

THE GEOMORPHOLOGY OF CEYLON
A STUDY OF TROPICAL TERRAIN
BASED ON AERIAL PHOTOGRAPHS

by

David Kinsey Erb

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Department of Geography,
McGill University
Montreal

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PREFACE

In the course of a Canadian Colombo Plan aerial survey of Ceylon, the need for a comprehensive description of the island's terrain and an interpretation of the physical evolution of the landforms composing this terrain became apparent. Because of the early development of various government branches responsible for scientific investigation, much of the basic information necessary for such a study is readily available.

Geological studies, completed or underway, have delineated the basic rock types and structure. Precambrian igneous and metamorphic rocks, as well as sedimentary rocks of Jurassic and Miocene age, have been subjected to extensive tectonic activity which has resulted in a complex pattern of folding, faulting, and jointing.

Climatological data are available in the published reports of the Meteorological Department dating back to 1868. The climate is essentially tropical although it varies from hot to cool and from arid to humid, depending on altitude and geographical location.

The island's vegetation has been described in general, and detailed studies of smaller areas have been carried out, by foresters, agriculturists, and botanists. Regionally the vegetation varies from coastal swamps, through dry, scrub jungle, lowland and highland wet jungle, and savanna-like Talawa, to open grassland Patana.

In addition, the survey mentioned initially made available complete, up-to-date, stereoscopic, aerial photograph coverage of the island together with aerial photograph mosaics. The aerial photographs are nominally at a scale of 1:40,000 and the mosaics at a scale of 1:31,680.

With these facts in mind, it was decided to make a geomorphological study of Ceylon based primarily on the technique of aerial photograph analysis and interpretation supplemented where possible by field investigation. Within the limitations of this approach, an attempt has also been made to evaluate the geomorphological process active under tropical conditions.

There are many questions left unanswered and many problems, particularly in the fields of slope analysis, soil development, and weathering processes, which must await further study. However, this technique has proven extremely valuable in delineating the basic landforms, stages of development, erosional and depositional levels, structural control, tectonic history, and physical evolution of Ceylon's terrain.

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CHAPTER I

GEOLOGY

Introduction

The geology of Ceylon, as it applies to this study, is basic in concept. The most important factors being the resistance of the rocks to weathering and erosion, and the tectonic activity, both local and regional, to which they have been subjected. These are the factors which, under the tropical conditions obtaining, control to a large extent the development of the various landforms characteristic of the area.

In general, the views outlined are those at present accepted by the geologists working in the area. No radically new ideas with respect to rock type, lithologies, or stratigraphic sequences are presented. Much of the tectonic history however has been deduced from photogeomorphologic evidence and may not agree entirely with presently held views.

History of investigation

In the period from 1801 to 1903, numerous papers and articles were published in as many journals, dealing principally with the minerals of Ceylon and the natural phenomena such as hot springs and

animal-shaped rocks. Titles such as "On the Graphite or Black Lead of Ceylon", (Jameson, R. 1832); "On Ceylonite Found near Trincomalee", (Henderson, Lieut. 1848); "On Geikielite, a New Mineral from Ceylon", (Dick, A. 1892); "Sur les Sources Chaude de Ceylon", (Davy, John 1823); "Durchsichtiger Blauer Spinell von Ceylon", (Bauer, Max. 1895); "Examen d'une Meteorite Tombu dans l'Isle de Ceylon le 13 Avril, 1795", (Meunier, S. E. 1901); "The Animal-Shaped Rocks of Kurunegala", (Modder, F. H. 1890); and "Gold, Gems, and Pearls in Ceylon", (Ferguson, A. M. 1888); are typical.

From 1903 to 1908 a more systematic study of the geology of Ceylon was initiated by the newly formed Department of Mineralogy, first under Dr. A. K. Coomaraswamy, and later under Mr. James Parsons and Mr. J. A. Daniel. The early administrative reports recount the difficulties encountered on traverses across and around the island during which the local geology was studied, samples were taken, and areas for future examination were noted. Many mineral specimens and specific geological features were described but no regional mapping was attempted.

During the period 1914 to 1916, Mr. E. J. Wayland held the post of Assistant Mineral Surveyor and produced his classic papers on the sedimentary Jurassic and Miocene deposits of the Tabbowa, Jaffna, and Minihagalkanda areas. In addition, he discussed at some length

the unconsolidated or semi-consolidated Pleistocene deposits, labelling them Pleistocene gravels or Plateau Deposits.

Professor F. D. Adams, of McGill University, examined the rocks of Ceylon during three brief visits in 1924, 1925, and 1927. His monograph, "The Geology of Ceylon", published in the Canadian Journal of Research 1929, was the first complete description of the island's geology and included its first geological map. It is a remarkably comprehensive study considering the time involved and the conditions under which he worked.

Professor Adams in this study discussed the basic synclinal structure of the island, the similarity of the rocks to the Grenville Series of the Canadian Shield, the presence of Charnockites, the presence of Jurassic and Miocene sedimentary rocks, and three plains of denudation which he believed to be incised into the rocky framework of the island at 100 feet above sea level, 1,600 feet above sea level, and 6,000 feet above sea level respectively. In addition, he has provided an excellent resume of geological work carried out prior to his visits.

From 1922 to 1934, the position of Government Mineralogist was held by Mr. J. S. Coates. His "Geology of Ceylon" was published in the Ceylon Journal of Science 1935. This was the second major work of a regional nature dealing with the geology and mineral deposits

of Ceylon.

No geological investigation was carried out from the time of Coates' retirement in 1934 until the appointment of Mr. D. N. Wadia as Government Mineralogist in 1938. From that time onward however, systematic geological mapping has been carried out as and when possible, considering the small staff, the disturbances of World War II, and the extensive administrative duties involved in the organization of a new department.

In 1945 Mr. L. J. D. Fernando succeeded Mr. Wadia as Government Mineralogist and has remained in that position to date. In 1948 Mr. Fernando delivered a lecture to the Imperial Institute, London, England, which was published in their Bulletin entitled, "The Geology and Mineral Deposits of Ceylon". This bulletin is the latest general discussion of the geology of Ceylon to be published.

The administration reports have presented the results of more detailed investigations carried out by members of the Department of Mineralogy since the advent of Mr. Fernando.

Subsequent to the initiation of the Canadian Colombo Plan aerial survey of Ceylon in 1955, several papers dealing with the geology and structure of the island have been published in The Ceylon Geographer. Reference to these papers will be made where applicable.

General geology

The island of Ceylon is composed almost entirely of crystalline rocks of Precambrian age. They have apparently resulted from various degrees of metamorphism, granitization, and intense deformation of ancient sedimentary and/or igneous rocks with occasional intrusions of granitic magma. With the exception of the granitic types, they consist of well foliated, banded, and much contorted crystalline rocks of varying composition. Within this association are crystalline limestones, quartzites, Charnockites, Khondalites, quartzo-feldspathic, granulitic rocks, and various biotite, biotite-hornblende, and complex gneisses.

In the north and northwest, the Precambrian basement is overlain by small patches of Jurassic sediments, the Tabbowa-Andigama beds, and more extensively by the Jaffna limestones of Miocene age.

On the southeast coast at Minihagalkanda, a small area of Miocene rock indicates the presence of a more extensive sedimentary cover at one time.

The unconsolidated deposits, which in many places overlie, or are derived from, the bedrock described above, consist primarily of the so-called Pleistocene gravels or Plateau Deposits, recent alluvium and colluvium, aeolian deposits, marine deposits, and residual deposits.

The geologic succession at present in use but under revision is shown in TABLE I.

Precambrian

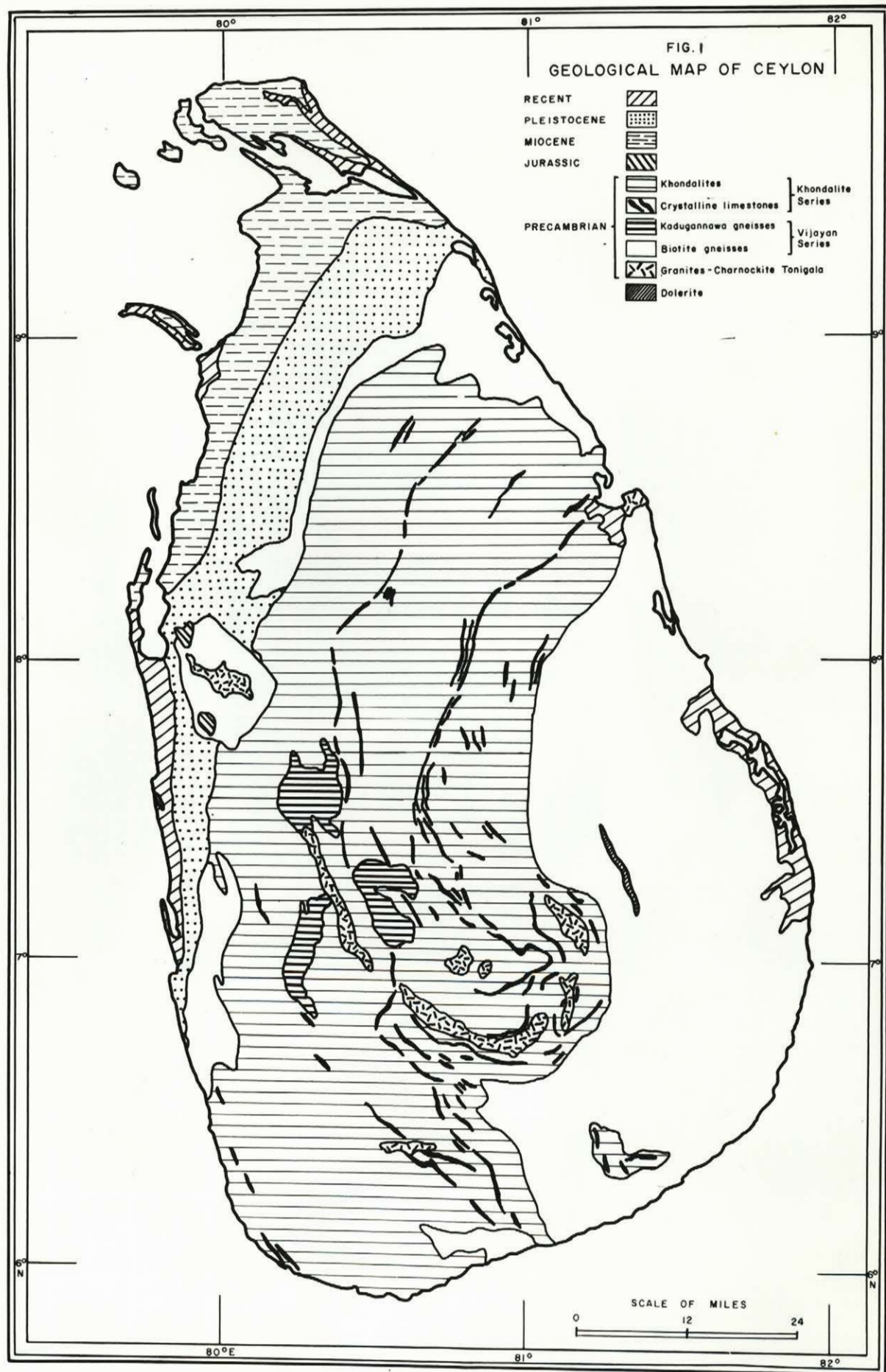
With the exception of deposits of Jurassic and Miocene age in the Tabbowa-Andigama, Puttalam-Jaffna, and Minihagalkanda areas, the entire island of Ceylon, as far as is known at present, is composed of crystalline rocks of Precambrian age. The latest published map showing their distribution accompanies L. J. D. Fernando's "Geology and Mineral Resources of Ceylon" (1948), (Fig. 1). Recent work by members of the Department of Mineralogy under Mr. Fernando has been aided by the use of aerial photographs (Vitanage, 1957-58). This work has modified, and will modify further, the boundaries shown.

