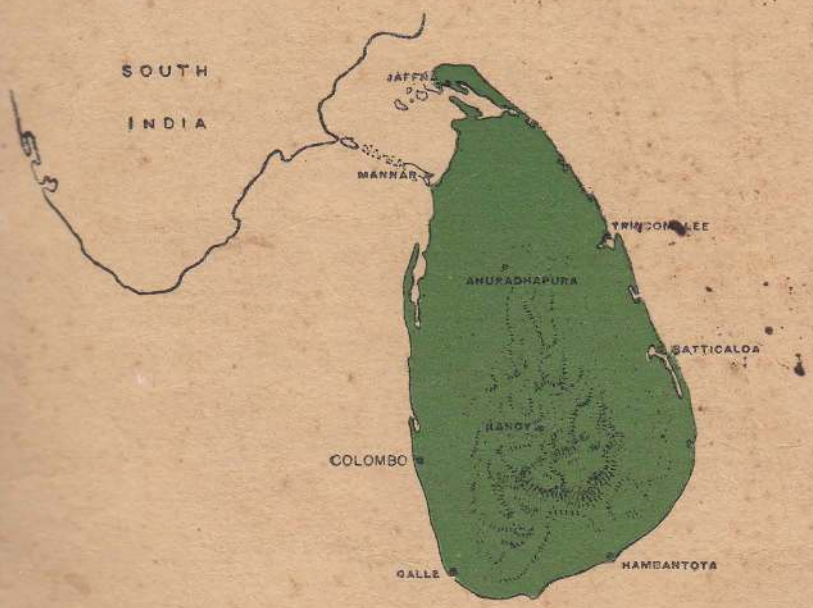
Vol. 3 No. 1 June 1948

# CEYLON GEOGRAPHICAL SOCIETY




# BULLETIN

# Bulletin of the CEYLON GEOGRAPHICAL SOCIETY

## CONTENTS

Volume 3 No. 1 June 1948

# Bulletin of the Ceylon Geographical Society



## EDITORIAL NOTES

*Meetings.*—The Eighth Annual General Meeting of the Society was held on March 19th, 1948, in The Geographical Department of the University of Ceylon with the President Mr. R. L. Brohier in the Chair. After the adoption of the Reports of the Secretaries and the Hony. Treasurer, the Office-Bearers for 1948-1949 were elected. Mr. Brohier who was unanimously re-elected President gave an address to the Society. This address and the names of the new Office-Bearers are printed in this issue of the Bulletin.

*Thanks.*—We hereby thank all our Office-Bearers of the past year and welcome the new Office-Bearers for 1948-49. Our thanks are also due to the Vice-Chancellor of the University for the use of the Geographical Department for our meetings and to the press for publicity.

We are glad to announce that the Government has promised the Society a grant and we are able to print the Bulletin from this issue. We regret that the issue of this number of the Bulletin has been delayed.

*Members.*—Mr. P. G. Cooray of the Department of Mineralogy, Editor and Secretary of the Bulletin and Mr. K. Kularatnam of the University of Ceylon, Hony. Secretary of the Society are both leaving the island to prosecute higher studies. We appreciate the up-hill work they have done to make our Society and Bulletin a success. We, wish both a happy voyage and success in their endeavours.

*Library.*— With the increasing number of Journals received in exchange, the problem of accommodation has risen and a suitable place which will be easily accessible to members and *bona fide* students must soon be found.

*Records.*—We would welcome the members of the Society and other well-wishers to write to us any geographical notes on recent occurrences in any part of the island so that we can record them in our Bulletin for the information of those who would like to carry out further investigations.

*Earth-Slips.*—We give a note in our columns with regard to the earth-slips occasioned by the heavy rainfall of August, 1947, in the Kadugannawa area. It has been reported that large-scale earth-slips have occurred in the Kotmale area and many families have been rendered homeless. We welcome

notes with regard to their cause, their nature and how to prevent them.

*Soil Erosion.*—We are encouraged to read a leading article in the *Times of Ceylon* with regard to soil erosion after our President's Address to the Society. 'Soil erosion is intimately connected with agriculture and irrigation'. The lasting source of wealth in any country is agriculture and therefore we should conserve our soil and retain its fertility at any cost.

EXCHANGES

*Geographical Review*
The American Geographical Society.

*Economic Geography*
The Editor, Clark University.

*Publications in Geography and Geology*
University of California.

*Geographical Journal*
Royal Geographical Society, London.

*Scottish Geographical Magazine*
Royal Scottish Geographical Society.

*Bulletin of the Imperial Institute,*
London.

*Bulletin of the National Geographical Society of India,* Benares.

*Reprints from the University of Otago,*
New Zealand.

The Society's thanks are due to the above mentioned institutions for the encouragement received. The Society also wishes to thank the New York Public Library for its gift of books and Mr. P. G. Cooray for the gift of maps and pictures.

# PRESIDENT'S ADDRESS

You have heard the report and statement of accounts of the Society during the past 12 months. Before I ask you to pass them formally for record as correct, it rests with me as your President to address you more generally on the main principles and aims of the Society and the matters, which come within our purview.

I cannot claim any outstanding event in the year's working, but that has not been entirely the fault of your Committee. We broke new ground in planning an interesting 3-day excursion. This unfortunately had to be abandoned as the response from members was not sufficiently encouraging. We next planned a one-day excursion, that too had to be cancelled owing to the unprecedented and unseasonal flood which the Island experienced in August last year.

