeletal remains limits their significance in a purely metrical comparative analysis with larger and more complete osteological specimens. Hence the data of the tables are less helpful than a morphological comparison in affording the reader a clear idea of the phenotypic similarities of the prehistoric inhabitants of Ceylon" (ibid.:183).

However, the validity of Kennedy's conclusions are diminished by those elements which never cease to plague physical anthropologists: inadequacy of sample size and poor preservation. Kennedy studied the remains of some eight individuals from Bellan-bandi Palassa. A data base as limited as this could only provide vague hints as to the range of past variability. The sample of Vadda specimens employed in the comparative study appears numerically to have been more satisfactory, comprising the remains of some sixty-four individuals from the British Museum, Royal College of Surgeons, and University College of London, and from the universities of Oxford and Cambridge, supplemented by data published in Hill's work (1941) (Kennedy 1965:183; v. id. 1971:38-43 for data on sample size). However, qualitatively the Vadda sample left much to be desired. The definition of the Vadda phenotype is nebulous, due primarily to inadequacies of sampling procedure in the field:

> The number of osteological specimens collected from Ceylon since 1827 and bearing the name "Vedda" on their labels is impressive and exceeds in size the series accessible for many other Asiatic tribal groups of higher population frequency, and the amount of anthropometric data pertaining to both osseous and living Vedda specimens is not inconsiderable. Nevertheless this abundance of data has not deceived the more perceptive students of the Veddas who have troubled themselves to investigate the histories of particular so-called Vedda specimens and communities. The history of the scientific investigation of Ceylon's aboriginal population has yet to be written, but a cursory glance at the published data indicates that evidence gleaned from small samples often has been considered applicable to the Vedda population as a whole. [Kennedy did publish an account of the scientific investigation of the Veddas (1971) as "a model of the kind of background survey that is prerequisite for the selection of any osteological series used in connection with . . . the study of human evolution" (ibid.:37).] In most cases the fact that the specimens were from Vedda populations at all is questionable, for the majority of collectors obtained them through Sinhalese and Tamil contacts by offering to pay the latter for every skull they could procure, leaving it up to the contacts to decide what was or was not a Vedda. The care taken by the Sarasins [42 individuals] and Hill [9 individuals] to get their osseous specimens from Vedda cave sites and cemeteries, personally excavated, is a commendable but infrequent condition in the history of Vedda osteological collections [id. 1965:205].

The above is a re-statement of Hill's view concerning Vadda osteological material (v. Hill 1941:85) and there appears to be little doubt as to its veracity (v. also Kennedy 1971:37). The problem of the Vadda sample is compounded by the considerable miscegenation which the Vaddas have undergone with Sinhalese and Tamil populations (v. id. 1965:203). Of the two groups of Vadda skeletal material which Kennedy affirms were reasonably competently acquired, namely those of the Sarasins and of Hill, only the latter comprising some nine individuals was studied (ibid.:38-43), and Hill's publication (1941) does not provide any data on the Sarasin material, which Kennedy could have employed at second hand.

In view of the above considerations it is not surprising if the biological comparison between Balangoda Man and the Vaddas cannot be effected with any degree of precision, although the application of current statistical procedures, particularly of multivariate analysis, might conceivably "squeeze" more out of the data.

Meanwhile, researchers perforce have to be content with viewing their hypotheses against a broad spectrum of information, much of which stems from beyond the strict limits of physical anthropology. Kennedy himself has modified his original hypothesis that the Vaddas and Balangoda Man bifurcated from a common stem several millennia prior to the occupation of Bellan-bandi Palassa, which would place this event ca. 10,000 years ago, if not earlier:

> It would seem . . . that both the Balangodese and the Vaddas are biologically united through their possession in the past of a common gene pool, although it must be stressed that the former are "pre-Veddas" in a chronological rather than in any direct phylogenetic kind of relationship. Both populations appear to have been subject to separate evolutionary pressures for a long period of time, but for reasons which are yet unknown the Balangodese phenotypic pattern did not persist into the historic period. It is the variety and nature of physical differences between these two populations that suggests their bifurcation from a common stem at a time several millennia prior to the

occupation of Bellan Bandi Palassa [Kennedy 1965:207,208].

It is now being held that these two populations represent a biological continuum through time, rather than two discrete entities: "the biological progenitors of the Veddas were the Late Stone Age people of which the specimens from Bellan Bandi Palassa constitute a local representation in Sabaragamuva at a time prior to the movements of the tribal people into the Veddarata of eastern Ceylon" (id. 1974:100; also v. id. 1973:38-9; 1976:174). Deraniyagala expressed a similar view from his preliminary analyses (1955*a*:301; 1955*b*:40; 1958*a*:258; 1960*a*:108).

The excavations at Beli-lena Athula cave (Gunaratne 1971:3,Pl.3a,b) yielded two fragments from a human cranium: an occipital and a left parietal. These were found in what appears to be a Mesolithic context dated to ca. 7,800 $^{14}$C BP, but have not been examined by a physical anthropologist.

Recent excavations at Beli-lena Kitulgala produced two individuals from a horizon dated to ca. 13,000 cal BP. These are fragmentary and are currently being investigated by Kennedy at Cornell University. He is also conducting an in-depth analysis of the remains of several individuals excavated from a layer dated to ca. 16,000 $^{14}$C BP and a mandible from ca. 28,500 $^{14}$C BP (the earliest evidence of modern man in South Asia) in Batadomba-lena (Kennedy et al. 1986; 1987). One of the latter specimens from ca. 16,000 BP is said to display dolichocephaly, very heavy supra-orbital ridges, a marked post-orbital constriction and a very prominent nuchal crest (Kennedy 1984: pers. comm.). These traits are also very pronounced in the assemblage from Bellan-bandi Palassa at ca. 6,500 TL BP, suggesting ca. 10,000 years of morphological continuity and an undoubted phylogenetic link. Kennedy's final report is eagerly awaited, particularly concerning the racial distance between these three groups from Batadomba-lena, Beli-lena Kitulgala and Bellan-bandi Palassa. That there are strong affinities cannot be doubted; but as to quite how strong these are is a tantalising question relevant to the problem of the nature of the successive settlement of Lanka in prehistoric times by various groups moving in from India. The apparent phenotypic diversity evident in the series from Bellan-bandi Palassa (id. 1965:183) is suggestive of previous admixture among several groups of differing genetic derivation. This is scarcely surprising in view of the intimate connection, throughout prehistory, between Lanka and that repository of physical diversity, India. However, Lanka represents a *cul de sac* where earlier strata of the prehistoric gene pool in India might have survived with a greater degree of intactness than in much of the sub-continent. This generates the hypothesis that prehistoric man in Lanka, represented at Batadomba-lena, Beli-lena Kitulgala and Bellan-bandi Palassa, constitutes a reference point as regards the morphology of *Homo sapiens sapiens* in South Asia from ca. 28,500 to 6,500 BP, and, since the Vaddas are considered to be directly linked to Balangoda Man, into more recent times. The corollary is that it would be a methodological prerequisite that Balangoda Man's physical traits be a backdrop against which the physical anthropology of prehistoric man on the Indian sub-continent be viewed, at least for the late Quaternary.

*5.3.14 India and Further Afield.* As with every other aspect of prehistoric culture in Lanka, the broader context of subsistence, settlement and related traits dealt with in the present chapter sub-heading (5.3) lies in the Indian sub-continent. Hence a general examination of the data from India (and further afield) is relevant to this chapter.

With regard to the Lower Palaeolithic, the Acheulean techno-tradition has been found in most parts of India, with the exception of the following areas: Sind, Marwar (desert Rajasthan), Ganges delta in Bengal, and Assam (heavy, evergreen forest), western Karnataka, Konkan and Kerala (heavily forested), and southernmost India, south of Madura and the Kaveri river, e.g., Tinnevelly District resembling Lanka's ecozones A and F (Foote 1916:49; Sarasin 1926:110; Sultanbawa 1969:50; Sankalia 1974:50,69,70,134-5). Nearly all the Acheulean sites in India occur in regions with ready access to water (annual rainfall 750-2,500mm) and raw materials for stone tool manufacture (particularly sedimentary quartzites). Sites are very rare at above ca. 800m +msl, the so-called handaxe from the Liddar valley in Kashmir (ca. 2,200m +msl; Sankalia 1974:33,Fig.10c) being scarcely within the Acheulean techno-tradition. Although the nature of the forest cover during Acheulean times remains undetermined, there appears to have been an avoidance of heavy forests and deserts: the evidence from Africa and further afield denote a preference by Acheulean man for grassland, savanna and open woodland, as opposed to evergreen forest or desert (Collins 1969:287; Clark 1969:141; 1970:94; Butzer 1971:452-3; Isaac 1971:15; Deacon 1975:550). (For a classification of the world's vegetation zones from rain-forest to desert v. Butzer 1971:51.) Jacobson's (1975:75; 1976) investigations in the Raisen District of eastern Malwa, Madhya Pradesh, indicate a preferential location of sites near seasonal streams on open plateaux or bases of hills, but not on hill-tops or on slopes. Many of the sites are said to average ca. 2,000m$^2$ in extent. Some of the factory sites associated with scree-rich bases of hills are apparently as much as ca. 1.5ha (probably comprising palimpsests of several settlements), while smaller occurrences of "a few hundred to a few thousand square feet" are also found associated with seasonal streams (id. 1976:3). The main anomaly is the lack of Acheulean sites in southernmost India, while they are numerous around Madras at ca. 12-16° N. lat. (v. Joshi 1970:58). One possible explanation is the lack of suitable quartzite in the region of the southern tip of India; but there are other materials suitable for biface manufacture, such as chert, quartz, and even granite, in this latter area, which could have been substituted for quartzite if there was any urgency about it. Bifaces on chert are known, for instance, from Rojadi in Saurashtra and Gulbal in northern Karnataka, and on quartz from Chirki in Maharashtra and from the Bankulia, Purulia and Midnapur Districts of West Bengal (Sankalia 1970:154; 1974:74,84-5,98-101). High-quality handaxes have been made on coarse granite at sites on the Shahzad river in Madhya Pradesh (id. 1974:109) and at Chirki, and on the Orsang river in Gujarat they occur on basalts and dolerites (ibid.:84-5,93). Hence, it is very difficult to explain the absence of the Acheulean tradition in southernmost India only on the basis of the non-availability of raw materials, since, despite the marked selection for quartzite in the Acheulean assemblages of India (ibid.:88), suitable substitutes such as chert do occur in this region. (Note that Sarasin (1926:112) considered Lanka's cherts suitable for biface manufacture.) The absence of the Acheulean tradition in the Wet Zone of Lanka is paralleled by the situation in Kerala, where the heavy forest appears to have been a disincentive for the taking-root of Acheulean techno-traits. Similarly, its absence in the Dry Zone of Lanka has its counterpart in the Tinnevelly District of South India, which, as outlined above, defies explanation, except on the basis of the lack of quartzite sedimentaries in both these latter regions, as opposed to the Madras tract with an otherwise similar environment. Synthesising these two situations, it is possible to hypothesise that the Middle Pleistocene carrying capacity of southernmost India and Lanka was not sufficiently attractive for Acheulean man to sacrifice his preference for quartzite tools for substitutes on chert or quartz: the urgency for settling in these regions was not there. There appears to be a strong element of cultural choice of a "non-core" nature in the absence of the Acheulean tradition in southernmost India and Lanka.

During Middle Palaeolithic times, there seems to have been a marked extension of human settlement into previously unoccupied regions in India, as for instance into the Marwar desert of Rajasthan (Sankalia 1974:127,147,188-94,198). The occurrence of a Middle Palaeolithic industrial complex in the basal gravels of the I Fm at Sites 49b and 50a in Lanka could be an extension of this same tendency, although the hypothesised existence of a Lower Palaeolithic on the island would invalidate this proposition. Nothing is known of Middle Palaeolithic subsistence traits, apart from the single instance of a *Bos* *namadicus* skull being found at Kalegaon in Maharashtra with a flake-tool embedded in it (ibid.:146).

The Upper Palaeolithic has only recently been defined in India, and not clearly at that. Although several sites have been reported (ibid.:208), it is premature to attempt formulating a general statement as to the pattern of their distribution, adequate sampling being a prerequisite. As for subsistence traits, the caves around Betamcherla in the Kurnool District of Andhra Pradesh (Murty 1975:Fig.1) have yielded large quantities of faunal remains which were found, apparently, in association with an Upper Palaeolithic industry (ibid.:132). Murty (ibid.:134-5) lists the various animals thought to have been exploited by Upper Palaeolithic man in these caves, namely from Muchchatla Chintamanu Gavi, Pedda Pavuralla Badde Gavi and the Billa Surgam caves. As with Lanka's Mesolithic, the range of exploitation is extremely varied (if indeed these animals represent food remains of prehistoric man): langur, toque monkey, tiger or lion, the smaller cats, hyaena, sloth bear, mongoose, bats, pangolin, squirrels, hare, bandicoots and other rats and mice, crocodile, *Varanus bengalensis* lizard, python, rat-snake, cobra, and the toad *Bufo melanostictus*. The ungulates comprise wild ass, a so-called extinct rhinoceros *Rhinoceros karnuliensis, Bos* or water buffalo, nilgai, chinkara *Gazella gazella bennetti,* black buck, four-horned antelope *Tetracerus quadricornis,* sambhur, spotted deer, barking deer, mouse-deer, Indian wild pig and a now extinct pig *Sus karnuliensis.* A few molars of *Capra* and *Ovis* are also said to have been discovered at Chintamanu Gavi and Badde Gavi (ibid.:136). Unfortunately, no quantitative data have been presented, and hence it is not possible to evaluate the pattern of exploitation of this broad faunal spectrum. It is possible that some of the forms represented were incorporated in the deposits by natural causes and through the activities of carnivores, and this problem requires assaying.

The Upper Palaeolithic (C) horizon at Patne in Maharashtra (pre-geometric microlithic) has yielded over 100 fragments of ostrich shell, among which was a bead and a piece with cross-incisions (Sankalia 1974:226-8). Considering the potential antiquity of the Upper Palaeolithic in India, over 28,500 years as per the age of Lanka's geometric microlithic assemblages (Chap.3.5), it is possible that the ostrich was native to India during the Upper Pleistocene as represented by Patne Upper Palaeolithic (C). On the other hand, it is also possible that the shell fragments were imported from further afield, such as the Arabian peninsula or Africa, the present range of distribution of this bird, although it could have well have extended to the Rajasthan desert in prehistoric times (note, Upper Pleistocene ostrich in Ordos and Choukoutien Upper Cave). If the latter hypothesis be confirmed, it will point to an extensive exchange network in the Indian Ocean region during the Upper Pleistocene, which could have far ranging implications as regards the diffusion of culture traits, such as blade technology or even human migrations, in this region at over 28,500 BP, with the network extending perhaps as far south as Lanka.

The occurrences of microlithic tools in India are said to indicate a major increase in density and range of distribution when compared with the preceding Palaeolithic industries (ibid.:234). Illustrating the point concerning density are the caves, rock-shelters and open-air sites at Bhimbetka in Madhya Pradesh, where Misra (1976:43) observes a three-fold increase of Mesolithic sites over Palaeolithic ones. With regard to overall distribution of Mesolithic sites, Misra (1965:60) affirms that "whereas Palaeolithic man had largely confined himself to river banks, Mesolithic man ventured into territories away from the river banks . . .", and for the first time the densely forested regions of the lower Ganges valley (U.P.) and of Assam are known to have been inhabited by prehistoric man (T.C.Sharma 1969:pers. comm.; Misra 1976:51). While East Bengal, Nepal, the Punjab plains and western Orissa have not as yet yielded evidence of Mesolithic occupation (Sankalia 1974:233), this probably reflects sampling inadequacy in these regions: Kerala, which was not supposed have had a Mesolithic phase (ibid.), has recently produced evidence of it (P.Rajendran 1985:pers. comm.). Being less hampered by the weight of heavy tools, Mesolithic man would appear to have had much greater mobility than his Palaeolithic predecessors. However, it is noteworthy that whereas certain areas bear traces of Palaeolithic occupation, Mesolithic sites are conspicuously lacking (e.g., the Malwa plains; Jacobson 1976:6). Jacobson (ibid.) affirms, with regard to the Malwa plains, that "it is not known to what extent these differences through time [i.e., Palaeolithic vs. Mesolithic settlement] were conditioned by changed environmental factors or exploitation techniques".

A lighter tool kit would have extended Mesolithic man's mobility, away from the sources of raw materials, and possibly increased his ability to exploit quick small game as opposed to slow-moving big game. This would have enhanced the carrying capacity of a given region, which was apparently reflected in an increase in site (?population) density. The one factor that would have persisted as a major obstacle to settlement was lack of water. It is noteworthy that the desert regions of Marwar have not yielded Mesolithic artefacts (Sankalia 1974:23,259-60). In Rajasthan most of the sites are in Mewar, especially in the Berach basin, where water is accessible unlike in Marwar (Misra 1976:29). In Pakistan, only a few sites have been reported (e.g., Jamalgarhi cave, north of Peshawar, and some sites near Rawalpindi (id. 1965:59)), but this is probably due to sampling deficiencies.