Biotite Gneiss

By far the most extensive general rock types in Ceylon are biotite gneiss and modifications of biotite gneiss. This category includes a complex group of ortho-gneisses, para-gneisses, migmatites, and granitic gneisses, variously termed the "Bintenne Gneiss", "Wanni Gneiss", and "Kadugannawa Gneiss", by Coates (1935); the "Vijaya Gneiss", or "Fundamental Gneiss" by Wadia (1941, 1943); and the "Vijaya Series" by Fernando (1948).

TABLE I
TABLE OF FORMATIONS

ERA	PERIOD OR SYSTEM	REPRESENTATIVE DEPOSITS IN CEYLON
Cenozoic	Recent	Residual soils, alluvium, sand, coastal sandstone, and coral.
	Pleistocene	Gravels, "Plateau Deposits".
	Miocene	Jaffna limestone and Minihagalkanda beds.
Mesozoic	Jurassic	Sandstones, grits, and shales of the Tabbowa-Andigama Series.
Precambrian		Khondalite Series - Para-gneisses, para-schists, quartzites, quartz-schists, granulites, leptynites, calc-gneisses, calc-granulites, crystalline limestones, and dolomites with intrusive granites. Vijayan Series - Ortho- and para-gneisses and schists, with intrusive granites.



The area south, southeast, and east of the central hill country is composed predominantly of a well-foliated, much-contorted, black and white, biotite-hornblende gneiss (Fig. 2). The dark bands are generally composed of biotite alone or biotite and hornblende with minor amounts of quartz and feldspar. The light bands are mainly composed of quartz and feldspar.

In places, these gneisses are cut by coarsely-crystalline pegmatites or have been modified by granitizing solutions. This latter process may have been active in the genesis of the well-jointed, resistant rocks which form most of the solitary hills or inselbergs rising above the general low level plain of the island (Oliver, R. L., 1958).

The biotite gneisses found in the Kalutara-Horana-Colombo area, to the west and southwest of the central hill country, consist of fine- to medium-grained, greyish, quartzose rocks with minor amounts of ilmenite and iron minerals.

In the northern portion of the island, between the central hills and the Miocene limestone, a pink-to-buff gneiss of varying texture is found. Granularity varies from fine to medium in the more well-banded types, to relatively coarse in the granitic types. Quartz and feldspar are the predominant minerals.

The Kadugannawa Gneisses form the Kadugannawa-Alagala range extending from near Dolosbage, northwards to Kurunegala and

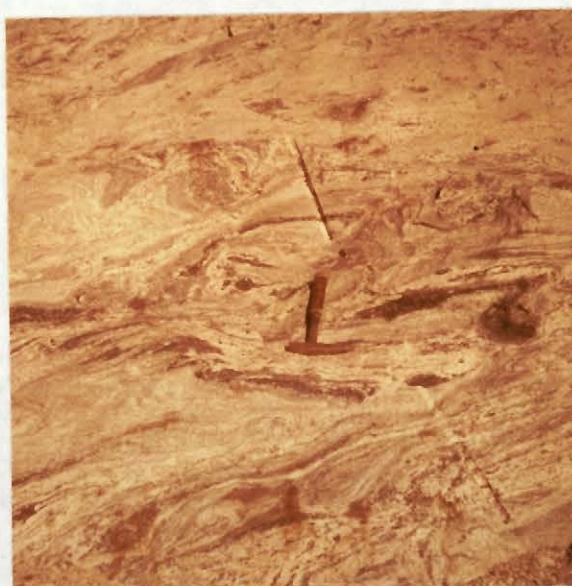


FIGURE 2

Biotite-hornblende Gneiss near Hambantota

beyond. They consist of hornblende-biotite gneisses with, in most cases, a high percentage of basic minerals.

Khondalite Series

The Khondalite group of rocks comprises an extensive series of well-bedded quartzites, quartzo-feldspathic rocks, granulites, calc-gneisses, crystalline limestones and dolomites, and sillimanite-garnet-graphite schists. The latter rock is the type Khondalite.

These rocks apparently overlie the Vijayan Series of biotite gneisses and are folded into a rough, synclinorial structure with its axial trend, depending on position, varying from almost east-west, through northwest-southeast, to north, and northeast-southwest. These beds extend from the southwest coast at Galle, through the Sabaragamuwa Hills and the Central Massif, to the northeast coast at Trincomalee.

Massive, well-jointed, coarse-grained quartzites form distinctive features throughout this area. In the northeast, steeply dipping quartzite beds form long, spectacular, hog-back ridges which dominate the topography (Fig. 3).

Numerous bands of crystalline limestone and/or dolomite of variable purity are commonly associated with the quartzites. It is largely the presence of these bands which make the Khondalite rocks appear so similar to the Grenville series of the Canadian Shield as

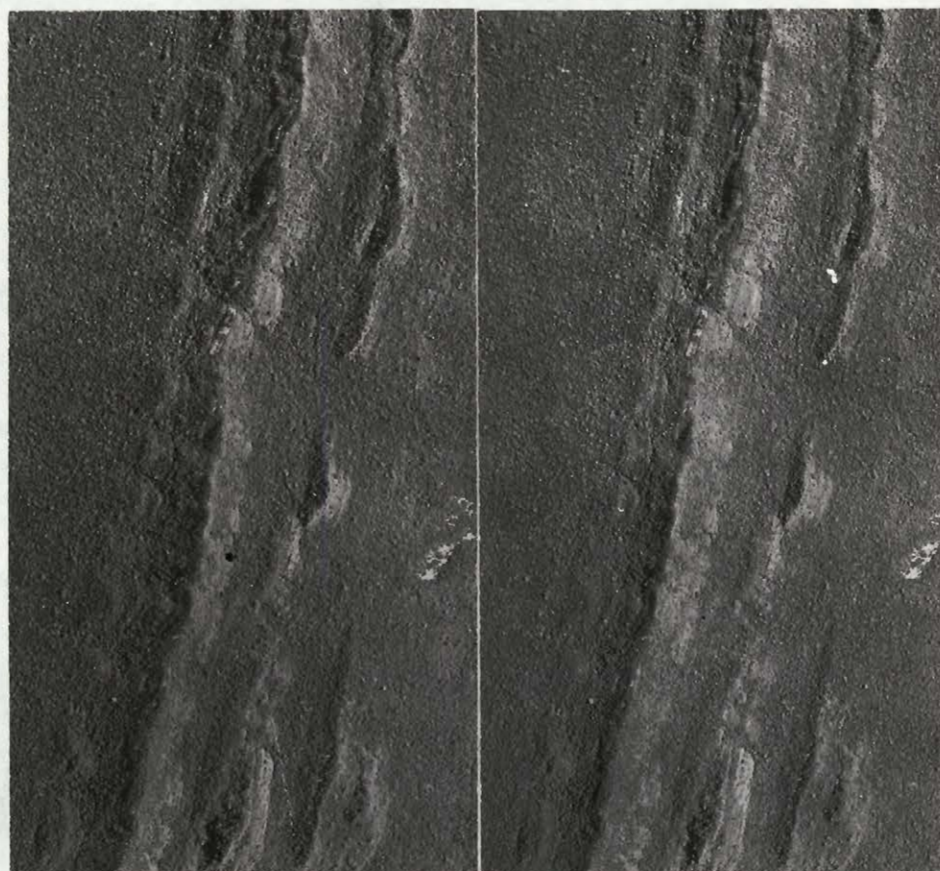


FIGURE 3

Sudakanda Ridge

Erzgebirge
PLOVER BRAND
25% COTTON FIBER
U.S.A.

reported by Adams (1929).

On the whole, the varied rocks of the Khondalite Series are thought to be the metamorphic equivalent of an extensive series of Precambrian sediments.

Charnockites

The Charnockites of Ceylon are granitic rocks characterized by the presence of hypersthene. They are generally equigranular, dark-coloured rocks with a varying proportion of hornblende, pyroxene, biotite, and garnet, on the basic side, and quartz, and plagioclase, on the acidic side. The relationship of the Charnockites to the other rocks of the Khondalite and Vijayan Series has not as yet been satisfactorily determined.

Granites

In addition to the Charnockites, two other granites have been described by Fernando (1948); the Tonigala granite, named from the village of Tonigala a few miles southeast of Puttalam; and the zircon-bearing granite of the "Balangoda Group" of Coomaraswamy (1904), from the type locality near Balangoda on the Ratnapura-Haputale road.

The Tonigala granite is rich in pink feldspar, which gives it a reddish or pinkish tone. It is widely distributed over the northern and

eastern parts of the island. It is intrusive into the Charnockites and gneisses and is therefore younger than either.

The zircon-rich granites and pegmatites of the "Balangoda Group" are found in several areas outside the Balangoda district, but are essentially of local distribution.

Basic dykes

In the eastern and southern parts of the island, basic dykes, intrusive into the biotite gneisses and metamorphosed sediments of the Khondalite Series, have been described by Parsons (Admin. 1907), Adams (1929), and Fernando (1948). The best known of these is an equigranular, dolerite dyke crossing the road just north of the rest house at Kallodai. The trend of this dyke is northwest-southeast and its length is almost forty miles.

Mesozoic

The only rocks in Ceylon belonging to the Mesozoic are of Jurassic age.

Jurassic

Only two deposits of Jurassic rocks are known and these are located north and west of Tabbowa tank, crossing the Puttalam -

Anuradhapura road between seven and one half and nine miles northeast of Puttalam; and at Andigama, about twenty-five miles to the south.

The Tabbowa Series, as it is known, consists, in descending order, of massive grits and sandstones interbedded with bands of clay containing numerous plant impressions and spores, shaly beds with occasional beds of nodular limestone, and argillaceous sandstones and grits. Wayland (1925) described them as containing coarse, angular quartz grains, abundant feldspar, and some mica; natural constituents of sediments formed from the igneous and metamorphic rocks of the island.

This series of apparently non-marine sediments, has been deposited on, and faulted into, the decomposed basement gneisses and granites of Precambrian age. Investigation of the plant remains and spores of the clay beds has established the age of these rocks as almost certainly Jurassic and probably Lower Oolite or Upper Liassic. According to Wadia (1941), they may belong to the southern extension of the Madras Group of Upper Gondwanas of India. This subject is treated at some length by King (1962) in his recent publication.

Cenozoic

In Ceylon the Cenozoic is represented by rocks of Miocene age and by unconsolidated Pleistocene and recent deposits.

Miocene

The Miocene limestones of northern Ceylon; the Jaffna Series, and the areno-argillaceous beds of the Minihagalkanda area, have been studied and described by Wayland (1923), Adams (1929), Fernando (1948), and others, but little has been done of recent date.

The Jaffna series extends from near Puttalam on the west coast, as a band widening toward the north to cover the Jaffna Peninsula. The southern limits of the limestone may be indicated by outcrops of Pre-cambrian rock which are visible; at Madhu Road Station on the Mannar railway line; north of Mankulam on the Jaffna road; and between Mankulam and Mullaittivu.

In general, the Jaffna Series consists of hard, compact, buff- to greyish-coloured, fossiliferous limestone containing chert nodules, overlain, probably unconformably, by a series of areno-argillaceous beds. In the Kudremalai area these latter beds are capped by a resistant, red sandstone.

