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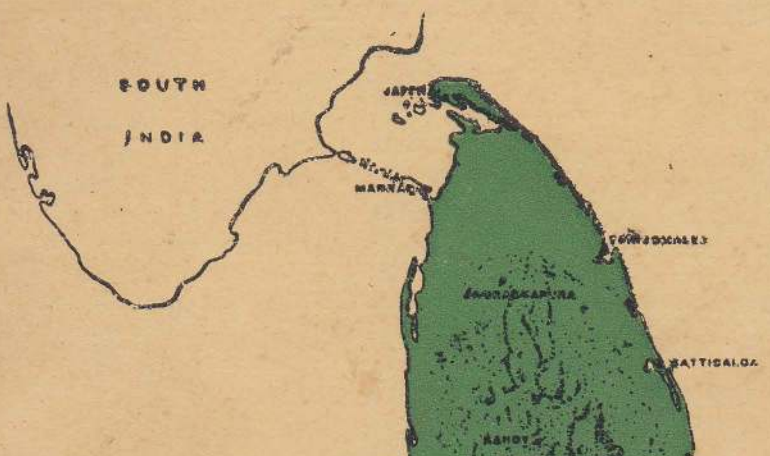
CEYLON GEOGRAPHICAL SOCIETY



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A SUMMARY OF THE METEOROLOGICAL CHARACTERISTICS OF CEYLON.

By G. S. Jayamaha

ABSTRACT

The air mass prevailing over Ceylon is generally Equatorial Air or Indian Continental Air. These control the monsoon activity, the former being the air stream of the South-West Monsoon and the latter the main current of the North-East Monsoon.

Convergence along the boundary of these air masses often affects the weather during inter-monsoon seasons. Whenever active convergence is absent during inter-monsoon periods the weather is diurnally controlled by thermal influences.

Another important factor in the Ceylon weather is depressional activity. Depressions, however, are not a common feature in these regions. Their influence on the weather is felt only occasionally.

INTRODUCTION

Nearly all the phenomena with which weather is concerned occur within the gaseous space surrounding the earth known as the atmosphere. Air consists of a mixture of various gases in a proportion which remains practically constant throughout the atmosphere. Water, in the form of vapour, is carried into the atmosphere from time to time on account of the evaporation that takes place almost continually from water surfaces like seas, rivers, lakes and damp land masses. The actual amount of water vapour in the atmosphere varies a great deal with respect to time as well as locality, but it remains a very important controlling factor in the atmospheric processes which are known as " weather ". The weather in a specified locality during any month or season of the year or during any particular time of the day is known when the conditions of the meteorological elements (such as temperature, pressure, humidity or vapour content, wind speed and direction, visibility, cloud and precipitation) are defined. In order to define these weather elements with respect to space and time it is necessary to study the meteorological processes that are taking place within the atmosphere.

The atmosphere consists of vast, almost homogeneous, masses of air which are distinct from each other. The behaviour or performance of any particular mass of air would undoubtedly depend on its properties and on the modifications which these properties are likely to undergo. The surface of separation between any two of these air masses is known as a " front ". Along such a front or boundary there will naturally be discontinuities in the weather elements—at least in some of the elements. These discontinuities are, more or less, abrupt and are generally associated with disturbed weather conditions—such as rain or squally showers and, perhaps, thunder.

GENERAL WEATHER FORECASTING IN THE TROPICS

In general, weather forecasting should be based on the properties and the movements of the different types of air masses and on the identification of fronts and frontal phenomena. This, in fact, is the technique that is usually adopted in the temperate regions. In the tropical zone, however, the weather situations differ so widely from those commonly experienced in the middle and high latitudes that it is sometimes even felt that the various techniques of weather forecasting employed in those regions are not suitable for adoption in the tropics. Yet, it should be borne in mind that the same types of physical and dynamical processes are taking place throughout the atmosphere and the same fundamental laws of nature apply to all regions, whether in the tropics or in the higher latitudes. The chief difficulty in the tropical regions is that the problems of weather forecasting appear to be less amenable to mathematical treatment than in the middle and high altitudes. For example, although the basic causes of the processes which produce clouds in the tropical regions are the same as those in the higher latitudes the meteorological significance of the various cloud types is often quite different. Further, the different well defined sequences in the types of clouds which are a significant feature of the weather situations in the temperate regions are practically absent within the tropics.

An important feature in tropical weather is instability because the manifestations of weather in these regions are mainly due to unstable conditions within the atmosphere. Other important factors in respect of which differences occur are the pressure fields, air mass properties and frontal phenomena. Pressure systems or isobaric forms are generally not clearly defined within the tropical zone, and there is apparently little or no real connection between the existing pressure fields and the prevailing wind speed and direction. Where air mass properties are concerned nearly all the air masses that are found within the tropical regions are warm and unstable, and there is usually hardly any difference in the properties of the various types of air masses that are present. Tropical fronts are much more diffuse than those of the higher latitudes. Moreover, these fronts appear to be more of the ' dynamic ' type than of the " thermal " type. That is, the discontinuities near the frontal surface is only in the windfield (wind speed or direction or both) and not in the other elements, such as temperature.

In addition to all these factors there are the important phenomena of convergence and divergence of air streams. In the tropical regions convergence and divergence of air streams must be detected and estimated from the observed wind distribution whereas in the middle and high latitudes these phenomena are deduced from the appropriate synoptic situations. Convergence of windfields, in particular, is found to be an important feature of the weather in the tropics.

AIR MASSES IN THE CEYLON AREA

Having seen the background on which the tropical weather should be studied it will now be possible to examine and analyse the salient features of the weather over the Island of Ceylon. It will, of course, be necessary to take into consideration the meteorological conditions of the larger meteorological region of which the Island forms a part. For this purpose the analysis should commence with the study of the properties of the various air masses that prevail over this region and the modifications they undergo.

As mentioned earlier, changes in air mass characteristics are not clearly defined within the tropical regions. Nevertheless, it is possible to classify the types of air which influence the weather over Ceylon and the neighbouring regions under five main categories. They may be identified as Indian Continental Air, Siberian Air, the North Pacific Trades, the South Pacific Trades and Equatorial Air (Fig. 1).

Indian Continental Air is air from the tropics which has subsided into the sub-tropical anti-cyclone region of the northern hemisphere. This air mass is initially cold and dry and of great vertical stability. It reaches India through the Western gap in the mountain range to the north and north-west of the Indian sub-Continent. During its southward journey back to the equatorial zone its lower layers become warmer due to the warmer surfaces it traverses and a certain amount of mixing of the air takes place. This causes instability within the air mass. These unstable conditions are, however, limited only to the lowest layers. The air stream reaches Ceylon from a direction varying between north-west and north-east. When it reaches the Island from a north-westerly or northerly direction it is very dry. This is as should be expected on account of its track over the dry Indian land mass. On the other hand, when Indian Continental Air comes from a north-easterly direction it would have travelled over a short sea track while coming down over a portion of the Bay of Bengal. Consequently, it would have absorbed a certain amount of water vapour. The actual amount of moisture contained within the air mass would depend on the length of the sea track. This air stream would be in a state of conditional instability by the time it reaches Ceylon. The trajectories of this and the other air streams are shown in Fig. 1. This type of air generally prevails over the Island from December to February.

Siberian Air, too, is subsided air of the sub-tropical anti-cyclonic belt of the northern hemisphere. During its southward journey the air mass moves over China and breaks through the gaps in the mountains of East-Central Asia. This air stream also starts off as a cold and dry mass but becomes warmer as it moves southwards. It begins to collect moisture after it bursts into the Bay of Bengal. Siberian air probably never moves as far south as Ceylon but it exerts an indirect influence on the weather over the Island because it affects the weather in the Bay of Bengal.

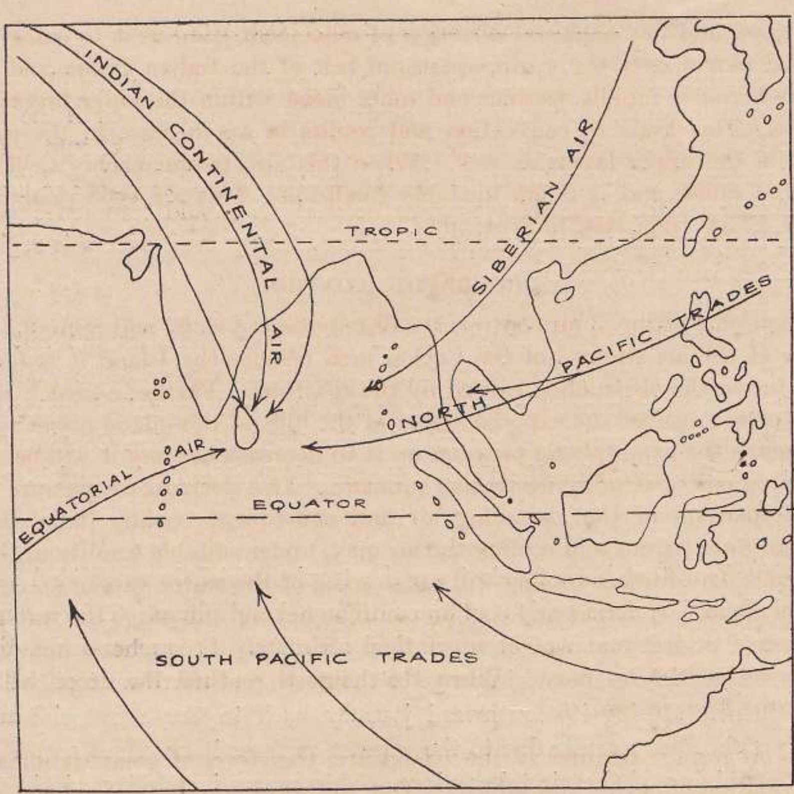


FIG. 1.—The types of air masses prevailing over Ceylon and the neighbouring areas. (The arrows show the usual trajectories of these air masses).

The North Pacific Trades are produced by tropical maritime air which has subsided over the North Pacific Ocean. This air mass is also cold and dry at its source. During its southward passage across the North Pacific Ocean its temperature and vapour content gradually increase but a certain amount of this moisture is deposited while the air stream crosses the land mass of South-East Asia. Further moisture is, however, absorbed by the air mass as it moves over the Bay of Bengal. This type of air reaches Ceylon only on very rare occasions during the three months from December to February.

The South Pacific Trades form the counterpart of the North Pacific Trades. The air mass originates from the subsided air over the South Pacific Ocean. It travels in a north-westerly direction across the South Pacific Ocean and later crosses into the South Indian Ocean. The air stream becomes warmer and collects a great deal of moisture while moving up towards the equator. During the period between May and September, or perhaps from April to October, the air stream of the South Pacific Trades moves right up into the equatorial zone but it rarely crosses the equator in a pure state. This air stream never reaches the Island but it has an influence on the weather immediately South of Ceylon.

The fifth type of air mass, *Equatorial Air*, is produced when the trade winds of either hemisphere move into the equatorial space and stagnate there owing to the absence of any appreciable pressure gradient. This air stream is sometimes referred to as the " Equatorial Westerlies " because it remains within the equatorial region and has a general direction of movement from west to east. Equatorial Air moves over the warm equatorial belt of the Indian Ocean and, consequently, becomes rapidly warmer and more moist within the lower layers of the air mass. This leads to convection and results in an increase in the moisture content in the upper layers as well. When this air stream reaches Ceylon it is warm and moist and is in an unstable condition. This air type predominates over the Island from May to September.

OROGRAPHIC CONTROL

Orographic lifting of air controls the distribution of cloud and rainfall. When any one of the air streams of the Ceylon area reaches the Island it is forced to ascend due to the obstruction caused by the coastline. Further ascent is induced when it comes against the exposed slopes of the hills of the inland areas. Ascent of air causes the atmospheric pressure on it to decrease because it will be ascending into regions of steadily decreasing pressure. This decrease of pressure results in the expansion of the ascending air and consequent cooling (adiabatically). With continued ascent and cooling the air may, under suitable conditions, become saturated. Any further cooling will cause some of the water vapour to condense and form cloud. If ascent and cooling continue beyond this stage the water drops will increase in size and weight until they ultimately become too heavy to be kept up within the air mass. When this stage is reached the drops will come down in the form of rain.

The orographic features of the Island are, therefore, of great significance in the distribution of clouds and rainfall. Due to this orographic control the heavier falls of rain are generally concentrated along the south-western and north-eastern slopes of the hills which are exposed to the wind currents of the rain-bearing air streams and, in a milder way, along the south-western and eastern coastal areas.

CONVERGENCE OF AIR STREAMS

Fronts or clearly defined surfaces of demarcation between different masses of air have been an important feature of the weather in the middle and high latitudes. They are well established in relation to the weather situations of these regions and form the basis of weather forecasting, but it was until recently thought that fronts did not exist within the tropics. As such the extension of frontal ideas to the tropical regions has not been easy.

The technique of modern synoptic meteorology, with emphasis on streamline analysis of the horizontal windfields, has however focussed the attention of tropical meteorologists (during the past decade or two) on the existence of discontinuities or fronts within the tropical areas. The boundary surfaces or fronts of the tropical regions are somewhat different from those of the higher latitudes. The discontinuities along these tropical fronts are generally only in the windfields. There are usually no abrupt changes in the other surface characteristics, such as temperature and humidity. These fronts are, therefore, identified by the discontinuities in the horizontal winds. Due to the changes in the windfields along a zone of convergence the air of each wind stream is forced to ascend. This ascent of air usually gives rise to the formation of clouds and, in certain cases, rainfall.

There are two such boundaries or zones of convergence within the meteorological region under consideration—that is, the wide region of which Ceylon forms a part. Each of these lies practically in an east-west direction. In the Indian Ocean region, Equatorial Air forms one boundary at its northern limit with either Indian Continental Air or the North Pacific Trades. This boundary or zone of convergence is commonly known as the Northern Convergence Zone. The other boundary occurs between Equatorial Air (at its southern limit) and the South Pacific Trades. This is usually referred to as the Southern Convergence Zone (Fig. 1). The existence of these two zones of convergence are a significant feature of the daily weather charts of this region.