The above outline of the distribution of microlithic assemblages in India suggests that Mesolithic man had settled in practically every ecozone of India except in the waterless deserts and at very high altitudes in the Himalayas. Further investigations will undoubtedly fill in any existing lacunae in the rest of the sub-continent.

With regard to subsistence strategy, the Mesolithic in India, as in Lanka, has been defined solely on the basis of its (aceramic) microlithic technology. The dating of the Indian Mesolithic is far from secure (Chap.3.5), there being few radiocarbon dates on charcoal, the most reliable being the ones on charcoal for Baghor in Madya Pradesh (and perhaps on burnt bone for Bagor and for Sarai Nahar Rai). The identification of the Mesolithic in the field is made extremely problematic by the survival of a significant component of geometric microliths into the Chalcolithic and protohistoric Iron Age of peninsular India – as at Langhnaj III, Bagor II and III, Adamgarh, Putti Karar shelters, Morhana Pahar and Tilwara (Sankalia 1974:251-2,258,262). While Chalcolithic people, for instance, showed a preference for chalcedony and agates for their implement manufacture (ibid.:233), this distinction in the raw materials employed by the Mesolithic and Chalcolithic peoples is by no means an infallible way of isolating the respective technological phases. Concerning subsistence traits, the data stem from a mere handful of sites, primarily Langhnaj, Sarai Nahar Rai, Adamgarh, Bagor and Tilwara, and these may be set out as follows (for $^{14}$C dates v. Chap.3.5).

The middle and lower levels, combined, at Langhnaj have been dated to ca. 4,000 $^{14}$C BP (uncharred bone). Remains (frequently calcined) of the following animals are said to represent food refuse of (technologically) Mesolithic man at this site (ibid.:257; Misra 1965:64-5; 1976:31; Clutton-Brock 1965:4; Thomas 1975:323-4): rhinoceros (*R. unicornis*), pig, nilgai, spotted deer, hog-deer (*Axis porcinus*), swamp deer (*Cervus duvauceli*), black buck, mongoose, squirrel, rats, terrapin and fish. Bones suspected of belonging to *Bos* and water buffalo await proper identification: the so-called cattle could in fact represent nilgai antelopes (Zeuner 1952:1). The Allchins (1974:63), however, do not rule out the possibility of the occurrence of pig, cattle and water buffalo domesticates at this site in view of its relatively recent age falling well within the Chalcolithic period of neighbouring regions (note finds of hand-made pottery and a copper knife at Langhnaj (v. Corvinus and Kennedy 1964:46; Sankalia 1974:252)). Despite suspicions of cannibalism having been prevalent, this theory has been discounted by Kennedy on the basis of the morphology of certain human skull remains (Sankalia 1965*a*:69). The nature of the charring on the bones indicates roasting in an open fire. Quantitatively, examination of a limited sample has revealed a clear predominance of bovines (Clutton-Brock 1965:25; Misra 1976:31). The relatively high modal age at death of the humans discovered, 30-40 years (Erhardt and Kennedy 1965:5,43), suggests a diet that was not too deficient in nutritional requirements. The occurrence of caries in the teeth of one of the individuals (ibid.:46) is possibly indicative of a soft diet, high in carbohydrates, although this hypothesis must be viewed with some circumspection in the light of the incidence of caries in Rhodesia Man (Broken Hill) at ca. 110,000 BP (amino-acid; Clark 1950:64; Le Gros Clark 1965:114). The disçovery of a stone "mace-head" could imply the use of digging sticks (?for agriculture). There is apparently no shift in the composition of the fauna exploited throughout the occupation at Langhnaj (Clutton-Brock 1965:2). *Dentalium* tusk-shell beads found in the so-called Mesolithic horizon highlight contacts with the littoral of the Arabian Sea (where such artefacts are said to have been common at ca. 8,000 BP (Sankalia 1974:255)).

The open-air site of Sarai Nahar Rai, U.P., has been dated to ca. 2,950 $^{14}$C BP (charred bone), the date of ca. 10,350 BP on uncharred bone being suspect. Excavations at this site have yielded elephant, *Bos indicus*, water buffalo, possibly gaur and rhinoceros, sheep, goat, terrapins, fish and lacustrine molluscs (ibid.:239; Misra 1976:50). The *Bos indicus* is thought to have been exceptionally large, and it is suspected that it belonged to a wild form, although this is somewhat doubtful in view of the relatively recent age denoted by the radiocarbon date. Similarly, it is likely that the sheep and goat in the assemblage represent domesticated forms.

Excavations in the rock-shelter ADG 1 at Adamgarh, U.P., produced geometric microliths and pottery in association with a faunal assemblage (Allchin and Allchin 1968:83; Sankalia 1974:258-9; Thomas 1975:322; Misra 1976:45-6). The last comprises approximately 50 per cent domesticates: dog, humped cattle, water buffalo, sheep, goat and pig. The wild species comprise ass, spotted deer, swamp deer, sambhur, porcupine, hare and the monitor lizard *Varanus grisius*. The dating of this site is insecure: ca. 7,450 $^{14}$C BP (shell), ca. 2,850 $^{14}$C BP (uncharred bone) (Misra 1976:46). There seems little doubt but that Adamgarh should be classified as post-Mesolithic, both technologically (pottery) and in terms of its subsistence base (50% domesticates), and it is rather strange that it should have been categorised as Mesolithic in the literature. A similar situation is true of the open-air site of Tilwara in Rajasthan (excavated but undated; ibid.:34; Sankalia 1974:274; Thomas 1975:326-7). A very small sample of animal bones, some of them charred and in association with hearths, was found with microliths and fragmentary wheel-made pottery at this site. Once again there is a very conspicuous component of domesticates comprising humped cattle, goat, pig and possibly dog, together with wild spotted deer, hog-deer, mongoose, an equid and molluscan remains. Cattle bones are predominant. Small clay balls found at Tilwara could have served as missiles in pellet-bows, and the querns might have been used for grinding cereals.

The open-air site of Bagor in Rajasthan is relatively securely dated: Phase I "Mesolithic" (with comminuted pottery), ca. 6,430-5,230 $^{14}$C BP (charred bone), Phase II Chalcolithic, ca. 4,700-4,060 $^{14}$C BP (charred bone) (Sankalia 1974:264; Misra 1976:37). Some 72 per cent of the bones identified (n = 2,266) came from Phase I (Thomas 1975:325-6; Misra 1976:37) and of these domestic sheep/goat (probably mostly sheep) accounted for ca. 64 per cent while domestic humped cattle constituted ca. 16, pig 4 and water buffalo 0.8 per cent respectively. The wild components comprised black buck and chinkara (ca. 4%), spotted deer (ca. 5%), sambhur (ca. 4%), hare (ca. 0.6%), fox (ca. 0.5%), mongoose (ca. 0.8%), terrapins and fish. The relative proportions in Phase II were similar to those of Phase I, with domesticates being predominant, although there is some uncertainty with regard to the separation of sheep/goat from black buck. Approximately 70 per cent of the bones in Phase I display traces of burning and several bear cut-marks. The sheep/goat category appears to have been selectively culled at 2-3 years, whereas cattle seem to have been killed at all ages although with a slight selection for young animals. The pigs may or may not have been domesticated, and possibly both wild and domestic forms are present. Among the wild elements, such as sambhur and spotted deer, there has been no selection in terms of age. Some of the querns found in Phase I (Sankalia 1974:261) could have been used for processing cereals and/or grinding ochre.

The picture presented by Bagor I is similar to that from Adamgarh: a culture that was technologically predominantly microlithic, with possible pottery association, and a subsistence strategy that included a prominent stock-raising component. The applicability of the term Mesolithic to Bagor I is somewhat dubious.

Having thus dealt with the substantive data concerning subsistence practices in "Mesolithic" India, the indirect evidence may now be considered. The early dates for farming at Bagor I appear to be corroborated by floral data from Lakes Sambhar, Didwana and Lunkaransar in western Rajasthan (Singh 1971; Agrawal and Kusumgar 1974:64; Gupta 1974:646-9). The occurrence of charred wood fragments from ca. 9,500 $^{14}$C BP onwards at these localities has been interpreted as beingrepresentative of deliberate burning of forests by prehistoric man, and the appearance of cerealia pollen at ca. 8,500 BP could signify cereal cultivation by swiddening, although there is the possibility that the grasses were in fact wild. It is noteworthy that the ceramic phase on the Belan, U.P., has been dated to ca. 10,000 BP (Thapar 1985:40-2) and Koldihwa on the Belan near Allahabad, supposed to be Neolithic with domesticated rice, has a radiocarbon date of ca. 8,000 BP (Agrawal et. al. 1975:3). These dates are not too out of line, considering the dates for the Afghan Neolithic: Ghar-i-Mar with domestic sheep and goat, ca. 9,000 $^{14}$C BP (Agrawal and Kusumgar 1974:63-5); Aq Kupruk I, with sickle blades among the flint assemblage, had sheep and goats at ca. 10,000 BP and cattle by ca. 8,000 BP (Dupree 1973:258;262; 1974:199).

In southern India, peat cores in the Nilgiri highlands are said to bear traces of extensive burning (Spate and Learmonth 1972:77) and pollen data from Kakathope (Vishnu-Mittre and Gupta 1971; Chanda and Chatterjee 1974:613) point to the presence of grasslands at over 38,000 $^{14}$C BP. It is noteworthy that these grasslands in the highlands of southern India are considered to be the result of human interference with the natural montane forest cover (Spate and Learmonth 1972:74,87) involving periodic burning and (in recent times) pastoral activities. It is probable that the forests were first fired by Palaeolithic man at a date prior to 38,000 BP to drive game. This is of direct relevance to the subject of the origin of the highland *wet patana* and upland *dry patana* grasslands of Lanka which could be of similar antiquity.

The above discussion of prehistoric subsistence practices in India serves to highlight the fact that the Mesolithic is ill-defined both technologically and chronologically and that farming activities seem to have a very early inception (? >9,500 BP) on the sub-continent. On the other hand, non-farming, hunting and gathering communities have survived up until very recent times as relict tribes in India (Misra 1976:40). Gordon (1958:16) summarises the scene:

> The words Mesolithic and Neolithic, used by archaeologists as terms of convenience to denote the Middle and New Stone Ages, have little real chronological significance when dealing with a large area like India. Recognising that these terms are now more generally used to define modes of living rather than those of preparing stone implements, two features must be taken into consideration: that transitions from one mode to another were not clean cut, the marginal stages must be somewhat blurred with food production and stock keeping at a very primitive level, and that these various

modes of life and stages of development persisted side by side in varying conditions of environment. Man in India in fact continued steadily up the ladder of progress, but some communities made little or no progress at all.

None of the so-called Mesolithic sites investigated so far in India (with the possible exception of Baghor, M.P.) has yielded reliable data on non-farming prehistoric subsistence traits, and hence it is not possible to compare Lankan Mesolithic assemblages with their Indian counterparts. Conversely, Lanka has yet to produce evidence of a pre-Iron Age farming phase comparable, for instance, to Bagor or Adamgarh. It can hence be concluded that the Indian data do not serve to enhance our perception of Lanka's prehistoric subsistence practices to any appreciable extent.

With regard to settlement, Mesolithic sites are ubiquitous in India, with the exception of the Thar desert where the lack of water made subsistence impossible, and in the high-altitude Himalayas. The sites occur in caves and rock-shelters (e.g., in the Vindhya and Kaimur ranges in U.P. and M.P.), desert dunes (e.g., Langhnaj, Bagor), coastal dunes (e.g., Tinnevelly), alluvial tracts (e.g., Sarai Nahar Rai), tidal creeks and mangrove swamps (e.g., Salsette Island) and on open rocky areas, usually factory sites (e.g., southern Rajasthan, Karnataka) (Mohapatra 1962:122; Misra 1965:60-1; 1976:29,32-5,40,47-8,51; Joshi and Bopardikar 1972:55; Sankalia 1974:259-60; Joshi 1975:11). There is no doubt that microlithic technology increased the mobility of Mesolithic man as compared to his Palaeolithic predecessors with their heavier tool kit (Jacobson 1976:5): at Sarai Nahar Rai the raw material source has been located some 40km away in the Vindhyas (Sankalia 1974:239; Misra 1976:47). It is this increased mobility that is reflected in the relative proliferation of Mesolithic sites.

As for site size, the Mesolithic component at Langhnaj has been excavated over an extent of ca. 1,280m$^2$ (Sankalia 1974:251) and Bagor I is known to be at least 6,400m$^2$ (ibid.:261), with Sarai Nahar Rai being estimated at ca. 2,000m$^2$ (Misra 1976:49). Birbhanpur (Lal 1958; Allchin 1966:88; Sankalia 1974:235) is also said to be a very large site. At all these localities it is not clear whether a single occupation component or palimpsests of several are involved. However, they do appear to represent much larger settlements than are modal (ca. 50m$^2$) for Lanka's Mesolithic, regardless of whether they are palimpsests or not; which, in the cases of Langhnaj, Bagor and Sarai Nahar Rai, could be attributed to the increase in carrying capacity which would have been a concomitant of stock-raising as opposed to a purely hunting and gathering subsistence strategy. The Mesolithic open-air sites (n=51) investigated by Jacobson (1975:77; 1976:5) in Raisen District, M.P., are thought to have been factory sites, although most of them are situated some distance away from the sources of raw material. These sites are said to range in extent from ca. 5 to 1,000m$^2$, with a mean of ca. 700m$^2$. Being factory sites, it is very likely that the larger ones represent raw material extraction and primary knapping over a long time-span and that they comprise palimpsests of several components, akin to the factory sites on the *vembus* of the Iranamadu Formation in Lanka (e.g., Site 40). Mesolithic habitation (as opposed to factory) sites in southern Rajasthan are said to range from 25 to 100m$^2$ (Misra 1967:107; Jacobson 1976:5), which is in excellent agreement with the site extents typical of Lanka. The rock-shelters with Mesolithic deposits in the Bhopal-Raisen area are thought to have been capable of providing living space for up to ca. 40 persons per shelter, with an average of about 4 per site (Jacobson 1976:5).

As for seasonality, the prime determinant of permanence is likely to have been the availability of water. In this regard, the large number of open-air sites associated with the dunes of Rajasthan and Gujarat with their rain-fed natural ponds would have been seasonal camps, with the population moving to wetter regions during the droughts when the water supply would have dried up. Permanent base-camps could always have been maintained at locations with a perennial availability of water, as on the river alluvia of Nimbahera in Rajasthan (Sankalia 1974:260; Misra 1976:35). Extraction camps in the drier regions of peninsular India, such as Rajasthan and Madhya Pradesh, could only have been habitable during the rainy seasons (v. Jacobson 1975:77; Misra 1976:35), and as Jacobson (1976:5) affirms, "a likely 'merging season' in a central-based wandering pattern . . . could have been the Monsoon rains". In Lanka, a parallel situation is likely to have existed in ecozones A and B, particularly with regard to the exploiting of the quartz gravels of the I Fm and the marine resources of the adjacent prograding coasts.

With regard to features observed in the so-called Mesolithic sites of India, the following may be enumerated:

(*a*) Post-holes at Birbhanpur (Lal 1958; Sankalia 1974:235)

(*b*) Hearths, with faunal remains, within circular stone arrangements averaging 2.25-3m in diameter, at Tilwara (Misra 1976:34).

(*c*) Stone-paved floors, ranging up to $200m^2$, circular stone arrangements averaging ca. 3-5m in diameter, and compactly paved areas of ca. 0.4-0.7m in diameter with a high concentration of faunal remains, at Bagor (Sankalia 1974:261,268).

(*d*) Four hearths, ranging from 0.2 to 1m in diameter, dug into a floor of ca. $23m^2$ of rammed burnt clay in a depression circumscribed by four post-holes, at Sarai Nahar Rai (ibid.: 239-40; Misra 1976:50).

(*e*) Stone cairns and single walls which are possibly coeval with the Mesolithic open-air sites of Raisen District, M.P. (Jacobson 1975:77; 1976:4).

(*f*) Circular stone alignments at Erangal, on the coast near Bombay (Allchin 1966:95)

These data do not suggest large communal dwellings, with the possible exception of Bagor. As in Lanka, most features appear to represent the activities and spatial requirements of single nuclear family units.