The Minihagalkanda beds are located about forty miles east of Hambantota, and about five miles east of the mouth of the Yala River, on the south coast of Ceylon. They consist of fragmentary areno-argillaceous rocks and interbedded limestones, unconformably overlying Precambrian basement.

A. M. Davies (1923) has dated fossils from the Minihagalkanda beds as Middle Miocene, and those from the Puttalam-Jaffna limestone as Upper Miocene in age. Wadia (op. cit.) states that the Jaffna limestone appears to be similar in age to the Quilon and Workalli beds of the Quilon (southwest) coast of Travancore and Cochin in India, that is, Middle Miocene.

Pleistocene

The Pleistocene is represented in Ceylon by the Plateau Deposits of E. J. Wayland (1923). These deposits consist of well-rounded to subangular, quartz-pebble gravel mixed with red earth and sand. The gravel beds vary in depth and may in places be over 100 feet thick. Their present distribution varies from the hilltop beds north and east of Colombo, to broad areas of indefinite thickness north of Chilaw (Fernando, 1948). Wayland (op. cit.) believed that when first deposited, the gravel covered a much greater area, but was subsequently eroded and reduced to its present status. The apparent source of these deposits is the Central Massif.

A feature of the Plateau Deposits is the presence of numerous ferruginous concretions, which are here considered to be fragments of the mid-Tertiary laterites described by Vermaat and Bentley (1955).

Recent

Colluvial deposits

Colluvial deposits, resulting from soil or rock movement of one form or another, are common in Ceylon. They vary in size from small slump deposits, to very large rockfalls and earthslides. They are discussed at greater length in subsequent chapters.

Alluvial deposits

Alluvial deposits are common throughout Ceylon. They consist of gravel, sand, silt, and clay brought down from the highland by the numerous streams and rivers of the island. Occasionally, large boulders and rocks of considerable size are transported by the streams in flood, but in general, this material is confined to the actively eroding upper reaches of these streams. (Bakker, 1957). When the streams reach the lowland plain, or some intermediate plain of local base level, the change in gradient causes deposition of the finer material. Filled valleys are often indicative of this sequence. A similar, but more striking feature, is the alluvial cone or fan.

Many of the valleys in Ceylon have flat, alluvium-mantled floors, alluvial terraces, and alluvial fans. Drilling, especially in the gem district of Ratnapura, has indicated depths of alluvium in excess of 100

feet. These depths have been obtained in valleys whose surface elevation is less than 100 feet above sea level and therefore indicate that the bottom of the bedrock channel is at present below sea level.

The alluvial terraces are generally remnants of earlier valley-bottom alluvium, dissected as a result of a local change in base level. They are rarely of use in regional correlation problems.

The alluvial fans have formed where mountain streams with steep gradients reach a terrace, a plain controlled by local base level, or an old erosion surface; in short, any surface where the gradient is lowered abruptly. Most of the fans in Ceylon have been deeply dissected by the present streams, indicating a possible decrease in their load resulting from decreased erosion upstream, or an increase in their flow. Either conditions would increase the erosive power and so foster down-cutting in the existing alluvium.

Marine deposits

Marine deposits in Ceylon include coral reefs, recent sandstone, and beach sands.

The coral reefs are found along the south, southwest, and west coast but are of little importance, except insofar as they act as protective barriers to wave action.

The sandstone, which in places is exposed at low water at the

base of the present beach slope, is composed of grains of quartz sand, ilmenite, garnet, magnetite, and fragments of shells, held together by a calcareous cement. The Pamunagam "reef", which fringes the shore from the mouth of the Kelani River to the headland off Negombo, and runs out to sea for a short distance beyond it (Fig. 4), is composed of this type of rock.

According to Branner (1905), the water of nearby lagoons, charged with organic acids, has percolated through the original sand and has dissolved shell fragments present in it. Subsequently, deposition of this calcium has cemented the sand grains and remaining shell fragments to form the sandstones.

Russell (1959) has described similar cemented beach deposits or beach rock in the Caribbean area but has not determined the exact mode of origin. His deposits however, apparently are not usually associated with lagoonal conditions inland, but rather with the existing fresh water table and the level of the sea at the time of formation.

Retrogression of the shoreline is indicated where these sandstones are exposed on the present beach. Where they are visible half a mile or more inland, as at Kalmunai and Mullaittivu, they indicate prograding conditions.

Beach sands occur around the entire coast of Ceylon, with the possible exception of the rocky headlands where wave action is attacking the bedrock directly.



FIGURE 4

Rock-cored Spit at Negombo,
Mannar Coastal Plain

Aeolian deposits

The major wind blown deposits in Ceylon are sand dunes. The most extensive dunes have been formed along the northwest coast, the northeast coast, and the southeast coast. These deposits commonly consist of transverse dunes, although longitudinal and modified longitudinal dunes may be present, depending on the direction of the prevailing wind with respect to the coast. In general, they are more or less well stabilized by the growth of scrub vegetation. The sources of sand for these dunes are the adjoining beaches.

Residual deposits

Residual deposits result from the weathering of the rock in situ and their development is dependent on the presence of suitable climatic and topographic conditions, and the absence of significant erosion. Where these favourable factors are combined with a rock which is easily weathered, deep residual deposits are formed. If the rock is resistant, or some of the critical factors are lacking, residual deposits may be thin or non-existent.

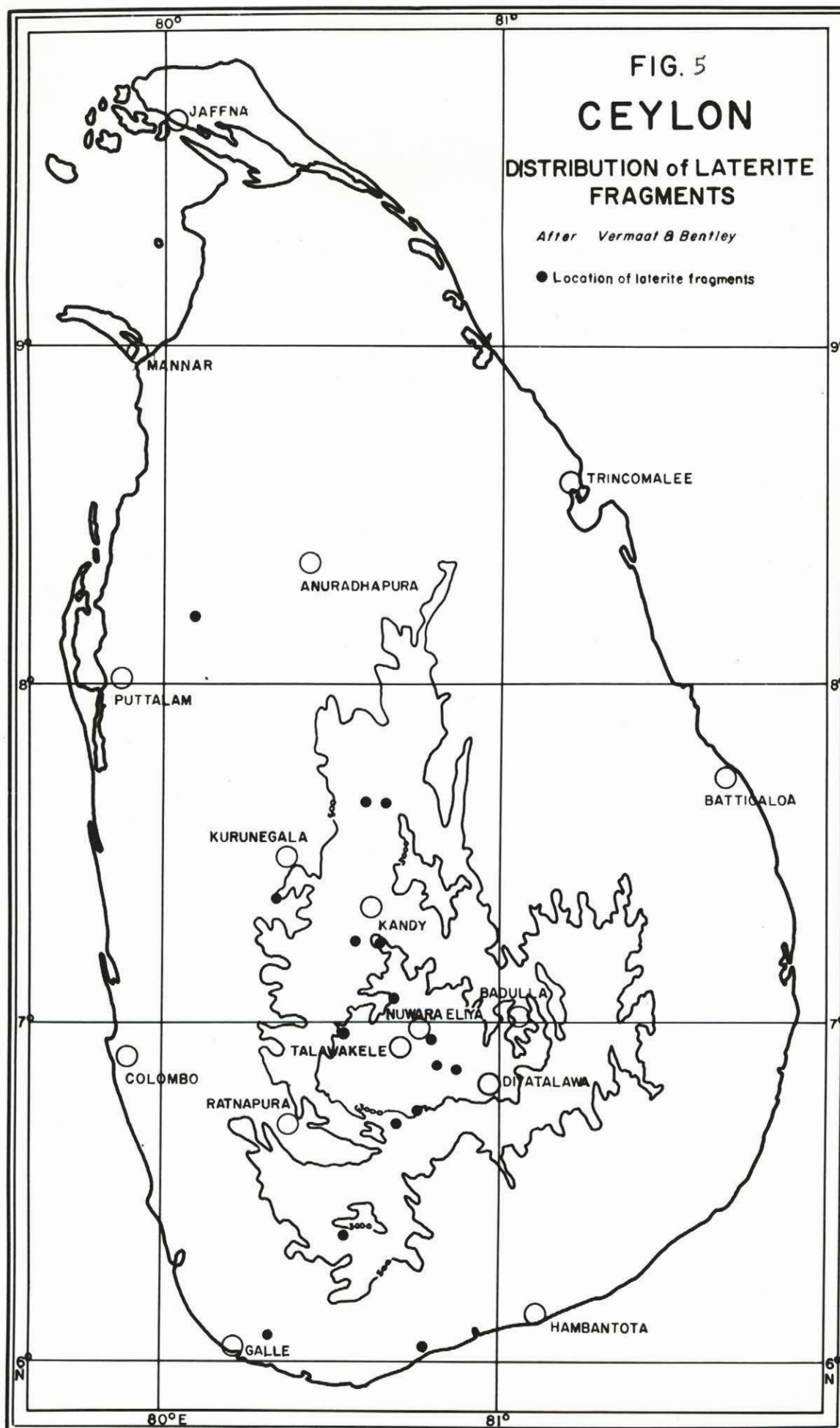
Residual deposits are characterized by many features but the most diagnostic is the extension of well-marked structure, usually bedding with light and dark beds, from the unweathered bedrock into the soil above. This feature may also be demonstrated by the extension of

structure from large residual boulders into the surrounding soil matrix. In many road cuts in Ceylon, the pattern of fractured bedrock continues unchanged, except for the weathering, into the soils above. Examples are also known where the structure, passing from the rock to the soil, has been displaced by the very slow movement of the overlying material down the slope.

In Ceylon, laterite, or "Kabouk" as it is known locally, consists of a highly-ferruginous, usually-vesicular, red-, brown-, and yellow-mottled, clay soil. Laterite of this specific nature is at present found in the southwest lowlands only, although lateritic soils are common elsewhere in the island (Joachim, 1935, 1954). When laterite is exposed to air, it dries to a hard, brick-like mass. Dried laterite, or "Panugal", fragments have been found at various points throughout the highlands of Ceylon (Vermaat and Bentley, 1955), as shown on the sketch map (Fig. 5). The significance of the distribution of these fragments will be discussed in a subsequent chapter.

Structure

The structure of Ceylon is extremely complex and is only in the initial stage of being worked out (Oliver, 1957). The major features have been emphasized by differential weathering and erosion, and are well shown by the aerial photographs and mosaics. These features,



plus the studies to date, indicate that the island consists of a major synclinorium. The axis of this synclinorium strikes northwest in the south-central part, and north to northeast in the central and northern parts. It plunges gently to the north and northeast beneath the Miocene beds.

The core of the synclinorium consists, for the most part, of metamorphosed sediments of the Khondalite group. These rocks include quartzites, crystalline limestones, granulites, and type Khondalites. The quartzites are the ridge formers and the limestones, granulites, and type Khondalites, are the valley formers. The Charnockites and similar granitic rocks are also mountain, highland, and ridge formers. The outer limbs of the synclinorium are composed of the various gneissic types, as well as Charnockites, quartzites, and other granitic rocks.

An extensive pattern of faults, joints, and fractures, cuts these rocks, both in the central hill mass and in the plains. In combination with the differential-weathering characteristics of the rocks themselves, these fractures have formed the loci of weathering and erosion processes. The resulting landscape, as shown particularly well on the aerial photographs and mosaics, delineates the basic structure of the island clearly (Fig. 6 and Fig. 7).