The South-West Monsoon:

These two zones of convergence do not show any regular speed of movement although they generally move northwards or southwards according to the season of the year. The extreme positions are approximately 25° or 30° latitude in the northern hemisphere and about 10° or 15° in the southern hemisphere. One or the other of these two zones may, however, remain stationary during a certain period. At any particular time of the year the convergence zone which is within the summer hemisphere and is further away from the equator is commonly known as the Inter-Tropical Front or Inter-Tropical Convergence Zone. On account of these movements the northern convergence zone crosses Ceylon through the lowest layers of the atmosphere during the month of April on its northward journey and during October on its return. The southern convergence zone, on the other hand, has not been known to lie over Ceylon. Perhaps, it never reaches the Island.

When the northern convergence zone moves away to the north of Ceylon the Island comes under the influence of Equatorial Air or the Equatorial Westerlies. This is the air stream of the South-West Monsoon. Monsoon activity, however, is not experienced over the Island until the latter half of May because an air stream of sufficient depth is required for such activity, and that is available only from about the middle of May. (This could be seen easily from Fig. 2, where a

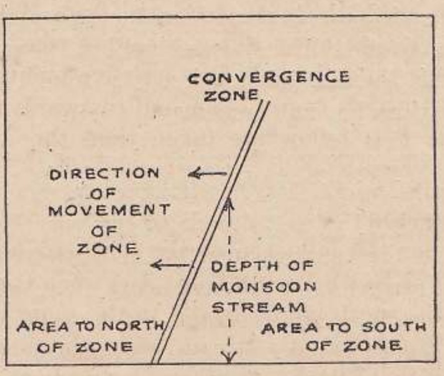


FIG. 2.—A vertical section of the convergence zone.

vertical section of the convergence zone is shown). The synoptic situation at 0001 G.M.T. on 31st August, 1954, with the South-West Monsoon conditions established over the Island, is shown in Fig. 3. *Vide Plate 1 for Figs. 3-6.

Against each land station or ship the wind speed and direction, temperature and pressure are plotted. The direction from which the wind is blowing is shown by the direction of the arrow while the speed of the wind is represented by feathers. Each long feather represents 10 knots while a short one represents 5 knots. The figure on the left is the air temperature in degrees Fahrenheit. The figure on the right is the atmospheric pressure in millibars. The thousands and the hundreds are not plotted. Only the tens, units and tenths are shown. In each case the figure 1000 should be added to the value shown in order to obtain the correct pressure. The isobars are drawn for every whole millibar pressure.

The onset of the South-West Monsoon is associated with heavy rain if the northern convergence zone is associated with a disturbance or low pressure system. In such cases the monsoon is popularly supposed to " burst " over the Island. Whenever this type of disturbance does not occur along the northern convergence zone during this time of the year, the monsoon sets in only gradually—that is, without the well-known " burst ".

As mentioned earlier this air stream of the Equatorial Westerlies has a very high moisture content and the conditions within the air mass are unstable. The lifting of this air stream when it strikes a coastline or a range of hills very often causes the building up of large cumulus and cumulonimbus clouds and, sometimes, the precipitation of rain. On account of this orographic effect the rainfall due to the South-West Monsoon is practically confined to the south-west quarter of the Island and the western and southern slopes of the exposed hills.

The average distribution of the South-West Monsoon rainfall in the south-west quarter of the Island is shown in Fig. 7. (The distribution over the entire Island can be seen from the map published in each " Annual Report of the Colombo Observatory " by the Department of Meteorology). The average total rainfall during the South-West Monsoon season is highest in the Watawala area where it generally exceeds 120 inches for the period of five months from May to September. The rainfall totals decrease steadily towards the southern and western coastal areas. The average values along the coastal belt are less than 60 inches, being 40 to 60 inches between Ratmalana and Weligama, and 20 to 40 inches from Dehiwala to Marawila along the west coast and from Matara to Tangalla along the southern coast. Further away along the west coast, as well as along the south coast, the average rainfall totals for these five months are quite low, being less than 20 inches northwards from Chilaw and eastwards from Tangalla. These figures and the others that follow are taken from the Annual Reports of the Colombo Observatory.

The North-East Monsoon:

Ceylon comes under the influence of the northern hemisphere air (that is, Indian Continental Air or North Pacific Trade Air) when the northern convergence zone moves away to the south of the Island in the same way as it comes under the influence of the Equatorial Air stream when this convergence zone moves away to the north of the Island. Northern hemisphere air generally prevails over the Island from the beginning of December to the end of February. This is the North-East Monsoon Season of Ceylon. An example of a synoptic situation during the North-East Monsoon period is given in Fig. 4. which shows the weather chart at 1800 G.M.T. on 8th February, 1954.

Orographic lifting due to the eastern coast line of the Island and the northern and eastern slopes of the central hills will induce clouds and precipitation whenever the prevalent air stream contains a sufficient quantity of moisture. The resultant rainfall will be chiefly confined to the northern and eastern portions of the Island with the heavier falls being concentrated along the windward slopes of the exposed hills.

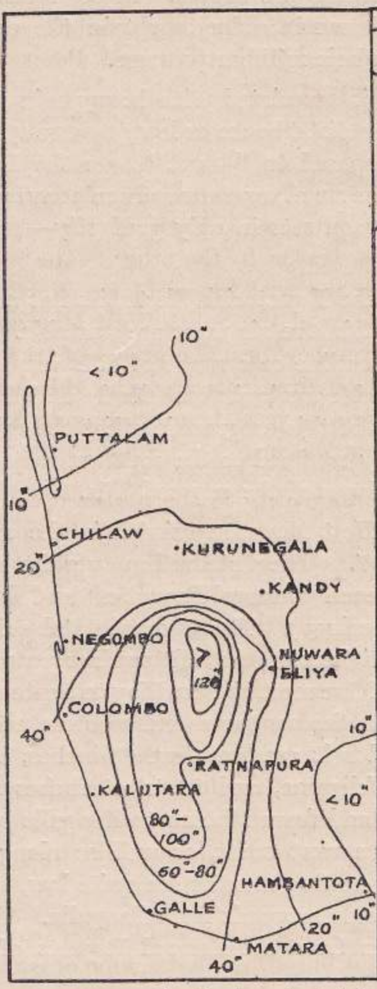


FIG. 7—The average distribution of rainfall in the south-west quarter of the Island during the months of the South-West Monsoon.

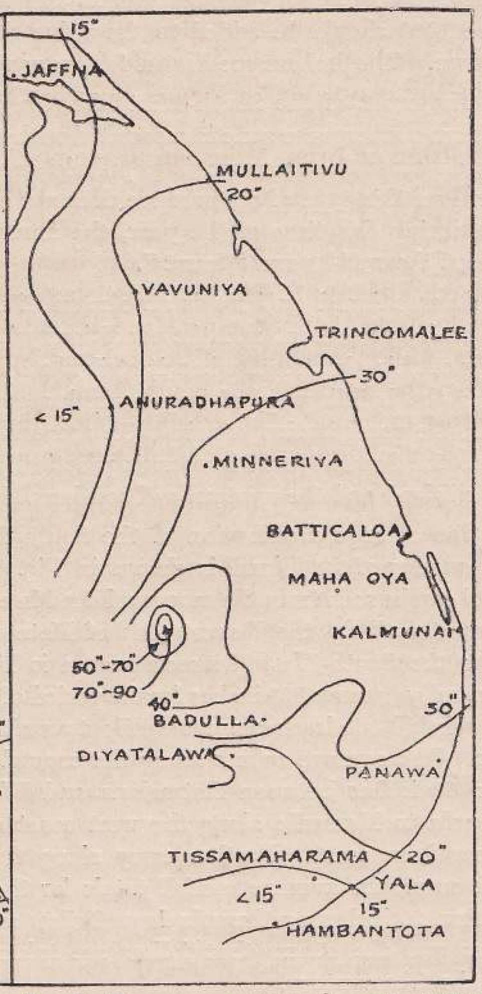


FIG. 8—The average distribution of rainfall in the north and east during the months of the North-East Monsoon.

The average distribution of the rainfall in the northern and eastern areas of the Island during the North-East Monsoon season is shown in Fig. 8. The greatest amount of rainfall in these regions during the three months of the North-East Monsoon season is usually recorded in the Nitre Cave area. The average combined rainfall total for this area during this period is between 80 and 90 inches. The areas around Madulsima, Gammaduwa and Urugala show the next highest averages with totals ranging from 50 to 70 inches for the period. In the coastal regions the maximum amount of rainfall is generally experienced in the areas surrounding Valaichenai, Batticaloa, Kalmunai and Akkaraipattu where the average totals for this period are between 30 and 35 inches. South of Akkaraipattu the season's rainfall decreases gradually towards the Pottuvil and Panawa areas where the averages range from 25 to 30 inches. Beyond Panawa the decrease is more abrupt, the average rainfall total in the Yala area being only about 15 inches. North of Valaichenai, too, there is a general decrease in the amount of North-East Monsoon rain along the coastal areas. The approximate average rainfall totals in the areas around Trincomalee, Mullaittivu and Point Pedro during this season are 25, 20 and 15 inches, respectively.

Transition or Inter-Monsoon Seasons :

The two periods of March-April and October-November are neither in the South-West Monsoon nor in the North-East Monsoon. Each of these periods forms a stage of transition from one monsoon season to the other. The months of March and April form the period between the withdrawal of the North-East Monsoon from the Ceylon area and the advance of the South-West Monsoon air stream, while the months of October and November form the period of transition between the retreat of the South-West Monsoon from this area and the onset of the other monsoon. On account of this, these two periods are commonly known as the Transition Periods or the Inter-Monsoon Seasons.

During these two transition or inter-monsoon periods the northern convergence zone is lying either across the Island or in its near vicinity, and the northern hemisphere air stream will converge with the air stream of the Equatorial Westerlies to produce large banks of cumulus and cumulonimbus clouds and also several layers of altostratus and cirrostratus clouds. Under these conditions the weather situation over the Island deteriorates and results in intermittent rain which is occasionally accompanied by thunder. In cases where this convergence zone is lying only in the neighbourhood of Ceylon and not directly over the Island the convergence will take place only at some distance away to the north or south of Ceylon. In such an event only stratiform medium and high clouds (altostratus and cirrostratus) will be present over the Island or over the affected portion of it. The resulting precipitation over the affected parts of the Island will then be in the form of light rain.

It has been noticed that a zone of convergence is active only when true convergence is taking place within the zone. It is only then that a zone of convergence will be associated with heavy clouding and precipitation. Whenever the northern convergence zone is inactive during any particular period of an inter-monsoon season the weather over the Island will be controlled by the thermal influence. (The thermal influence is at a maximum during the two inter-monsoon seasons). During these two seasons there is hardly any pressure gradient across the Ceylon area. An example of a synoptic weather situation during an inter-monsoon season is given in Fig. 5 where a portion of the weather chart at 0600 G.M.T. on 8th October, 1954, is reproduced. Due to the lack of a pressure gradient in this region the prevailing winds over the Island will be light and variable in direction. This will result in the air stream becoming virtually stagnant. The occurrence of clouds and the weather sequence will show a significant diurnal variation. From sunrise to the early forenoon period the sky will be generally clear. If the lapse rate in the atmosphere (that is, the rate at which the temperature of the air decreases with increase in height within the free atmosphere) is very high, the conditions within the atmosphere will be markedly unstable and the differential heating of the land mass will set up intense convection currents in the inland areas. If, in addition, the air is moist, this convective action will lead to the building up of large cumulus and cumulonimbus clouds in the inland areas, particularly over valley locations such as Ratnapura and Diyatalawa. Thunder activity will commence at mid-day and will gradually spread towards the coastal areas during the late afternoon or evening, the process starting earlier if the lapse rate is steeper—in other words, if the instability conditions are more marked. If, however, the lapse rate is only moderately steep (or less unstable) the convective action and the resulting clouds and precipitation will be restricted to the hill country. With the decrease in the instability conditions after sunset the clouds will quickly dissipate and only fragments of stratocumulus and altocumulus clouds may be present at sunrise on the following morning. These will be burnt off rapidly after sunrise.

It follows, therefore, that the weather over the Island is controlled by two important factors during these two inter-monsoon seasons. One of these factors is the influence of the northern convergence zone when it exists in an active state. In such a case the weather would possess certain frontal characteristics. The other important factor is the thermal effect. During these inter-monsoon seasons the weather over the Island would generally be diurnally controlled by the thermal influence whenever the northern convergence zone is inactive.

Weather Associated with Tropical Storms:

Another important feature of the weather in the Ceylon area is the depressional activity that is experienced occasionally. Low pressure systems or depressions in this region are commonly known as cyclones or (if they are intensely active) tropical storms. Cyclones influence the weather over Ceylon only on rare occasions and that, too, only for short periods. On an average only two or, perhaps, three tropical storms may occur every year sufficiently close to Ceylon in order to affect the weather over the Island. The highest frequency is recorded during the month of November when the average number of occurrences is about one per year. October experiences the next highest frequency with approximately one cyclone in every two years. The synoptic situation during one of these storms is shown in Fig. 6 which represents the weather map at 0600 G.M.T. on 16th December, 1954.

The general characteristics and effects of these cyclones will be best understood from the description of the general weather sequence over the Island during one of these storms. (These details are taken from the records of the Department of Meteorology). The tropical storm of October, 1945, is taken as an example. The sequence of the general weather situations is given below.

Between the 12th and 14th of October, 1945, there was moderate to heavy rain of a widespread nature over the Island. This rain was generally accompanied by thunder in most places. The pressure distribution over the Island was, on the whole, above the average for this time of the year.