The trading network of Mesolithic man in India is a nebulous entity. The ostrich shell fragments (n=>100) found with the Upper Palaeolithic (C) at Patne (Sankalia 1974:226-8) could conceivably represent importation from as far as the Arabian peninsula, although a *Struthio* sp. could well have lived in the desert regions of northwest India and further afield during the Upper Pleistocene. Then there are the tusk-shell (*Dentalium*) specimens which have been found at Langhnaj (ibid.:254-5). These could have had their provenance in the Arabian Sea, not far from the site. Oxygen isotope analysis on these shells could conceivably provide data as to their origins (v. Shackleton and Renfrew 1970); but despite the popularity of tusk-shells in the eastern Mediterranean at 9,000-7,000 BP, the significance of their occurrence at Langhnaj is difficult to evaluate in terms of prehistoric trade. They are still esteemed as ornaments in the Andaman Islands where they are harvested and processed (Chap.6.8.4).

Stone tools, pottery and metal artefacts could have been bartered between Neolithic and Chalcolithic communities on the one hand and peripheral Mesolithic groups on the other (Allchin and Allchin 1974:65). The two celts on chlorite schist found at Langhnaj (Sankalia 1974:254) appear to have been imported from a considerable distance. However, most of the basic raw material sources for stone tool manufacture seem to have been situated at no great distance from the base-camps: ca. 5 km for the sources of chalcedony in the Raisen District (Jacobson 1976:4-5); quartzite hammer-stones from 20-30km and sandstone grindstones from ca. 50km at Langhnaj (Sankalia 1965*a*:39); quartz at Sarai Nahar Rai from ca. 40km (id. 1974:239). But the very large factory sites (?in palimpsest) of Madhya Pradesh, spanning the Middle Palaeolithic and the Mesolithic, as at Pandav Falls (ibid.:185), could have been nodal to an extensive network of distribution of raw materials. The morphological traits of Mesolithic stone tools in the interior of peninsular India apparently suggest relative insularity of these communities with respect to the coastal techno-traditions (Allchin 1966:99).

Concerning prehistoric art in India, the sandstone hills of Madhya Pradesh, from Bhopal to the west to the eastern limit of the province, has numerous (literally hundreds, e.g., around Bhopal itself) caves and rock-shelters. Many of these have deposits with microliths, and some have paintings and drawings in ochre. Some 500 caves and shelters in Raisen District contain on their walls and ceilings paintings dating possibly from as far back as the Mesolithic down to the mediaeval period (Misra 1976:42). However, while there are suspicions that some of these paintings are coeval with the Mesolithic, as at Bhimbetka IIIF-23 (ibid.:44), so far it has not been possible to assign them to an indubitably pre-ceramic horizon (Sankalia 1974:257-8). Abraded pieces of yellow and (mostly) red ochre in Mesolithic deposits (e.g., at Bhimbetka IIIF-23 (Misra 1976:44), Langhnaj (Sankalia 1965*a*:39), Bagor (id. 1974:261) and other coloured minerals (Bhimbetka IIIF-23) could represent some of the pigments used on the paintings.

Apart from cave art, as exemplifed in Madhya Pradesh, some engravings in basalt surfaces between Ganeshkhind and Dhone, east Poona, have been suspected of being prehistoric (ibid.:247). Art in any other form has not been found in the pre-ceramic horizons of India's Stone Age, and it is noteworthy that this situation prevails in Lanka as well. Beads and pendants found in pre-ceramic contexts could be considered to represent an incipient phase in the development of three dimensional art: e.g., pendants on teeth at Billa Surgam (ibid.:209), disc-beads on ostrich shell at Patne (ibid.:226-8), bone pendants and stone beads at Bhimbetka IIIA-28 (Misra 1976:44), stone beads at Langhnaj (Sankalia 1965*a*:41), and stone and bone beads at Bagor I (Sankalia 1974:270). In Lanka this is paralleled by the occurrence of bone and shell beads in the Mesolithic of Beli-lena Kitulgala and Batadomba-lena respectively from ca. 28,500 BP onwards.

The mortuary practices and physical traits of India's so-called Mesolithic man are varied, which is scarcely surprising considering the lack of resolution with regard to the technological and chronological status of the assemblages investigated so far (Chap.3.5). The following listing will suffice to demonstrate the range of variability:

(*a*) Langhnaj (Erhardt and Kennedy 1965:1,3,7,9,13-21,29-38,43-8,72-3; Misra 1965:65,80; 1972:64; 1976:31-2; Sankalia 1965*a*:12,15; 1974:255-7,354): Culture, ?pre-ceramic "Mesolithic"; sample, 14 individuals; burials, no pits visible due to sandy matrix; bones not calcined; interments possibly secondary and fractional; position, very tightly flexed except in one instance; orientation, east-west; grave goods and ritual, the skeleton of an Indian wolf with its skull crushed lay ca. 70cm from one of the skeletons, and one of the human skulls appears to have been trepanned.

The physical traits of Langhnaj man have been described in general terms on the basis of the analysis of skeletons I-XIII (Erhardt and Kennedy 1965:43-6): stature, 158, 167, 174cm for skeletons XII, III, V respectively; gracile; cranium, hyper-dolichocephalic; relatively large cranial capacity, approximating to that of an average modern European; broad forehead, ranging from vertical to inclined; depressed nasal root in some; short, broad nose with flat bridge; medium to low face-height; only skeleton III has pronounced superciliary ridges; cheek bones, medium robusticity; orbits, rectangular; mandible, with a protruding chin as in that of a European; alveolar prognathism in some; bite, edge-to-edge.

Skeleton XIV, excavated by Kennedy (Erhardt and Kennedy 1965:63-70), was found in association with thrown pottery but is considered to be anthropometrically similar to the rest of the skeletal series from Langhnaj. Its salient features are said to be as follows: fully adult (25-30 years); stature, ca. 166.5cm; skull, dolichocephalic, vertical forehead, massive superior nuchal crest and zygomae, low nasal root, shallow canine fossa, large palate with marked alveolar prognathism, very large mandible with deep corpus and moderately projecting chin and without alveolar prognathism; uncrowded dentition, with slight shovelling in maxillary incisors. Erhardt and Kennedy (ibid.:48,72) summarise by stating that the skeletons are predominantly Mediterranid with Vaddid (?Balangodan) racial features; and Kennedy (1973:38-9) affirms that the Langhnaj people had "a skeletal anatomy very much like the inhabitants of north-western India from the period of the Harappan Civilisation to the present day".

(*b*) Bagor I (Misra 1972:60-3; Sankalia 1974:261,269; Thomas 1975:324): Culture, ?pre-ceramic "Mesolithic"; sample, 5 individuals; burials, in living floor with habitation debris piled over them and new floors constructed over them by strewing sand and stones; position, extended, supine (flexed in Bagor II); orientation, northwest-southeast; grave goods, none observed; physical traits, indeterminate, sample too fragmentary for analysis.

(*c*) Sarai Nahar Rai (*IAR* 1968/69:40; Gupta 1972:29; Sharma 1973:138-9; Sankalia 1974:239; Misra 1976:49-50): Culture, ?pre-ceramic "Mesolithic"; sample, 24 individuals; burials, clusters of graves in low mound, at times with small tumuli over them; position, extended, with one forearm diagonally across body; orientation, east-west (head to west); grave goods, microliths and shells, microliths found in hip girdle of one skeleton; miscellaneous, backed bladelet found piercing ribs in one case; physical traits, no data.

(*d*) Lekhahia Shelter RS 1 (Ghosh 1967:52-3; Gupta 1972:19-21; Kennedy 1973:31; Sankalia 1974:237-9; G.R.Sharma in Leshnik and Sontheimer 1975:77-8; Misra 1976:41-2): Culture, ?pre-ceramic microlithic; sample, 17 individuals; burial, secondary (4 skulls missing, but possibly primary, poorly preserved) in oblong pits, often superimposed on each other (?8 phases), in habitation deposit of interior of shelter; position, extended, supine; orientation, east-west (n = 15), north-south (n = 2); grave goods, ochre and lateritic nodules with 5 skeletons; physical traits, mostly indeterminate due to poor preservation, very robust, large stature, probably dolichocephalic.

Two fossilised "pre-Mesolithic" human skulls were found in a pit in the shelter, in association with a fossilised mandible of an animal. These obviously represent fractional interments.

(*e*) Bhimbetka IIIA-28 (Misra 1976:44): Culture, Mesolithic; sample, 1 adult (fragmentary); burial, interred; grave goods, microliths, disc-beads, nodules of yellow ochre and other coloured minerals; physical traits, no data.

The above data correspond with those from Mesolithic mortuary contexts in Lanka with respect to (*a*) the occurrence of inhumations within the main habitation deposits (e.g., Lekhahia RS 1, Bagor I); (*b*) the flexed burials at Langhnaj; and (*c*) the fractional interments in the pre-Mesolithic of Lekhahia RS 1. Apart from these random parallels, which might or might not represent links in mortuary practices between Mesolithic Lanka and "Mesolithic" India, there is nothing in the extant data which would serve as a premise for further inference.

As for the physical traits of India's Mesolithic, those of the Langhnaj specimens are the only ones to have been investigated in any detail. The general impression is one of considerable heterogeneity. The "Vaddid" traits in Langhnaj man (e.g., in cranial features) have their correlates in Balangoda Man and there is a case for hypothesising that there is indeed a phylogenetic link between the two populations. But the correlation must perforce stop at this: the apparent chronological distance between these two sets of data is wide and Chalcolithic influences are evident in the case of Langhnaj which might have had corresponding repercussions on the genetic composition of Langhnaj man.

Enquiring into the broader geographical context of prehistoric human settlement of the Indian sub-continent, the Himalayan mountain range to the north would have presented an almost impenetrable physiographic and climatic barrier. To the northeast, the north-south trending mountain ranges (e.g., Naga hills) extending through Burma into Southeast Asia, would not have been quite so formidable a barrier as the Himalayas. However, the deeply dissected physiography and the high rainfall (Assam: >3,000mm per annum) with its attendant dense rain-forests would scarcely have been attractive as a prehistoric thoroughfare, although there have been some population movements into India via this terrain in protohistoric and historical times. This leaves the north-western flank of the sub-continent as the primary region of transit between the rest of the world and India – as firmly attested on numerous occasions in protohistoric and historical times – which manifested itself usually as movements into the sub-continent from the northwest, as opposed to outwards: India has been a zone of attraction. There are numerous passes from Afghanistan and Iran which have historically provided easy access to the Indian plains from West and Central Asia: Kurram and Khyber (from Kabul), Bolan (from Kandahar and Quetta), Gomal (north Pakistan), Kej and Dasht (south Baluchistan), and also the inhospitable coastal lowlands of the Makran. With due allowance being made for Quaternary environmental shifts as they might have affected human settlement, it can be assumed that these routes functioned as arteries of human mobility during much of the Quaternary. The only aspect which need not have conformed to the protohistoric and historical pattern is that the movement out of the Indian sub-continent into West Asia, and perhaps Central Asia, could have been more extensive in prehistoric times – although there is no evidence as yet to support this speculative hypothesis, and the indications are that even in Acheulean times India was a zone of attraction as opposed to Iraq and Iran.

Despite the sparseness of reliable dates for the Lower Palaeolithic of India, the Upper Acheulean techno-tradition would appear to have arrived from the west, whether by physical immigration or stimulus diffusion, perhaps only slightly subsequent to the appearance of this technological phase in East Africa at ca. 700,000 BP. (Claims that a Lower Acheulean occurs at Mahadeva Piparia in Narsimhapur District in India (Sankalia 1970:154) are questionable.) However, there is a remarkable dearth of information on Acheulean occurrences in Iraq (possibly present at Barda Balka), Iran (Smith 1971) and Afghanistan. The elevation of the Iranian plateau at over 1,200m +msl was possibly not very conducive to the manifestation of the Acheulean techno-tradition – note that in India it scarcely ever occurs at above ca. 750m +msl. It is probable that the Acheulean tradition reached India from Arabia (where it is well represented) via the coastal tract of Iran during periods of low sea level and that these sites either await discovery or are now submerged.

I have tentatively proposed an Eem, possibly Riss, lower age boundary for the Middle Palaeolithic techno-tradition of India (Chap.3.2.4). Stylistically it is scarcely possible to state if it was primarily a local development or the result of external impulses. The Middle Palaeolithic stone tool industries of Iraq, Iran, Afghanistan and Soviet Central Asia are characterised by the absence of an Acheulean biface component. The Levallois technique has been employed only occasionally in these regions – although it has been observed beside the Deh Luran plain (Hole and Flannery 1967), and at Bisitun (Coon 1951), Ke Aram I (McBurney 1964) and Teshik Tash (Movius 1953). According to McBurney (1964), the nearest typological correlates of this complex occur in the Mousterian industries of the Transcaucasus and eastern Europe. The common factor of asymmetrical triangular points with a plano-convex cross-section is considered by him to be significant, in that these are absent in the Levalloiso-Mousterian of the Levant, which, as its designation implies, comprises a strong Levallois element.

However, in India, the presence of a Middle Palaeolithic which at times includes a conspicuous proportion of small bifaces in the Acheulean tradition and of Levallois elements suggests a link with the Levalloiso-Mousterian of the Levant. It is possible that this postulated "link" signifies the diffusion of cultural (and perhaps genetic) traits between the Levant and India along the coastal plains – much as the Acheulean might have diffused – while the rest of Iraq, Iran, Afghanistan and Soviet Central Asia formed a distinct cultural zone with Transcaucasian and eastern European connections. This view is highly speculative due to the scant data base, but deserving of note. However, it is also to be borne in mind that inferring population movements on the basis of correlations of generalised techno-traits is methodologically fraught with hazard.

The Upper Palaeolithic techno-tradition of India is as yet too ill-defined chronologically as to warrant correlation with industries outside the sub-continent. But it would be surprising if it had no phylogenetic link with the blade traditions of West Asia, notably the Baradostian of Iran. Blade technology is too specialised a trait to have sprung up independently in two loci as closely situated as Iran and India – particularly since there are no major environmental barriers between the two zones. As for the westerly affiliations of the Baradostian, not much can be said at the present juncture: there are possible links with the Upper Palaeolithic tradition of the Transcaucasus (e.g., Virchow's Cave; also v. Smith 1971:690), which in turn has been correlated with industries on the Mediterranean littoral (v. Sulimirski 1970:14-5).

As indicated in Chapter 5.2.12, the lower age boundary of geometric microlithic technology in India is as yet unknown. However, considering the date of ca. 28,500 $^{14}C$ BP from Lanka for geometric microliths and the compatibly early dates from Iran and Iraq (e.g., in the Baradostian of ca. 35,000-27,000 $^{14}C$ BP at Shanidar), it is probably simply a matter of waiting for comparable dates to emerge from India. Assuming that this will be the case, it will require a great deal of chronological resolution, coupled with a fine-combed lithic classification on a comparative basis, before it will be possible to conceptualise on the rise of geometric microlithic technology in this region – be it by diffusion or convergent evolution. East of India and Lanka, the present evidence, meagre as it is, suggests progressive diffusion eastwards of geometric microlithic technology until it reached Australia at ca. 5,000 BP (Mulvaney 1969:111-2; 1975:230,236) via the Andaman Islands (e.g., found in shell middens on Beehive Island (Dutta 1966)), the Bandung Plateau in Java, caves in southern and central Sumatra, and south-western Sulawesi (6,000 $^{14}C$ BP) (v. Glover 1973:61). It has been suggested that the dingo reached Australia at ca. 8,000 BP in association with the introduction of geometric microlithic technology through the "actual movement of people eastwards out of India" (ibid.:51; also v. ibid.:61; Mulvaney 1975:138,211). The recently extinct Javanese Tengger dog is thought to have been ancestral to the dingo and an Indian dog is said to be another such animal. It is significant that Deraniyagala (1965:187,193) remarks on the close similarities apparent between the dogs of the Congo, New Guinea and the Sinhala hound of Lanka. It is thus tempting to see a phylogenetic continuum in the microlithic tradition from Africa to Australia (and Africa and northern Europe), but this can only be considered speculation based on the flimsiest of evidence and should be regarded as such for the present.