This visitation once again brought very forcibly to notice the devastation to which Ceylon is periodically subjected and the problems of flood control. Whereas in centuries gone the primeval forests which canopied the central mountain ranges of Ceylon must have induced a much greater rainfall than we have in present times, no mention is made in the annals of devastating floods in the low-lands. The foliage which served to break the force of the rainfall, to retain the surface soil and to help the ground absorb the moisture, has in process of years been replaced first by coffee, next by tea. In the mid-country the forests have made way for rubber, and in extents amounting to thousands of acres, to land-utilization schemes.

For centuries little or no provision was made to counteract the unbalancing of nature. Sub-soil springs have dried up, and no river can today be said to carry a full perennial flow. The rain on the hill slopes has run off unchecked, carrying debris, earth, and the fine soil of the forests. The courses of our rivers have silted. Many of them, for miles from the mouth, have little or no fall. Every big flood raises the bed-level and reduces the capacity of the river-channel to hold the water.

This in essence is the back-ground of our flood problems. They are receiving the attention of engineers, but are equally well within the orbit of the geographer, and I commend this problem as a subject of study and research to our members.

Another matter, upon which I shall touch briefly, and to which geographical science must devote its attention more, is the ramification, if I may call it so, of population which is becoming excessive in certain areas. Geography in this human aspect, which leads to the publication of regional and land utilization maps and a national atlas, should receive the attention of those who can put forward ideas on such subjects. The Society will do its best to commend the work of members to the notice of authorities responsible for the issue of maps.

Turning a moment to the subject of historical maps, I don't think all members are aware that there are three collections in Ceylon—namely, at the Museum, the Archives, and the

Surveyor General's Office. I commend to the notice of members a recent innovation at the Museum which has made a display of some of these maps. The amenities of a map-room, and greater facility for the study of these maps are matters for constructive attention which I hope this Society will take up in the near future.

Before passing from the subject of maps, I think it should be among the objectives of a geographical society to know the problems of map production and what advances if any, have been made in publication. In the last published administration report of the Surveyor General, he has stated the enormous and unprecedented call on his Department for the printing of maps during the war years. The suspension of work on the popular editions was not merely inevitable but also justified by enactments which restricted the issue of large-scale maps for security reasons. In subsequent efforts to meet the demand of the public who had during the war years acquired a live sense of the importance of maps, the map-publishing branch of the Survey Department was set a heavy task.

More recent publications include the revised Motor Map, a re-designed layered edition of the 1/4 inch map of Ceylon, and Historical maps of Anuradhapura, in English and Sinhalese. There have been other editions of importance of the 1 inch contoured sheets of the Island and one-chain sheets of Colombo Town. Another rather unique production is an azimuthal map of the world centred on Colombo showing the air routes. It was both computed and printed in Ceylon. I hope to have the privilege of reproducing a reduction in our Bulletin. The desirable innovation which makes it possible now to purchase maps from any reputable firm of stationers and book-sellers, should go a long way to promote a greater interest in maps and add to the scientific instruction they convey.

The lectures arranged by the Society have ensured that we have not been behindhand in bringing to our members geographical science in all its branches. I trust that fresh interests have been awakened and hope that many others may be prevailed on to come and listen to the theories and lucid explanations contributed by the lecturers. All our lectures deserve a publicity that would bring a large attendance for them. I take this opportunity of reiterating the thanks of the Society to those who have placed their methodical research and time at the disposal of the Society.

I now come to the Bulletin, the corner-stone of our Society's virility, which despite the rather abstruse sound of some of the titles of the subjects discussed, has provided instruction on the science or art—call it what you will, of geography taken in all its breadth. It has proved itself a quarterly publication which any Society may well be proud of, and the appreciation of its high stand has been shown by the frequent requests from abroad for back copies.

We are under a great debt to the Editor, Mr. P. G. Cooray, for the labour and scholarship which has placed the Bulletin on such a satisfactory and international basis. His ardour has been undiminished by the great odds under which the numbers have made their appearance. He has been compelled to relinquish this responsibility in view of his impending departure on study leave, but I have no doubt he will continue to co-operate with his successor with whom we may con-

fidently leave the future of this useful medium for the diffusion of geographical knowledge.—Your Committee will give due consideration to the *format* and financial problems connected with its publication.

The membership of the Society is a matter for immediate and active concern. We in the Society should do our best to increase its numbers in every possible way. I must leave this matter in your hands with the hope the numbers will before long be largely increased.

In regard to the financial position of the Society as disclosed in the Balance Sheet, I cannot say that it reflects stability. The cost of the production of our Bulletin has been heavy. We have made an appeal to the authorities immediately concerned, for financial assistance, but I regret to say without any success. The Association of Science has very fortunately come to our assistance. I should like to say how deeply grateful we are to them not merely for the temporary assistance in money which they have so readily helped us to, but for that gesture which has implied appreciation of the contribution we are making to science and the strength they have afforded us, when we venture to make a further application for governmental assistance.

It is a matter of great encouragement that we again have a Professor of Geography, and what is even more, that the Society has his goodwill. We offer a welcome to Dr. G. H. Lebon to Ceylon, and express appreciation of the interest he has evinced for promoting the usefulness of the Society.