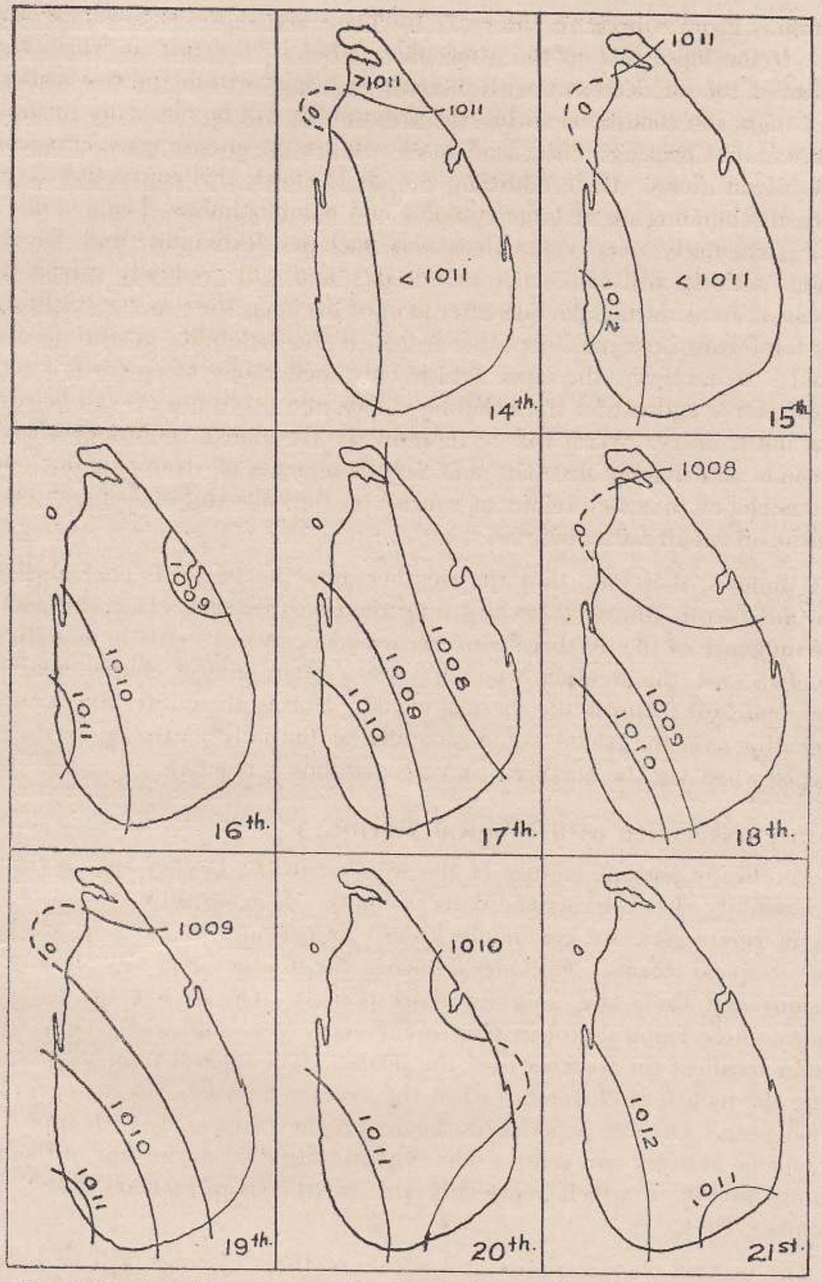


FIG. 9.—The distribution of pressure over the Island at 8 a.m. from 14th to 21st October, 1945, (The isobars are drawn for every millibar).

On the 15th the pressure continued to be above normal but the general distribution indicated a light westerly gradient (Fig. 9). The surface winds in the coastal regions were light. The surface temperatures during the day were below average due to the heavy clouding. Night temperatures, too, were below normal except in the hill country. Thunder and widespread, moderate to heavy, rain were again experienced while the general weather situation indicated that the conditions were becoming unsettled. The weather conditions in the south-eastern region of the Bay of Bengal also became unsettled and favoured the formation of a depression in the neighbouring area. Later in the day a depression was actually identified in the Bay in a direction due east of Ceylon. The central portion of this depression was found to be within a degree of the position of latitude 09°N and longitude 91°E at 5 p.m. (local time). The disturbance showed signs of moving in some north-westerly direction.

By 8 o'clock on the following morning (viz. 16th), the atmospheric pressure over the entire Island had decreased appreciably but was still slightly above average. With the clouds and precipitation persisting the day temperatures continued to be below normal, particularly in the south-west quarter of the Island. At night the temperatures were slightly above normal in the ' up-country ' areas but remained below average in other places. The coastal winds were generally light at first but strengthened later during the day and became gusty along parts of the sea coast areas. Rain was again widespread and heavy in places. The depression itself had intensified during the previous night into a cyclonic storm and had moved in a north-westerly direction. By 8 a.m. on the 16th it was centred within a degree of latitude 10°N and longitude 90°E.

A further fall in the pressure was observed over the Island on the 17th morning. This drop in preasure was particularly marked in the eastern half of Ceylon. Consequently, the pressure gradient became fairly steep while its direction changed slightly towards south-west. The surface winds along the coastal areas strengthened considerably and were generally moderate to fresh in force and south-westerly in direction. Occasional gale winds were also experienced. The peak values of the surface winds during this spell were reached on the 17th. The temperatures remained below average during the day, but at night they were a little above average in the north and among the hills, and below normal in the other parts of the Island. Rain was moderately heavy and, again, widespread. In the meantime the cyclonic storm had moved away along its north-westerly course and was close to latitude 12°N and longitude 87°E at 5 p.m. It was now situated to the north-east of the Island. The track of this storm is shown in Fig. 10.

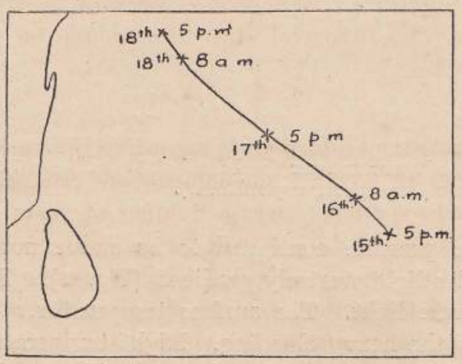


Fig. 10.—The track of the storm of October, 1945, is shown for the period from 5 p.m. on 15th to 5 p.m. on 18th.

On the 18th morning practically no alteration was observed in the pressure distribution. The surface winds along the coasts continued to be moderate to fresh and south-westerly in direction. Occasional stronger gusts also occurred but, in general, the winds showed signs of easing off towards evening. Temperatures were still below normal during the day but at night they were a little above average almost throughout the Island. With the moving away of the central area of the disturbance the rainfall over Ceylon was now only moderate. Meanwhile, the cyclonic storm had intensified further and at 8 a.m. its central region had moved up to within a degree of latitude 14½°N and longitude 84½°E. It continued to move further in a north-westerly direction during the day and by 5 p.m. it was centred near latitude 15°N and longitude 84°E. At 10 p.m. the storm, was found to be crossing the east coast of India.

As the storm moved further away from the Ceylon area its influence over the Island's weather began to decrease. As its energy began to dissipate after crossing the Indian coast its effect over the Island ceased and the weather conditions once more returned to normal. The pressure rose a little between the 18th and the 19th, and during the morning of the latter day the winds at the coasts were only moderate south-westerly. Later in the day they were observed to be dying down considerably, particularly during the evening and night. With the breaking up of the clouds the temperatures were irregularly distributed over the Island during the day as well as at night. The rainfall was practically nil.

With the return of the weather situation to normal conditions the pressure gradient gradually disappeared. The diagram of 21st October shows a fairly uniform distribution of pressure throughout the Island.

CLIMATOLOGICAL STATISTICS

Due to the fact that instability conditions predominate over the weather situations within the tropical zone it is found that weather forecasting has sometimes to be carried out on a statistical basis because instability phenomena are not capable of precise prediction. Further, on account of the other drawbacks, such as the general absence of well defined pressure systems and well marked frontal characteristics, climatological statistics assume on added importance in the tropical regions.

A great deal of statistical information regarding the various weather elements and the different types of weather phenomena are now available for Ceylon—thanks to the recorded experience over a number of years. From an organized study of these climatological data it will be generally possible to find out the tendencies of the weather in any specified locality during a particular season of the year. By studying the actual weather situation for the day in conjunction with these general tendencies due to the climate the forecaster will certainly be in a much better position to predict the future weather than if he were to take only the former type of formation into consideration.

GENERAL SUMMARY OF THE WEATHER SITUATIONS

The year, as is well known, may be divided into four seasons. The most important season is that of the South-West Monsoon which generally prevails over the Island from May to September. The North-East Monsoon season lasts from December to February. The other four months form the two inter-monsoon seasons. The period of March-April is sometimes called the Pre-Monsoon Season (that is, with particular reference to the South-West Monsoon) while the period of October-November is at times referred to as the Post-Monsoon Season.

The type of air that prevails over the Island during the months of the South-West Monsoon is Equatorial Air. During the season of the North-East Monsoon the predominating type of air mass is Indian Continental Air but this air mass occasionally withdraws from the Ceylon area when there is a forward surge of the North Pacific Trades. The rainfall of the South-West Monsoon stream is orographically confined chiefly to the south-west quarter of the Island and to the southern and western slopes of the central hills. The rainfall of the North-East Monsoon is similarly distributed in the northern and eastern areas of the Island and particularly along the northern and eastern slopes of the central hills.

During the two inter-monsoon seasons the prevailing air type over the Island is generally a mixture of northern hemisphere air and Equatorial Air. The northern convergence zone has a marked influence over the Ceylon weather during these four months. The effect of the diurnal heating of the land, however, takes control of the weather situation over the Island whenever this convergence zone is inactive during these two seasons.

The chief features of the Ceylon weather may, therefore, be considered as the South-West and North-East Monsoons, the northern convergence zone, thunder activity due to thermal control, and tropical storms.

From the above discussion it is clear that the problem of weather forecasting, whether in Ceylon or in any other part of the world, should be tackled on a strictly scientific basis by taking into consideration the various processes that are taking place within the atmosphere and also those that are likely to take place within the relevant period of time. In the tropical regions, in addition to the above, it is essential to have all the available statistical information always at the background. Thus, weather forecasting in these regions should be based on the current weather situations as well as on the climatological data.

Acknowledgement.—I must express my thanks to Dr. D. T. E. Dassanayake, Director of the Department of Meteorology, for allowing me to use the data and the weather charts of the Department.

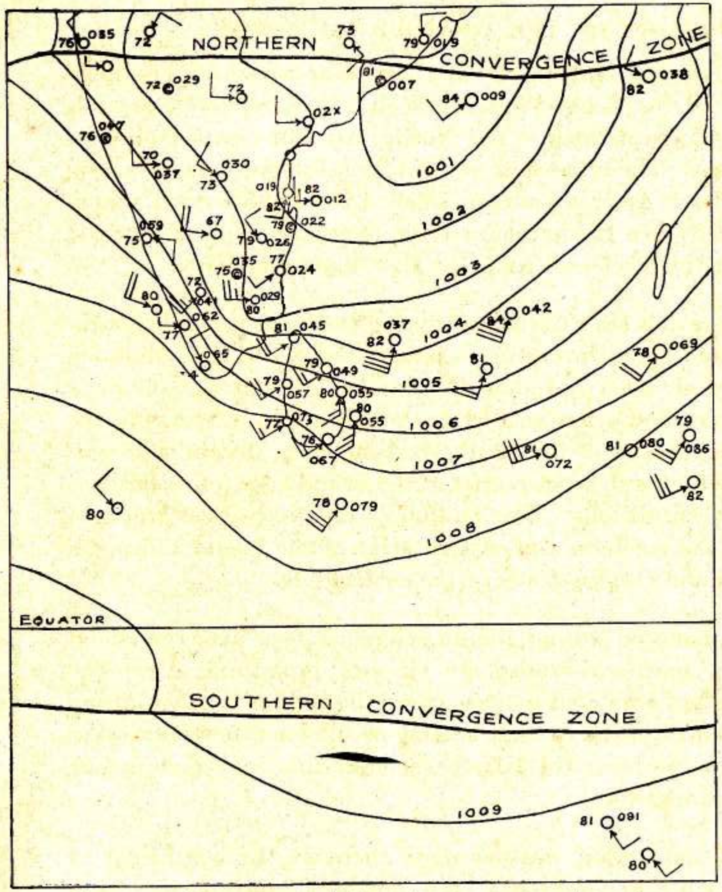


FIGURE III The synoptic situation at 0001 G.M.T. on 31st August, 1954.