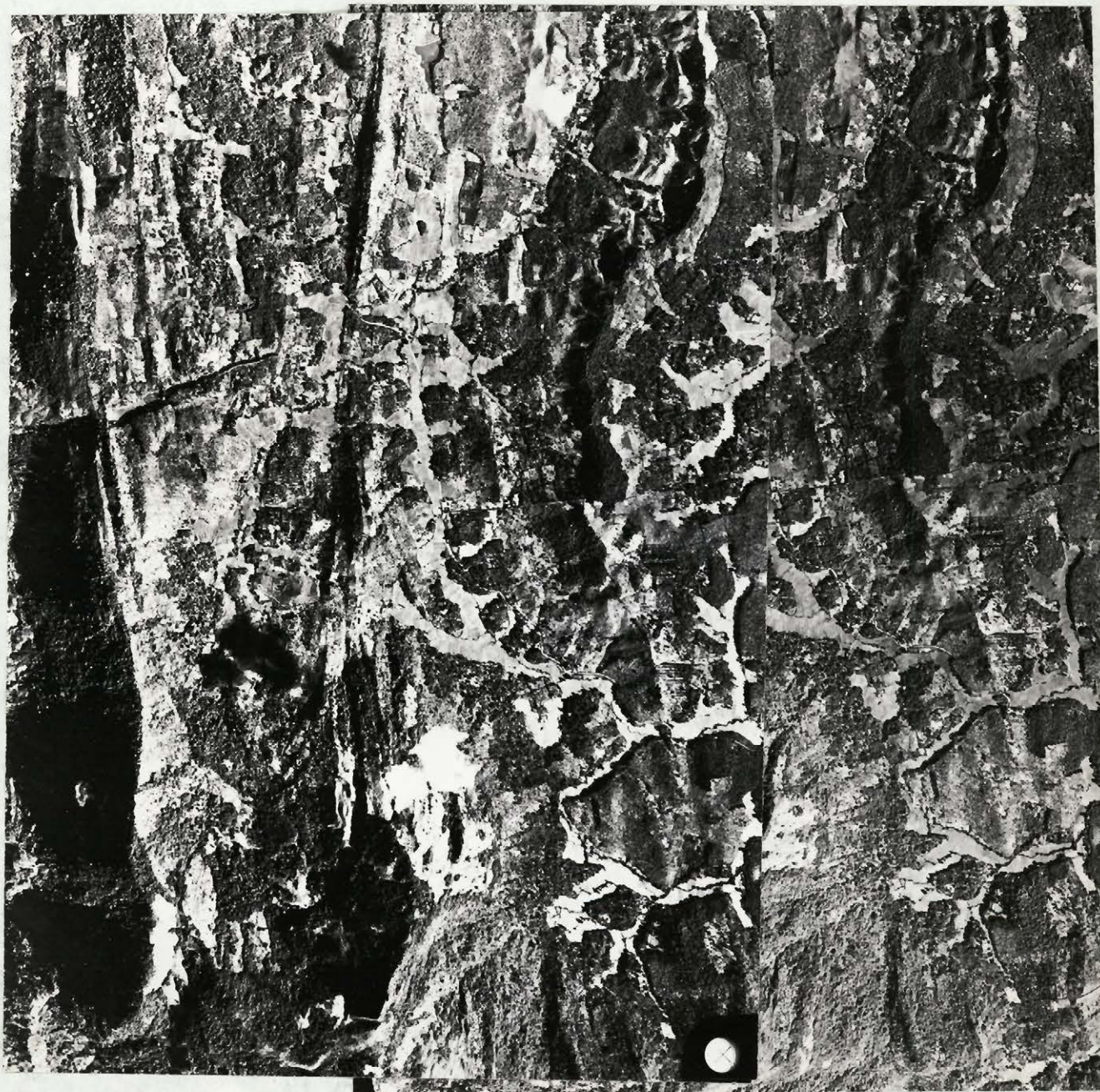


FIGURE 6

Structure of Bedrock Outlined by Weathering and Differential Erosion



FIGURE 7

Drainage Controlled by Bedrock Structure

Tectonics

Several authors have indicated that Ceylon is geologically part of India. In fact, both Charnockite and Khondalite rocks have their type localities in Peninsular India. However, present knowledge of Indian tectonic history does not agree entirely with that of the island of Ceylon. Wadia (1953) describes Peninsular India as having been a stable land mass or shield since Precambrian time, and the lack of deposits of Palaeozoic sediments would seem to substantiate this theory. In addition, he is also in favour of a major fault origin for the central mountains of Ceylon (Wadia, 1945). The fact that no Palaeozoic sediments are known on the island may indicate that until post-Palaeozoic time, Ceylon was part of the stable shield of southern India, and was subsequently subjected to the tectonic activity postulated. Examination of aerial photographs and mosaics has indicated the presence of a large number of major, as well as innumerable minor, fault traces throughout the island. In the Central Massif, many of these well marked fault traces, bound angular, mountain-forming, blocks. Although little detailed field work has been done in these areas, it is considered here that these are true fault-block mountains, the proof lying in the geomorphological criteria rather than in specific geologic data.

Based on photo-interpretive studies, a sequence of tectonic events has been evolved which incorporates the basic factors determined

to date. This sequence of events is intimately associated with the geomorphologic history of the island and will be discussed in Chapter V. It should be sufficient to say here that the land mass of Ceylon, as a whole, has apparently never been beneath a sea, for any significant period, since Precambrian time. However, local downwarping and upwarping of the island's coastal plain has resulted in the deposition of Jurassic and Miocene sediments, and their elevation and erosion. In addition, major block faulting or wrench faulting has, in part, resulted in the elevation and/or relative displacement of the Central Highlands, Sabaragamuwa Hills and Knuckles Massif.

CHAPTER II

CLIMATE AND VEGETATION

Introduction

It is intended that the following brief review of the climate and vegetation of Ceylon should provide sufficient data for the subsequent evaluation of the influence of these factors on the geomorphologic processes active in this area.

Climate

General

The island of Ceylon lies just off the southern tip of India between 6 degrees and 10 degrees north latitude (Fig. 8) , and is therefore within the much discussed Monsoon system (Fig. 9). This regime is characterized by a strong, heavily moisture laden wind from the southwest, the southwest monsoon, and a not so strong, not so heavily moisture laden wind from the northeast, the northeast monsoon. The southwest monsoon usually begins in late May and ends in early September; the northeast monsoon begins in late November and ends in early March. These winds, when established, are sufficiently strong and persistent to smother the calm convectional thunderstorm system in effect during the two inter-monsoon periods.