The work of the Society during the last year has been accomplished largely by the labours of our joint-secretaries. Rather unfortunately, our Treasurer Mr. ~~Latif~~ Leitner, was not able to carry on and we have had to make a change in mid-stream. I should like here, to express our sense of gratitude to Mr. ~~Latif~~ Leitner. He was an original member of the Society. His contributions to discussions were always helpful and instructive and his papers contributed to the Bulletin will bear testimony to his active interest in our ambitions.

I trust that, in the future, when we shall have more constructive plans to put in force, we will be able to count on equally ungrudging work from our Committee and principal office bearers.

I have just one appeal more to make before closing this address to you. We are at present feeling our way and it depends largely on the co-operation you give the executive of the Society by supporting the programme they arrange, whether we go forward, or wreck ourselves on the rock of discouragement. Please attend our lectures and bring others with you. Help in any excursions the Society might arrange and lastly, don't hesitate to tell us if there is anything which you think will further the interests of the Society, or about something we are doing, or not doing, which you are unhappy or disturbed over.

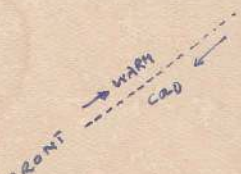
I now formally move the adoption of the Report and Accounts and after it has been seconded I shall be glad to hear any comments or criticisms members may wish to offer.

# TROPICAL CYCLONES AND THEIR EFFECT ON CEYLON CLIMATE

By A. P. Kandasamy Esqr., B.Sc.(Lond.), F.R.Met.S., F.R.A.S.,
Asst. Supdt., Colombo Observatory

*Air Masses.*—A study of weather map shows that the properties of the air are often nearly the same over areas extending many thousands of miles. Such a uniform body of air is called an Air Mass. Having stagnated for a considerable interval of time in a region where the earth's surface is homogeneous it assumes uniformly properties derived from this part of the earth's surface. The principal regions in which formation of air masses takes place are the tropical and sub-tropical zones on one side, the arctic and subarctic regions on the other side. Consequently the two principal types of air masses are the "tropical" and the "polar." In middle latitudes the uniformity of conditions and the light winds are generally lacking so that practically no source regions are found here.

*Fronts and their Origin.*—In an air mass there is very little or no change in the properties of air in a horizontal direction. In passing from one mass to another a change of properties must necessarily occur and the rapidity of the change depends on the width of the zone of transition. When different masses of air move from their sources towards each other the zone of transition becomes narrower and the contrast between properties sharper. If this zone of transition becomes sufficiently narrow so as to appear as a line on a weather map it is called a front. Although an accurate criterion cannot be given, transition zones of width less than 50 miles are usually regarded as fronts. Wider zones are often called the frontal zones.




Strictly speaking a front is the intersection of the frontal surface separating two air masses of different properties and the ground, although the term "front" is often used to designate the whole surface of separation, which is also the surface of discontinuity.

*Wave Theory.*—The accumulating cold air of the polar regions flows equatorward and thereby acquires an east-west component. Similarly the warm air from the lower latitudes moves poleward acquiring a west-east component. When they approach sufficiently close to each other a frontal surface as described above develops in the atmosphere, and wave motion starts spontaneously on the surface of separation, just as water waves are formed on a water surface which is the surface of separation between water and air. Important results have been obtained which make it certain that unstable waves of the right length and velocity can originate at the surface of discontinuities in the atmosphere as a hydrodynamical phenomenon. This wave of instability in the boundary surface between warm and cold air (also called the cyclone wave), is supposed to be the process that starts extratropical cyclone formation. The cyclone wave later develops through the process of occlusion into

a cold vortex. Thereby a portion of the warm air is lifted and is replaced in the lower troposphere by cold air. This process transforms potential energy into kinetic energy which shows up as a strengthening of the cyclonic winds. Since wind forces and horizontal pressure gradients are closely connected, an accentuation of the pressure profile and usually a deepening of the pressure centre must accompany the development from wave to vortex. The above is the wave theory put forward by the Norwegian meteorologists led by Bjerknes and Solberg and is the most widely accepted one.

*Barrier Theory.*—Exner advanced another theory to explain the genesis of cyclones at the fronts. According to his hypothesis, the existence of a temperature discontinuity in the air is regarded as a condition necessary for the formation of a cyclone as in the wave theory. He considers an outbreak of polar air where a cold mass from the polar region intrudes in the region of westerly winds in the temperate latitudes. (The cold air moves either westward, or much more slowly eastward, than the warmer air of the temperate latitudes). It acts as a barrier to the motion of the warm air, hence Exner's theory is known as the barrier theory. Because the faster moving warmth to the east of the cold tongue retains its velocity owing to inertia, the pressure is here reduced considerably. The formation of the region of low pressure changes the direction of air motion at A, B, and C, so that a cyclonic vortex develops. Because the cold tongue C forms part of this cyclonic vortex, its direction of motion becomes also mainly eastward.

In a similar manner a continent, especially a mountainous continent, may act as a barrier. Exner refers in particular to Greenland and suggests that the Icelandic minimum to the east of the Southern tip of Greenland may originate as a barrier effect.

However it appears doubtful that the pressure deficit in the lee of the barrier is strong enough to lead to formation of cyclones except in very special cases. A mathematical analysis of Exner's theory that would give a reliable estimate of the pressure deficit has not yet been undertaken.

*Tropical Cyclones.*—Most meteorologists who have studied the mechanics of the tropical cyclone agree that its formation is connected with vertical instability in the atmosphere and that the energy of the cyclone is derived from the latent heat of condensation released during the ascent of warm moist air from the surface of the sea.