There is no doubting the fact that India witnessed a series of technologically evolutionary steps on the European model: Upper Acheulean → Middle Palaeolithic → Upper Palaeolithic blade industries → geometric microlithic Mesolithic. As indicated above, it is as yet premature to hypothesise on the processual aspects of this technological evolution, despite an intuition that the primary impulses arrived in the sub-continent from the west. With regard to subsistence strategy, the Indian data are totally inadequate for reconstructing pre-farming economies. All the technologically Mesolithic sites to have yielded data on subsistence appear to have a farming component, as in Bagor I. However, the evidence from West Asia and Africa suggests that there was no major shift in subsistence strategy from the Middle Palaeolithic to the Mesolithic technological phases. While it is probable that the bulky Acheulean tool kit was particularly adapted to exploiting large, slow-moving animals, such as elephant, hippopotamus and bovines, the introduction of lighter (faster) tools with the advent of the Middle Palaeolithic seems to have resulted in the hunting of a wider spectrum of animals with a significant small fauna component – a configuration which persisted into the Mesolithic. There is no evidence in Iraq, Iran or Afghanistan of a major shift into stressing the exploitation of shellfish, as opposed to the hunting of ungulates, with the advent of the Mesolithic, as has traditionally been inferred for northern Europe. (These West Asian data stem from Shanidar in Iraq (Middle Palaeolithic to Mesolithic; Solecki 1966; 1971; Smith 1971:690), the Khorramabad sites, Belt and Ali Tappeh caves in Iran (Coon 1951; 1957; Hole and Flannery 1967:162-3,198; McBurney 1969), Aq Kupruk II and Kara Kamar in Afghanistan (Coon 1957; Dupree 1972), and also Djebel and Dam Dam Chashma I and II in Soviet Central Asia (Masson and Sarianidi 1972). Although it has been suggested that there was an increase in the exploitation of shellfish and other aquatic forms from the Middle Baradostian ( >25,000 $^{14}$C BP) onwards in the case of Yafteh in Khorramabad (Hole and Flannery 1967:162) and in the Mesolithic Zarzian of Iraq (Smith 1971:692), the subsistence pattern apparently did not undergo any major change in the transitions from the Middle to the Upper Palaeolithic and from the latter to the Mesolithic: the predominance of ungulates such as auroch, sheep, goat, deer and onager continued. A similar picture emerges from tropical and sub-tropical Africa (Isaac 1971:14-5) and from the more southern parts of Europe, such as Sered I in Czechoslovakia (Barta 1973:57-62; also v. Butzer 1971:537-8). This, it is hypothesised, was also probably true of India. Hence the progressive evolution in technology appears to have been symptomatic of factors far more complex than a simple one-to-one correlation with changes in subsistence practices. Although there is some evidence to indicate that from the Upper Pleistocene onwards an increasing proportion of small fauna, such as invertebrates, were being exploited, this appears to be more apparent in the higher latitudes than in tropical and equatorial regions such as Niah Cave (ca. 30,000 BP onwards) and Batadomba-lena (ca. 28,500-11,500 BP).

It has been mentioned (Chap.5.3.10) that the modal extent of the Mesolithic settlements of Lanka approximates around 50m$^2$. The Indian sites, such as Birbhanpur, Langhanj ( >1,280m$^2$) and Bagor I (>6,400m$^2$), are described as being considerably larger, and it may be inferred that this reflects, in large measure, the increase in carrying capacity of a given site-territory that would have been a concomitant of a change from a hunting and gathering subsistence strategy to one with a farming component. Hence the Indian data are not relevant to a study of Lanka's Mesolithic settlement and it is therefore advisable to look further afield for sites representing a purely hunting and gathering subsistence economy; and the following instances may be considered:

(*a*) Oldowan (Zinjanthropus) floor at Olduvai Gorge: ca. 7×5m=35m$^2$ (Leakey 1971). Another floor has been described as being ca. 300m$^2$ (Clark 1970:94). Most Oldowan sites in East Africa range from ca. 50m$^2$ to ca. 175m$^2$.

(*b*) Olorgesailie's Upper Acheulean base-camp areas: ca. 175-300m$^2$ (Isaac 1966:142; 1969:9)

(*c*) Acheulean at 'Ubediya, Israel, probably of late Matuyama age: ca. 200-500m$^2$ (id. 1975:878; Bar-Yosef 1975:597).

(*d*) Upper Acheulean hearth at Kalambo Falls: ca. 1m in diameter (Clark et al. 1969); Baradostian hearths at Shanidar: 0.5-3m in diameter (Solecki 1966; 1971).

(*e*) Upper Palaeolithic open-air sites in the Ukraine, e.g., Timonovka, Pushkari I, Pogon: ca. 25,000-80,000m$^2$ (Sulimirski 1970:19).

(*f*) Early and Middle Mesolithic base-camps in the northern Netherlands: 20.5×13m (=267m$^2$) – 40×26m (=1,040m$^2$), while Final Mesolithic settlements (de Leian-Wartena Complex) average ca. 2,730m$^2$. The extraction camps of the Early and Middle phases range from ca. 8 to 35m$^2$ (Newell 1973:402-3).

(*g*) Mesolithic settlements of the Ostromer Group in Bohemia (ca. 10,000 BP): ca. 25m$^2$ (Vencl 1966*a*:338-40).

(*h*) Mesolithic Capsian sites in Tunisia and Algeria: several hundred square metres; economy based on intensive collecting (Butzer 1971:585-7).

(*i*) Mesolithic sites on the Nile flood-plain in Nubia (ca. 14,500 $^{14}$C BP onwards): very large;

economy based on intensive collecting (ibid.:587).

Isaac (1972) opines that the Lower and Middle Palaeolithic sites in Europe and Africa average ca. 175m$^2$ in extent, while Upper Palaeolithic sites tend to be bigger. He concludes thus (1975*a*:518-9):

> At present, in East Africa and many other regions it appears that where the sizes of individual hunter-gatherer camps can be discerned, they are of much the same magnitude regardless of age. . . . The most notable exceptions are the Upper Pleistocene mammoth hunting stations of eastern Europe. . . . Other Pleistocene sites seem generally to be of a size that would be appropriate to ten to fifty persons. Some larger accumulations of material occur, but these are suspected to be geologically disturbed or, in effect, partially overlapping palimpsests of successive occupations, the aggregate size of which, therefore, does not reflect the size of the occupying group.

Isaac's experiment with the effect of scavenging by animals on bone refuse shows a high degree of loss, particularly of the larger bones, and dispersal of bones up to 10m from the locus at which the experimenter initially placed the bones, thus highlighting a potential source of distortion of settlement size.

The data set out above indicate sites that are on an average larger (ca. 175m$^2$) than the ones encountered in Lanka (ca. 50m$^2$). This is undoubtedly a function of respectively different carrying capacities of the savanna, flood-plain and woodland environments of East Africa, Nubia and Europe on the one hand and the equatorial rain-forests of Lanka on the other. The former are known to have very much larger carrying capacities than the latter, and Boulière's (1963) estimates for ungulate biomass are revealing in this regard (v. Collins 1969:293):

| *Ecozone* | *Ungulate Biomass (kg/km$^2$)* | *Plant Biomass (exploitable)* |
|---|---|---|
| Savanna | 15,000 | little |
| Temperate grassland | 3,500 | little |
| Open woodland | 3,500-1,000 | some |
| Tundra | 800 | none |
| Semi-desert | 200 | little |
| Tropical rain-forest | 5 | high |

While the high degree of species diversity among the fauna and the relative abundance of edible food plants in tropical rain-forests compensate somewhat for the low ungulate biomass, these by no means bring the carrying capacity of a rain-forest to anywhere approaching the range of, for instance, a savanna, or even a woodland in West Asia (v. Flannery 1969:79). Hence it is not surprising that Lanka's prehistoric sites should be modally smaller, representing a smaller number of occupants, than sites typical of any one of the other ecozones enumerated above. It is probable that the deciduous woodlands (monsoon-forest) which are thought to have constituted the climax vegetation of much of peninsular India (except parts of Kerala) would have had a higher carrying capacity than Lanka's rain-forests and that hence the Mesolithic sites in these areas could be expected to be modally slightly larger than the Lankan ones. It is significant that the hearths at Kalambo Falls approximate in extent to the examples found in the Mesolithic of Beli-lena Kitulgala at ca. 13,000 BP, contrary to the ones in the Upper Palaeolithic at Shanidar which are at times appreciably larger, suggesting that they serviced a more numerous group in the settlement.

Transhumance in the drier environments would have been a much more prominent feature than in the ecozones typifying Lanka with their relatively abundant supplies of perennial water. In the drier parts of sub-Saharan Africa, during the Middle Pleistocene, "the pattern of movement in summer rainfall areas can be expected to have been one of radiation, following the game during the rains and of concentration during the dry season as the game returned to the permanent water and grasses of the home territory" (Clark 1975:647). Generalised hunter-gatherers, exploiting a large spectrum of small game which does not migrate seasonally, tend to move less far and less often than specialised hunters (cf. Harris 1969:8), and such is likely to have been the case with Lanka's prehistoric groups.

The periodic firing of the upland and montane grasslands that appears to have occurred since at least 28,500 BP in Lanka was probably accompanied by small-scale seasonal movements into the hills during the February droughts in the highlands and in the February and June-August droughts in the intermediate Dry Zone's uplands. As to when firing was first practised in Lanka is not known: fire was known to Peking Man in Choukoutien Locality 1 (Howell 1965:79), the Lower Acheulean of Terra Amata, Nice (Clark 1970:95), the Upper Acheulean of Kalambo Falls (Hole and Heizer 1965:205), and in the Upper Acheulean again at Ambrona and Torralba in north-central Spain where charcoal suggests deliberate fire-setting to drive animals (Howell 1965:80; Clark 1970:101). As Isaac (1975:884) affirms, "presumably, addition of fire to man's technological repertoire was part of the background to the colonisation of the temperate latitudes in the early Brunhes [≤700,000 BP] epoch". Periodic firing was probably responsible foı *he replacement of forest by grassland in the Nilgiri highlands at over 38,000 $^{14}$C BP (Chap. 4.5.1), as they appear to have done in the highlands of New Guinea at >5,000 BP (Golson 1977). By 11,000 BP there is apparently firm evidence of large-scale burning of forests in Belgium, the Netherlands and south-western Germany, which Butzer (1971:482-3) interprets as possibly designed "(*a*) to permit easy sighting of game, (*b*) to favour the growth of plants and grasses required by the desirable game species, (*c*) to increase the size of game pasture at the expense of the forest, or to localise grazing areas and so facilitate hunting. . . ." These same factors were probably operative in the origins of Lanka's *patana* grasslands, possibly as early as the Middle Pleistocene.

The occurrence of ostrich shell in the Upper Palaeolithic (C) of Patne in Maharashtra (Joshi 1975:13) raises the question as to whether they are of local or imported origin: the ostrich is known to have had a much wider range of distribution during the last glaciation than in recent times – its remains have been found as far afield as Shuitungkou in the Ordos and in Choukoutien Upper Cave. Ostrich shell was favoured for the manufacture of beads and pendants in several industries of Africa's later Stone Age; for instance, beads were made of this material in the Nubian Mesolithic of ca. 7,750-5,650 $^{14}$C BP (Butzer 1971:590). Should it be established that the shell fragments found at Patne were in fact imports from the Arabian peninsula, it would serve to corroborate the hypothesis suggesting the possibility of West Asian influences being manifest in India's Upper Palaeolithic (v. above).

The tusk-shell beads found at Langhnaj (Sankalia 1965*a*:Pl.14) could well have originated in the Arabian Sea which is located not far from the site. Similar specimens were also found in the Chalcolithic levels of Rangpur IIA and III (ibid.:73). The tusk-shells found in the Zarzian at Pa Sangar in Khorramabad are thought to have been imported over long distances and they were also discovered in a Natufian context in El Wad cave (Hole and Flannery 1967:160,163). It is apparently impossible to distinguish between the forms found in the Indian Ocean, Persian Gulf, Caspian and the Mediterranean, and hence the question of *Dentalium* imports into the Mesolithic of India must remain in abeyance, unless oxygen isotope analysis provides some clues. Note that tusk-shells are very to conducive to being used as beads (cf. Andamanese preference for these in recent times (Chap.6.8.4.)) and their presence in diverse prehistoric contexts need not imply phylogenetic cultural links, a process of independently convergent cultural choice being very plausible.

Evidence of casual trade contacts between coast and hinterland and/or physical movement of groups between these areas have been forthcoming from the Coastal

Wilton of the Wilton Complex of southern Africa, where marine molluscs have been found at distances in excess of 50km from the sea (Sampson 1974:312). This is paralleled in Lanka at Beli-lena Kitulgala by the occurrence of marine shells at ca. 80km from their potential source. It is as yet impossible to assess whether such finds represent trade or transhumance, until further detailed stratigraphic and faunistic data become available. It is noteworthy that the Oldowan horizon at Olduvai Gorge had one instance where chert had been brought to the site from ca. 30km away (Clark 1970).

To conclude on miscellanea relating to settlement, the use of red ochre, presumably as a pigment, in the Mesolithic of India and Lanka is no cause for surprise. It occurs, for instance, in the Lower Acheulean of Upper Bed II at Olduvai (0.7 my) (Cole 1963; Clark 1970), the Mousterian of Pech de l'Aze I (together with limonite) (Bordes 1972:93), the early to late Baradostian of Yafteh cave in Khorramabad ( >40,000-25,000 BP) (Hole and Flannery 1967), and in the Zarzian of Ghar-i Khar in Iran (Smith 1971). Three Upper Mesolithic (ca. 10,500 $^{14}$C BP) human burials in Belt Cave had the bones coated with red ochre (Coon 1951:75,79). Concerning mortuary practice, that of interring human remains in a flexed position, as observed in the Mesolithic of Lanka, has a considerable antiquity and range of occurrence: for instance, the Neanderthalers of Le Moustier, La Ferrassie and La Chapelle-aux-Saint in the Perigord of France (Le Gros Clark 1965:107; Howell 1965:129; Coles and Higgs 1969:219), and the Shanidar Neanderthalers at >50,000 BP (Solecki 1966; 1971). This position could merely have served to minimise the size of the graves and thus reduce the effort required to dig them, and no further cultural connotations may be involved.

*5.3.15 Conclusions.* The data on prehistoric subsistence practices in Lanka indicate a hunting and gathering economy based on the exploitation of a broad spectrum of fauna and flora. While there are some hints that the domestic dog was found at Nilgala cave and perhaps also at Bellan-bandi Palassa, and that a *Bos* species (?*indicus*) just might have been a domesticate, there is no unequivocal evidence of the exploitation of domestic plants or animals. Considering the occurrence of domestic dogs in West Asia at ca. 9,000 BP and in England and North America from ca. 10,000 BP onwards (Coon 1951; 1957; Braidwood 1952:67; McBurney 1969; Leonard 1973:93; Bökönyi 1975:167), it would not have been unusual to find a domestic dog at Bellan-bandi Palassa at ca. 6,500 BP. Of course, the difficulty is to distinguish between dog and jackal (Clason 1974:81), and intensive studies are required on this subject. With regard to cattle, the Allchins (1974*a*:75) have hypothesised that wild *Bos indicus* was being domesticated in the Neolithic of peninsular India at ca. 2,000 BC. Should this hypothesis be confirmed, it would be possible to extend the same hypothesis to the Mesolithic techno-phase pending testing. The water buffalo definitely has been found in a Mesolithic context in Lanka; but it is not possible as yet to state if any of these specimens represent domesticates. Note that this animal had been domesticated in southeast Sicily and southern Italy at over 3,000 BC (Vishnu-Mittre 1968:99), and that wild buffaloes were being noosed and tamed in Lanka, particularly in the Vilpattu region, up to about twenty years ago (for description of the wild vs. domesticated forms v. Deraniyagala 1953*c*). The remains of sheep have not as yet been found in a prehistoric context in Lanka; nor have those of domestic fowls. However, there is an ancient breed of sheep in ecozone F and in the drier parts of A in the north and northwest of the island (distinguished by very small, almost vestigial, ears), which might have had prehistoric domesticated antecedents. The origins of this breed are not known and deserve investigation. Note that wild sheep have been found in a so-called Upper Palaeolithic context in the Kurnool caves of Andhra Pradesh in India (Murty 1975:136), and the peninsular Neolithic had domestic sheep by 2,000 BC (Thapar

1965:91). It is probable that the short-eared sheep of Lanka were brought over to the drier parts of the island in distant antiquity, perhaps in prehistoric times at least as old as the peninsular Neolithic at ca. 2,000 BC when Lanka would still have been in its Mesolithic technological phase. Domestic chickens are known from the Indus Civilisation of ca. 2,500-1,700 BC, and also from the Chalcolithic of peninsular India, and it is possible that the late Mesolithic of Lanka had these as well. An ancient breed of fowls, termed ***Ruhunu kikiliyo*** (S.), was found in the southern sector of the island until about 50 years ago (Deraniyagala 1965:193; pers. comm.). These resembled the well-documented Sinhala game fowl of Lanka (id. 1927) and were noted for their egg laying capacity.

Neolithic farming practices appear to have had a considerable antiquity in India, as in Rajasthan at ca. 8,500 BP (Singh 1971), and there is evidence of incipient farming at Bagor at ca. 6,400 BP (for general world chronology of domesticates v. Brothwell and Brothwell 1969:37). It appears, however, as if Lanka had been a backwater as far as Neolithic subsistence traits were concerned – rather like Madya Pradesh and Kerala in peninsular India. One reason for this situation could have been that the island's environment, particularly in the Wet Zone whence most of the subsistence data have been retrieved, was unsuitable for sheep/goat farming and cereal/legume cultivation with Stone Age technology. The drier parts of the Dry Zone (e.g., ecozone F) could conceivably have been farmed in prehistoric times; however there is a marked dearth of information from these areas due to lack of problem-orientated investigations.