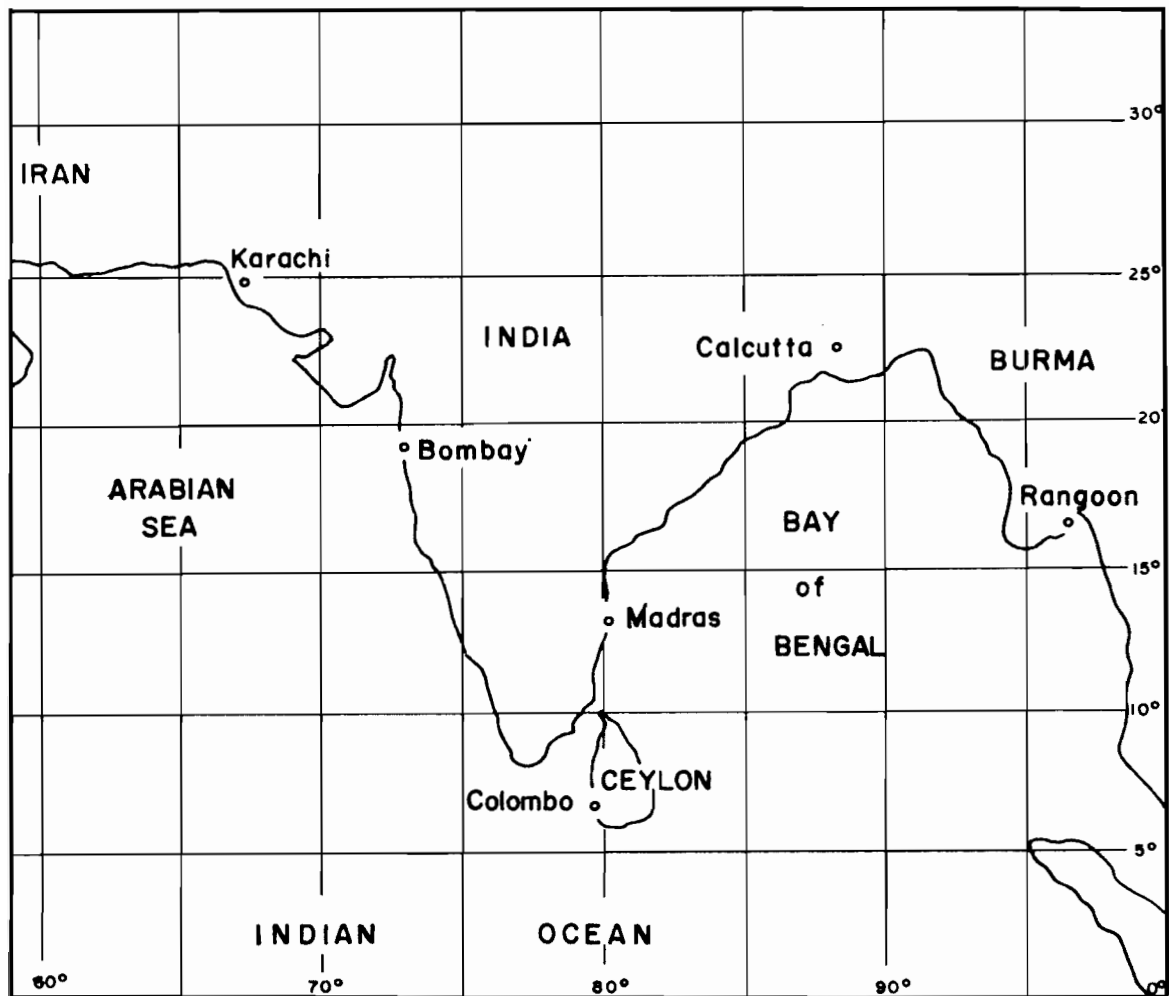


FIGURE 8

Location Sketch Map of Ceylon

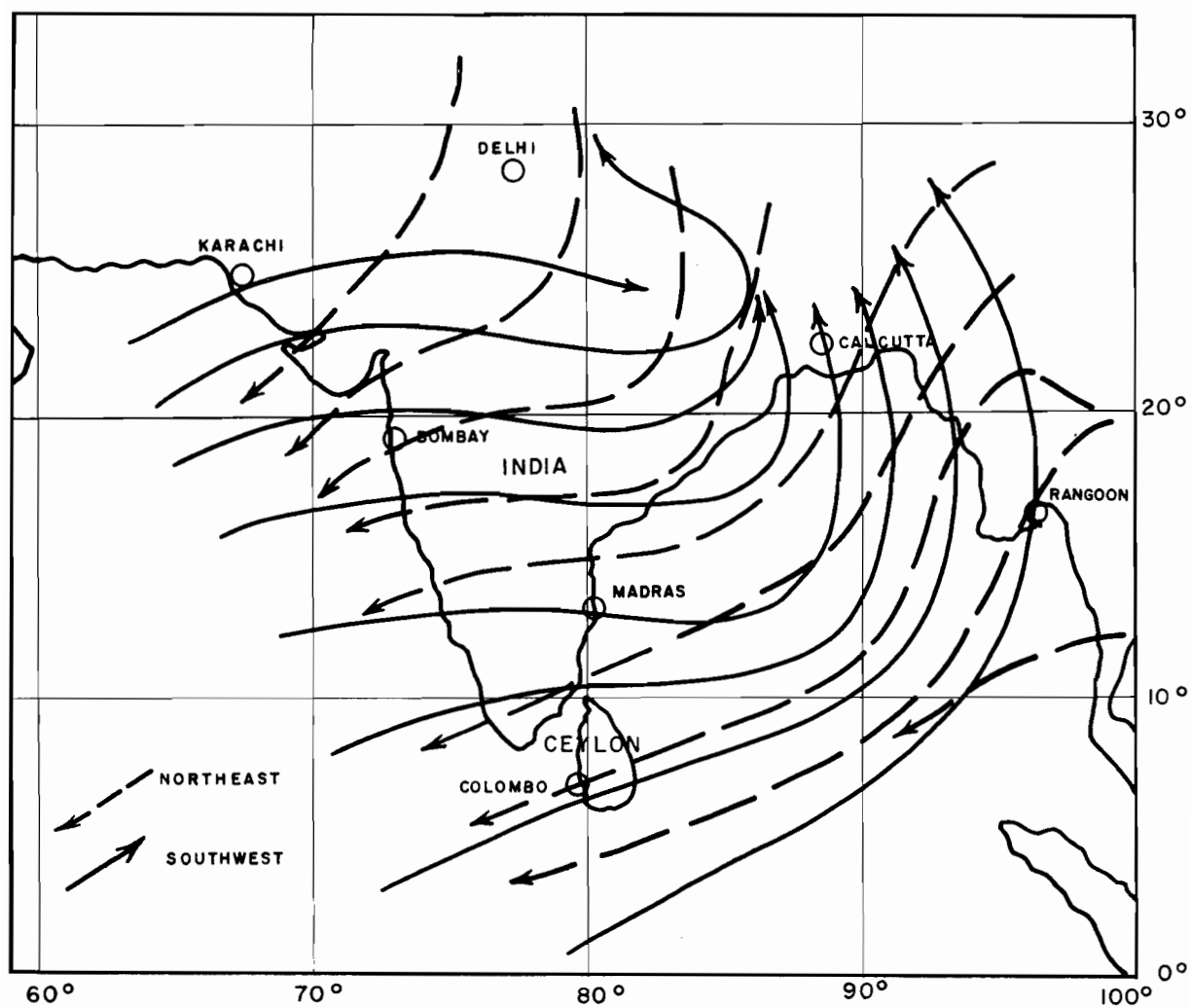


FIGURE 9

Monsoon Circulation Over Ceylon

In addition to the four "seasons" noted above, Ceylon is influenced by tropical cyclones originating in the Bay of Bengal. These disturbances, which are most common from October to December, are not always strong and often only affect the northeast coastal zone of the island. However, when they do develop, they bring very intense rain and sometimes high winds to this area. This supplementary rainfall explains the difference in precipitation distribution shown in Figures 12 and 13.

Temperature

Because of its geographical location, Ceylon is subject to very small seasonal variations of temperature (Table II). Thermometers at the meteorological stations in Ceylon, are exposed in large sized Stevenson Screens. Temperatures (recorded in degrees Fahrenheit), and averages, are taken entirely from screen readings. The average monthly mean temperatures range from 77.7 degrees Fahrenheit to 81.1 degrees Fahrenheit for the southwestern, southern, and southeastern coastal plains; from 76.6 degrees Fahrenheit to 87.4 degrees Fahrenheit for the northwestern, northern, and northeastern coastal plains; and from 50.0 degrees Fahrenheit to 77.4 degrees Fahrenheit for the central highland zone. Apparently the proximity of the ocean with its moderating affect, and the frequency of cloudiness during the time of

TABLE II
SEASONAL VARIATIONS OF TEMPERATURE
(Average Monthly Mean Temperatures)

Station	Period (yrs)	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Anuradhapura	27	76.3	78.3	81.5	83.0	83.6	83.2	83.3	83.5	83.4	81.2	78.6	76.7	81.2
Badulla	29	70.0	71.1	73.4	75.2	76.0	75.4	75.3	75.3	75.0	74.2	72.4	70.6	73.7
Batticaloa	28	77.6	78.3	80.3	82.3	84.1	85.0	84.4	83.5	83.0	81.2	79.2	77.8	81.4
Colombo	28	79.1	79.6	81.0	81.8	82.3	81.4	80.8	81.0	81.0	79.9	79.3	78.9	80.5
Diyatalawa	29	64.7	65.9	67.9	69.2	70.4	70.4	70.2	69.8	69.4	68.4	67.1	65.4	68.2
Galle	27	78.4	79.5	80.7	81.4	81.6	80.4	79.7	79.7	79.9	79.3	78.9	78.5	79.8
Hambantota	27	78.8	79.5	80.6	81.9	82.2	81.6	81.8	81.6	81.4	80.8	79.7	78.8	80.7
Jaffna	29	77.6	79.1	82.3	84.9	84.9	83.8	82.3	82.7	82.8	81.9	79.5	77.8	81.7
Kandy	28	73.6	74.9	77.5	78.9	78.3	76.4	75.5	76.0	74.9	76.7	75.2	73.9	76.0
Kurunegala	27	78.2	79.8	82.3	82.8	82.7	81.1	80.8	80.9	81.0	80.2	79.4	78.2	80.6
Mannar	31	78.8	80.0	82.4	84.2	85.2	84.4	83.3	83.1	83.3	82.1	80.2	78.9	82.2
Nuwara Eliya	27	57.4	57.5	58.7	60.6	61.9	60.7	60.1	60.3	60.1	59.9	59.5	58.4	59.7
Puttalam	29	77.8	79.3	81.4	83.1	83.7	82.8	82.2	82.3	82.4	81.0	79.4	78.0	81.1
Ratnapura	28	80.2	81.5	82.3	82.5	82.0	80.8	80.5	80.5	80.4	80.0	79.6	79.8	80.5
Trincomalee	28	80.1	79.2	81.1	83.4	85.5	85.7	85.5	84.7	84.6	81.8	79.2	78.0	82.2

greatest insolation in the afternoon, assist in preventing any drastic diurnal, monthly, or seasonal variations in temperature. The average monthly means of daily temperature range are given in Table III.

The affect of relief on temperature is well marked throughout the island (Fig. 10); 300 feet of rise being generally considered equivalent to a 1 degree decrease in temperature.

Precipitation

Ceylon is subject to the tropical convection pattern of air circulation. During the periods when the monsoons are not over-riding this system, the heavily moisture laden air rises due to convection and/or orographic effects, resulting in heavy cloud formation and precipitation. This type of rainfall is heaviest along the margins of the central hill mass, and is accompanied by thunderstorms.

The distribution of rainfall during the southwest and northeast monsoons is illustrated by four maps (Fig. 11a, b, c, and d). Tropical cyclone activity in the Bay of Bengal during October and November usually adds to the rainfall, particularly in the eastern and northeastern parts of the island. As illustrated by Figure 12, the southwest monsoon strikes the coastal zone, the Sabaragamuwa Hills, and the central hill mass, and in rising, releases very heavy rainfall in these areas. In general this wind does not bring much rain to the eastern side of the