It is explained that the formation of a warm column of air by convection, causes the isobaric surfaces at the top of the air column to be raised, and an outflow of air at this level results from the rise in pressure. The outflow causes a reduction in the total weight of the column and produces a fall of surface pressure. The surface winds then converge towards the newly formed low, and produce a cyclonic circulation as a result of the deviating force of the earth's rotation.

This briefly is the accepted mechanism for the formation of cyclonic

storms in the tropics, although the importance of converging air streams and of the intertropical fronts have also been stressed by various authors. It has however been realised that there is an important omission in the theory of the tropical cyclones outlined above, in that it fails to explain what mechanism continues to remove air from the upper levels of the cyclone, after the initial rise in pressure has been equalised and the circulation has become cyclonic at all levels. The simplest mechanism which has been postulated, is an upper current whose direction differs from that of the current in the lower troposphere. The outward moving cirrus from the centre of cyclonic systems has been taken as evidence of such a current.

*Comparison.*—In tropical cyclones the wind velocity is much higher than in the extratropical cyclones of temperate latitudes. The pressure at the centre of the tropical cyclones reaches sometimes very low values 920 mb. and less; but similarly low values have also been observed in temperate latitudes. The characteristic difference between tropical and extratropical cyclones is the pressure gradient which is much steeper in tropical cyclones, for their diameter is considerably smaller than the diameter of extratropical cyclones.

Tropical cyclones rarely form closer to the equator than at 5° to 6° latitude, which indicates that the deviating force of the earth's rotation is an important factor in their development. It seems that the tropical cyclones develop over the sea only.

They move generally in a westerly to north westerly direction in the Northern Hemisphere. Many assume a north-easterly or northerly direction at latitude 20° to 25°, and thus their track resembles a parabola. When they reach higher latitudes, about 30°, their diameter increases. Consequently the pressure gradient becomes less steep, and the tropical cyclone often changes into an extratropical cyclone. On the other hand the extratropical cyclone never invades the region of the tropical nor assume its distinctive characteristics. The isobars of the tropical cyclone generally are more symmetrical and more nearly circular than those of the extratropical. The temperature distribution around the vortex of the tropical cyclone is practically the same in every direction, while about the extratropical it is very different.

A peculiarity of many tropical cyclones is the calm centre, the so called "Eye of the Storm". When the centre of a tropical cyclone passes over a given locality, the wind which has been very violent dies down suddenly, either to an absolute calm or at least to a much lower velocity, and the precipitation ceases. There have even been cases reported of the sky clearing. The diameter of the eye of the storm may be about 10 to 30 miles. The pressure drop of the tropical cyclone generally begins with the winds; in the extratropical it usually begins much sooner. The tropical cyclone has no anticyclone companion; the extratropical usually has—to the West.

In tropical cyclones; rains are torrential and more or less equally distributed on all sides of the centre; in the extra-tropical, rains usually are much lighter and very unequal in different quadrants.

The frequency of tropical cyclones is very small compared with that of the extratropical cyclones. They occur almost exclusively during the warm season, whereas the cyclones of the temperate latitudes are stronger and more frequent in winter.

*Size.*—The diameter of the tropical cyclone varies greatly. Near their origin some storms may be no more than 50 miles across, while others when well developed may have diameters varying from 200 to 1,000 miles.

*Velocity of wind.*—The velocity of the wind in a tropical cyclone also varies greatly from one storm to another, and even more from one to another portion of the same storm. Near the centre or within the eye of the storm the wind is very light. Away from this centre especially on the right hand side in the northern hemisphere (going with the storm) the winds often reach destructive velocities of 90 to 110 or even 140 miles per hour, but decrease in violence rather rapidly with increase of distance from the centre, dropping to about 35 miles per hour at a distance of say 200 miles.

*Velocity of Travel.*—The velocity of travel of the cyclone as a whole or of its centre, varies from almost zero near its place of origin to perhaps 500 miles per day. Over the Bay of Bengal, Arabian Sea and the China Seas the velocity averages about 200 miles per day. Over the South Indian Ocean the velocity ranges from 50 to 200 miles per day. Over the West Atlantic the average velocity before and during recurvature is about 250 miles per day, but after recurvature about 400 miles per day.

The cyclone of the Indian Seas, the hurricane of the West Indies and the South Pacific, and the typhoon of the West Pacific and China Seas, are all tropical cyclones.

Tropical cyclones are apt to occur during the seasons of calms at irregular and infrequent intervals. There is a danger period which follows after the farthest poleward migration of the belt of calms, as the table below shows.

Average Annual Frequency. Percentage of Total.

| | J | F | M | A | M | J | J | A | S | O | N | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N.H. | 1 | 1 | 1 | 1 | 2 | 4 | 16 | 25 | 25 | 15 | 6 | 3 |
| S.H. | 26 | 22 | 23 | 9 | 4 | 0 | 0 | 0 | 0 | 1 | 4 | 11 |

In the Indian Seas (Bay of Bengal and Arabian Sea), the necessary conditions are fulfilled during the periods of calms which come between the two monsoons. There are two annual maxima as shown in the table below :—

Average Annual Frequency Percentage of total.

| J | F | M | A | M | J | J | A | S | O | N | D |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 0 | 1 | 12 | 19 | 19 | 2 | 3 | 5 | 17 | 13 | 6 |

*Effect on the Climate of Ceylon.*—Owing to the proximity of Ceylon to the Equator, the cyclones that strike Ceylon are more often than not in their early stages when they are known as depressions, which are cyclonic in character but milder in respect of wind movements. I give below a table showing the actual number of cyclonic depressions that had been observed to have affected Ceylon during the period 1925-1944 :

| J | F | M | A | M | J | J | A | S | O | N | D |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 0 | 3 | 3 | 2 | 0 | 1 | 0 | 2 | 10 | 19 | 5 |

(Total 48).