It is not (as yet) possible to discern any clear zonal differentiation in prehistoric exploitation patterns or intensities in Lanka – apart from the obvious coastal versus hinterland dichotomy. Most of the hunting appears to have been focused on small game such as monkeys, squirrels and porcupines. Larger forms such as pig and sambhur are encountered only occasionally in prehistoric contexts, and elephant and bovines are very rare indeed. It is probable that the *schlepp* factor, whereby the composition of bone refuse is a function of their transportability from the kill sites (Isaac 1971:4), was at least partially responsible for this apparent selection against the representation of big game in the assemblages at base-camps: the heavier bones would have been stripped of their meat and left at the kill sites, whereas the smaller ones were transported back to the base-camps to survive in the archaeological record (for evidence of the *schlepp* factor in the Baradostian of Khorramabad v. Hole and Flannery 1967).

The consumption of arboreal and freshwater molluscs seems to have been an important source of proteins in the hinterland of Lanka, a situation paralleled by shellfish gathering along the coastal tracts, as per the evidence from Mandakal-aru. It is difficult to assess the role of fishing in the prehistoric economy. Fish bones are occasionally found, as at Batadomba-lena and Beli-lena Kitulgala (e.g., mahsier), but they do not represent a prominent component in the faunal assemblages. The dugong found at Mantai in a Mesolithic context could represent scavenging on a washed up carcass; or else it is not at all improbable that Mesolithic man did exploit offshore resources in the shallow Gulf of Mannar.

As for the exploitation of plant materials in prehistoric Lanka, very little is known due to analytical work on this subject being in its infancy. Large assemblages of carbonised plant remains from Beli-lena Kitulgala and Batadomba-lena await study. But there is clear evidence that wild breadfruit (carbohydrates, fats), *kekuna* nuts and kernels of *gal veralu* (proteins, fats) and wild bananas (sugars) were being exploited from at least as early as ca. 13,000 BP at Beli-lena Kitulgala. The importance of wild food plants for human subsistence in lower latitudes is well known (v. Butzer 1971:151) and a glance at Appendix IV will indicate that Lanka is no exception to this rule.

In general it can be affirmed that there are no indications of any shifts in subsistence strategy in Stone Age Lanka from at least 28,500 BP onwards, as indicated by the evidence from Batadomba-lena. It is perhaps noteworthy that this is paralleled by the homogeneity of the geometric microlithic (i.e., Mesolithic) technological traits that prevailed during this period (Beli-lena Kitulgala, Batadomba-lena and Sites 49 and 50 of the I Fm). Moreover, there is no indication of food procurement procedure ever having been specialised as in the selective, intensive predation on a circumscribed set of forms: it apparently remained a broad-based strategy, exploiting a very wide spectrum of fauna and flora. This reflects the food resources available in an equatorial environment with a high degree of species diversity compared, for instance, to tundra environments. As for the Pleistocene/Holocene transition in Lanka, as represented at Beli-lena Kitulgala, there is nothing indicative of any shift in exploitation patterns due to environmental and/or cultural factors. It is probably safe to hypothesise that this was true of tropical Asia as a whole.

The modal extent of Mesolithic open-air sites in Lanka appears to be ca. $50m^2$, although precise estimates have still to be worked out. Hence these sites do not seem to have been occupied by much more than a single nuclear family at a time. The size range of the several hearths encountered in a horizon dated to ca. 13,000 BP at Beli-lena Kitulgala corroborates this hypothesis, as they appear to be too small to have serviced a larger group of people. The low carrying capacity of tropical rain-forest environments (Boulière 1963) was probably the prime determinant of this phenomenon ($5.6kg/km^2$ ungulate biomass of rain-forest in Ghana vs. up to $19{,}540kg/km^2$ for Ugandan savanna). Hence it is scarcely surprising that Lanka's site-territories could not support a large number of individuals, even though exploitation was not restricted to ungulates. It is probable, however, that seasonal mergings of prehistoric groups did occur during spells of short-term increase in carrying capacity at certain loci in the drier parts of the island (e.g., around the wet doline *villus* of ecozone A); but material evidence for such occurrences, in the form of exceptionally large camp sites, has so far not been recognised. In India, the conspicuously large extents occupied by sites such as Bagor I may be explained by postulating that the carrying capacity of the site-territories would have been high (relative to a purely hunting and gathering economy) due to the incipient exploitation of domestic animals. It is probable that the smaller Mesolithic sites in Rajasthan, for instance, did not have this element of domesticates.

While the settlement units were small in Mesolithic Lanka, there does seem to have been an extensive network of trade between various ecozones: evidence of salt being brought into Beli-lena Kitulgala from coastal evaporates situated over 80km away at over 18,000 BP; marine products from a distance of over 60km in Batadomba-lena at around 17,000 BP and at 13,500 BP; and *Acavus* shells appear have been an item of exchange between the Wet and Dry Zones. It is hence very probable that inter-group contact between Mesolithic communities was island-wide, and that during phases of low sea level (e.g., at $\geqslant$35,000-7,000 BP; v. Chap.4.5.3) this communications network would have extended into southern India and possibly further afield. Unfortunately the extant data from India are too inadequate for it to be possible to amplify on this theme of inter-regional communications; the only tantalising piece of evidence lies in the discovery of ostrich shell fragments (?from the Arabian peninsula) in the Upper Palaeolithic (C) of Patne in Maharashtra. The use of sea-craft, since at least as early as the middle of the Upper Pleistocene, for travel along the coast of peninsular India is not at all an unlikely proposition: note the settling of Australia at over 50,000 BP across ca. 100km of deep sea (Calaby 1971; Mulvaney 1975:148) and the view (Golson 1977:4) that much of the Pacific Ocean had been traversed and the islands settled in by 3,500 BP if not earlier (?ca. 6,000 BP) through major sea voyaging. If this was indeed the case, it would have greatly facilitated inter-regional communications from over 50,000 BP onwards in South and Southeast Asia bordering the Indian Ocean. Assuming that this was so, there is ample room for speculation as to whether there could have been a maritime communications mechanism which manifested itself in the appearance of geometric microlithic industries in the Andaman Islands, Java, Sumatra, Sulawesi and Australia with India and Lanka as the springboard for such diffusion. It is noteworthy that the occurrences of geometric microliths in Southeast Asia appear to be exclusively from the coastal regions as opposed to the deep interiors, although this picture could well change with more adequate sampling.

With regard to ritual and mortuary practices in prehistoric Lanka, there are: the red ochre coated fractional human burial from Fa Hien cave; and the drilled human frontal bone, smeared with red ochre, found at Ravanalla. It is scarcely surprising to find red ochre in these horizons, since its use as a pigment appears in a Lower Acheulean context at Olduvai Gorge in East Affrica, and in more recent prehistory it has been very widespread in various parts of the world. India had it associated with the so-called Mesolithic burials at Lekhahia RS-1 and Bhimbetka IIIA-28. Nothing akin to the interment of a wolf, apparently with its head crushed, next to a human at Langhnaj has been as yet found in Lanka. The burial of the dead in occupation debris appears to have been common in Mesolithic Lanka (Bellan-bandi Palassa ca. 6,500 BP ; Beli-lena Kitulgala ca.13,000 BP ; Batadomba-lena ca. 28,500, 16,000 BP). Secondary (at times fractional) interment seems to have been in general usage, and the more complete skeletons were invariably found in tightly flexed positions, as at Bellan-bandi Palassa and Batadomba-lena. Isolated fragments of human bones occurring among the food debris, as at Beli-lena Kitulgala and Batadomba-lena, could be indicative of redeposition due to disturbance of burial strata in prehistoric times, of a function as amulets or of cannibalism. At any event, they do not suggest a supernatural fear of the dead, contrary to Vadda attitudes in recent times.

It is noteworthy that the Indian evidence also indicates interment within habitation deposits, as at Bagor I; but flexed burials are rare, most of the instances being in extended positions. The data on secondary and fractional burial practices are almost non-existent for Mesolithic India; but it is perhaps significant that the evidence from the "pre-Mesolithic" horizon at Lekhahia RS-1 suggests a considerable antiquity for the custom of fractional burial on the sub-continent.

Considering the relatively recent age of the so-called Mesolithic burials of India, when cultural impulses from Neolithic and Chalcolithic communities are likely to have been felt, it is probable that mortuary traits as known from the Indian Mesolithic represent "hybrid" forms resulting from the interaction between Mesolithic and Neolithic/Chalcolithic culture traits. It is also possible to speculate that fractional and flexed interment represent a pre-Neolithic sub-stratum of mortuary practice in India, which in Lanka continued right up to the advent of the Iron Age.

Continuing with the metaphor of "sub-strata", the physical traits of Lanka's Mesolithic humans (Bellan-bandi Palassa ca. 6,500 BP; Beli-lena Kitulgala ca. 13,000 BP; Batadomba-lena ca. 16,000 BP) can in general terms be described as Australoid, and more particularly as ancestral Vaddid. The range of distribution of Australoids seems to suggest that they represent a genetic sub-stratum among the present-day populations of South and Southeast Asia and of course Australia; and Balangoda Man, the Mesolithic human of Lanka, could be directly ancestral to the Australoids of South Asia – in the manner Kennedy has conclusively established for the Vaddas of Lanka. Serological studies have indicated a close link between the Vaddas and various tribal communities in South and Southeast Asia (Büchi 1958-59;Wickremasinghe et al. 1963; Kennedy 1974:101). The details (and complex ramifications) of these phylogenetic links with regard to Lanka, India and further afield in Southeast Asia and Australia deserve to be worked out intensively.

## 5.4 PREHISTORY–PROTOHISTORY TRANSITION

*5.4.1 Introduction.* The term protohistory, in Lanka's context, denotes that period which succeeds the Stone Age and precedes the appearance of writing. So far, there is no evidence to indicate that a Chalcolithic or Bronze Age intervened between the Mesolithic and Iron Age technological phases in Lanka. The transition appears to have been rather abrupt. The present chapter seeks to delineate the main strands of what little is known of this complex phase: a detailed treatment is outside the scope of the present work (for Lanka's protohistory v. Seneviratne 1987). The data base is murky and inadequate; but it is important to set the stage for the formulation of macro-strategy to probe this very important episode in the evolution of Lanka's cultural scene; hence the overview presented below (for revised periodisation and chronology v. Addenda I, II).

*5.4.2 Chronology and Technology.* The chronology of the upper limits of Lanka's Stone Age is very imperfectly known (Chap.3.4.2). Stratigraphically, it has long been noted that the Stone Age seemed to have been abruptly superseded by the historical period of Lanka (Sarasin 1926*a*:6-7). Evidence for this has been forthcoming from several sites. Some instances are as follows – where prehistoric deposits have been overlain by cultural material, such as pottery, brick structures and iron tools, which are assignable to the historical period: Galge, north and south caves in ecozone C (Sarasin and Sarasin 1908:7-8); Nilgala cave in ecozone C (ibid.:11-2); Bendiya-galge in ecozone C (Seligmann and Seligmann 1911:22-4); Beli-galge Bambarabotuva in ecozone D1 (Sarasin 1926:87); Bambaragala shelter in ecozone B (Deraniyagala 1943:102); and Bellan-bandi Palassa in ecozone B (S.Deraniyagala and Kennedy 1972:20,23,40-2). In none of these instances is there the slightest techno-stratigraphic indication of a transitional episode occurring between the Mesolithic and the Iron Age: stone tools have yet to be found in an Iron Age context.

The only detailed picture of the transition from Stone to Iron Age in Lanka has been provided by the excavations conducted under my direction at Gedige in the citadel of Anuradhapura in 1969 (S.Deraniyagala 1972) followed by a season in 1985 with the goal of securing greater stratigraphic resolution than in 1969 and thence a reliable radiocarbon chronology (id. 1986*a*). Anuradhapura has been the protohistoric and historical capital of the island for some 1,500 years. The lowermost Stratum I at Gedige comprised the basal gravels of a Reddish Brown Earth Formation. These gravels have not been dated radiometrically, but they do contain a Mesolithic stone tool assemblage (id. 1972:56-7) which may hypothetically be correlated with that of the basal gravels of Site 43a II in the RBE Fm which in turn has been cross-dated typologically with 49b III of the I Fm at ca. 28,000 TL BP (Chap.3.3.4; but v. Addendum I).

It is postulated that the top of Gedige Stratum I represents a major erosion surface. Stratum II overlying I was a clayey loam which, sedimentologically, appears to represent a ploughed horizon. Stratum IIIa above II comprised a habitation deposit, and II is assignable to the same cutural horizon as IIIa. II and IIIa have a radiocarbon age of ca. 800-500 cal BC (id. 1986*a*; Addendum II). The material culture of II and IIIa was distinguished by protohistoric Black and Red Ware pottery (BRW), lots of iron tools, wattle and daub structures, (which, incidentally, appear to have given rise to the massive accumulation of sediments in IIIa and IIIb), "protohistoric" clay roof-tiles, domesticated rice and the domestic horse and cattle. This cultural assemblage has been periodised by me as Protohistoric A (ibid.) and it resembles the protohistoric Iron Age assemblages characterised by BRW in much of peninsular and Indo-Gangetic India; but pending the fine delineation of the latter from adequately excavated habitation (as opposed to mortuary) facies, not much else can be stated concerning the relationship between Lanka's and India's protohistoric Iron Age. There are bound to be regional nuances, ranging from the Painted Grey Ware culture of the Indo-Gangetic doab in the north to the "Megalithic" Complex of the south, which, once defined adequately, will add a great deal to our comprehension of the culture dynamics that manifested themselves during this period; and what I stated over two decades ago (1972:122) seems yet (unfortunately) to be applicable:

> The occurrence of the highly specialised Type 13a(i) from the "Megalithic" level at Gedige (Pl.1b) as plain ware Type 44 in the NBP [Northern Black Polished Ware] levels at Hastinapura re-poses the problem of the relationship between the "Megalithic" culture of the south and the NBP and pre-NBP cultures of the north. It was Codrington who first grasped the essential unity between these two complexes (1930:196). His hypothesis was shelved by subsequent workers, largely because they were excessively involved in the Aryan-Dravidian question at the expense of disciplined archaeological thinking and also because NBP had not been found in the south, except as an importation. It now appears as if both PG [Painted Grey Ware] and NBP were localised phenomena flowering out of a basic "Megalithic" type culture using Black and Red Ware and iron. The pitfalls of over-stressing index types need no restatement, and the absence of what is a localised attribute (NBP) of a homogeneous general culture in regions far from the [Imperial] Mauryan metropolis, need not signify a great deal.

And again (ibid.:159-60):

> Historical sources assert that although the initial colonisation of Ceylon by civilised man was effected by Aryan speakers from northern India, contact was subsequently established with the south [v. Basham 1952; Paranavitana 1959*a*; Nicholas and Paranavitana 1961:22ff]. Corroborative evidence occurs in phase IIIa where within a "Megalithic" cultural assemblage similar to those obtaining in South India, certain inclusions occur which are typical of North India, the most striking being ceramic Type 13a(i) which has a correlate at Hastinapura. . . .
>
> Developing Codrington's hypothesis of 1930, the Allchins state that the spread of iron and of the Black and Red Ware tray-bowl (form 16) suggests a broad cultural unification in India (1968:232). They also suggest that these cultural attributes were probably associated with the outer band of Aryans in North India (ibid.:329). The pre-NBP horizon in India is usually marked by a predominance of Black and Red Ware – even in the Painted Grey Ware levels which have been assigned to the early Aryans – and the occurrence of the horse and iron (ibid.:214,217-9; Banerjee 1965:172-3,204-8,217,223,234). These data would appear to complicate the interpretation of the "Megalithic" culture of South India which is also characterised by the presence of Black and Red Ware tray-bowls, the horse and iron. . . . However, apart from posing the problem, nothing can be resolved until the data from the pre-NBP Black and Red Ware strata of North India have been adequately compared with their southern counterparts.

The protohistoric Iron Age (Megalithic Complex) of southern India, which technologically seems to correlate with Gedige IIIa, has several radiocarbon dates, among which the following (cal, v. Addendum II) would serve to define its lower chronological boundary: Hallur in Karnataka, ca. 1000 BC (Neolithic-Prohistoric Iron Age overlap period; TF-570, ca. 1240 BC; TF-575, ca. 1065 BC; TF-573, ca. 990 BC); Veerapuram in Andhra Pradesh, ca. 1430 BC (PRL-730), ca. 1040 BC (PRL-728); Korkai in Tamilnadu ca. 830 BC (TF-987; Nagaswamy 1970:52-3). It is possible to conclude that the protohistoric Iron Age in southern India commenced at ≥1200 cal BC and that further sampling in Lanka's Protohistoric A should provide dates of similar antiquity.