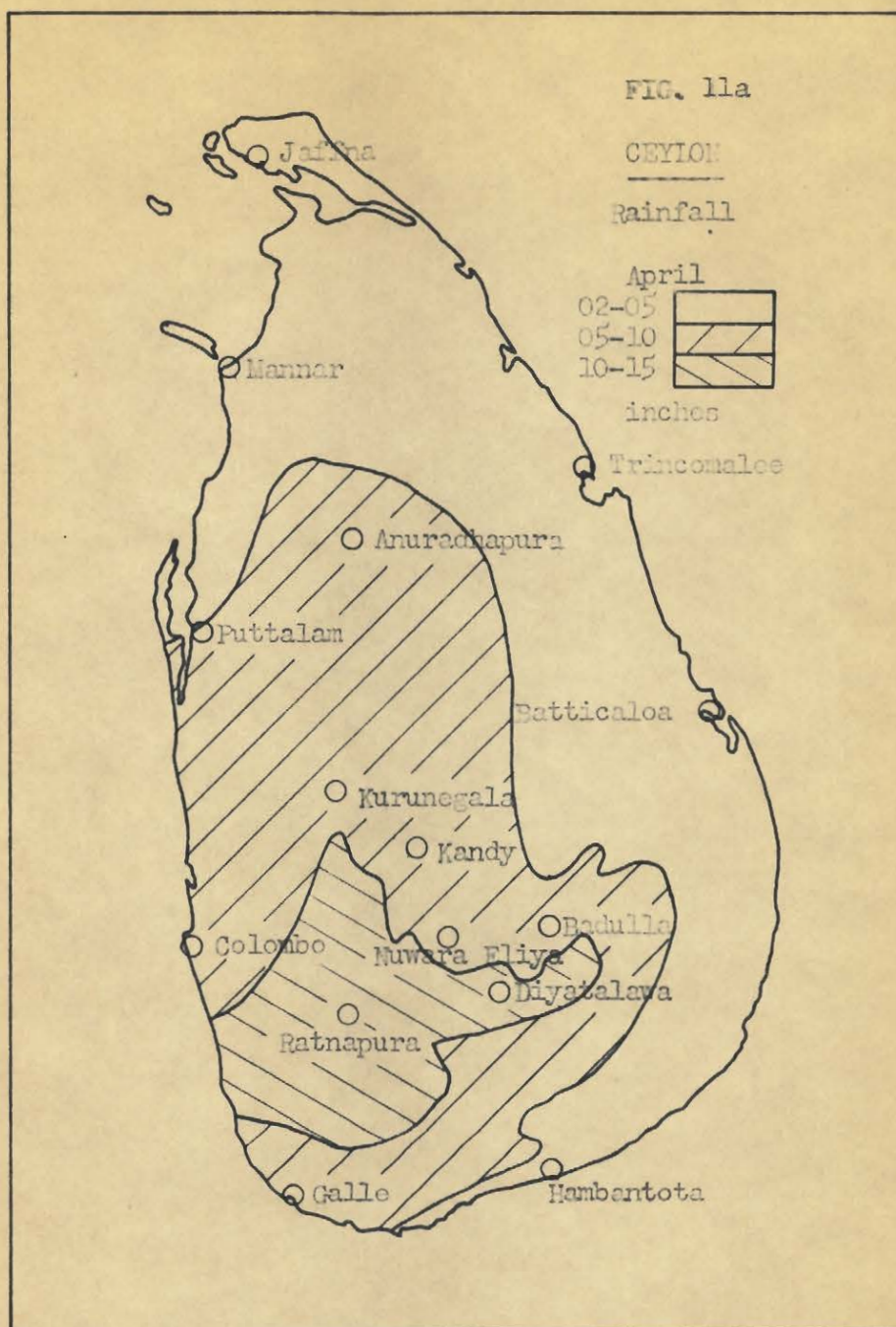
TABLE III
AVERAGE MONTHLY MEANS OF DAILY TEMPERATURE RANGE

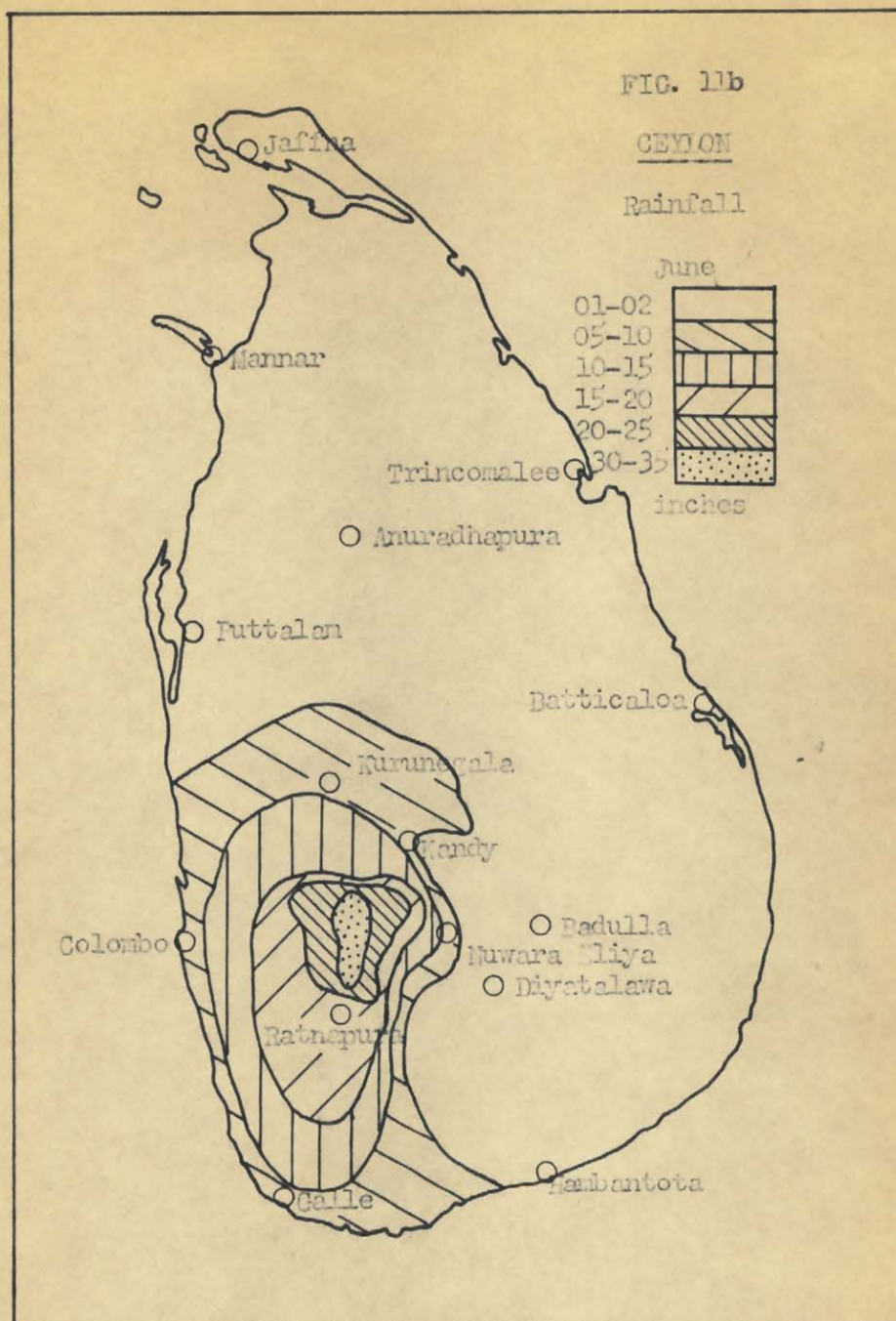
Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Anuradhapura	14.0	17.7	19.7	17.2	14.4	13.6	15.0	15.9	16.8	15.4	14.4	13.1	15.6
Badulla	12.4	15.8	18.1	17.9	19.1	20.0	21.9	21.9	21.3	17.3	13.9	12.1	19.3
Batticaloa	7.9	9.2	10.3	11.2	12.5	14.6	15.0	13.9	13.5	11.7	10.0	8.3	11.5
Colombo	14.6	15.0	13.9	12.0	9.4	8.1	7.8	7.9	8.9	10.1	11.9	13.2	11.1
Diyatalawa	14.0	18.0	19.3	17.3	16.7	14.4	12.4	16.2	16.9	15.8	20.7	13.5	16.0
Galle	10.8	11.5	11.3	9.3	6.9	6.4	6.0	6.0	6.1	7.5	9.4	10.3	8.5
Hambantota	12.2	12.9	12.6	11.4	9.2	9.6	10.9	10.8	10.5	10.9	11.4	11.6	10.8
Jaffna	10.8	13.3	12.8	9.4	9.4	5.8	6.3	6.8	6.9	8.1	9.3	9.4	9.0
Kandy	17.1	21.1	20.8	17.7	15.4	11.6	11.3	12.4	14.8	17.4	15.5	15.9	15.9
Kurunegalla	16.5	20.2	20.6	16.4	13.1	11.0	11.1	12.0	13.4	14.0	15.0	15.0	14.9
Mannar	9.1	12.3	13.9	12.3	8.7	7.6	8.3	8.7	8.9	9.6	8.9	7.9	9.7
Nuwara Eliya	20.4	24.2	24.4	21.2	17.1	9.9	10.4	11.7	13.7	15.4	16.7	18.7	17.0
Puttalam	15.5	17.9	17.0	12.4	9.5	7.2	7.8	8.7	9.2	10.7	12.5	13.5	11.8
Ratnapura	18.0	20.1	21.8	17.5	14.1	12.1	12.2	12.6	13.8	14.3	15.6	16.4	15.5
Trincomalee	5.2	6.7	8.9	11.6	13.4	13.2	13.8	14.8	15.0	12.4	8.8	6.2	10.8

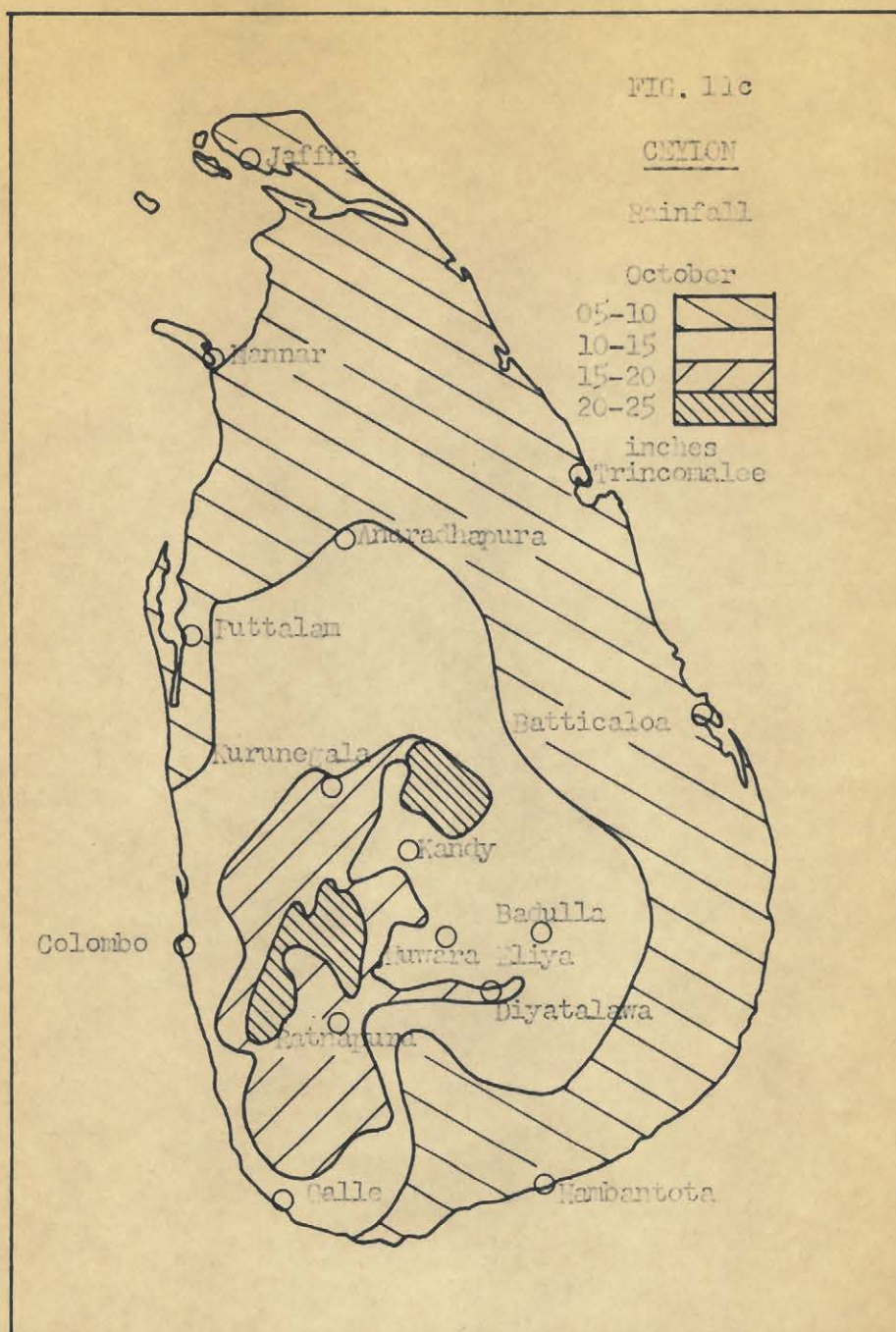
Station	Altitude in feet above sea level	Average Monthly Mean Temperature (1955)			
		January	April	July	October
Batticaloa	9	78.8	82.0	83.1	81.5
Trincomalee	11	79.0	83.5	85.2	83.6
Mannar	12	79.2	83.6	82.8	83.0
Jaffna	14	78.7	84.2	82.5	81.8
Colombo	24	79.0	81.0	80.2	80.0
Galle	41	78.7	81.0	79.4	79.7
Hambantota	61	78.5	81.1	80.8	81.7
Ratnapura	113	79.7	82.3	80.3	80.0
Anuradhapura	295	76.8	82.2	82.5	80.3
Kurunegala	381	77.6	82.1	80.7	79.8
Kandy	1,572	74.0	77.8	74.8	74.9
Badulla	2,197	70.6	75.0	74.8	74.3
Diyatalawa	4,093	65.2	69.4	69.4	69.1
Nuwara Eliya	6,170	58.9	60.2	60.0	61.0