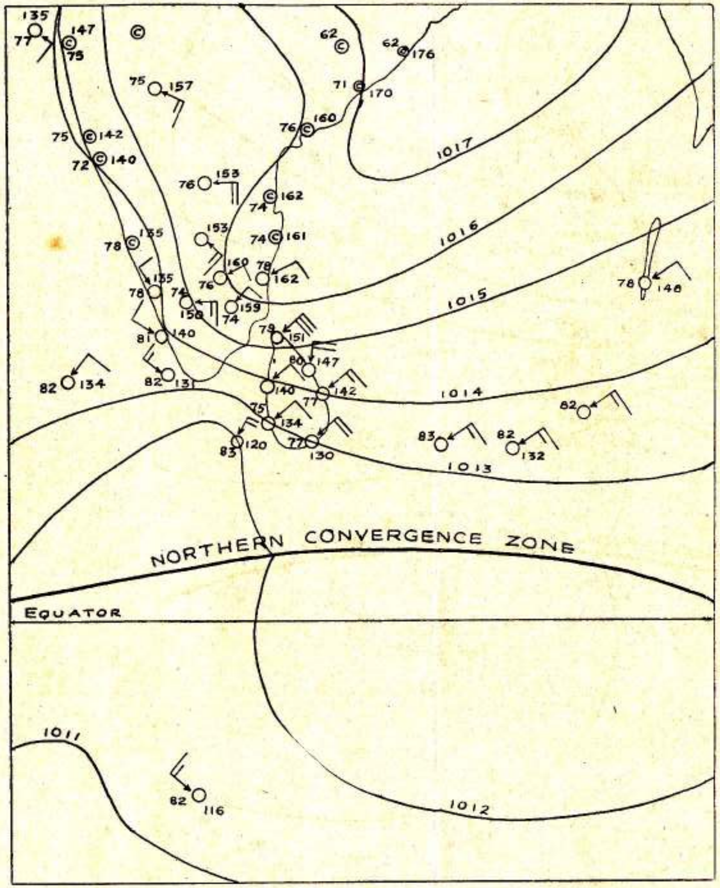
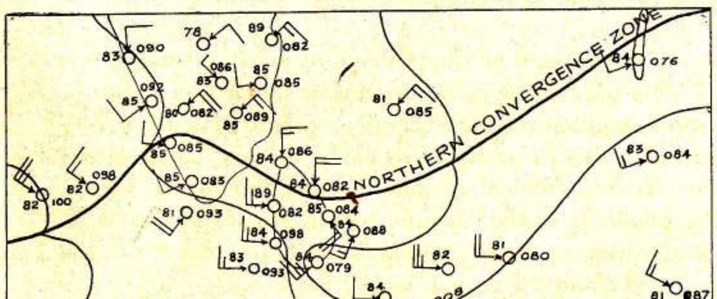
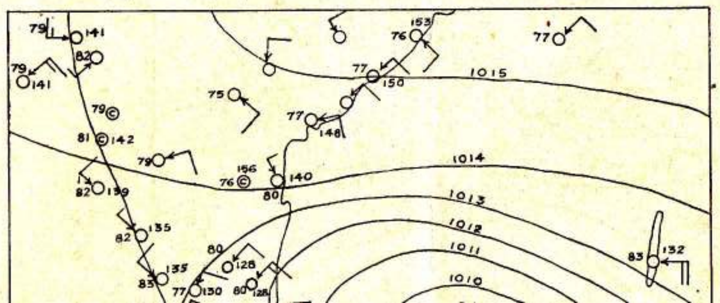


FIGURE IV The synoptic situation at 1800 G.M.T. on 8th February, 1954.





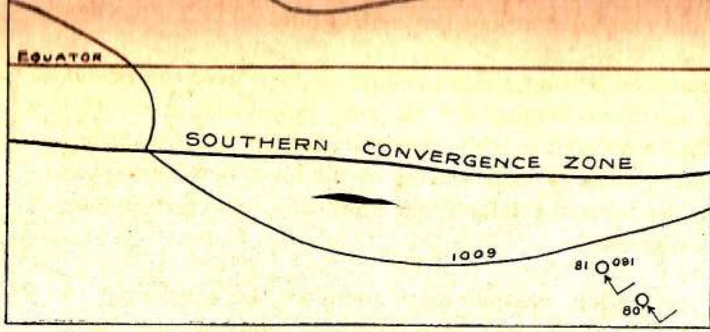


FIGURE III The synoptic situation at 0001 G.M.T. on 31st August, 1954.

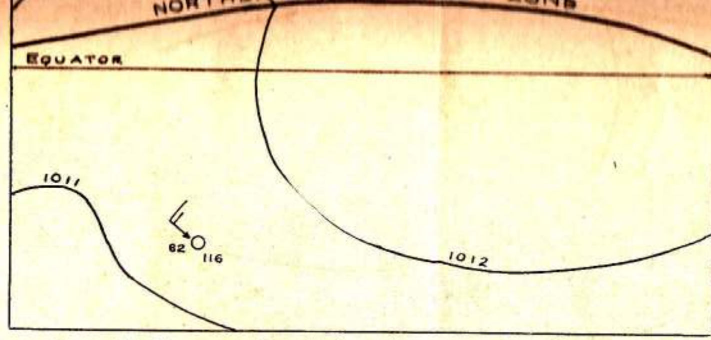


FIGURE IV The synoptic situation at 1800 G.M.T. on 8th February, 1954.

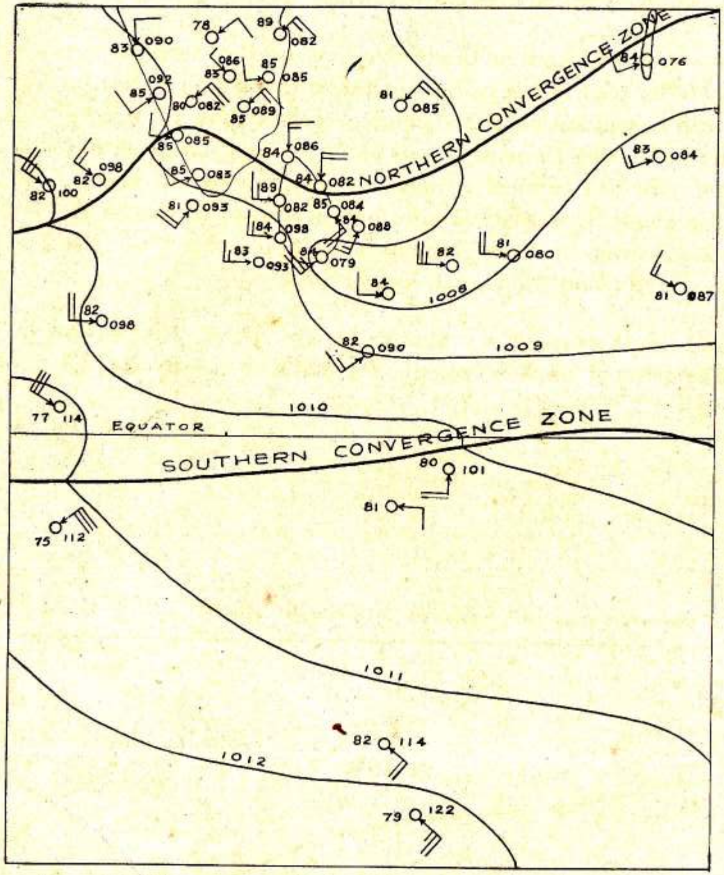


FIGURE V The synoptic situation at 0600 G.M.T. on 8th October 1954

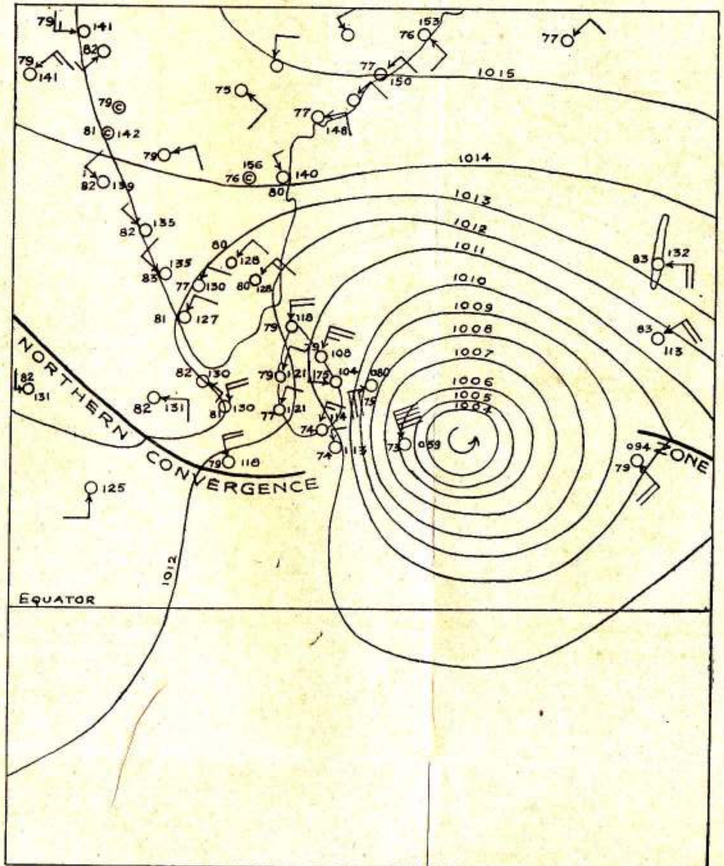


FIGURE VI. The synoptic situation at 0600 G.M.T. on 16th December 1954.

OIL RESOURCES EAST OF SUEZ

By P. D. Finn

Ceylon, like so many other countries of the Commonwealth, is not endowed with resources of oil. It is possible that at some future date oil may be located here, but geologists and other experts have not so far offered much hope of this. It is when a country has no indigenous oil production, of course, that the facts of world oil resources and oil trade become of major importance in its economic life. In this talk I have been invited to say something about the resources of oil in the world East of the Suez Canal.

I do not propose to deal with any technical aspects of oil production, but I will endeavour to indicate where oil resources in this area are located, explain their significance in relation to oil reserves in the world as a whole and make an appreciation of what the future holds in store.

SIGNIFICANCE OF OIL RESOURCES EAST OF SUEZ

I will start by giving you a rough picture of how consumption and production East of Suez are related to those in the rest of the world. As the requirements of Russia and China and the other Communist States are met from internal resources, I propose to ignore these countries in the rough figures I shall give. If the world is divided by a line extended North-West and South-East from the Suez Canal, the area to the West, which consists of Western Europe, Africa and the Americas, is that in which the greater proportion of the world's oil is produced and consumed. During the past 10 years moreover, the level of consumption in this area West of Suez has risen to such an extent that in spite of producing nearly 80% of the world's oil, it is now consuming 90% and thus needs to import very considerable quantities.

On the other hand, the large land-mass East of Suez consumes less than 10% of the world's oil production, but is already producing more than 20%. The principal significance of this area in the present world oil picture thus lies in the fact that it is able to meet an essential part of the oil requirements of Western Europe, of Africa and, even to a much smaller extent, of the Americas.

MAIN AREAS OF PRODUCTION AND OF RESERVES

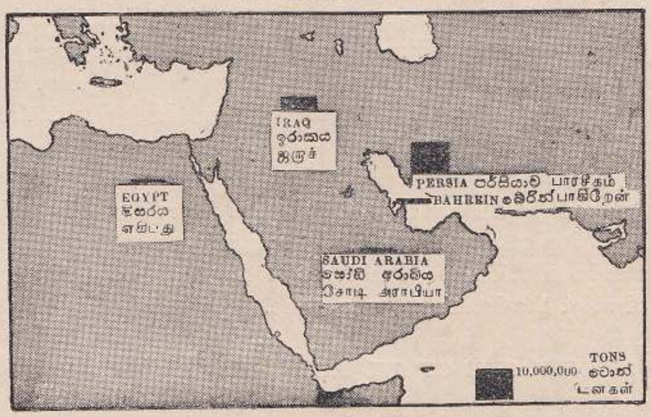
The most important of the producing areas East of Suez is located round the shores of the Persian Gulf. The discovery of oil in this area was first made in Persia before the 1914-1918 war. During the period between the two world wars, the oil resources of what can be called the "Middle East" were gradually harnessed to the energy needs of the world. By 1938 the level of production had reached 16·2 million tons a year. The distribution of this production at that time among the different countries of this area and in Egypt is shown on chart 1. This level was the result of a vigorous and costly exploration programme, which had also disclosed valuable reserves in Persia, Iraq, Bahrein Island, Saudi Arabia and Egypt. Oil had also been located in Kuwait.

Chart 1 සටහන 1 படம் 1

MIDDLE EAST CRUDE OIL PRODUCTION 1938
16, 200,000 TONS

මැද පෙර දිග අමු තෙල් නිෂ්පාදනය 1938
ටොන් 16,200,000

மத்திய கிழக்கு மண் எண்ணை உற்பத்தி -1938
16. 200,000 டன்கள்



During the war years production in the Middle East continued to increase and by 1946 had reached the figure of $35\frac{1}{2}$ million tons a year. This rapid rate of increase which had doubled production in 8 years was, however, soon to be greatly exceeded. By the end of 1953 a tremendous surge in demand matched by increasing development had raised production to no less than $3\frac{1}{2}$ times the 1946 figure. The full significance of the events of the past 15 years is illustrated in chart 2.

This chart shows the level of production in each producing country of the Middle East in 1953 compared with 1938. It will be seen that of the pre-war sources the most remarkable growth of output has taken place in Saudi Arabia and Iran. The increases in Egypt and in Bahrein Island have been very much smaller. In addition there are two areas where production has only started since the war. Of these by far the more important is Kuwait which has proved to be such a prolific source of oil that in 1953, after only 7 years, it became the largest producing country in the Middle East. The other area that has been developed since the war is Qatar but this is of relatively minor importance so far.

The only outstanding exception to the general picture of expansion in the Middle East has been Persia. In 1950, as in 1938, Persia was the largest of the Middle East producers, but the unfortunate dispute between the Persian Government and the oil producing company lead to a disastrous decline in production, and by 1952 this had fallen away to only about one million tons yearly. Happily, agreement has been reached this year between the Persian Government and a consortium of British, Dutch, American and French Companies, with the result that the early re-entry of Persia into the world oil picture can now be expected with some confidence.

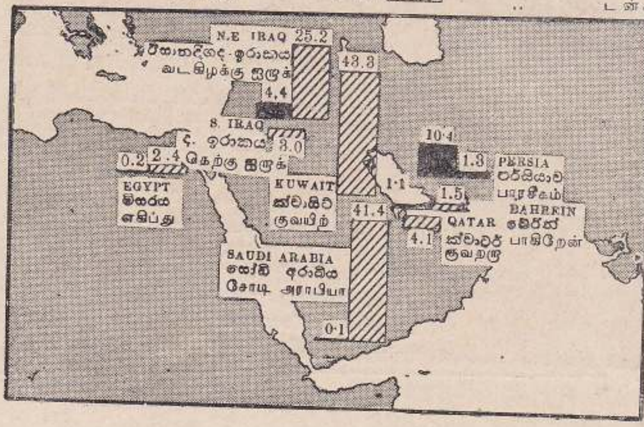
Chart 2 සටහන 2 படம் 2

MIDDLE EAST CRUDE OIL PRODUCTION 1938 & 1953
මැද පෙරදිග අමු තෙල් නිෂ්පාදනය 1938 සහ 1953
மத்திய கிழக்கு எண்ணெ உற்பத்தி 1938 & 1953

MILLION METRIC TONS
මැට්‍රික් ටොන් එක්කෝටියයි
10 லட்சம் மெற்றிக் டன்கள்

1938 16,200,000 TONS
1938 - ටොන් 16,200,000
.. .. டன்கள்

1953 122,200,000 TONS
ටොන් 122,200,000
.. டன்கள்



What I have said so far will have given you a general impression of the extraordinary growth in the utilization of the oil resources of the Middle East during the short space of 15 years, during which production has risen by no less than seven times. This growth has stemmed from many causes, but the most important has been the post-war position of Western Europe.