This will illustrate how irregular and infrequent they are, and their distribution. The above figures include depressions which failed to develop subsequently into a cyclone.

Since the occurrence of cyclonic depressions are rather infrequent, their effect on climate in terms of average figures will be negligible when averaged over a number of years. But, however, they affect the Ceylon Climate, in that they cause a distinctive type of weather which forms an integral part of its climate.

Briefly the weather associated with a cyclonic depression is as follows :—

"Continued overcast skies with consequent loss of sunshine, low day temperatures, and high night temperatures, deviations being generally not more than 4°F. but occasionally increasing to 10°F. Winds varying in direction and strength sometimes exceeding gale force causing damage to life and property. Continuous widespread rain frequently heavy, falls of over 5″ being common, resulting in flooding of rivers and lowlying lands. Orographic influence on rain not marked".

It will be interesting to note here that most of the highest daily falls recorded are results of depressions. *e.g.* Nedunkeni, 31.72″.

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| | |
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*Reports on the Colombo Observatory.*

# THE WEATHER ALONG THE DIRECT AIR ROUTE FROM COLOMBO TO NUWARA ELIYA

By D. T. E. Dassanayake, B.Sc., Ph.D.(Lond.), D.I.C., F.Inst.P., F.R.Met.S., F.R.A.S.
Supdt., Colombo Observatory

The weather in Ceylon is liable to be affected occasionally by depressions from the Bay of Bengal. They may give several days of heavy rain, with sheets of low rain-clouds, and strong winds. They are most frequent from October to December, but are also occasionally experienced between January and May.

Ground winds are to a large extent affected by the topography of the immediate neighbourhood, but are generally only light to moderate. Observational data of wind are available only for the Colombo end of the route. Strong winds are sometimes experienced, particularly at the beginning of the south-west monsoon, in May and June. During these months, winds may sometimes average 30 to 40 m.p.h. for several hours, while gusts up to 60 and even to 70 m.p.h. may occur. High gusts of wind are also frequently associated with torrential rain at other seasons.

During the south-west monsoon, winds veer from south-westerly near the ground to westerly at altitudes of 3,000 feet or more. During the north-east monsoon, winds veer from north-easterly to easterly with increasing height. But this latter effect may be of less importance to airmen, owing to the comparative weakness of the upper winds during the north-east monsoon season.

A factor of considerable importance to airmen flying on the direct route Colombo-Nuwara Eliya is the risk of running into "air pockets" in the hill-country. For the last 20 miles of the route, the ground is more than 4,000 feet above M.S.L. while Nuwara Eliya itself is at an altitude of over 6,000 feet. Although no direct observations are available, the existence of "air pockets" between the hills, more particularly on the leeward side of hills, cannot be ruled out. Since air streams tend to follow the normal contour of the earth's surface, descending currents will naturally exist on the leeward side of hills. These descending currents will vary with the strength and character of the wind, and with strong and squally winds they are frequently considerable. Surface irregularities generally affect the upper air to a height equal to three or four times that of the object. Well-defined regions of descending air are likely to be experienced in the very turbulent atmosphere associated with thunderstorms and squalls generally.

*January.*—Rainfall along the route is only moderate, monthly totals averaging from 5 to 7 inches. In the low-country portion of the route, there is a marked diurnal variation in the rain, nearly all of which falls between 3 p.m. and 11 p.m., the maximum frequency being between 5 p.m. and 9 p.m.; while up-country the diurnal variation is not so marked. These rains are usually in the form of local thunderstorms, which start appreciably earlier inland.

The mornings are generally bright and fairly clear, but clouds often start spreading from the hills about the

middle of the day, and reach the coast as sheets of stratus a few hours later. This cloud is usually not low, but masses or sheets of low cloud may form underneath it, with rain and thunder. In the low-country, visibility is usually good, except in so far as it is reduced during rain. Low visibilities are also experienced sometimes in fine weather at night or in the early morning, when low-lying mists may form. Up-country, the visibility is generally only moderate. Very poor visibilities are experienced with mist or drifting low cloud.

*February.*—In this month there is an appreciable diminution in the probability of rainfall, the average monthly rainfall being less than 5 inches. As in January the rain is usually the result of local thunderstorms, and the diurnal variation is similar, most of the rain falling between 3 p.m. and 11 p.m. The rain starts earlier inland.

Conditions as regards cloud and visibility are the same as in January, except that the tendency to cloud is distinctly less.

*March.*—The rainfall is somewhat heavier this month. Monthly averages range from just under 5 inches at the coast to over 10 inches at the foot-hills. As in the previous months, most of the rain falls between 3 p.m. and 11 p.m. maximum frequency occurring between 4 p.m. and 9 p.m. in the low-country, and somewhat earlier up-country. The rain is often accompanied by thunder. The tendency to cloud is a little greater than in February.