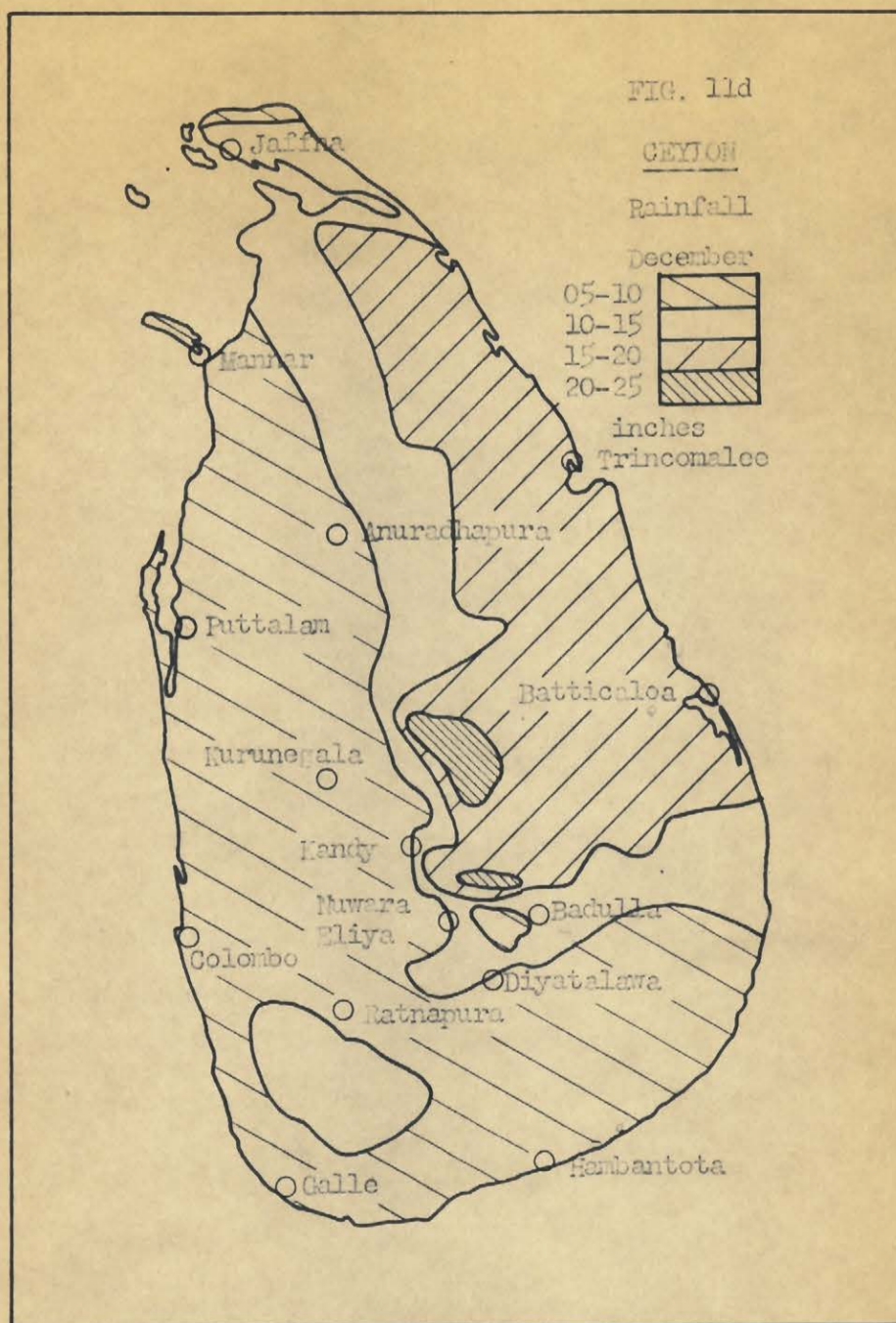
Figure 10

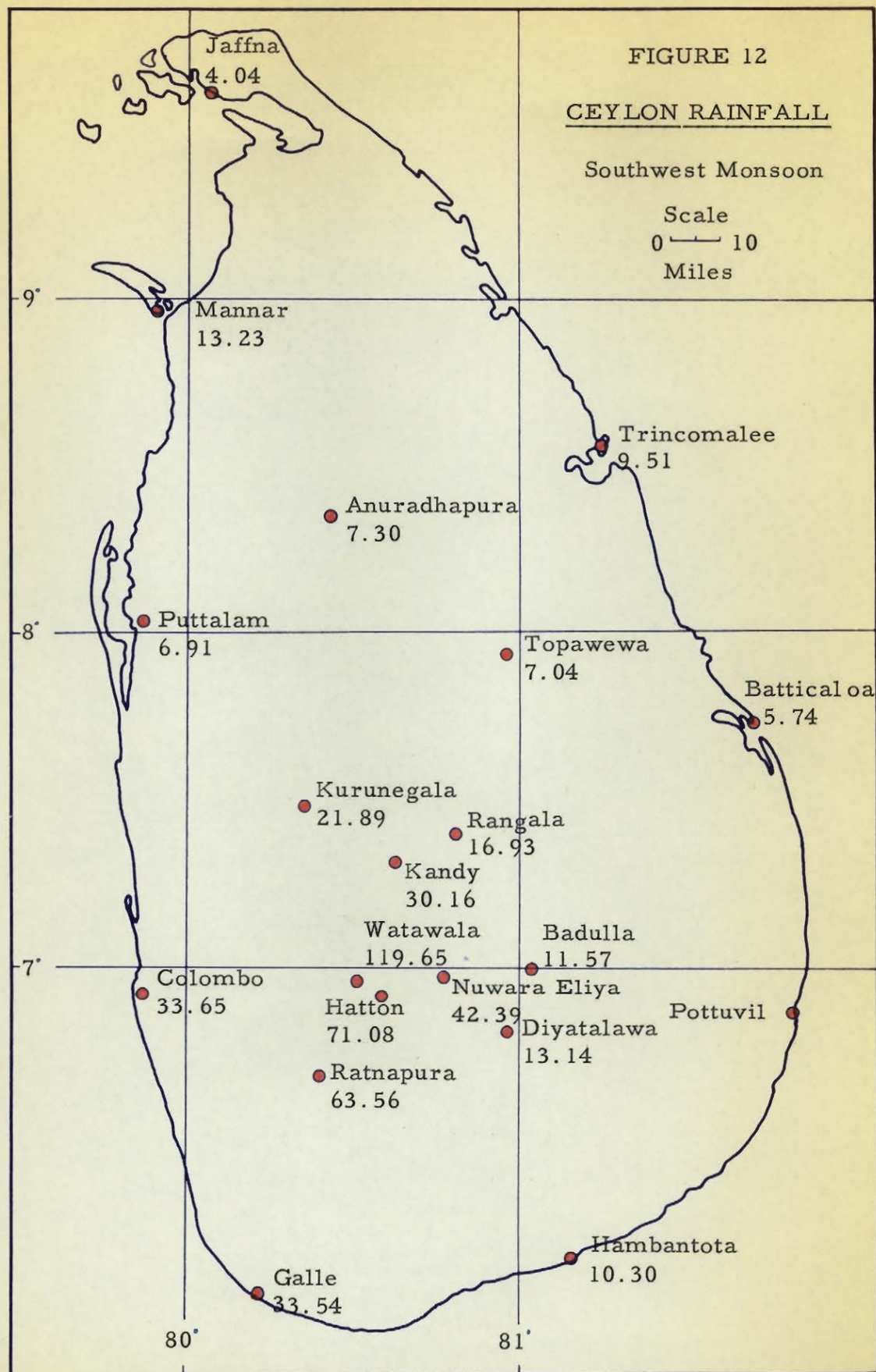
Variations of Temperature with Altitude











mountains, or to the northeast, east, or southeast plains. However, occasional intense convectional disturbances over the very hot eastern plains may force the monsoon wind to rise with accompanying condensation of moisture and rainfall. The northeast monsoon brings rain to the northeastern lowlands but most is concentrated on the northeast-facing hills and mountains of the Knuckles-Matale area, and the central hill mass as a whole (Fig. 13).

As a result of the intense insolation in Ceylon, the rainfall in some areas is insufficient to make up for the high losses to evaporation and transpiration; a moisture deficit exists; and arid conditions obtain. The dry zones of the south and southeast, and the north and northwest lowlands are of this type.

Thornthwaite Classification of Climate

An evaluation of Thornthwaite's Classification of Climate (1948) as it applies to Ceylon, has been made by K. O. Koelmeyer (1958 and unpublished? manuscript). His findings indicate the change in climatic type with altitude (Table IV), as well as the moisture surplus available for runoff and the areas of moisture deficit (Table V). These tables show that surplus moisture available for runoff and groundwater recharge, is greatest along the southwest face of the central hill mass in the Ratnapura district, and within the highlands in the Hakgala, Kandy,

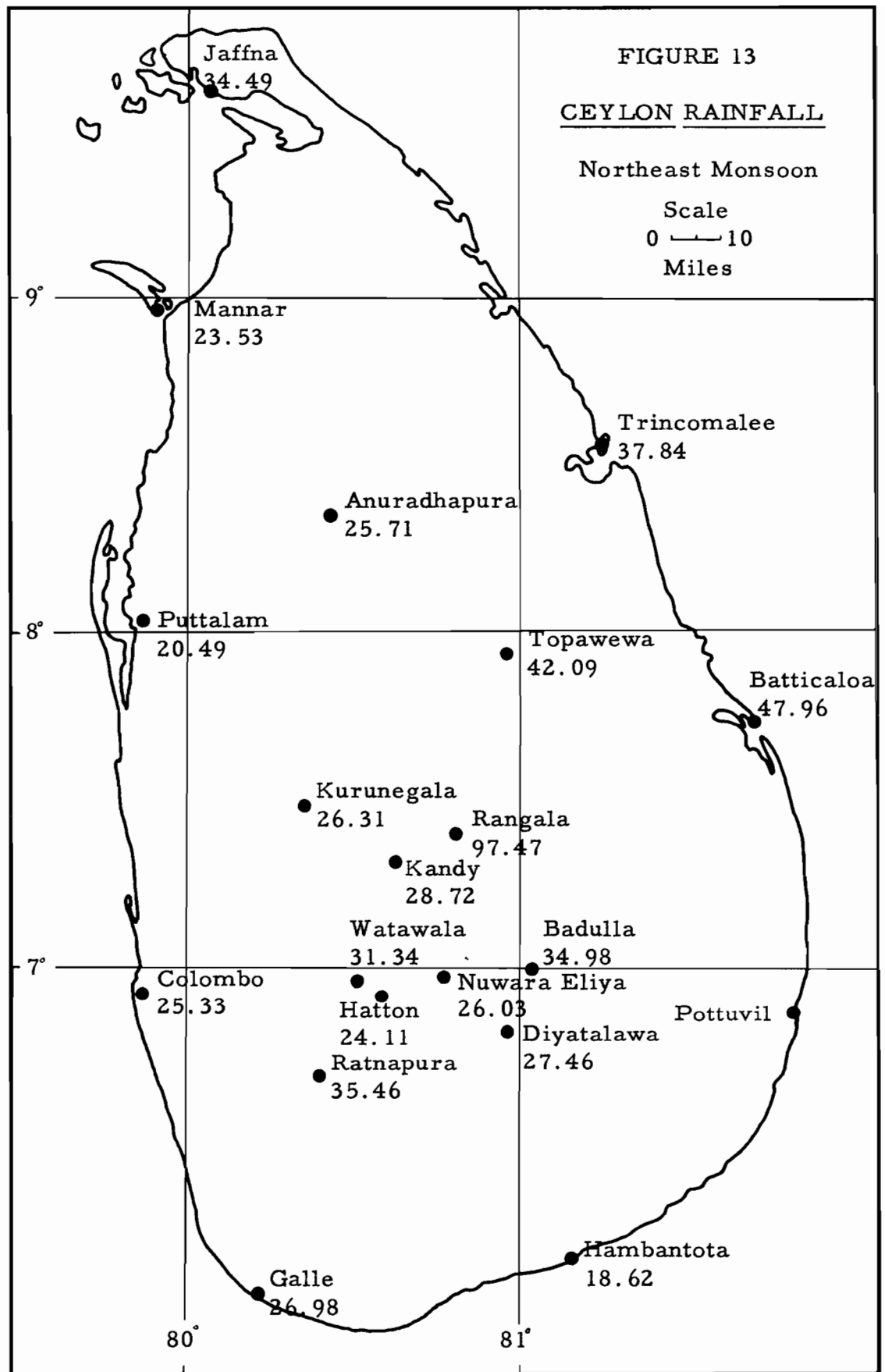


TABLE IV
 VARIATION OF THORNTHWAITE CLIMATIC TYPES
 WITH ALTITUDE

Station	Elev. in feet		Climate Type
1. Colombo	20	B ₂ r A'a'	Humid, megathermal, no water deficiency, equable temperature.
2. Puttalam	10	C ₁ d A'a'	Dry, sub-humid, megathermal, no water surplus, equable temperature.
3. Mannar	10	D d A'a'	Semi-arid, megathermal, no water surplus, equable temperature.
4. Jaffna	10	C ₁ S ₂ A'a'	Dry, sub-humid, megathermal, large summer water deficiency, equable temperature.
5. Trincomalee	30	C ₂ S ₂ A'a'	Moist, sub-humid, megathermal, large summer water deficiency, equable temperature.
6. Batticaloa	20	C ₂ S ₂ A'a'	Moist, sub-humid, megathermal, large summer water deficiency, equable temperature.
7. Hambantota	60	D d A'a'	Semi-arid, megathermal, no water surplus, equable temperature.
8. Galle	70	B ₂ r A'a'	Humid, megathermal, no water deficiency, equable temperature.