Prior to the last world war Western Europe relied for its supplies of petroleum chiefly upon the area of the Caribbean Sea and the United States. After the war, consumption of oil grew very rapidly not only in Western Europe but in the United States as well, and in 1948 the United States, although still the largest producing country of the world, became a net importer of petroleum for the first time in its history. Most of its requirements were obtained from the Caribbean. Western Europe, therefore, turned more and more towards the Middle East as the main source of oil to meet its mounting requirements.

OTHER PRODUCING AREAS

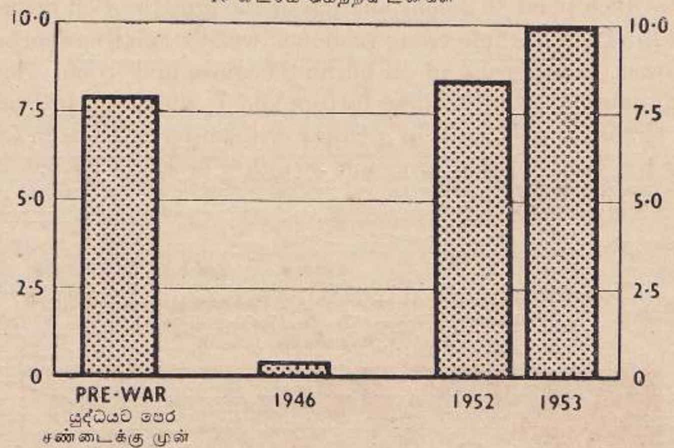
The other important producing areas East of Suez are Indonesia and British Borneo, but neither country can claim productive capacity in any way comparable to the major Middle East producers like Saudi Arabia or Kuwait, for instance. Before the last war Burma was a source of oil for Southern Asia, ranking second to the Netherlands East Indies, but the ravages of war and the political instability of the country in the post-war period reduced output to a trickle. I am glad to say that within the last year conditions have substantially improved, and a joint venture has been undertaken by the Government and an Oil Company to rehabilitate the oilfields. It is to be hoped that within a few years production in Burma will recover, but since reserves are small—less than 7 million tons have been proven—the prospect of Burma becoming a major producer is very small indeed.

The case of Indonesia is rather different. Proven reserves are known to be about 260 million tons, and the country has a long established and important production. Chart 3 illustrates the drastic drop in production caused by the Japanese invasion in 1942, which left the oilfields completely disrupted. Production was re-established in 1946 at about 300,000 tons and has recovered slowly to a level of about 10 million tons a year in 1953. The potential productive capacity of Indonesian oilfields is considerably higher than current levels would suggest. No significant increase is likely to be reached, however, until internal stability is achieved. For example, certain oilfields in Sumatra are still out of action or are producing at a fraction of capacity. These cannot be rehabilitated at present owing to disrupted communications and civil disturbance.

Chart 3 සටහන 3 படம் 3

PETROLEUM PRODUCTION—INDONESIA
පෙට්රෝල් නිෂ්පාදනය-ඉන්දුනීසියාව ටොන් ප්‍රමාණය
பெற்றோலிய உற்பத்தி—இந்தோனேசியா

MILLION METRIC TONS
මැට්‍රික් ටොන් එක්කෝටියයි
10 லட்சம் மெற்றிக் டன்கள்



British Borneo is in a rather better position than either Indonesia or Burma. Although the oilfields were also severely damaged by fighting in 1942 and 1945, the re-establishment of stable Government after the war has enabled them to be brought back into production. The output is in fact now up to 5 million tons a year as compared with 1 million tons pre-war. Production in this area is of considerable significance to the Commonwealth since British Borneo now ranks second only to Canada as a Commonwealth producer and is the largest exporter of crude oil. Proven reserves in Borneo amount to over 70 million tons—sufficient to maintain current production for at least 15 years.

In other areas East of Suez production and reserves are small and are at present confined to Assam in India, West Pakistan and Japan. So far none of these areas shows signs of developing into a major producer. Before leaving the question of production, however, I would like very briefly to mention Australia.

After many years of unsuccessful exploration in the sedimentary basins on the Eastern side of that continent attention has more recently been directed to the Western fringe and an oil strike was announced earlier this year. The importance of this discovery has yet to be assessed, and although in the earlier stages enthusiasm and expectation ran very high, a firm idea of what are the prospects in this region has not yet been formed.

THE FUTURE

Up to this point I have been concerned with the past and present position and, above all, with the growth and importance of oil production in the Middle East. It may also be interesting to have a brief look both at the future importance of oil for the countries East of Suez and at the prospects for developing further resources. The scope for error in any form of crystal gazing is immense, but in respect of the importance of oil resources there are fortunately certain factors which can lead us to a fairly clear picture of what the general position is going to be.

In the first place, since the value of oil resources depends upon the demand the question arises, what is the future demand for oil likely to be? There are many factors which point to a continuation in the growth of oil demand throughout the world. These include rising economic wealth, relative shortages of other sources of power, growing use of oil burning engines and so on. Time does not permit me to enlarge upon all these factors and I, therefore, propose to confine my remarks to that one which is of greatest direct interest to us in Ceylon. This comes under the head " rising economic wealth " or could be broadly classified in one word as " development ".

Chart 4 සටහන 4 படம் 4

PER CAPITA CONSUMPTION OF PETROLEUM PRODUCTS
පෙට්‍රෝල් නිෂ්පාදන භාවිතය එක් අයෙකුට ගැලුම් ගණන
பெற்ரோலியம் பாவனை—தலைக்கு.

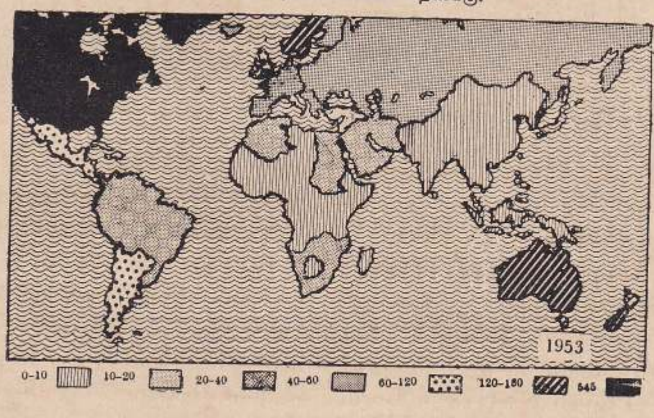


Chart 4 shows the consumption of petroleum products per head throughout the world in 1953. You will at once observe that the level of consumption varies to an enormous extent; the highest level in North America is as much as 545 gallons a head per year, and from this point we come down through the medium levels on each side of 100 gallons a head per year in Australasia and

Western Europe to the lowest end of the scale in Asia, where consumption is under 10 gallons per head. Ceylon is one of the exceptions to the overall Asian position since we consume here about 12 gallons per head per year.

Although the connection between petroleum consumption and general wealth does not, as our statisticians would term it, " represent a close co-relation ", it is clear nevertheless that those countries with high incomes per capita are also the countries with a large per capita consumption of petroleum. From this it may be assumed that where scope for development exists, there are prospects of a substantial growth in oil demand.

On the long term, the scope for economic development in the world is immense, particularly in Asia, Australasia, America, and Africa. In South-East Asia we have a series of imposing national plans incorporated in the Colombo Plan. A study of conditions and prospects in Ceylon and elsewhere in the Colombo Plan area indicates that, although development is being undertaken, the resulting material progress will not be such as to transform poverty into wealth overnight. All the same, at this very moment, sound foundations are being laid upon which can be built a growing prosperity in the future. This can lead to a rise in the demand for energy ; be it for tractors, saw mills, power stations, cars, buses, fishing boats, lamps or factories.

To meet this demand there are a variety of sources of energy. Wood and waste products are plentiful in some areas but are normally inefficient, especially as industrial fuel. Coal, whilst ample in some countries is scarce in others, and overall there is no large exportable potential. Hydro-electricity is both limited and local in its application ; while apart from the United States and, possibly, Italy, natural gas is also limited in both use and distribution. It is, therefore, to oil that the world must naturally look to meet a fairly large proportion of any increase in energy requirements over the next few decades.

Overall it is expected that world petroleum demand will increase by something of the order of 100% over the next 22 years. Whilst very considerable increases are expected in all areas, the greatest rate of growth will probably be in the area called Rest of the Eastern Hemisphere which is in effect Asia, Africa and Australasia (less China and Russia).

There can be little doubt that given peace and freedom to develop, the future prospects for oil are good. The question now arises—**Will oil resources be adequate**?

RESOURCES FOR THE FUTURE

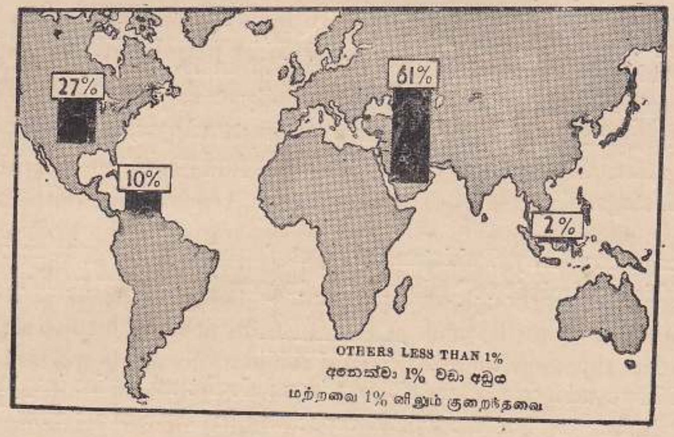
Although the important factor at any moment is how oil production and demand balance, when one takes a long view into the future the most important consideration is obviously the level of reserves.

At the beginning of this talk I emphasised the importance of the Middle East as a source of oil supplies to the West. Chart 5 gives some indication of the relative size of the reserves contained in this area of the world. It underlines unmistakably the significance of the Middle East in the future of oil.

Chart 5 සටහන 5 படம் 5

FREE WORLD PROVEN OIL RESERVES JANUARY 1954
නිදහස් ලෝකයේ පිරිසුදු කරන ලද තෙල් ගබඩා — 1954
நிருபிக்கப் பட்ட உலகின் எண்ணெய். 1954

17,770,000,000 TONS.
ටොන් 17, 770, 000, 000
17,770,000,000 டன்கள்



At the beginning of this year, the proven oil reserves of the non-Communist world amounted to about eighteen thousand million tons. Of this total about 63% are located East of Suez and 61% in the Middle East alone. This level of proven oil reserves is sufficient to meet the present rate of demand for 30 years, but if demand continues to expand at the rate suggested above the free world has only established proven reserves sufficient for twenty years.

In case you should deduce from these figures that there is an imminent prospect of the free world's oil supplies petering out, I hasten to add that by the term "proven oil reserves", we in the oil industry mean only those accumulations of oil-bearing strata which have been thoroughly demarcated and the oil content assessed. Since exploration during any one year has never failed to prove additional resources at least equivalent to the oil extracted during the year, proven oil must only be regarded as an extremely conservative estimate of the actual total.

As the principal location of reserves both in the area East of Suez and in the whole world, the Middle East deserves our special consideration. This area contains a vast expanse of sedimentary rocks covering roughly the region known as the "Fertile Crescent", extended at both ends round the coastal area of the Arabian Peninsula. Existing zones of proven reserves occupy only a fraction of the total area here which is geologically liable to contain oil. Although it is impossible to assess the eventual level of reserves which may be located in the Middle East, it is almost certain that they are at least $4\frac{1}{2}$ times the proven reserves already established.

The other sedimentary basins East of Suez are in West Pakistan, North-East and North India, Central Burma, Indonesia and the East Indies, parts of the Philippines, Japan and Australia. Prospects in most of these areas are modest, but valuable new reserves may well be found at any time in any or all of these areas, and exploration is going on almost continuously.

Before concluding this talk, I would like to mention natural petroleum gas. Vast quantities of natural gas exist, particularly in the Middle East, and most of what is now produced in the course of oil operations is going to waste. I have already mentioned that the use of natural gas has only been developed at all fully in Italy and the United States, but given settled political conditions in Europe there is no reason why its use should not be extended, and it would constitute a valuable supplementary fuel for industrial and domestic heating. In addition, it would provide a raw material for synthesis into many chemical and oil products. Apart from pipelines, by which gas is usually transported, investigations are currently being made into the shipment of natural gas, whose bulk could he enormously reduced by refrigeration ; but this project is still very much in tbe experimental stage.

In other areas, only Pakistan has yet found natural gas resources under conditions which permit it to be harnessed to growing energy needs.

CONCLUSION

What I have said can have left you in no doubt as to the importance of the oil resources in our part of the world, especially in those areas round the Persian Gulf. Indeed it could even be said that much of the future economic progress of a considerable part of the world will for many years depend upon the oil reserves of the Middle East.

Production is already important ; it is constantly increasing, and the reserves to be drawn upon are immense. The vast economic significance of the Middle East and its oil resources has not, however, been developed merely through the simple operation of getting oil out of the ground. Behind the scenes large sums of money have been invested over many years in the development of the oilfields ; decades have been spent, often fruitlessly, in the search for oil ; when its presence has been indicated, intricate negotiations have had to be carried out with the Government of the sovereign states concerned. In the continuing endeavour to match oil production to the future needs of the world, the same factors will arise, but perhaps the most significant pre-requisites for success are peace, political stability and harmonious relations between oil company and Government.

The prospect of peace is subject to unpredictable fluctuation. Political stability is happily already well established in many producing countries, but in others the process of assimilating and adapting modern techniques of Government and Parliamentary institutions is a long way from complete, and much depends upon the wisdom of the present rulers. So far as Government relations with the oil companies are concerned, these are closely linked with political stability. The present widespread practice of a 50 : 50 profit-sharing in producing areas has, however, been proving an admirable working basis for ensuring satisfactory conditions for both parties.