*April.*—The rainfall along the route is distinctly heavier than in March, monthly totals averaging 10-15 inches. Near the coast, the greater part of the rain again falls between 3 p.m. and 11 p.m., while inland practically the whole of the rain is confined to the hours between noon and midnight. Maximum frequency is somewhat earlier than in March. Near the coast there is a greater tendency to rain between midnight and dawn than in the preceding months. Thunderstorms are now more frequent. The tendency to cloud has again increased this month.

*May.*—Average monthly rainfall along the route increases from about 15 inches at the coast to about 30 inches at the foot-hills, and decreases again to less than 10 inches at Nuwara Eliya. There is comparatively very slight diurnal variation now in the liability to rain, which is likely to occur at any hour of the day or night, with a slight tendency, however, to greater frequency at night in the low-country, and in the afternoon up-country. There is further increase in cloudiness. The liability to prolonged, intense, and extensive rain in the south-western low-country of Ceylon is much greater during this month than in any other. There is often a considerable amount of thunder during the setting in of the south-west monsoon, which takes place this month. In the low-country, except during rainy weather, visibility is usually fairly good, and in fine weather low cloud is not usually seen in sheets, but in broken patches. Up-country, ground visibility is generally moderate, sometimes even poor, due to increased clouding.

*June.*—Variation in monthly rainfall averages along the route is more marked in June than in May, being a little under 10 inches at the coast, increasing to 40 inches at the foot-hills, and decreasing again to about 10 inches at Nuwara Eliya. In the low-country, particularly at the coast, the rain as a rule comes in short, sharp squalls. Here prolonged rain is comparatively infrequent, except perhaps at the

beginning of the month. Rain is almost equally likely at any hour of the day or night. Except during heavy rain, visibility in the low-country is generally fairly good, but up-country liability to low visibility is much greater than in the previous month. Thunder is comparatively infrequent.

*July.*—The distribution of rainfall along the route is similar to that in June, but the averages are slightly less. The general weather conditions are similar too. In the low-country the rain usually comes in short, sharp showers, prolonged intense rain being infrequent.

*August.*—There is a further diminution in rainfall this month ; otherwise weather conditions are much the same as in the preceding month.

*September.*—Rainfall averages are on the increase. A diurnal variation of rainfall is once more in evidence, rain in the low-country being distinctly more probable between midnight and 10 a.m. than at other hours of the day, with maximum frequency between 3 a.m. and 7 a.m., while up-country, rain being more probable between noon and 7 p.m., with maximum frequency between 1 p.m. and 5 p.m. Thunder becomes more frequent this month. Tendency to low visibility up-country is slightly less than in the preceding months.

*October.*—There is a further increase in the rainfall, monthly averages ranging from about 13 inches at the coast to over 25 inches at the foot-hills. At Nuwara Eliya the monthly average is about 10 inches. Near the coast the liability to rain is appreciably less between 9 a.m. and 2 p.m. than at other hours of the day, with minimum frequency between 10 a.m. and noon. In the hill-country, the diurnal variation of the rainfall is more marked than in the low-country, the greater liability occurring between noon and 11 p.m., with maximum frequency between 2 p.m. and 8 p.m. Thunder is more frequent this month. There is a considerable amount of cloud, while the tendency towards clear mornings and cloudly afternoons is again beginning to manifest itself.

During this month depressions from the Bay of Bengal sometimes affect the Island. Although the south-west quarter, as a rule, escapes the worst effects of these depressions, there may be sheets of low cloud, and heavy rain, for several days, which may affect the whole or a large part of the Island. High winds are usually associated with these depressions.

*November.*—The rainfall distribution is now more even, the monthly averages being 15 to 20 inches over the greater part of the route. There is a well marked diurnal variation in the rainfall. Near the coast, the maximum frequency is between 5 p.m. and 10 p.m., while the chance of rain is least between 9 a.m. and 3 p.m. Inland, practically the whole of the rain falls in the afternoon or evening, maximum frequency occurring between 3 p.m. and 8 p.m. There is a general tendency towards fairly clear mornings and cloudy afternoons, while clouds are not usually very low except during wet or threatening weather. The rain is frequently accompanied by thunder. Visibility is generally good in the low-country, except during rain or occasional early morning mists, while up-country visibility is generally moderate in the forenoon and low in the afternoon, evening or early morning. As in October, the Island comes under the influence of depressions from the Bay of Bengal.

*December.*—Rainfall is appreciably less this month, monthly averages being 5 to 10 inches. The diurnal variation or rainfall continues to be marked, nearly all the rain falling between 1 p.m. and 11 p.m., with maximum frequency between 5 p.m. and 7 p.m. The rain is frequently accompanied by thunder. Cloud has decreased, while the tendency to clear mornings and cloudly afternoons continues, the clouds usually spreading from the hills to the coast as a sheet of high stratus, under which low rain-clouds may form. The thunderstorms generally start a little earlier in the day inland, and travel to the coast. Poor visibility and sheets of low cloud are not usually experienced in the low-country, except in rainy weather. There are, however, occasionally, ground mists in the early morning. Visibility conditions up-country are slightly better than in the previous month. Depressions from the Bay of Bengal sometimes affect the Island.