Stratum IIIb, as delineated in the season of 1985, comprised the same depositional facies as IIIa. It has been dated to ca. 500-250 BC (charcoal; Beta-18436,15342) and the material culture of this stratum represents the commencement of rapid cultural change leading up to a climax in Stratum IV. Distinctive of IIIb, which has been designated Protohistoric B (S.Deraniyagala 1986*a*), is the appearance of BRW with so-called Early Historic forms (e.g., rims) and of "Early Historic" roof-tiles. A transitional layer between A and B – in which Early Historic

BRW and Protohistoric A roof-tiles occur together – has been stratigraphically isolated in 1985 and dated to an estimated 600-500 BC (charcoal; Beta-15348). The discovery of a sherd of Northern Black Polished Ware (NBPW) in the upper level of IIIb, with a date of ca. 300 BC (v. Addendum II), is significant in that it approximately coincides with the date of the formal introduction of Buddhism to the island under the patronage of the Emperor Asoka Maurya in north-eastern India. NBPW is known to have had its manufacturing epicentre in the Gangetic valley, and this sherd from Gedige (the first to have been identified in Lanka) constitutes material evidence of links between the core of the Mauryan culture sphere and Lanka. (The identification of the sherd has been confirmed by specialists in the Indian Archaeological Survey (K.K.Singha) and Deccan College, Poona (S.B.Deo), 1986; three more specimens were excavated from the citadel of Anuradhapura in 1987.) It should be borne in mind, however, that protohistoric material traits survive in IIIb. (Protohistoric B is now designated Lower Early Historic, Add.II).

Stratum IV at Gedige displayed a change in depositional facies: the bedding appeared culturally concentrated and more clear-cut than in III, possibly due to a decline in the use of wattle and daub as a building technique. IV has been dated to ca. 250-0 BC (charcoal; Beta-18437,15345,15346,15347), and it has been stratigraphically phased into early (IVa) and late (IVb). The techno-chronology of IV, based on cross-dating with Indian material (id. 1972:159), corroborates the radiocarbon dating of this stratum: ceramics were foremost, supplemented by palaeography, numismatics and beads. Stratum IV has been designated Early Historic on the basis of the occurrence of writing in IVa at ca. 250 BC. Apart from the presence of the Brahmi script, new elements in IV included coinage, high quality (e.g., blue) glass and a distinctive ceramic popularly referred to as Rouletted Ware (RLW). It manifests a cultural efflorescence of trends evident in IIIb, which can be assigned to far-ranging cultural impulses, as exemplified in the formal introduction of Buddhism (as accurately recorded in the chronicles) and of the Brahmi script, which were centred about the Mauryan empire which dominated much of the Indian sub-continent at ca. 322-185 BC. It is noteworthy that ceramic Types 21a(i), 23a(i) and 24a(i) from Gedige IVa of 1969 have been identified as being Hellenistic (Bouzek and S.Deraniyagala 1985). This identification has been checked in the case of Type 23a(i) by specialists in Paris, who have confirmed its accuracy (J.Gaucher 1985:pers. comm.). On the basis of the palaeographic and radiocarbon chronology for IVa, these imports are assignable to ca. 200-100 BC. The Hellenistic interaction with the Mauryan empire has been documented historically, and its material manifestation in Lanka represents a signal instance of archaeological corroboration of such rarified historical evidence. It is postulated here that the technology of manufacturing Rouletted Ware was of Hellenistic derivation, considering the strong resemblance in fabric between the imported Hellenistic pottery and RLW, while the forms of the latter were derived from NPBW. Once again, as with IIIa and IIIb, the survival of techno-traits from IIIb into IV is very marked. Further investigation could well reveal that IIIb was after all an early phase of the Early Historic as represented in IV, with writing occurring in contexts that are much earlier than hitherto imagined (cf. "bone styli" from pre-NBPW levels at Hastinapura, Ujjain and Nagda (Banerjee 1965:204-8). The closest Indian correlate of Gedige IV appears to be the Andhra phase in the Early Historic period of peninsular India (v. Wheeler 1948:203). (For confirmation of occurrence of writing in IIIb v. Addendum III.)

Evidence corroborating the dating set out above for Gedige IIIb (and perhaps IV) has been forthcoming from Kandarodai on the Jaffna peninsula. This site was excavated in 1970 by B. Bronson and V. Begley of the University of Pennsylvania. BRW was observed to occur from the basal layer upwards and, while the excavation report continues to pend, several radiocarbon dates have been secured (Bronson 1977:pers. comm.) which, when tabulated according to tentative ceramic correlations with Gedige, assumes the following form (calibrated after Pearson and Stuiver 1986;

Stuiver and Pearson 1986);

(*a*) Kandarodai III, correlating with Gedige IV characterised by RLW:
P-2521; Trench A, Stratum IV; 2020 ± 50 BP (36 cal BC)

(*b*) Kandarodai III/II interface, correlating with uppermost Gedige IIIb:
P-2518; Trench A, Stratum IV/V; 2290 ± 50 BP (390 cal BC)

(*c*) Upper levels of Kandarodai II, correlating with the upper levels of Gedige IIIb:
P-2520; Trench A, Stratum V; 2180 ± 60 BP (339, 323, 203 cal BC)
P-2514; Trench B, Stratum V; 2250 ± 60 BP (375 cal BC)
P-2529; Trench X, Stratum III; 2350 ± 200 BP (401 cal BC)

(*d*) Middle and lower levels of Kandarodai II, correlating with the middle levels of Gedige IIIb:
P-2524; Trench A, Stratum VI; 2340 ± 50 BP (399 cal BC)
P-2515; Trench B, Stratum VI; 2990 ± 60 BP (1261 cal BC)
P-2516; Trench B, Stratum VI; 2070 ± 60 BP (101 cal BC)
P-2522; Trench B, Stratum VII; 2110 ± 60 BP (160 cal BC)
P-2523; Trench B, Stratum VIII; 2060 ± 60 BP (96 cal BC)
P-2525; Trench B, Stratum VIII; 2730 ± 220 BP (897 cal BC)

(*e*) Kandarodai I, correlating with the lower levels of Gedige IIIb:
P-2519; Trench B, Stratum IX; 2290 ± 60 BP (390 cal BC)
P-2526; Trench B, Stratum X; 2090 ± 50 BP (111 cal BC)
P-2517; Trench X, Stratum IV/V; 2250 ± 50 BP (375 cal BC)
P-2528; Trench B, Stratum XI; 2370 ± 60 BP (404 cal BC)

As Bronson himself states (1977:pers. comm.), the radiocarbon dates for Kandarodai do not form a coherent series with regard to the stratigraphy. In fact, I myself recall seeing what appeared to be ceramics typical of Gedige IVa appearing in the bottom of Trench B. Hence, in view of the stratigraphic complexity of the site due to the structures having been built of pisé and wattle and daub, the sequential nature of the radiocarbon series needs to be viewed with caution. However, the date range can be accepted, and they do tend to cluster. The concentration of dates around 400 cal BC is pronounced, which is in agreement with the data from Gedige IIIb. The anomalously young dates for P-2516,-2526 and early dates for P-2515,-2525 are best attributed to sampling deficiencies, although the latter could in fact refer to an as yet undefined Protohistoric A phase at the site despite the provenance data as presented. It is possible to conclude that the evidence from Kandarodai indicates a 5th century BC age for the Protohistoric B phase as defined at Gedige.

It is noteworthy that the "Early Historic" horizon at Kanchipuram in Tamilnadu has been dated to ca. 400 cal BC, while a similar phase at Dharnikota in Andra Pradesh has two dates of ca. 400 cal BC and at Paiyampalli in Tamilnadu of ca. 380 cal BC (Addendum II), thus further corroborating the evidence from Gedige IIIb. These radiocarbon dates for the Early Historic period suggest that the technological traits defining the "Early Historic" period in South India had a lower age boundary of ca. 500 BC – which coincides approximately with the radiocarbon age of the commencement of the NBPW phase in northern India (v. Agrawal et al. 1975:6,10). It thus appears as if the chronology of Lanka's Protohistoric B phase, which technologically correlates with the "Early Historic" of peninsular India, coupled with data on the radiocarbon age of the latter, necessitates a drastic revision of the entire concept of the Early Historic techno-tradition in peninsular India, with vital implications as to the link between this tradition and the urbanisation that had set in during this phase in the Gangetic culture complex (index fossil, NBPW) in the north (v. Addenda II,III).

The cultural sequence as represented at Gedige seems to have broad connotations for Lanka and peninsular India in that Begley (1983), in her incisive reappraisal of Wheeler's (1946) and Casal's (1949) data from Arikamedu in South India, has reformulated a chronological sequence which I have attempted to relate to Gedige. This correlation has been set out as follows (v. Deraniyagala 1986*a*;

the Arikamedu phasing and chronology is as per Begley 1983, whereas the Gedige periodisation is after S.Deraniyagala 1972):

*Arikamedu Phase A*: Protohistoric Iron Age, over 150 BC; correlated with Gedige IIIa.

*Arikamedu Phase B*: Early Historic Iron Age with Rouletted Ware, 150-120 BC on basis of stratigraphy and palaeography; correlated with Gedige IIIb.

*Arikamedu Phase C*: Early Historic, with structures on large scale, bone styli, amphorae, Rouletted Ware, blue glass, pre-Arretine ceramic phase, 120-0 BC; correlated with Gedige IVa.

*Arikamedu Phase D*: Early Historic, with Rouletted Ware and Arretine, 0-25 AD on basis of Arretine dating; correlated with Gedige IVb.

*Arikamedu Phases E, F, G*: Considerable structural activity, Arretine disappears whereas spouts appear, amphorae continue, Rouletted Ware of inferior quality compared to earlier Phases; 25-200 AD on basis of Arretine dating; correlated with Gedige VI.

Begley's chronology for Phases A and B will have to be extended, in the light of the chronology for Gedige and Kandarodai, considering that these latter have been radiometrically established. On stratigraphic and palaeographic grounds, Begley (1983:461) is in agreement with my proposition (1972:160) that Wheeler's dating of 0-200 AD for RLW is untenable and that a more extended chronology requries to be adopted, which I have estimated at ca. BC 250-200 AD, although Begley's is stated as ca. BC 150-200 AD (v. Addendum II).

The current programme of excavations in the citadel of Anuradhapura (which includes Gedige) has been designed primarily to bring further chronological resolution with regard to Lanka's proto- and Early Historic periods. It is proposed to effect this by securing more radiocarbon dates supplemented by employing a refined version (based on ware- *cum* form-analysis) of the classificatory system used on the ceramics from Gedige (v. S.Deraniyagala 1972 vs. 1984; Addendum II). Palaeography is of little use during the pre-Christian era since the chronology of early Brahmi is ill-defined (Paranavitana 1970:xxi) and perhaps the inception of writing in India and Lanka is much older than the hitherto accepted lower boundary of ca. 250 BC (v. ibid.:xxiii,li): note that bone points which appear to have functioned as styli have been found in "Protohistoric" contexts in the Painted Grey Ware levels of northern India (Hastinapura) and in the pre-NBPW levels of Ujjain and Nagda (ca. 1,000-500 BC; Agrawal et al. 1975:9; v. Lal 1955*a*; Banerjee 1965:208; S.Deraniyagala 1972:132; Sankalia 1974:566). As for the ancient chronicles of Lanka, the ***Dipavamsa*** and ***Mahavamsa***, these tend to progress into the realm of legend from beyond ca. 150 BC, although it now appears as if the radiocarbon chronology for Gedige IIIb vindicates the basic accuracy of the chronicles as regards the island's protohistoric period.

*5.4.3 Subsistence and Settlement.* As with technology, an abrupt transition appears to have taken place in the subsistence economy at the interface between pre- and protohistory in Lanka. The present evidence indicates that a solely hunting and gathering mode of subsistence was rapidly superseded by a fully fledged farming economy with the advent of the protohistoric Iron Age. The results of the excavations at Gedige support the statements in the ***Mahavamsa*** that irrigated agriculture was prevalent in Anuradhapura by the 4th century BC.

The stratigraphic evidence from Gedige (S.Deraniyagala 1972:57) indicates that wet-rice cultivation existed in Anuradhapura from the period represented by Stratum II (ca. 800 BC) onwards, and historical sources mention the existence of irrigation reservoirs from after ca. the 4th century BC (Nicholas and Paranavitana 1961:98-9). Paddy husk had been employed in tempering daub and clay roof-tiles in Gedige IIIa. It seems very likely that this rice belonged to a cultivated variety, since it had already been a domesticate in the Harappan of Kathiawar at ca. 2,000-1,700 BC, at Chalcolithic Ahar at ca. 1,800 BC (Rao et al. 1963:170; Banerjee 1965:208; Sankalia

1974:407,422), in the Painted Grey Ware contexts of the Indus-Ganges doab at ca. 1,000-500 BC (Lal 1955*a*:132; Banerjee 1965:197; Allchin and Allchin 1968:212,214) and among the protohistoric Iron Age people of peninsular India (Banerjee 1965:210; Allchin and Allchin 1968:266). The last named (and perhaps the non-elite aspects of the Painted Grey Ware complex) correlates culturally with Gedige IIIa. It is significant that the "Megalithic" people of Hallur are considered to have cultivated paddy at ca. 1,000 BC (Allchin and Allchin 1968:265; for further details on protohistoric Iron Age cultivation of paddy in South India v. Srinivasan and Banerjee 1953:109; Banerjee 1965:53). Sickles have been found in "Megalithic" iron tool assemblages (Banerjee 1965:216). Paddy was also discovered, apparently, in association with the "Megalithic" burials of Lanka (R.H.de Silva 1972:pers. comm.). Three seeds of Job's tears were found in Stratum IVa and two in IVb. This is an edible cereal which grows in paddy fields and it is said to have been naturalised in Lanka (Trimen and Hooker 1900:192; Macmillan 1949:299), thus providing indirect evidence of the existence of paddy fields during the period spanned by Stratum IV at Gedige. The occurrence of remains of the soft-shelled terrapin in Gedige IIIa-IVb suggests the existence of sedentary or slow-moving bodies of water within the vicinity of Anuradhapura during this period (cf. their presence in the pre-Arretine phase at Arikamedu; Wheeler 1946:115), which could signify their association with artificial irrigation systems, although not necessarily so. (For an account of the ancient irrigation systems of Lanka v. Brohier 1934-5; paddy husk impressions in burnt daub and roof-tiles from Gedige IIIa-IVb have been despatched to T. Watabe of the University of Kyoto for taxonomic studies (1985).)

Deraniyagala's analysis (in S.Deraniyagala 1972:155-8) of the faunal remains from Gedige is as follows:

IIIa: *Melanochelys* and *Lissemys* (terrapins), *Axis* and *Rusa* (deer), *Bubalus* (buffalo), *Bos* (neat cattle), *Equus* (horse), *Sus* ((pig). [Weight ca. 7kg.]

IIIb: *Melanochelys, Lissemys,* birds, *Axis, Rusa, Moschiola* (mouse-deer), *Sus.* [Wt. ca. 5kg.]

IVa: *Melanochelys, Lissemys, Varanus bengalensis* (land monitor lizard), *Axis, Rusa, Moschiola, Acanthion* (porcupine), *Sus.* [Wt. ca. 9kg.]

IVb: *Melanochelys, Lissemys, Axis, Rusa, Bubalus, Bos, Sus.* [Wt. ca. 2.5kg.]

The majority of bones appear to represent food remains, since several specimens display marks inflicted with metal knives, and ash and charcoal deposits were found in association – particularly in IVa. Very few of the bones reveal traces of direct exposure to fire, indicating that they were cooked in water or oil.

The frequency of occurrence of bones from IIIa to IVb indicates a scarcity of domestic dogs in the Gedige sector during this period, because the osseous remains would otherwise have been chewed up.

The faunal assemblages show no marked change from IIIa to IVb. It has not been possible to establish whether some of the forms, namely *Bos, Bubalus* and *Sus,* had been domesticated. The high incidence of cervid remains indicates that hunting was important.

It is significant that *Melanochelys* should have been eaten, since it is today considêred unclean due to its being a garbage eater and the musky stench it emits. . . .

Two specimens of remains of *Bos* were encountered in IIIa and IVb respectively. The former is a talus . . . and the latter is a sub-conical left horn-core. . . .

The fossilised holotype of *Gona sinhaleya* (Deraniyagala 1958:146) . . . is only slightly different from the above described horn-core. . . . Should the discovery of further specimens of this ?Pleistocene form prove that it is a subspecies of *Bos indicus,* its name will need to be altered to *Bos indicus sinhaleyus.* Behaviourally it is significant that the hybrid feral specimens of *Bos indicus* in the southern game sanctuary at Yala in Ceylon are well able to survive, despite the pressure of predators [leopards] and buffaloes. This is largely due to their speed of foot, semi-gregarious organisation and aggression when necessary. [Foote 1917:35 records the same phenomenon in the scrub jungle of Tinnevelly District in South India.]