Although in Ceylon we are not privileged to possess our own resources of oil, yet we have a vested interest in these problems. For us, the security, development and wise utilization of petroleum—the world's greatest accumulation of wealth—is of the utmost importance.

GEOGRAPHICAL RECORD

RECENT GEOGRAPHICAL WORK IN AUSTRALIA

Academic geography in Australia, until recently lagging well behind developments in the sister Dominion of New Zealand, has latterly made considerable progress. I have summarised the situation in *The Geographical Journal* (CXX, March, 1954, p. 114-15), and need only note that since then two or three Universities have put Geography well up on the priority list for new Chairs, while the Australian National University has trebled its student membership—indeed it almost qualified for a miniature of Dr. Kularátnam's proposed Association of Commonwealth Geographers, having recruited from Australia, Canada, India, New Zealand, and the United Kingdom—not to mention the United States !

This progress was reflected in the highly successful meetings of the Geography Section at the 1954 (Canberra) and 1955 (Melbourne) sessions of ANZAAS. Both sessions produced excellent handbooks : *Canberra : A Nation's Capital*, edited by H. L. White (Angus and Robertson, Sydney) and *Introducing Victoria*, edited by G. W. Leeper (Melbourne University Press). Both these books are much more than local guides and are of considerable general interest.

In one respect New Zealand retains a commanding lead : *The New Zealand Geographer* is certainly much better in regularity, bulk, format, and illustration than its opposite number published by the Geographical Society of New South Wales : as one of the Editors of *The Australian Geographer* I should like to know more of New Zealand finances ! However it may fairly be claimed that the journal has made considerable progress in its current Volume VI : among articles of general interest may be cited R. H. Greenwood, " The Economic Aspects of Geography " (June, 1952) ; D. S. Simonett, " Climate and Cattle Production in North Australia " (March, 1953) ; K. A. MacKirdy, " Geography and Federalism in Australia and Canada " (March, 1953) ; Ann Marshall, " The Purpose of Classification of Climate " (a stimulating criticism of Thornthwaite, May, 1954) ; P. Scott, " Hobart : An Emergent City " (January, 1955). Our neighbours in the " Near North " are not neglected : D. L. Serventy, " Indonesian Fishing Activity in Australian Seas " (June, 1952) ; W. L. Conroy, " Notes on some Land Use Problems in Papua and New Guinea " (March, 1953) ; D. W. Fryer, " Food Production in Malaya " (May, 1954).

Much, and much of the best, Australian geography comes from official agencies of the Commonwealth or of its component States ; the Premier's Departments of New South Wales and Victoria, for instance, are publishing a series of very informative regional surveys. The Commonwealth Department of National Development at Canberra has published two very interesting resource surveys, each with an atlas, on the Murray Valley (1947), and Papua and New Guinea (1951). But its major effort is the *Atlas of Australian Resources* which when complete will comprise about 50 large coloured maps, with explanatory pamphlets ; some of the maps present novel cartographical techniques and all are worthy of careful study. Amongst the most interesting of those so far published are Water Resources, Agricultural Production, Density of Population, Increase and Decrease of Population, Power and Fuel, and Major Development Projects.

At Canberra also is located the Land Research and Regional Survey Section of the Commonwealth Scientific and Industrial Research Organization (understandably better known as CSIRO, a household word in Australia). Under the energetic leadership of Mr. C. S. Christian the LRRSS (these modern initials !) has developed a very interesting technique for the survey of difficult and sparsely-populated country by teams of experts working in the closest liaison : much store is set by the geomorphologist's contribution. Surveys so far published (by the CSIRO headquarters at Melbourne) cover the Katherina-Darwin and Barkly Regions in the Northern Territory and the Townsville-Bowen Region in Queensland. As examples of " applied geography " these are of the greatest interest and value. The CSIRO's general publication *The Australian Environment*, of which the third edition is now in preparation, is a brief but very useful and stimulating introduction to some aspects of Australian geography.

Finally we may note a publication not specifically geographical but containing much essentially geographical matter on a topic of great importance. This is *Northern Australia : Task for a Nation* (Angus and Robertson, Sydney, 1954), which consists of the papers and discussions of a symposium organised by the Australian Institute of Political Science. Here, better perhaps than anywhere else, the overseas enquirer may find why the North is empty and what can be done about it.

All this adds up to a flourishing if rather utilitarian output. It is unfortunate that the share of academic geographers is rather limited ; but in no aspect of Australian life, perhaps, is the shortage of manpower so marked as in the Universities. What may be termed the " public relations " calls on a University teacher's time and energy are very great, and it is difficult to find time to carry out any comprehensive plan of work. But the general advance of geography in the Universities is already producing its effect, and the value of specifically geographical training is more and more realised. Some idea of the range and quality of academic work may be gained from the forthcoming Australian number of the Berlin periodical *Die Erde.*

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A FIELD COURSE AND A SYMPOSIUM IN AMERICA

In North America June, July and August are the vacation months and for academic geographers a time of relaxation from the regular routine of teaching—a time for travel and for field work—though many departments of geography offer special summer courses and some of us are engaged in conducting these courses. Summer thus means cessation of the ordinary activity, or at least less intense activity, a tendency which was encouraged this year (1955) by the prolonged heat waves and violent tropical storms experienced in the eastern parts of the United States. Except for about ten days of camping with my family in the Adirondack Mountains of upper New York State, I have remained at my home in New Jersey preparing materials for publication.

Two local events will be of interest to readers in Ceylon : the first, an annual field course in " Geo-Ecology " offered by Rutgers University from 6th to 11th June in Burlington County, New Jersey ; and second, the International Symposium on " Man's Role in Changing the Face of the Earth," sponsored by the Wenner-Gren Foundation for Anthropological Research of New York and held 16th to 22nd June in Princeton, New Jersey. Both are examples of the kind of inter-disciplinary co-operation that provides valuable stimulus to workers in geography and related fields.

GEO-ECOLOGY FIELD COURSE :

Geo-Ecology, as the title indicates, is a hybrid course in wh ch geographic relationships of geology, pedology, botany and zoology are studied. Here at Rutgers the course has now been offered for the seventh successive summer. It has not only been a unique experience for the students, who are drawn largely from the biological sciences and agriculture, but has also been instructive for staff members. More than one research paper has originated in the findings of staff members in teaching the course. The course was conceived and has been carried on chiefly by Dr. Murray F. Buell, a botanist and Vice-President of the American Ecological Society. This year Dr. Robert A. Norris, a zoologist, and I, serving in the role of physical geographer and pedologist, assisted Professor Buell.

The three staff members and nine students stayed for a week in small log cabins, located in Bass River State Forest near Tuckerton in the southern Coastal Plain of New Jersey. Four days were spent in intensive field investigation of conditions at three contrasting areas and one day was spent in automobile reconnaissance in other parts of the Coastal Plain. At the end of the week each student wrote a report based on the field studies and the reconnaissance survey.

Perhaps it will be of interest to describe our procedure in somewhat more detail. The nine students were divided into three groups which worked in turn with each staff member. For example, in the day of our study in the coastal marsh, dominated by the salt-tolerant grass *Spartina alterniflora*, Group A worked with Professor Buell, identifying plant species and mapping plant distribution in a belt transect (2 × 20 meters). This group also made salinity tests at various points in the transect, beginning at the edge of open water in the bay. Group B under the direction of Dr. Norris sieved a surface layer about 10 cm. in depth in a quadrat measuring one meter square to make counts of all surface and burrowing invertebrate species, such as snails, crabs, etc. This group also walked about to ascertain the kinds of higher animals, particularly birds, present in the general area. Group C under my direction began boring into the salt marsh peat to determine the depth and nature of the deposits at each of a series of stations about 200 meters apart. After a few hours, Group A left Dr. Buell and came to me, Group B left Dr. Norris and worked with Dr. Buell, and Group C left me and went to Dr. Norris. Later another shift of all groups was made, so that they all would have experience in each type of work. No group repeated precisely the work of any other group, however, and when we finished the day, the data were pooled so that the results of all our work would be available to all of the students. It was possible for them to draw a cross-section of the salt marsh and to give quantitative as well as qualitative data on plant and animal communities observed from the seaward to the landward margins of the marsh.

The same general procedure was followed in the study of the ecology of uplands and bogs in the central part of the Coastal Plain in Lebanon State Forest. This locality is representative of the sandy region known as the Pine Barrens, where there are extensive tracts of scrub forest made up predominantly of Pitch Pine (*Pinus rigida*). During one and a half days of work we examined a series of six soil profiles in pits dug to the water table and described the *catena* of soil types all developed on a sand formation of Tertiary age under differing slope and drainage conditions. The soils ranged from the drouthy podzolized soil of the uplands to the peaty half-bog soil of the lowlands. The botanical and zoological data collected here by transect maps, quadrant counts and other means could be related by the students to the varying soil and ground water conditions.

The third locality studied was near Buddtown on the margin of the Inner Coastal Plain, a region where clay and marl (glauconitic greensand) formations of Cretaceous and early Tertiary ages are prevalent, instead of the almost pure quartz sand of the Outer Coastal Plain. Here the typical upland and terrace soils are gray-brown podzolic types which originally developed under a mixed deciduous forest of oaks, hickories, ash and maples and now are utilized for agriculture (fruit, vegetable and dairy farming). The study site was actually on the flood plain of a small stream, tributary to the Delaware River. Such alluvial land is usually not plowed by American farmers, though it may be cleared for pasturage. I could not help imagining the rice paddy landscape which would have been created on this floodplain if the area had been settled by Oriental farmers. In this case, the floodplain is covered by second growth ash (*Fraxinus americana*), maple (*Acer rubrum*), elm (*Ulmus americana*) and a rich undergrowth of shrubs and lianas. There are old marl pits here, dating from the 19th century when glauconitic material was obtained from the underlying marine deposits by digging through the alluvium and was applied to the upland fields for its fertilizing and tilth improving value.

On a previous visit to this spot near Buddtown I had discovered in the stream channel a fragment of hard rock, unlike any local formation, which could only have been transported to the Coastal Plain by human beings. It is shaped in the form of a pestle and was undoubtedly used for grinding maize in a stone mortar. Many evidences, such as grinding stones, arrow and axe heads, fireplaces, and burials of the aboriginal, so-called " Indian ", inhabitants have been found in New Jersey. The artifacts nearly all relate to the occupance of the area by the Lenni-Lenape (Delaware) tribe whose tenure was terminated in the early 17th century by the arrival of Dutch, Swedish and English colonists.

Next year the field area for the class in Geo-Ecology will be located in the Appalachian Piedmont in the north-western part of this state and in adjacent Pennsylvania. The following year the field area will be in the Appalachian Highlands in extreme northern New Jersey. In this manner all the major physiographic provinces of the state are to be visited in rotation and students who enroll in three successive years will gain an understanding of each province.

SYMPOSIUM ON "MAN'S ROLE IN CHANGING THE FACE OF THE EARTH":

The theme of the Wenner-Gren conference on "Man's Role in Changing the Face of the Earth," was set forth nearly a century ago by George Perkins Marsh in his pioneer work, "Man and Nature," first published in 1864 and subsequently published in 1882 under the title, "The Earth as Modified by Human Action." (See David Lowenthal, "George Perkins Marsh and the American Geographical Tradition," *Geographical Review*, 43 : 1953 (2), pp. 207-213). Marsh wrote that ". . . man is everywhere a disturbing agent. Wherever he sets his foot, the harmonies of nature are turned to discords." Man, he stated, is "essentially a destructive power" in nature.

Since the days of Marsh the impact of man on nature has become still more intense and more wasteful. The problems caused by use of soil, timber, iron, coal and other resources, which led Marsh to write his book, have become generally recognized in all countries. The conservation movement in America, for example, promotes social awareness of the need for more careful management of resources. Today we have been successful in protecting certain areas of soil through co-operative efforts of the government and farmers and some forests are growing under proper management for sustained production of timber. However, most crop-land pasture and timberland in the United States is not properly managed for maximum production in the long run and it is obvious that metals and mineral fuels are irrecoverable. Thus, we continue our wasteful exploitation of the earth.

The aim of the conference at Princeton as set forth by Professor Carl O. Sauer, one of the three co-chairmen, was not so much to analyze the resource problems of today or of the foreseeable future, but rather to elucidate the capacity of man to alter his environment through his control of physical and biological processes. The story of man's role in changing the face of the earth begins with the invention of fire-making, the domestication of plants and animals; continues through his trade, warfare, migrations and the spread of transportation facilities, fields, and settlements; and culminates in the development of modern mining and manufacturing. Every human group has had to evaluate the economic potential of the area it inhabits and to organize its life about its environment in terms of available techniques and the values accepted as desirable. Differences in techniques and in values and hence in utilization of the environment have distinguished one human group from another. The effects of man on the earth thus are geographically varied and are historically cumulative. Some of the changes wrought by man are not destructive. Many were not planned. Moreover, the results were not anticipated and have gone undetected. Man is ecologically dominant on the earth and we need the insights of scholars and scientists in nearly all branches of learning to understand what has happened and is happening.