**Average amount of rain in inches falling in each three-hourly interval of the day during the different months.**

| Period | Jan. | Feb. | Mar. | Apr. | May | Jn. | July | Aug. | Sep. | Oct. | Nov | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COLOMBO (Derived from 10 years' observations, 1931-40.) | | | | | | | | | | | | |
| M. -3 a.m. .. | 0·21 | 0·28 | 0·16 | 1·05 | 2·66 | 1·32 | 0·51 | 0·75 | 1·06 | 2·96 | 1·89 | 0·65 |
| 3 a.m.-6 a.m. .. | 0·17 | 0·16 | 0·02 | 0·58 | 3·16 | 1·53 | 0·83 | 0·99 | 1·13 | 1·79 | 1·74 | 0·22 |
| 6 a.m.-9 a.m. .. | 0·14 | 0·01 | 0·10 | 1·40 | 2·84 | 1·19 | 0·75 | 0·98 | 0·99 | 1·98 | 1·24 | 0·20 |
| 9 a.m.-N. .. | 0·16 | 0·02 | 0·06 | 0·59 | 1·79 | 0·83 | 0·46 | 0·86 | 0·68 | 0·57 | 0·84 | 0·06 |
| N. -3 p.m. .. | 0·20 | 0·05 | 0·25 | 0·39 | 0·86 | 0·74 | 0·51 | 0·87 | 0·59 | 0·64 | 0·72 | 0·13 |
| 3 p.m.-6 p.m. .. | 0·96 | 0·50 | 1·03 | 2·27 | 1·08 | 0·82 | 0·65 | 0·76 | 0·66 | 1·71 | 2·25 | 1·96 |
| 6 p.m.-9 p.m. .. | 1·15 | 1·69 | 1·63 | 2·18 | 2·10 | 0·90 | 0·47 | 0·76 | 0·60 | 2·15 | 3·60 | 1·68 |
| 9 p.m.-M. .. | 0·82 | 0·63 | 0·90 | 1·02 | 1·70 | 0·60 | 0·33 | 0·79 | 0·58 | 2·75 | 2·11 | 0·49 |
| LABUGAMA (Derived from 10 years' observations, 1931-40). | | | | | | | | | | | | |
| M. -3 a.m. .. | 0·20 | 0·66 | 0·39 | 0·27 | 3·56 | 2·23 | 1·31 | 1·24 | 1·16 | 1·85 | 1·42 | 0·20 |
| 3 a.m.-6 a.m. .. | 0·07 | 0·35 | 0·12 | 0·24 | 3·55 | 2·35 | 1·54 | 1·96 | 1·62 | 1·47 | 0·89 | 0·19 |
| 6 a.m.-9 a.m. .. | 0·09 | 0·10 | 0·02 | 0·30 | 2·33 | 1·98 | 1·33 | 1·17 | 1·04 | 1·25 | 0·69 | 0·10 |
| 9 a.m.-N. .. | 0·03 | 0·04 | 0·02 | 0·57 | 2·78 | 2·11 | 1·34 | 1·54 | 1·44 | 1·51 | 0·52 | 0·03 |
| N. -3 p.m. .. | 0·27 | 0·46 | 0·72 | 1·57 | 2·41 | 1·88 | 1·75 | 1·19 | 0·97 | 2·02 | 2·24 | 0·41 |
| 3 p.m.-6 p.m. .. | 1·75 | 3·74 | 7·45 | 7·74 | 3·87 | 1·89 | 1·18 | 1·54 | 1·54 | 5·34 | 6·37 | 4·54 |
| 6 p.m.-9 p.m. .. | 1·58 | 1·20 | 2·46 | 2·70 | 2·34 | 1·80 | 1·21 | 1·32 | 0·93 | 3·18 | 4·26 | 1·41 |
| 9 p.m.-M. .. | 0·69 | 0·58 | 0·42 | 0·93 | 1·98 | 1·42 | 0·97 | 0·70 | 0·66 | 2·15 | 1·96 | 0·31 |
| WATAWALA (Derived from 10 years' observations, 1931-40). | | | | | | | | | | | | |
| M. -3 a.m. .. | 0·31 | 0·20 | 0·05 | 0·22 | 3·37 | 3·88 | 3·57 | 2·59 | 2·35 | 1·87 | 0·98 | 0·44 |
| 3 a.m.-6 a.m. .. | 0·26 | 0·06 | 0·09 | 0·35 | 3·59 | 4·43 | 3·67 | 3·47 | 2·76 | 1·84 | 0·94 | 0·22 |
| 6 a.m.-9 a.m. .. | 0·28 | 0·08 | 0·04 | 0·25 | 3·24 | 3·60 | 2·67 | 2·08 | 2·16 | 1·46 | 0·62 | 0·31 |
| 9 a.m.-N. .. | 0·41 | 0·07 | 0·03 | 0·36 | 4·07 | 4·38 | 3·70 | 2·36 | 2·35 | 1·76 | 0·51 | 0·19 |
| N. -3 p.m. .. | 0·51 | 0·59 | 0·92 | 2·19 | 5·47 | 6·63 | 5·69 | 4·09 | 3·86 | 4·07 | 2·49 | 1·12 |
| 3 p.m.-6 p.m. .. | 0·96 | 1·55 | 4·12 | 4·75 | 5·33 | 4·93 | 3·39 | 3·79 | 3·83 | 6·13 | 5·74 | 2·31 |
| 6 p.m.-9 p.m. .. | 0·85 | 1·14 | 0·87 | 1·98 | 3·30 | 2·52 | 2·59 | 2·32 | 1·90 | 3·77 | 2·91 | 1·56 |
| 9 p.m.-M. .. | 0·51 | 0·54 | 0·16 | 0·54 | 3·09 | 2·72 | 2·13 | 1·92 | 1·52 | 2·12 | 1·24 | 0·50 |
| NUWARA ELIYA (Derived from 6 years' observations, 1935-40). | | | | | | | | | | | | |
| M. -3 a.m. .. | 0·47 | 0·24 | 0·01 | 0·16 | 1·20 | 0·90 | 1·41 | 0·68 | 0·64 | 0·52 | 0·69 | 0·74 |
| 3 a.m.-6 a.m. .. | 0·48 | 0·14 | 0·02 | 0·19 | 1·28 | 1·12 | 1·26 | 0·73 | 0·43 | 0·29 | 0·35 | 0·72 |
| 6 a.m.-9 a.m. .. | 0·48 | 0·18 | 0·02 | 0·18 | 0·87 | 1·01 | 1·06 | 0·51 | 0·43 | 0·23 | 0·24 | 0·92 |
| 9 a.m.-N. .. | 0·38 | 0·06 | 0·05 | 0·23 | 1·12 | 0·61 | 0·80 | 0·50 | 0·32 | 0·32 | 0·23 | 0·47 |
| N. -3 p.m. .. | 0·57 | 0·30 | 1·52 | 1·42 | 1·62 | 1·47 | 2·07 | 0·99 | 1·21 | 1·40 | 1·76 | 0·82 |
| 3 p.m.-6 p.m. .. | 0·55 | 1·04 | 1·44 | 1·68 | 2·08 | 1·18 | 1·19 | 0·92 | 1·52 | 1·39 | 1·93 | 1·61 |
| 6 p.m.-9 p.m. .. | 0·74 | 0·42 | 0·45 | 0·75 | 0·88 | 0·84 | 0·89 | 0·65 | 0·64 | 1·39 | 1·73 | 1·93 |
| 9 p.m.-M. .. | 0·66 | 0·12 | 0·16 | 0·22 | 0·82 | 0·83 | 0·59 | 0·43 | 0·56 | 0·66 | 0·98 | 0·91 |