The indigenous neat cattle of Ceylon, generally termed Sinhala cattle, were a remnant of an archaic breed that once populated southern Asia until displaced by larger forms from more northern latitudes (id. 1951*b*:196). Isolation in Ceylon had preserved it in a greater state of purity than upon the Indian sub-continent.

They were first noted by the present writer in 1937. J. de la H. Marett, the Assistant in Ethnology at the Colombo Museum, who was also an expert on cattle, urged their display at the National Museum before the breed became extinct. His foreboding proved correct. During World War II, these cattle which could be purchased for a few rupees each were more or less exterminated by butchers, and subsequent hybridisation with the larger imported breeds has resulted in the hybrid "Sinhala" cattle of today. Extracts from the present writer's original account are reproduced below (id. 1938:F4-5):

"Towards the end of December, I visited the rain-forest of Sinharaja Adaviya in Sabaragamuva by the Kudave route. . . . This area is comparatively isolated owing to the numerous streams being unbridged, except for an occasional log thrown across, and the degree of isolation is realised when it is noted that . . . the giant West African agate snail . . . [has not] penetrated into this region. . . . The domestic cattle are also of the greatest interest as they are probably less mixed than the Sinhala cattle of most parts of Ceylon. They breed more true to type, are small, black [to red] and rather slenderly built with an occasional dark grey animal; the tongue is dark [never pink], horns short [3/4 ear-length], hump and dewlap small, the tail tuft [which is ball-shaped] does not reach lower than the hock, and above each hoof is a fringe of bristly hair probably as an adaptation against leeches. The height is about three feet at the withers."

A more detailed description appeared subsequently (id. 1939*c*:88-92). Other significant features are that the dew claws are large and the penis is close to the body and not slung in a loose fold of skin as in Indian cattle.

*Bos* appears to have been eaten by the people of Gedige IIIa and IVb. The consumption of beef has, since the 1st century AD, according to literary sources, been considered extremely base (Ellawala 1969:67), and in Late Historic times the gladiator's usual taunt to his adversary was "thou beef-eating dog" (Deraniyagala 1959*a*:17). Since the artefact assemblage at Gedige, comprising deluxe objects such as Rouletted Ware, indicates that the occupants of Gedige possessed a relatively high social status, it appears as if the prohibitions on beef eating were not quite effective. Remains of *Bos indicus*, at times possessing knife marks, were found at Arikamedu in horizons ranging from the pre-Arretine phase to 100 AD (Wheeler 1946:115), and they have also been found within a "Megalithic" culture context in India (Banerjee 1965:211). It thus appears as if beef was eaten by those who were within the main social framework ca. BC 800-100 AD in peninsular India and in Ceylon. It is possible that the "tabu" on beef was imposed in Ceylon during the Middle or Late Historic period when there was a marked increase of Hindu influence on Sinhalese culture.

The first skeletal part of a horse to have been described from an archaeological context in Ceylon was an os pedis . . . from 10.5ft below the surface at Gedige (Deraniyagala 1958*e*:195-6). . . . The next fragment to be secured is the present one from IIIa at Gedige. . . . It is a . . . premolar belonging to a small animal . . . a four-year-old (B.Lundholm 1971:pers. comm.). . . . The dimensions of the two skeletal parts from Gedige, which appear to be derived from two separate individuals, confirm the supposition that the ancient horse of Ceylon was the small breed with a chunky head (a primitive feature) that has been depicted in ancient Sinhala sculpture and fresco (v. Deraniyagala 1958*e*:195-6). As these remains occur in kitchen midden material, the possibility [of their being used for food] cannot be overlooked.

It is not out of place to draw attention to the herds of feral ponies that have continued to inhabit the island of Delft off northwest Ceylon where the Dutch had subsequently attempted to maintain a breeding station of large imported horses. The Dutch were probably led to select Delft upon seeing the sleek condition of the indigenous ponies there. Mannar and Puttalam to the northwest, as Hambantota to the south, also possess such feral herds. The animals from all these localities more or less resemble one another in size which agrees with the horse remains from Gedige. The colour of these ponies ranges from a reddish to light brown.

> The *Mahavamsa* chronicle records that horses were tamed in Ceylon by the two early Sinhala kings Vijaya and Pandukabhaya, and the fact that horses were imported from Scind and were regarded as superior to those of Ceylon during the time of Dutu Gamunu at ca. 150 BC, suggests that Ceylon did possess an indigenous breed. . . . The breed might have been introduced . . . in early ferro-lithic "protohistoric" times and become feral. These could subsequently have been hunted for food and also captured and trained for work. It is noteworthy that the horse was known to the "Megalithic" people of ca. 1,000 BC at Hallur (Allchin and Allchin 1968:230) and to the Painted Grey Ware people of Hastinapura ca. 700 - 600 BC (Lal 1955*a* :107).

The water buffalo, *Bubalus bubalis*, represented at Gedige from IIIa onwards is likely to have been of both domesticated and wild forms (for distinction v. Deraniyagala 1953*c*). The former are frequently employed in the ploughing of paddy fields and the threshing of the harvest today, and should their presence be established for Gedige IIIa it would serve as corroborative evidence for the prevalence of paddy cultivation during the protohistoric Iron Age in Anuradhapura.

Although no canid remains were found in a stratified context from the Gedige excavations of 1969, there could scarcely be any doubt that the domestic dog was around from at least as early as phase IVa, and perhaps much earlier. Deraniyagala's work on the ancient dogs of Lanka (1960*f*) has provided us with some idea of what the animal would have looked like, and this breed seems to have survived up until very recent times in remote areas (e.g., Amparai) as the animal formally classified as the Sinhala hound by the Kennel Club of Lanka. Its dominant type (id. 1965:193) is terrier-like with pointed, erect ears and a tightly curled tail. The eyes are black or yellowish and the fur black and tan, reddish brown or brownish yellow. Puppies tend to possess a dark median dorsal stripe extending from the snout as far as the neck, as in the New Guinea dogs. The Sinhala hound has a tendency to combine barks with howls, akin to the vocalisation of the indigenous Congo and the New Guinea dogs. It is perhaps noteworthy that the chronicles mention domestic dogs in Lanka when the legendary founder of the Sinhalese settlements, Vijaya, reached the island, supposedly at ca. 500 BC (*Mahavamsa*:56). It is probable that among the bird bones from Gedige IIIb were those of domestic chickens, possibly akin to the recently extinct breed termed *Ruhunu kikiliyo* of the Ruhuna region, which in its turn was similar to the Sinhala game varieties (v. Deraniyagala 1927; 1965:193). It is unlikely that the short-eared sheep of the Jaffna and Mannar regions, possibly a very ancient breed, were reared in ecozone B (i.e., Anuradhapura), it being too moist for these animals. The data from Kandarodai should clarify this point concerning their antiquity. (Note that the Neolithic of peninsular India had a domestic sheep at ca. 2,000 BC (Thapar 1965:91).)

In general, the subsistence data as indicated by the evidence from Gedige II to IVb, suggests that in proto- and Early Historic Anuradhapura a mixed strategy was being practised based on irrigated paddy cultivation and domesticated cattle and water buffaloes, supplemented by the hunting of game such as sambhur, spotted deer and pig. While this picture would have been true of the metropolitan region centred about Anuradhapura in the north and Tissamaharama in the south, it is very probable that the subsistence economy during this period in the more peripheral regions would have been much more dependent on hunting and gathering, grading into areas which were almost totally so (e.g., Sabaragamuva, Bintenne).

The Protohistoric A period settlements of Lanka appear to have been concentrated in the northern Dry Zone, with outliers in the west, centre and southeast of the island, as evinced by the occurrence of "Megalithic" cemeteries (v. Begley et al. 1981; Seneviratne 1984). It has been hypothesised that the location of these settlements was in large measure dictated by the amenability of the land to irrigated paddy cultivation, which led to preference being given to areas with Reddish Brown Earth soils (Panabokke 1979). These soils are chemically fertile and the advent of the Iron Age overcame their resistance to the plough. (From the Early Historic period onwards, much of the Dry Zone is thought to have been cultivated at some stage or the other in antiquity, as per the vegetational history reconstructed by Holmes and others (Holmes 1956; Mueller-Dombois 1968:49; Spate and Learmonth 1972:798); this would have been a combination of irrigated paddy cultivation and swidden activities. (For distribution of ancient irrigation reservoirs v. map in Abeywickrama 1955.)

While the Protohistoric A settlements appear to have been concentrated in the northern and north-western (and perhaps south-eastern) sectors of the island (Gedige IIIa is the only occupation site to have been discovered so far), the entire island can be considered to have come under the direct influence of Sinhalese civilisation during Early Historic ((?and Protohistoric B) times, as chronicled by the *Dipavamsa* and the *Mahavamsa,* which is confirmed by the epigraphical evidence predating the Christian era (Collins 1933:180-3; Nicholas 1959:Map; 1959*a*). Further corroboration of this aspect of diffusion comes from the widespread occurrence of Early Historic Black and Red Ware pottery (first defined for Lanka at Gedige, 1969): Kandarodai (Bronson in S.Deraniyagala i.p.*b*), Mantai (Carswell and Prickett 1984), Kuchchaveli, the cliffs of Pookulam with pearl oyster shells, Kudremalai, Kollan Kanatta Site 3 (S.Deraniyagala 1972*c*:10-3), Illankaiturai (id. in Solheim and S. Deraniyagala 1972:21-6), Beli-lena Kitulgala, Ambalantota, Akurugoda in Tissamaharama (Parker 1885), Kataragama, Ravanalla cave, Bambaragastalava cave (S.Deraniyagala in Solheim and S. Deraniyagala 1972:30), Kudumbigala Yoda-lena cave (ibid.:31), Panama-modera-gala (ibid.:32-6), Itikala lagon (ibid.:30), and also several sites on the Jaffna peninsula (e.g., Anaikottai; S.Deraniyagala i.p.*c*).

The two main foci of Early Historic civilisation in Lanka were Anuradhapura in the north and Tissamaharama in the south, with an urban economy based on irrigated paddy cultivation supplemented by swidden agriculture. However, hunter-gatherer tribes continued to exist as relict populations in those regions which were unsuited for irrigated paddy cultivation, and from among such groups the Vaddas are the best documented (for details of documentation v. Kennedy 1971). The latter continued to survive in the infertile Non Calcic Brown Earth regions of Bintenne, physiographic Sub-Zone 8, (v. Sarasin and Sarasin 1892:78-82,Pl.1; Seligmann and Seligmann 1911:1; Collins 1933:159; Hill 1941:37), while tribes termed Savaras and Pulindas, according to the ancient literature, are said to have lived in the rain-forests of the Wet Zon (*Mahavamsa*:60,68; Parker 1909:20,23). Hocart (1925:54) has identified the range of the Pulindas as being on the north-eastern flank of Adam's Peak, in the Hatton region. The so-called Nittawo, said to have been exterminated by the Vaddas in recent times (19th century) in south-eastern Lanka, probably constituted one such group, possibly with physical traits distinct from the Vaddas (v. Nevill 1887; Lewis 1915:128-9; Hocart 1925; Noone 1945:263). In this connection, with reference to various hunter-gatherer groups, it is noteworthy that the physical variability among Vaddas has been observed to be considerable (Deraniyagala 1940*a*:354; Kennedy 1971:37), suggesting a gene pool with diverse sources. Toponymic surveys have indicated that Sabaragamuva Province is particularly replete with names referring to the aborigines of Lanka (e.g., the villages Sabaragamuva, Vaddagala; v. de Zoysa 1881; Seligmann and Seligmann 1911:9; Malpas 1939:F11; Wijesekera 1949:44; Kennedy 1974:102). The occurrence of Vadda art in parts of the Dry Zone outside Bintenne, as at Tantrimalai (Still 1911:74-5) where the paintings appear to post-date the cutting of the drip-ledge in (?early) historical times, denotes that the distribution of the Vaddas was far more extensive up to relatively recent times. (The subject of the progressive shrinking of Vadda territory in the Dry Zone has been treated by Kennedy (1974:104) as per historical evidence in Knox (1681:99-100), Valentyn (1726:8,32) and Cordiner (1807:91,137).) It appears as if the Vaddas re-occupied the regions which they had previously abandoned in the face of Sinhalese settlement once the latter's Dry Zone civilisation commenced to crumble around the 12th century AD. This point is demonstrated at Tantrimalai as mentioned above and at Alu-galge at Kapu-yaya near Siyanbalanduva (S.Deraniyagala i.p.*a*) where there is evidence of three phases of occupation: I, Mesolithic; II, Early Historic, as per the early Brahmi inscription in the cave; and III, Vadda. The last is denoted by typical Vadda art on the walls of the cave, depicting, among symbols and other animals, a peacock, which is a form that is generally considered to have been introduced to Lanka in historical or protohistoric times (as with the *bo* tree *Ficus religiosa*). Bendiya-galge cave in Bintenne revealed a similar sequence of occupation, with a basal Stone Age phase succeeded by Early Historic occupation as evinced by the cutting of steps and a drip-ledge in the rock, and the Vaddas living in the cave when the Seligmanns (1908:161; 1911:22,24: Seligmann 1908:113; also v. Sarasin 1926*a*:6) conducted their investigations. Seligmann (1908:116) states his impressions thus:

> Whether or no the quartz workers actually were Veddas, as suggested by the Sarasins, and, as seems reasonable enough, they occupied the caves used recently and at the present day by the Veddas of Uva, and, since these caves present undoubted evidence of being used by the Sinhalese of about 2,000 years ago, it may be presumed that the Sinhalese turned the cave-dwellers out of their rock-shelters, or, perhaps, peaceably occupied these, and that when the Sinhalese neglected the part of Uva in which the caves are found the cave-dwellers drifted back to them.
>
> Taken with the inscription [near] Bendia-galge cave, in which the common Vedda name Nila [*sic*, this should be Vela] is mentioned, this suggests that the quartz workers were, in fact, Veddas. If this be so it appears to indicate a much older and more intimate association between cave-dwelling Veddas and the Sinhalese than is usually realised....

The relationship between the Vaddas and the Sinhalese in historical times has been one of symbiosis, with the former gathering forest produce for the products of Sinhalese technology, such as iron tools which had completely superseded stone artefacts, possibly at a very early stage in the historical period of Lanka (v. Davy 1821:117; Seligmann and Seligmann 1911:93-4; Sarasin 1926:83). The incorporation of the Vaddas into the main social fabric of the Sinhalese (at a relatively high status, i.e., *Goivamsa*, in the caste hierarchy) constitutes a field of investigation that deserves close attention. Vadda chieftains had a special niche in the Sinhalese court from the earliest historical times down to that of the last (Kandyan) kingdom (v. *Mahavamsa*:71,74; Davy 1821:115; Parker 1909:19,24-8,103; Seligmann and Seligmann 1911:8,13). With reference to King Pandukabhaya's (ca. 400 BC) relations with the Yakka hunter-gatherers of Dhumarakkha (Dimbulagala) mountain, as per the *Mahavamsa*, Parker (1909:26) affirms thus:

> It is easy to see that it was by means of a close alliance with the Vaeddhas that this astute king, the greatest organiser the country has ever had – who is recorded to have made the first land settlement by defining the boundaries of the villages throughout the country – succeeded in deposing his uncle and gaining the throne. The natives were evidently far too numerous and powerful and well-organised to be put aside afterwards like the unfortunate Kuweni; and the politic king found it advisable to recognise the authority and influence of their leaders as nearly equal to his own.

Pandukabhaya is also said to have accommodated Yakka allies on three sides of his capital at Anuradhapura, and a Yakka chief apparently watched festivites with him from a throne of equal eminence.

The historical evidence concerning the hunter-gatherers inhabiting Lanka at the commencement of Sinhalese settlement has been treated admirably by Parker (1909) and there is little to be added. Most of the information stem from the *Dipavamsa*, completed during the mid-4th century AD, and the *Mahavamsa*, the first part of which was composed in its present form during the the 6th century AD (ibid.:9-10; Perera 1959:48-9). The latter was based on earlier historical works, one of which was compiled by Buddhist monks of a monastery founded in the 3rd century BC at Anuradhapura, and apparently edited for compactness. Concerning the reliability at the *Mahavamsa*, Parker (1909:10-1) states:

> It is important to understand clearly that as regards the pre-Christian and early post-Christian details which are found in the *Mahavamsa* we have got, not the opinions or fancies of a monk who lived 500 years after Christ, but a work carefully compiled from annals that were committed to writing in the second or third century before Christ, and continued without a break up to the time of the revered author. With respect to the information to be collected from the work regarding the earliest rulers, we have at least the opinions of analists, or traditions recorded by them, dating from a time that was perhaps only a century and a half later than the earliest local events of which they preserved the story. Some of these early chroniclers may have seen, or have known persons who had seen, the great king Pandukabhaya, the record of whose reign is of the utmost value for the light it throws on the position occupied by the aborigines in the third and fourth centuries before Christ.