The conference, therefore, was planned by Dr. William L. Thomas (Jnr.), of the Wenner-Gren Foundation to bring together outstanding scholars and scientists from all fields bearing on the subject of man in relation to the earth. More than twenty fields of knowledge were represented, ranging from philosophy to electrical engineering and from demography to physics. Among the persons invited to attend were Miss E. K. Janaki Ammal of the Botanical Survey of India and Professor Radhakamal Mukerjee of the University of Lucknow, who was unable to come to Princeton, however. Dr. Soliman Huzzayin, Professor of Geography at the University of Cairo, also attended. Among the European geographers attending were the Drs. H. C. Darby, University of London; E. Estyn Evans, Queen's University, Belfast; Pierre Gourou, University of Brussels; Gottfried Pfeifer, University of Heidelberg; and Hermann von Wissmann, University of Tubingen. Among the American geographers attending were the Drs. Clarence Glacken, University of California (Berkeley); Andrew H. Clark, University of Wisconsin; Edward Ullman, University of Washington (Seattle); Chauncy Harris, University of Chicago; Lester Klimm, University of Pennsylvania; Stephen Jones and Albert Burke, Yale University; and David I. Blumenstock, Rutgers University. Of some eighty persons in attendance, less than twenty were professional geographers. The other fields of learning represented by more than one participant were: botany, zoology, geology, soil science, hydrology, climatology, anthropology and archaeology, sociology, economics, history, public health medicine, and city planning. In addition to Professor Sauer of the Geography Department at the University of California

(Berkeley), there were two other conference co-chairmen : Dr. Marston Bates, Professor of Zoology, University of Michigan, and Mr. Lewis Mumford, Professor of City and Land Planning, University of Pennsylvania.

In order to facilitate the exchange of ideas 53 of the participants had prepared background papers which were reproduced and distributed in advance to all participants by Dr. Thomas of the Wenner-Gren Foundation. No formal papers were read at the conference sessions. Instead discussions were centered in certain broad topics, as follows : Man's Tenure of the Earth ; Subsistence and Commercial Economies ; The Industrial Revolution and Urban Dominance ; Techniques of Learning—Their Limitations and Fit ; Changes in Physical Phenomena ; Changes in Biological Communities ; Limits of the Earth—Materials and Ideas ; Technological Civilization, Values and Aesthetic Standards ; the Unstable Equilibrium of Man in Nature. A verbatim recording of all the sessions was made. The Background Papers, together with summaries of the discussions, will form two volumes which are to be published in April, 1956, by the University of Chicago Press.

One of the conclusions gathered from reading some of the Background Papers is that man's presence on the earth has led not only to changes in soil fertility, water supply, mineral reserves and other resources having utility in the economic sense but also that man's activities have profoundly altered the so-called " natural environment." This process is well described in Background Paper No. 36 submitted by Dr. Edgar Anderson of Washington University and the Missouri Botanical Garden, St. Louis, entitled, " Man as a Maker of New Plants and New Plant Communities," and also in Dr. Marston Bates' Paper, No. 37, entitled, " Man as an Agent in the Spread of Organisms." They point out that the secondary result of purposeful activities such as farming and trading is the non-purposeful spread and evolution of plants and animals. New or modified species commonly regarded by man as weeds, pests, and diseases, are dependent upon man for their existence just as are most cultivated plants and domestic animals.

" Whole landscapes are now occupied by man-dominated (and in part man-created) faunas and floras. This process began so early (its beginnings being certainly as old as *Homo sapiens*) and has produced result of such complexity, that its accurate interpretation must await research as yet scarcely begun," says Professor Anderson. " Think of this total inter-connected mantle which accompanies man : the crops, the weeds, the domesticated animals, the garden escapes such as Japanese Honeysuckle and orange daylily, the thorn scrub, the bamboo thickets, the English sparrows, the starlings, the insect pests. Think of the great clouds of algae, protozoa, bacteria and fungi, the whole complex communities of micro-organisms that inhabit our soils, our beverages, our crops, our domesticated animals and our very bodies."

" As biologists," says Professor Bates, " we are apt to deplore (the influence of man in spreading organisms), to brush it off, to try to concentrate on the study of nature as it might be if man were not messing it up. The realization that, in trying to study the effect of man in dispersing other organisms, I was really studying one aspect of the human habitat, came as a surprise to me. But with the realization clear in my mind, I wonder why we do not put more biological effort directly into the study of this pervasive human habitat."

Contrasts in man's utilization of humid tropical lands are brought out by Professor Pierre Gourou in Background Paper No. 9, entitled, " The Quality of Land Use of Tropical Cultivators." and by Dr. Harley H. Bartlett in Background Paper No. 34, entitled, " Fire in Relation to Primitive Agriculture and Grazing in the Tropics." In both papers comparisons are made between methods of land use in the three great tropical realms of Asia, Africa and America. Dr. Bartlett has carefully documented his thesis that primitive agriculture in the tropics has always been at the expense of forest which can be cleared by deadening and burning the trees and planted without plowing. The ashes fertilize the soil and after one or two good crops are obtained the clearing is abandoned and another one made. Much tropical scrub forest and savanna land has been created and maintained by many in this way. Professor Gourou observes that the low intensity of tropical agriculture is not the direct result of unfavourable physical conditions, *i.e.*, the hot moist climate and leached upland soils, but is the result of techniques (and of civilizations in a broad sense). Large areas of tropical lateritic soils are low in fertility and tropical cultivators in Indonesia, Africa (including parts of Madagascar) and America have limited themselves to utilizing these poor soils by practicing axe and fire clearing and shifting cultivation. This extensive kind of land use, poor in output per acre and poor in terms of return per day of labor, is not typical of Asia. The cultivators of the Asiatic tropics have applied their intensive techniques of paddy rice growing to the swampy and heavy soils of the valley bottoms and plains. Here the greatest number of tropical cultivators are concentrated in a small part of the tropical world. Intensification of tropical agriculture of the lowlands in Africa and Asia would greatly enhance the population-supporting capacity of the earth.

Another conclusion found in a number of the background papers is that man's tenure of the earth is limited by the finite quantities of resources available for use by the rapidly increasing population and the expanding requirements of modern technological civilization. Population growth cannot go on indefinitely at the rate which has prevailed during the past few decades (since 1900 about a fifty per cent. increase), or there will come a time when we arrive at the ridiculous extreme of "standing room only." Some new equilibrium of numbers must be reached if man is to continue his existence. This is true even if the moon and planets can be reached and used.

Long before the physical limits of the earth are reached, however, the human adventure may culminate because of intense interaction of human minds. The cultural *noosphere* (from the Greek noos-mind, and *sphaera*-sphere) has become coterminal with the earth. In the words of Dr. Pierre Teilhard de Chardin in Background Paper No. 6, entitled, "The Antiquity and World Expansion of Human Culture," (prepared before his death 10th April, 1955), mankind is now experiencing "a tremendous and incoercible 'raprochement' and compression of both human bodies and human minds, co-arrangement and co-reflection are now rising toward astronomical values at the interior of the Noosphere. Even if humanity is not becoming either better or happier in the course of the process, it is today forced, more than ever . . . under two irresistible factors (that is, by the double curvature of our rounded mother-planet and of our converging minds) to move toward unheard of and unimaginable degrees of organized complexity and of reflexive consciousness." According to Teilhard de Chardin's view, this fast converging process will probably end, sooner or later, through an implosive concentration of the cultural *noosphere*, like the physical phenomenon of the star *nova*.

The very real possibility of man exterminating himself through atomic warfare makes Teilhard de Chardin's view all the more probable. In Background Paper No. 41, entitled, "Effects of Fission Material on Air, Soil and Living Species," Dr. John C. Bugher, Director of the Division of Biology and Medicine, United States Atomic Energy Commission, points out the many direct and indirect effects of radioactivity now known as a result of governmental experimentation with weapons and power production.

Although I was not invited to attend the conference, I found many of the Background Papers to be of unusual interest and I will look forward to their publication.

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CARTOGRAPHY IN ASIA AND THE FAR EAST

The first Regional Cartographic Conference for Asia and the Far East, sponsored by the U.N. Economic and Social Council, was held at Mussoorie from 15th to 25th February, 1955. Seventy-five delegates representing 18 countries and 5 international organizations attended the Conference. Dr. P. S. Lokanathan, Executive Secretary of ECAFE opened the Conference on behalf of the U.N. Secretary-General. Dr. Sampurnanand, Chief Minister of Uttar Pradesh, delivered the inaugural address.

In his opening address, Dr. Lokanathan observed that the holding of the first cartographic conference in Asia was significant. The continent of Asia had a wide range of topographical features and was inadequately surveyed and relatively unexplored. Systematic geological survey could be achieved only through systematic topographical mapping. Dr. Lokanathan revealed that the Economic and Social Council had studied various questions relating to international co-operation in cartography and had taken measures to assist governments in developing their mapping facilities. The United Nations Organization and its specialized agencies had rendered technical assistance to projects in various branches of cartography in this region. The ECAFE Secretariat had assisted in producing maps, particularly in the field of mineral resources development. A working party of senior geologists, set up by the ECAFE in collaboration with the International Geological Congress and the United Nations Cartographic Office, has reached agreement on the main features of regional geological maps for Asia and the Far East. The secretariat had been requested by mining experts to compile a mineral distribution map for Asia and the Far East, to be followed by a map showing metallogenetic epochs and provinces of the region.

The deliberations of the Conference were conducted under the presidentship of Brig. I. H. R. Wilson, leader of the Indian delegation. Four committees were constituted to deal with questions of geodesy and gravimetry, topography and photogrammetry, and special mapping and global mapping. The discussions covered a wide range of topics including evolution of international cartographic standards, establishment of standard base-lines, establishment of a regional inter-governmental cartographic organization, programme of magnetic observations in the Indian Ocean, use of photogrammetric methods in making topographic maps, preparation of an international map of the world (I.M.W.) on the millionth scale and technical assistance to less developed countries for expediting the survey of the world.

The conference also reviewed recent developments in the cartographic field in the region, including the development of new techniques and instruments. While there was general satisfaction that the importance of cartography as an indispensable tool of economic development was recognized by all the participating countries, the information presented showed that some countries of the region were still to make up much leeway in this field.

GEODESY

Connecting India and the Andamans and Nicobars : The conference considered the question of connecting the Andaman and the Nicobar Islands to the mainland of India for the purpose of locating the islands and for establishing a unified geodetic net of triangulation so as to form a base for more accurate cartographic work. At present the geodetic framework on which the mapping of these islands has been based is unconnected with the main triangulation framework of India. The use of airborne electronic devices was suggested as the most expeditious methods for mapping purposes. However, owing to the limitations of electronic devices, it was necessary that a direct connection of these islands to the trinagulation extending along the coast of Burma should be established as a first step towards the realization of the bigger task of linking the India-Burma triangulation to that of Indonesia and ultimately to that of Australia. The Conference recommended that the countries having the necessary equipment and experienced personnel for this type of work, such as Canada and the U.S.A., should be approached by interested governments with a view to determining how this project might be executed.

A Standard Base-line in India : Base-line measurements were carried out in India during three different periods. During the first period—1800 to 1825—ten base-lines were measured with steel chains. These were not helpful for controlling the principal triangulation ; they were superseded by 10 base-line measured between 1830 and 1869 with the help of Colby Compensation Bars, calibrated in terms of Standard Bar A, which was brought to India in 1839. The bulk of the geodetic triangulation of India was also done during this period and the length of its sides, in terms of the Indian foot, was defined by this standard. From 1930 to date, nine further base-lines have been measured with the help of " invar " wires standardized against modern metric standards. Steel BAR A does not fulfil the modern requirements of a national standard of length and was not made use of in measuring the base-lines, although the triangulation of India is still in terms of Indian feet as defined by this obsolete standard. There is thus an element of discordance between the older triangulation based on the Indian feet in terms of STANDARD Bar A and the new triangulation based on modern metric standards which are converted to Indian feet. The Conference, therefore, recommended that a few standard base-lines should be established in the region by the VAISALA method. The Vaisala comparator developed at the Finnish Geodetic Institute has given accurate results and the adoption of the method would ensure a uniform scale in all network and enable the calibration of invar tapes and other equipment.

Magnetic and Gravity Observations : The magnetic and gravity work in India and adjacent countries has so far been confined only to the land areas. Without any observations in the Bay of Bengal and the Arabian Sea it is not possible to have a complete picture of either the magnetic or the gravity field in the whole region. Magnetic observations in the sea are also essential for bringing the isogonal charts up to date. It was pointed out that a non-magnetic surface vessel, necessary, for such a survey, was available. A few magnetometers were being developed in the Canadian Dominion Observatory, which may probably become available for the International Geophysical Year 1957-58 and these may be used for these observations. The Conference recommended to the Special Committee for the International Geophysical Year the inclusion, in this programme, of magnetic observations in the Indian Ocean, particularly in the Bay of Bengal and in the Arabian Sea.

The Conference recognized the need for carrying out programmes by the countries of the region with regard to gravity observations in deep sea waters and requested the U.N. authorities to extend necessary facilities.

Levelling Connections between Neighbouring Countries : The importance of levelling and triangulation connections for homogeneous mapping and other purposes has long been recognized and the subject has been discussed at a number of international conferences. The International Union of Geodesy and Geophysics have recommended such connections for the study of fluctuations of sea levels. On the American continent, all the nations have connected the triangulation and levelling nets. The need for junction of the triangulations of Iran, Iraq, Syria and Turkey was emphasized at the Conference and it was recommended that the four interested countries meet together to study the arrangements that might be made in this respect.

TOPOGRAPHIC MAPPING

Small Scale Photographic Coverage : Methods for obtaining a regular small scale coverage for eventual use in compiling maps and for purposes of exploiting national resources were discussed at the Conference. It was suggested that governments should take adequate measures, adapted to local conditions, to obtain coverage by high quality small scale photographs of regions which have not been adequately covered. For large areas, the necessary control can be obtained either by astronomical measurements or by the use of electronic means. In the latter case, the choice is between radar-controlled photography and the use of radar for the determination of ground control. The radar altimeter can be considered as a promising means for improving vertical control. The choice between the various methods depends on local conditions of topography, available means, etc. The best results are obtained with modern cameras with wide angle lenses.

Cadastral Survey Methods : It was pointed out on behalf of India that cadastral surveys are, in general, greatly divorced from the national trigonometrical or topographical surveys. They are mostly executed in the form of isolated patches, based on local systems with different standards of accuracy and with different origins. It was desirable to improve and standardize the present methods. The delegate from the Netherlands informed the Conference that one of the scientific commissions of the European Organization for Experimental Research was in charge of a detailed study of the application of photogrammetry to large-scale precision surveys. The problems under study by the Commission include the relation between precision and scale of photographs, the precision of restitution of topographic details which coincide with property boundaries, and the differences between film and plate cameras.