# A GEOLOGICAL INVESTIGATION OF THE EARTH-SLIPS AT KADUGANNAWA

By K. Kularatnam, M.A.(Lond.), Dip. in Gemology
University of Ceylon

During a geological tour of the areas in the hill country of Ceylon affected by the unusual precipitation of August, 1947, the opportunity was taken of making a detailed geological examination of the Kadugannawa earth-slips. These occurred near the 62nd. milestone on the Colombo-Kandy road.

*Lithology.*—In composition, the rocks of the area consist of a series of intensely metamorphosed biotite-garnet schists and schistose gneisses, generally intermediate to basic in character. These are intruded in places by extensive granitic material as at Belungala, but at the site of the slips, the rocks are essentially schists and gneisses with only *lit-par-lit* injections and permeations by granitic magma.

Thes rocks are finely foliated, and of variable thickness consisting generally of bands of (*a*) biotite-garnet (hornblendic only in certain cases), (*b*) granular quartz and (*c*) plagioclase-quartz. In the warm humid climate of the area, the thicker micaceous and feslpathic bands weather readily into argillaceous and chloritic sheets through hydration, whilst the layers of granular quartz remain unaltered and friable. The processes of weathering do not attack all the bands uniformly. They are guided by several other factors such as exposure, jointing, cleavage and shear planes, both along folia as well as transversely. Not less important is the factor of insolation, whereby under alternate cooling and heating, the different bands expand and contract differentially, setting up strains and stresses and aiding the process of block disintegration. As a result of all these, the hill slopes come to consist of large and small boulders and blocks of rock, some partly attached at their roots to the parent strata and other buried in the residual earthy products of disintegration and decomposition.

*Structure.*—The general structure of the region has a N.N.W./S.S.E. strike with the strata dipping N.N.E., in conformity with the surrounding areas. But there are several and severe modifications to this at the site of the slips. In view of the displacement of the loose blocks and boulders formed by uneven weathering, this general structural arrangement is disturbed, the blocks re-aligned and tilted at varying angles, producing an extremely high range of pseudo-strikes and dips. Thus the area may be summarised as consisting of a series of highly inclined strata, each dipping uniformly, but changing from one to the other.

These facilitate lateral and downslope movement on to the road and valley below.

*The phenomena and mechanism of earth-slips.*—During periods of pronounced precipitation, large quantities of surface water percolate the quartzose layers at the outcrops, which are very porous owing to their loose and granular

texture. On reaching the base of each quartzose layer, the water is trapped by the subjacent argillaceous sheet and it there accumulates, thus forming a very effective lubricant. In addition to this, the water-saturation of the earthy residual material in which the detached boulders and blocks are embedded, releases the latter which are now ready to slide down, gathering momentum in the process.

Acted on by gravity and aided by water filling the interfaces as a lubricant, huge blocks and entire hill slopes move down along the inclined foliation planes at different levels in an avalanche. The phenomenon and the mechanism behind it are thus explicable in terms of structure, lithology and climate alone. Differential weathering, inclined strata, and lubrication of interfaces, which are the fundamental factors here, always imply instability, and there is little doubt that further slips must necessarily take place in future. The popular belief that these slips have been caused by earth-quake activity is far-fetched and not correct.

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