According to the chronicles, the island was inhabited by aborigines referred to as the Yakkas, until they were displaced in the northern and western sectors of Lanka by new settlers from India called the Nagas (?Protohistoric A peoples) (*Dipavamsa*:125; *Mahavamsa*:6-7; Parker 1909:13-4; Seligmann and Seligmann 1911:26; Sarasin 1926:83). This episode may be construed as having taken place prior to the time of the Buddha and of Vijaya, the mythical founder of the Sinhalese kingdom in Lanka, namely before the late 6th century BC (*Mahavamsa*:56-8; Parker 1909:12,23). According to the *Rajavaliya*, the Yakkas sought refuge in remote forests in the face of this confrontation. By the 7th century AD, Hsuien Tsang (Beal 1911 ; Spittel 1933 :70 ; 1961 :xiii) refers to the Yakkas being in the south-eastern sector (i.e., Bintenne), as a relict group. Knox (1681:62) mentions Vaddas in the Hurulu Palata, to the north of Bintenne, whither groups had apparently moved in after the demise of the Sinhalese Dry Zone civilisation in Reddish Brown Earth terrain.

While the above historical references to the aboriginal groups of Lanka and the proto- and Early Historic Iron Age settlers offer insights as to the processes of interaction that might have occurred, they remain mere (tantalising) glimpses, which require to be fleshed out with substantive data. The retrieval of such data will perforce have to be encompassed within the framework of a discrete research design. Meanwhile, on the basis of the historical evidence, it is possible to formulate the following hypotheses to be tested: (*a*) the Nagas were Protohistoric A people who displaced the Stone Age (Mesolithic) Yakka hunter-gatherers from the northern and western sectors of Lanka from around 1,000 BC onwards; (*b*) from ca. 500 BC onwards a major cultural impulse was felt throughout peninsular India, reaching into Lanka as represented in the Photohistoric B period, which led to the dawn of the historical phase with its cultural epicentre in the Gangetic valley, and which manifested itself in Lanka in the spread of Buddhism, writing and other sophisticated culture traits, particularly under the aegis of the Mauryan imperial court. Excavations have been resumed in the citadel of Anuradhapura (1984) with a specific goal of testing these hypotheses (v. Addendum II: the Protohistoric B now reverts to Lower Early Historic).

While the term Vadda signifies hunter in Prakrit (Kennedy 1971), the Vaddas do constitute a very distinctive physical anthropological entity (Virchow 1886; Sarasin and Sarasin 1892; 1893; Hill 1941; Stoudt 1961). It has long been proposed on the basis of historical accounts that the Vaddas are the mixed descendants of the Sinhalese and the aboriginal Yakkas (Sarasin and Sarasin 1908:21; Parker 1909:19,23; Seligmann and Seligmann 1911:4); however substantiation of this hypothesis was not forthcoming until Mesolithic human skeletons (Balangoda Man) were subjected to detailed examination by Deraniyagala and Kennedy (Chap. 5.3.13). Kennedy's comparison of this material with various pre- and protohistoric populations of South and Southeast Asia, and also with Vadda osteological material, revealed unequivocally that the Vaddas were by far the closest biologically to Balangoda Man (Kennedy 1973:38). Assuming that late Balangoda Man of Lanka is coterminous with the Yakkas of the chronicles (and there is no reason to doubt this assumption), the literary evidence relating to the history of the aborigines of Lanka stands corroborated by the biological evidence. It has been demonstrated by Kennedy that the Vaddas constitute a population that forms a direct phylogenetic continuum with Balangoda Man, although with admixture of genes from later groups arriving in the island. Conversely, the Protohistoric A people of Lanka, as exemplified in the human remains excavated at Pomparippu, have been observed to possess certain physical traits that have undoubtedly been derived from Balangoda Man (Lukacs 1976:197,207-8; Lukacs and Kennedy in Begley et al. 1981) and there is evidence that this is true, in varying degrees, of the present-day Sinhalese as well (Deraniyagala 1955*a*:301; 1960*a*:108; Stoudt 1961:157; Kennedy 1965:207), particularly in the remoter rain-forest regions of the Wet Zone (personal observation; e.g., around Vaddagala).

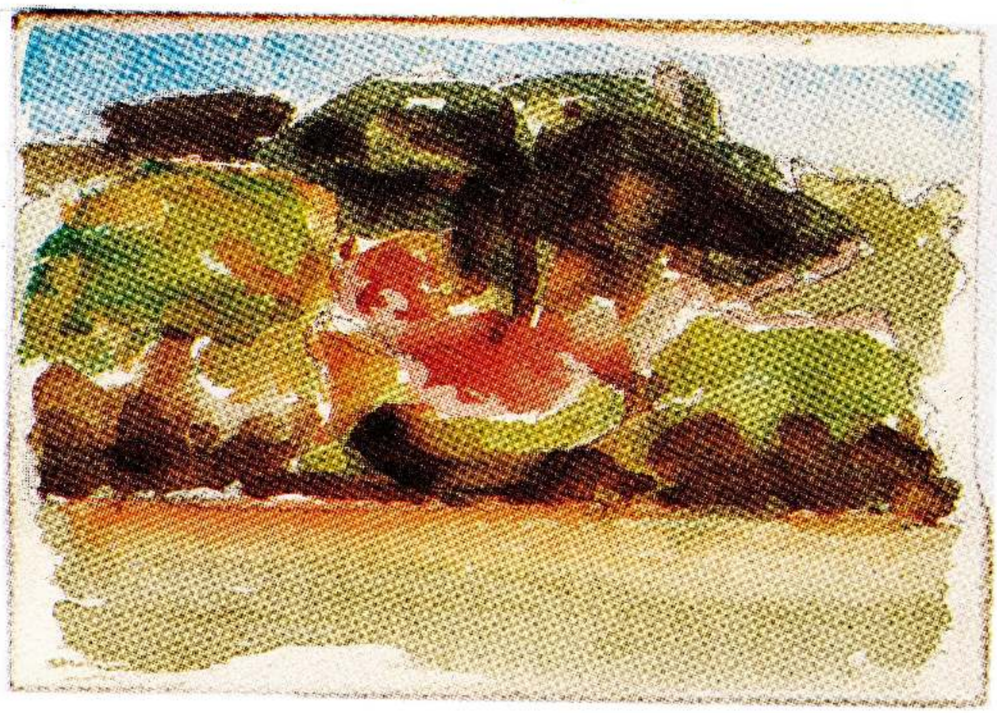
Although the genetic link between the Vaddas and Balangoda Man has been established beyond dispute, the cultural connection has yet to be defined on the basis of substantive evidence. There is no instance which can be cited as showing how the Vaddas developed into an Iron Age technological phase from the Stone Age. There is only one tenuous clue that has been afforded: the shrine of Sella Kataragama in southern Lanka is sacred to the god Kataragama and to the Vadda deity Valliamma. The ancient stupa-base adjoining Valliamma's Cave consists, in part, of alluvial gravel transported from the Menik river which borders the location. These gravels contain artefacts of quartz and chert, and it can be hypothesised that these cultural remains refer to an ancient Vadda habitation in the vicinity, thus establishing a very fragile link between the Stone Age and the present-day Vaddas.

*5.4.4 Conclusions.* The origins of farming in India could be very early indeed: possibly ca. 9,500 $^{14}$C BP for swiddening in Rajasthan; ca. 8,000 $^{14}$C BP (charcoal) for the Neolithic at Koldihwa near Allahabad; and ca. 6,400 $^{14}$C BP at Bagor I (Singh 1971; Agrawal et al. 1975:3). These dates are not anomalous in the light of the data from Afghanistan, with which region the sub-continent is likely to have had cultural interaction: domesticated sheep and goat in the aceramic Neolithic of Ghar-i-Mar at ca. 9,000 $^{14}$C BP; and at Aq Kupruk I, sheep and goat at ca. 10,000 BP and cattle at ca. 8,000 BP with sickle blades among the flint assemblages (Dupree 1973:258,262; 1974:199; Agrawal and Kusumgar 1974:63-5). The Indian dates are somewhat later than those for the rise of incipient farming in the Fertile Crescent at $\leqslant$ 11,000 BP (v. Brothwell and Brothwell 1969:37; Butzer 1971:55,541,554) and, while not discounting the possibility of local origins for certain types of domesticates, such as chickens (present in the Harappan of ca. 2,500 BC and in the Jorwe Chalcolithic of Nevasa (Sankalia 1974:508)) and possibly in the realm of horticulture (cf. Sauer 1952; Golson 1977 for Southeast Asian aspects), it is still possible to hypothesise that the main impulse for the advent of animal husbandry and cereal agriculture in India stemmed from West Asia. An analogous pointer comprises the evidence for the origins of the technique of producing true blades employing the *lame à crête* in India. This appears to have arrived from West Asia during the Chalcolithic of the sub-continent: note that Baluchistan has yielded a date of ca. 3,500 BC for such artefacts (Gordon 1958:21; Misra 1965:67; Sankalia 1974:311-2). It is also probable that a subsidiary process of interaction would have existed with Southeast and East Asia with regard to early subsistence practices. Note (*a*) the similarities between certain categories of eastern Indian and Assamese Neolithic stone celts and their counterparts in south-western China and Vietnam (Sankalia 1974:297); and (*b*) farming practices as evinced in the plant domesticates from Thailand at $\geqslant$9,000 $^{14}$C BP (Solheim 1969*a*:2) and in the New Guinea highands at ca. 10,000 BP (Golson 1977). This topic concerning the origins of farming in India, from a processual point of view, is complex and falls well outside the scope of the present work; however, the above (?simplistic) assertions may be considered an adeqate backdrop against which the prehistory/history transition in Lanka may be viewed.

From ca. 2,500 BC onwards, major sectors of the Indian sub-continent seem to have come under the influence of Neolithic or Chalcolithic cultures, with settled farming as a basic subsistence strategy (for chronology and distribution of Harappan, ca. 2,500-1,700 BC, v. Sankalia 1974:564-5; Agrawal et al. 1975:8; for peninsular Chalcolithic, ca. 2,000-1,100 BC, v. Agrawal et al. 1975:6,8-9). The south-central peninsula became the epicentre of a very distinctive Neolithic culture which superseded the local Mesolithic and has been dated to ca. 2,000 (?2,500)-1,000 $^{14}$C BC (v. Sankalia 1974:Fig.68,304-5,514,538,541,544,555,556; Agrawal and Kusumgar 1974:67; Agrawal et al. 1975:7; Paddayya 1975:330). This southern Neolithic has been described thus (Allchin and Allchin 1974*a*:73-4): "While various elements may have found their way into the southern Deccan from adjacent regions, the culture itself is primarily an indigenous growth." However, there were certain tracts of territory in peninsular India that were not receptive to the "Neolithic revolution" and which seem to have persisted in a hunter-gatherer mode of life. Noteworthy among these refuge regions are Madhya Pradesh and Kerala (for areas of attraction or nuclear zones of higher culture, relative isolation, isolation and extreme isolation v. Subbarao 1958:19). This phenomenon has been succinctly delineated by Subbarao (ibid.:12): "The whole pattern of development of material culture in India may be defined as one of horizontal expansion of the higher cultures, leading to a displacement, contraction, and isolation of the lower cultures, in different parts of the country, at different periods, and at different cultural levels." And again Gordon (1958:15) states: "even to the present day this process of the development of favoured areas and the stagnation of less favoured can be seen in the many contemporary cultural stages existing side by side". With specific regard to Madhya Pradesh, Misra (1976:40) affirms: "Central India with its hills and forests is also the largest refuge zone in the country, inhabited by many primitive tribal communities living at different technological and economic levels from hunting-gathering to regular plough agriculture. And archaeological evidence shows that the past of these tribal peoples is deeply rooted in the prehistory of the region". Basic to this view is one of sequential arrival of varying culture traits, their differential regional development, overlap and the survival of earlier traits in certain regions (v. Allchin and Allchin 1968:53). The physical anthropological implications of this process has been excellently set out by Kennedy (1973:38-9).

As with Madhya Pradesh and Kerala, the present evidence indicates that Lanka was a cultural backwater, a refuge area, with respect to the advent of Neolithic/Chalcolithic subsistence practices of farming. None of the pre-Iron Age sites investigated so far has yielded any firm evidence of the prevalence of domesticates. The subsistence pattern apears to have transformed itself rapidly from a hunting and gathering basis to a full-fledged agricultural *cum* stock-raising economy with the advent of the Iron Age at ca. ≥900 BC, with hunter-gatherer relict tribes such as the Yakka/Vaddas surviving in regions with low agricultural potential. It is noteworthy that the southern Neolithic of the Deccan did not extend into Kerala or Tamilnadu south of the upper Vagai river (Sankalia 1974:Fig.68). It seems probable that the working of the heavy soils in these regions (and of Lanka) was not feasible without iron implements. Before the advent of iron technology, there is some possibility that swidden crops, such as legumes and non-irrigated cereals such as millets, were being cultivated on a very limited scale in these apparently blank regions (for chronology and distribution of such crops in the Chalcolithic of India, e.g., at Navdatoli, v. Vishnu-Mittre 1968:94-7; Sankalia 1974:460,560-3), but the substantive evidence for such practices has not been forthcoming as yet – although it probably will, with more intensive investigations.

The dawn of the Iron Age in Lanka witnessed the rapid rise to urbanism of certain sectors of the country, notably in the North-Central Province centred about the capital at Anuradhapura; the rest is history, which does not concern the present work (for an exhaustive bibliography v. Goonetilleke 1970/76). As for the prehistory/history interface in Lanka's cultural evolution, it is amply evident from the above account that it is shrouded in a haze of scholarly ignorance – to dispel which requires the formulation of an independent research design. The only site to have provided a complete sequence from prehistory to the Early Historic period in Lanka is the Citadel of Anuradhapura (S.Deraniyagala 1972), although vestiges of the transition were notably lacking. It is with a view to delving into this compelling, but complex, subject that I have inaugurated a fresh series of excavations at this site (id. 1986*a*) and it is hoped that at least the chronology will be based on a firm footing with yet more radiocarbon dates. This will serve as a springboard for launching a programme directed at amplifying the present (somewhat meagre) data base as to the culture traits and their implications with regard to the proto- and Early Historic periods of Lanka (v. Addendum II).



Landscape, Iranamadu Formation: Kudiramalai *(R.Y. Deraniyagala del. 1978; aquarelle x 1)*

Stone Age is discussed from several angles within the context of the peninsular Indian situation, and certain Middle Palaeolithic elements identified for the first time on the island. The anomalously early appearance of geometric microliths constitutes another aspect of prehistoric technology that is considered at length, as is the other enigma of the absence of the Neolithic tradition of making polished axes and pottery as represented in peninsular India. With regard to subsistence traits, the broad-spectrum exploitation of plants and animals, at least over the last 35,000 years, is discussed against a backdrop of present-day practices of hunting and gathering wild food plants and honey in Sri Lanka. Prehistoric settlement configurations are dealt with, leading to hypotheses on fluctuations in population densities, based on ethnographic data. The formulation of future research strategy is impelled by a concise statement of the current problematique. A comprehensive index provides ready access to practically every item of information incorporated in this work.

Methodologically, with reference to the interpretation of the archaeological record, the explicit use of a theoretical framework of cultural palaeo-ecology, of ethnographic analogy and of a diverse array of environmental data – ranging from meteorology to biomass statistics – has broken new ground in South Asian archaeology. The analytical system employed on the stone tools is similarly *avant garde* for lithic systematics in general, with applications to a wide range of non-specialised assemblages in the tropics. The structuring of the data and the resultant hypotheses constitute a vertically integrated hierarchy – leading up from the simple (where the relationship between data and inference is obvious) to the complex (where simple and seemingly disparate propositions coalesce into complex hypotheses). This in itself is of considerable methodological import in that it reflects a research design that has been thought through from start to finish. The upshot is a work of immense scope and depth, with immediate and long-term relevance to the archaeology of South Asia as a whole, which is likely to be the springboard for prehistoric research in Sri Lanka for several decades to come.

The author, S.U. Deraniyagala (M.A., *Cantab.*; Postgrad. Dip., *Inst. Arch. Lond.*; Ph.D., *Harvard*), has been Assistant Commissioner (Excavations) of the Archaeological Survey of Sri Lanka from 1968 to 1983. Since then he has been adviser to the same institution for research orientated excavations and is at present the Director-General of the Archaeological Survey. Deraniyagala is currently completing the initial stage of a research programme which concerns the archaeology of the final prehistoric to Early Historic periods of the island (ca. 900 BC – 300 AD). This complements the research design which dealt with the prehistoric period *per se*, and as such its preliminary results are set out as addenda in the present publication.

Printed at the Department of Printing, Government of Sri Lanka

ISBN 955 - 9159 - 00 - 3