TROPICAL MAPS

Several delegates emphasized the need for, and the significance of, topical or special subject maps as essential tools for the planning and efficient execution of various national and international projects. The Conference considered that international co-operation would be necessary to prepare topical maps involving two or more countries. In this connection reference was made to the meeting of senior geologists held in Bangkok (Thailand) in November, 1954, under the joint sponsorship of the Economic Commission for Asia and the Far East, the International Geological Congress and the United Nations Cartographic Office for the preparation of a regional geological map for Asia and the Far East. Agreements were reached on the scale of the map, border correlations, tectonic data, stratigraphic scale, topographical background, limits of the map, and other technical conventions. There was general agreement on the desirability of free exchange of technical information concerning the methods of preparation and production of topical maps to the mutual benefit of the countries concerned.

NATURAL RESOURCES

The Conference noted that many projects were being launched in various countries of the region for the development of natural resources to meet the needs of changing economic and technical conditions. As decisions on the scope and practicability of a proposed development required, at its inception, a knowledge of the environmental factors, both human and physical, or of the region within which the project might be sited, it was desirable to prepare statistics and inventories, usually in the form of a cartographic presentation, of the incidence of such physical factors as climate, hydrology, soils, etc., and also of such human factors as were relevant to resource development.

It was emphasized that countries of the region should, whenever possible, make full use of the modern techniques of aerial photography and photo-interpretation as an aid in the survey of physical factors over wide areas and also in the detailed examination of development sites. Countries without sufficient technical personnel and facilities might obtain, where appropriate, the assistance from international agencies and other countries in establishing institutions and services for the execution of such surveys and inventories and in training technicians for the interpretation of environmental factors.

INTERNATIONAL MAPS

Several delegations emphasized the need for, and the desirability of, the early completion of ICAO aeronautical charts and the International Map of the World (I.M.W.) on the scale of 1 : 1,000,000. As the ICAO and I.M.W. series catered for different needs, it was essential to maintain both series. Although the two series had different specifications, *e.g.* projections and limits of sheets, it was felt that one basic compilation could be used in the preparation of both. Considering that large areas of the globe had already been covered by maps of the I.M.W. series, the Conference recommended that the countries of this region should stimulate progress in completing for their own territories the I.M.W. series so as to attain as soon as possible world coverage. Further, they should take steps to expedite the completion of various aeronautical maps and charts to meet the requirements of civil aviation. The Conference also made recommendations with regard to the limits of mapping responsibility for the 'Carte Internationale du Monde au Millionieme' series.

INTERNATIONAL CO-OPERATION

The Conference recognized the need for creating inter-governmental organizations on a regional basis, within the framework of the United Nations, in order to impress upon governments the need for progress in all fields of cartography. The means suggested to achieve this object was to work on the basis of regional cartographic conferences. The setting up of small central advisory boards consisting of one representative each of the regional organizations and of the international technical institutions concerned was recommended. The board would advise the United Nations on matters of cartographic policy and related technical questions.

Several delegations urged the creation of a central organization to which problems on cartography could be referred, and from which information on instruments and techniques could be obtained. The Conference favoured, as a first measure, the establishment of a committee or several committees for a specific field. These committees might approach countries or particular institutions when expert guidance was needed.

TECHNICAL ASSISTANCE

Various delegations emphasized the need for technical assistance to countries of the region in the field of cartography. In view of the fact that basic self-sufficiency in cartography is an essential pre-requisite to national development in every field and in view of the great amount of work to be done in the various fields of cartography by countries of this region, the Conference expressed the hope that it may in time be possible for the Technical Assistance Programme of the United Nations Organization to have a fixed and continued budget for the furtherance of a long-term programme.

The Conference recommended the convening of a second Cartographic Conference for the region not later than 1958.

(*Journ. of Sci. & Industr. Res., New Delhi, Vol.* 14A, *No.* 5, *1955, pp.* 241-244).

THE HEIGHT OF MOUNT EVEREST

The height of Mount Everest has long been a subject of much discussion. Its accepted height is 29,002 feet but several other values have also been quoted from time to time. The Technical Paper No. 8 of the Survey of India deals with the work undertaken by the Geological Survey of India during 1952-54 for determining the height of Mount Everest accurately. The new value for the height of the peak, obtained on analysis and reductions of new data from these investigations, is 29,029 feet, which, it is hoped, is not likely to be in error by more than 10 feet.

The first desideratum was to carry a triangulation series as close to the peak as possible. For this purpose the chain of minor triangulation run in Nepal during 1946-47 was reinforced by 3 measured bases and 3 spirit-levelled connections. The triangulation extended to the north in 1952-53, so that its most northerly stations were at distances of 30 to 40 miles from the peak. Mount Everest was observed from 8 stations ranging in height from 8,670 to 14,762 feet and great care was taken to ensure that the heights of these take-off stations were well fixed in terms of spirit-levelling. Previous attempts to fix the height were hampered by complete lack of geodetic data. In 1953-54 comprehensive plumbline deflections and gravity observations were carried out to delineate the geodial rise under Mount Everest. These observations are unique in many ways and are of great significance in revealing the mechanism of compensation of this interesting region.

This is the first instance when the height of an inaccessible peak has been determined by rigorous technique involving complicated nexus of facts and ideas.

(*Journ. of Sci. & Industr. Res., New Delhi, Vol.* 14A, *No.* 5, *1955, p.* 251).

OIL IN INDIA

The Search for More Oil in India

At both ends of the long chain of operations in a full scale petroleum industry, India sees new developments of far-reaching importance taking place this year. In refining--almost the last link in the chain—the erection of new plant will increase the industry's capacity to turn out oil products for the Indian market and thus reduce the nation's dependence on refineries abroad. In prospecting—the very first link—encouraging news is reported from Upper Assam where the indigenous petroleum industry was born more than half a century ago, and where a new well, the first to penetrate oil-bearing rocks underlying the alluvium of the Brahmaputra valley, was recently put on production.

At present India's only producing oil field is that at Digboi, in north-eastern Assam, which has yielded a little over 40 millions barrels of petroleum since its discovery in 1889. Production from this field, however, meets only a small faction of India's total requirements in terms of refined products and close interest follows today's intensive efforts to find more sources of crude oil.

Sub-alluvial Oil Prospects

The search for more petroleum in India has been pursued for many years. Tests wells drilled in several different places thought likely to hold prospects of oil accumulation were disappointing; and following the guidance given by seismic operations before the war, attention turned to the possibility of finding oil in structures concealed beneath the alluvium of the Brahmaputra valley in Assam. Upper Assam was not the only region embraced by these studies. Another alluvial area, that is now commonly referred to as the Bengal basin, was also considered for its hidden oil potentialities but the Brahmaputra valley, of which Digboi is near the head, received priority because the extensive facilities required for prospecting were nearer at hand.

The first well drilled in this vast alluvial area of Upper Assam was at Nahorkatiya, a small town in the Dibrugarh sub-division of Lakhimpur district, only 18 miles or so distant from the main Digboi oilfield. Work on it began in May, 1952. A year later it had reached a depth of 11,715 feet making it by far the deepest well in India. Signs of crude oil were encountered in sandstone rocks at different depths between 9,700 feet and 10,000 feet, and following a long series of scientific tests, the well was put on regular production in February this year. Current output is at the rate of about 500 barrels (20,000 gallons) daily.

Immediately following this welcome and important discovery of oil at Nahorkatiya, the Assam Oil Co. pushed ahead with plans for further deep drilling in the area. A second well, located on the south bank of the Burhi Dihing river, about a mile from the No. 1 well, was started in December, 1953, and is now approaching completion at a depth of 10,500 feet. This well holds the record for speedy drilling in India.

Sites for further deep wells to be drilled into the rocks underlying the valley's alluvium have been chosen; drilling at Nahorkatiya No. 3 will begin in a few months' time.

A new road has recently been cut through forest and jungle to link Nahorkatiya with Digboi, and alongside it pipe lines are being laid to transport oil and gas from the producing area to the Digboi refinery.

Geophysical Surveys

A direct result of the discovery of oil at Nahorkatiya is the intensification of geophysical survey work throughout the alluvial area of Upper Assam, and an elaborate programme of exploration was begun in the middle of last year.

As part of this programme, an aerial magnetometer survey was flown during which continuous magnetic measurements were made along nearly 15,000 miles of flight lines. Simultaneously a gravity survey (which by February this year had made over 4,500 observations) and a seismic survey were mapping and charting the attitude of rock formations to depths varying from a few hundred to many thousands of feet. Helicopters were brought to Assam to help in the speedy movement of men and materials from place to place in the difficult countryside.

(*J. Sci. Industr. Res., Vol.* 13, 1954, *pp.* 203-204)

Burmah-Shell Refinery Goes Into Production

The two-million-ton Burmah-Shell Refinery erected at Trombay Island (Bombay) at a cost of Rs. 30 crores came on steam in January, 1955.

Work on the erection of the refinery, the second of the three modern units to be set up in India, began on a 450 acre site in April, 1953, and by the end of 1954, a year ahead of schedule, the major part of the construction work on the project had been completed.

The crude oil intake capacity of the plant in the initial stages will be c. 5,000 tons per day. The unit will produce c. 475 millions gallons per annum of different petroleum products—kerosene, motor spirit, high-speed diesel oil, light diesel oil, furnace oil and bitumen.

The total annual production of the two Bombay refineries, when in full production, will be 773 million gallons. With the erection of the Caltex refinery at Vishakapatam, the three refineries, together with India's refinery at Digboi (Assam), will meet 80% of India's requirements of petroleum products and will effect an annual saving in foreign exchange of about Rs. 10 crores.

(*J. Sci. Industr. Res., Vol.* 14A, 1955 (*March*) 119).

SUGGESTIONS TO CONTRIBUTORS

1. **Manuscripts** should be typewritten on one side of paper only, with double spacing and wide margins, and should as far as possible be original copies.

2. Each major article should contain an **abstract** which gives a concise summary of the content, including both major and minor points. It should not exceed 100 words.

3. **References** should be given at the end of the article under the heading REFERENCES CITED, and not in footnotes. They should be arranged in alphabetic order of authors' names and chronologically under each author as shown below :—

FARMER, B. H., 1951 ...	Some thoughts on the Dry Zone. Bull, C.G.S., Vol. VI, pp. 165-178.
LEITER, N., 1947 ...	Denudation chronology and the drainage pattern of the Central Massif of Ceylon. Bull, C.G.S., Vol. II, pp. 64-69.
..............., 1949 ...	Geographical Study of the Nitre Cave District. Bull, C.G.S., Vol. III, pp. 61-72.

In the text, references to the literature cited should follow this form : (Leiter, 1947, p. 67).

4. The lay-out of the paper should be clearly shown. **Headings** should be of three types :—

Primary ...	Capitals, centre of line.
Secondary ...	Simple, centre of line.
Tertiary ...	Simple, beginning of line.

The three types of headings are shown in the following example :—

LAND USE IN THE PATANAS

Forms of Land-Use

Market Gardens : ' Market gardening has been.........'

5. **Maps, line drawings and diagrams** should be prepared on white drawing paper with Indian Ink. Care should be taken not to overload maps with irrelevant detail, or, at the other extreme, to use excessive amounts of space to convey relatively little information. Authors are urged wherever possible to submit maps, diagrams, drawings, and graphs in such a form that they can be reproduced directly, *i.e.* not more than 5 × 8 inches. If originals are to be reduced, they should not exceed 20′ × 32′. The scale (preferably linear) and the North point should be shown on all maps and diagrams.

6. **Lettering** on maps and figures must be written clearly, neatly. and with care remembering that the minimum height of letters after reduction should be 1 mm.

7. **Photographs** should be sharp, printed on glossy paper, and of the size in which they are to appear in the Bulletin. Wherever a photograph is used that was not taken by the author, credit for the source should be given.

8. **Tables** should as far as possible be incorporated in the text and should be as few and simple as possible. Or else they should be typed on a separate sheet and affixed to the end of the article.

9. **All text figures** (maps, diagrams, line drawings, graphs) should be marked for identification on the back, lightly in pencil. They should be numbered consecutively and the author's name given. The explanation of all text figures should be typed on a separate sheet of paper at the end of the manuscript. The explanations or captions should not be attached to the drawings.

10. **Fifteen reprints** will be issued to each author, free of charge. Further copies required will have to be paid for by the author.

11. All manuscripts submitted for publication and all books for review should be addressed to the Editor.

Vol. 9, Nos. 1 & 2 January-June, 1955

CONTENTS

(*Extracts from the Rules of the Ceylon Geographical Society*)

Name and Objects :

1. The Society shall be called the Ceylon Geographical Society.
2. The Office of the Society shall be in Colombo.
3. The object of the Society shall be to promote the study and discussion of the Geographical Sciences, and research on problems of the geography of Ceylon. For the purpose of securing this object, the Society shall provide for :—
   (*a*) The reading of papers on such problems and the discussion of such papers.
   (*b*) The dissemination of information so gained, especially regarding geography of Ceylon, by a publication of a regular Bulletin, and by any other publications or means deemed necessary.
   (*c*) Any other activity calculate to promote an interest in geographical problems, especially those relating to Ceylon.

Constitution :

4. The Society shall consist of :—
   (*a*) Ordinary members.
   (*b*) Student members.
   (*c*) Honorary Life Members.
5. Any person interested in the promotion of the objects of the Society shall be eligible for election as an Ordinary Member. Students on the recommendation of the head of the institution where they prosecute their studies should be eligible for election as student members. Student members shall not be entitled to vote at meetings of the Association.
6. Persons eminent for their contribution to or promotion of geographical study in Ceylon shall be eligible for election as Honorary Life Members.

Subscriptions :

16. (1) Every ordinary member shall pay an annual subscription of Ten Rupees. Student members shall pay an annual subscription of Two Rupees.

Library :

10. The Society shall maintain a Library and a collection of Maps, Cha Photographs, and Instruments connected with Geographical Sci to which members and *bona fide* students shall have free access, un such restriction as may appear advisable to the Committee.

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