TABLE IV (Continued)
 VARIATION OF THORNTHWAITE CLIMATIC TYPES
 WITH ALTITUDE

Station	Elev. in feet		Climate Type
9. Ratnapura	130	A r A'a'	Perhumid, megathermal, no water deficiency, equable temperature.
10. Kurunegala	380	B ₁ r A'a'	Humid, megathermal, little or no water deficiency, equable temperature.
11. Anuradhapura	300	C ₂ S ₂ A'a'	Moist, sub-humid, megathermal, large summer water deficiency, equable temperature.
12. Hakgala	5,580	ArB' ₂ a'	Perhumid, mesothermal, no water deficiency, equable temperature.
13. Badulla	2,220	B ₃ rB' ₄ a'	Humid, mesothermal, no water deficiency, equable temperature.
14. Kandy	1,610	B ₃ rA'a'	Humid, megathermal, no water deficiency, equable temperature.
15. Nuwara Eliya	6,170	ArB' ₁ a'	Perhumid, mesothermal, no water deficiency, equable temperature.
16. Diyatalawa	4,120	ArB' ₂ a'	Perhumid, mesothermal, no water deficiency, equable temperature.

TABLE V
PRECIPITATION, MOISTURE SURPLUS, AND MOISTURE DEFICIT

Station		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Colombo Elev. 20'	P	04.0	02.6	04.7	09.1	15.5	08.7	05.5	04.0	06.8	13.7	13.1	05.6	93.2
	MS	00.0	00.0	00.0	00.0	09.2	02.8	00.0	00.0	00.0	08.1	08.0	00.7	28.8
	MD	00.0	00.0	00.4	00.0	00.0	00.0	00.0	00.0	00.0	00.0	00.0	00.0	00.4
Puttalam Elev. 10'	P	03.4	01.4	03.1	04.9	03.8	01.4	01.0	00.6	01.6	07.4	10.1	05.6	44.3
	MS	00.0	00.0	00.0	00.0	00.0	00.0	00.0	00.0	00.0	00.0	02.6	01.0	03.6
	MD	00.0	00.4	02.8	01.2	02.8	04.9	05.4	05.7	04.4	00.0	00.0	00.0	27.6
Mannar Elev. 10'	P	03.8	01.7	01.8	03.4	01.8	00.4	00.4	00.7	01.2	06.6	10.2	07.8	39.8
	MS	00.0	00.0	00.0	00.0	00.0	00.0	00.0	00.0	00.0	00.0	01.5	02.8	04.3
	MD	00.0	00.4	04.3	03.0	05.1	06.2	06.2	05.8	05.0	00.0	00.0	00.0	36.0
Jaffna Elev. 10'	P	04.4	01.5	01.6	02.2	02.0	00.4	00.6	01.1	02.5	09.2	17.3	10.4	53.1
	MS	00.0	00.0	00.0	00.0	00.0	00.0	00.0	00.0	00.0	00.0	11.3	06.0	17.3
	MD	00.0	00.0	03.7	04.4	04.9	06.3	06.0	05.2	03.5	00.0	00.0	00.0	34.3
Trincomalee Elev. 30'	P	08.3	02.6	02.3	02.1	03.2	00.9	01.7	03.6	03.4	09.6	13.9	13.0	64.8
	MS	03.9	00.0	00.0	00.0	00.0	00.0	00.0	00.0	00.0	00.0	08.7	08.6	21.2
	MD	00.0	00.0	01.8	04.2	03.7	06.0	05.2	03.0	03.0	00.0	00.0	00.0	26.9
Batticaloa Elev. 20'	P	12.9	04.2	03.5	02.3	01.8	00.9	01.0	02.0	02.4	07.2	13.9	17.0	67.1
	MS	08.4	00.0	00.0	00.0	00.0	00.0	00.0	00.0	00.0	00.0	06.3	12.5	27.2
	MD	00.0	00.0	00.0	01.9	04.9	05.8	05.7	04.6	03.8	00.0	00.0	00.0	26.7

TABLE V (Continued)

PRECIPITATION, MOISTURE SURPLUS, AND MOISTURE DEFICIT

[illegible]

Nuwara Eliya, and Talawakele districts. The Diyatalawa and Badulla districts, although they may be classed as highland stations, appear to be affected both by topographic and seasonal factors.

Hydrologic figures for Ceylon's rivers (Anketell-Caine, 1953) substantiate the high runoff potential of the southwest face of the central hill mass and the much lower runoff potential of the southeast, east, and north. For example: the Kelani Ganga drains an area of 885 square miles along and within the western ranges of the central hill mass. The mean annual runoff of this river is 4.956 million acre feet or 5,600 acre feet per square mile. The Kalu Ganga, which drains 1,050 square miles of the Ratnapura-Sabaragamuwa Hills area, also facing the southwest monsoon, has a mean annual runoff of 5.880 million acre feet or 5,600 acre feet per square mile. On the other hand, the Menik Ganga, which drains 497 square miles of the southeast dry zone, has a mean annual runoff of 0.398 million acre feet or approximately 800 acre feet per square mile. The Kumbukkan Oya, in the same general area, has a drainage basin of 656 square miles; an estimated mean annual runoff of 0.492 million acre feet or 750 acre feet per square mile. In the northwest dry zone, the Aruvi Aru has a drainage basin of 1,268 square miles and a mean annual runoff of 0.405 million acre feet, which is equal to approximately 318 acre feet per square mile. Of somewhat intermediate status is the Mahaweli Ganga. This river drains the largest area in

Ceylon but only its headwaters lie within the central hill mass exposed to the higher rainfall. As a result, the mean annual runoff from a drainage basin of 4,034 square miles, is 3.227 million acre feet or approximately 800 acre feet per square mile. The similarity between this figure and those for the southeast dry zone, may be explained by the fact that it is, in effect, the average between the runoff for the headwaters above Peradeniya (459 square miles), which amounts to approximately 3,819 acre feet per square mile per year, and the runoff for the remaining 3,575 square miles below Peradeniya, which amounts to approximately 412 acre feet per square mile per year. Of this latter figure, a part is made up by the drainage from the "moderate surplus" Badulla-Diyatalawa area (Table V).

It should also be noted that the potential evapotranspiration calculated for the low altitude dry zone stations such as Mannar, Puttalam, Trincomalee, Batticaloa, and Hambantota, is relatively high, whereas that for the highland stations such as Badulla, Kandy, Nuwara Eliya, Diyatalawa, and Hakgala is relatively low. This relationship may be restated as follows: the high level, high precipitation stations are within a low potential evapotranspiration zone, with the result that there is a large amount of surplus moisture available for runoff, and the low level, low precipitation stations are within a high potential evapotranspiration zone, with the result that there is a well marked moisture deficiency and low runoff in these areas.

Vegetation

General

Natural vegetation in Ceylon is influenced by a number of primary factors. Of these, rainfall, temperature, altitude, and soil appear to be the most important.

Temperature, except as it varies with altitude (Fig. 10), is essentially uniform throughout the island (Table II) and its effect is mainly that of determining the tropical nature of the vegetation. At higher altitudes, where lower temperatures and lower potential evapotranspiration conditions prevail, vegetation is less dense, fewer tropical types exist, and the vegetation that does exist is dependent partly on the moisture regime and partly on the existence of soils suitable for growth. At lower altitudes, where higher temperatures and higher potential evapotranspiration conditions obtain, the density, type, and distribution of the vegetation is determined almost entirely by the moisture regime. Thus areas with low rainfall characteristics tend to produce thorny, scrub jungle of a xerophytic nature; areas with high rainfall tend to produce dense rain forests; and areas of intermediate rainfall produce a transition between these.

The various vegetation zones indicated above have been described by De Silva (1952) as Thorn Forest, Dry Zone Tropical Forest, Wet

Zone Forest, and Wet Zone Upper Hills. He includes the Patanas or grasslands in the latter zone. E. K. Cook (1951) describes the equatorial forest or wet jungle, the intermediate forest, and the dry jungle, but does not make divisions among them. She describes the grasslands of Ceylon under the classification: Patanas, or grassland without trees, and Talawa, or grassland with trees. Swamps are described as characteristic of coastal lagoons, river mouths, abandoned river channels, and local regions of impermeable subsoil with a high watertable.

For the purpose of this discussion, the natural vegetation of Ceylon has been divided into six main classes. These are: Lowland Wet Jungle (true tropical rain forest), Highland Wet Jungle (montane rain forest), Dry Intermediate Forest, Dry Scrub Jungle, Talawa (savanna), and Patana (high grassland).

Lowland Wet Jungle

Lowland Wet Jungle is found predominantly in the southwest part of the island from the lower slopes of the central hill mass (Mawanella, Yatiyantota, Deraniyagala, and Ratnapura) westward to the coast, and from the Kegalle-Ambepussa region in the north to the Rakwana-Morawaka-Akuressa-Galle region in the south. This area is included roughly within the 100 inch isohyet and has local sections where 200 inches of rainfall (annually) is exceeded. It includes the Sabaragamuwa

Hills, which locally exceed 3,000 feet in altitude and which would, vegetatively, come within the Highland Wet Jungle category in a more detailed classification.

The jungle, where it occurs within this region, is a typical hot, humid, equatorial rainforest. The trees are generally tall, broad-leaved types, but where breaks occur in this canopy, a lower stratum of vegetation consisting of dense undergrowth develops. Numerous large creepers or lianas connect this undergrowth to the upper stories (Fig. 14). Elsewhere the lower stratum of the jungle is generally not dense. Tree ferns, varieties of rhododendrons, especially in the higher areas, and bamboo near the rivers, are characteristic.

Highland Wet Jungle

Highland Wet Jungle usually occurs along the windward slopes of the highlands where orographic rainfall is heavy (Fig. 15 and Fig. 16). The western slopes of the central hill mass from Kadugannawa, through Dolosbage and Maliboda, to Carney and Galiella, and the western and eastern slopes of the Knuckles and Dumbanagala ranges respectively, are characteristic. Vegetation is transitional from the tropical rain forest type to a slightly more temperate climate type. The lowering of temperature with altitude appears to be the controlling factor in these modifications. Outwardly the forests look similar, but more conifers



FIGURE 14

Lower Strata of Lowland Wet Jungle



FIGURE 15

Highland Wet Jungle on the West Slope of Adams Peak Range



FIGURE 16

Alupola Falls on a Tributary of the Bombarabotuwa Oya

Corabelle
FLOWER BRAND
25% COTTON FIBER
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are present and there is a greater development of rhododendron. Vines or lianas are still present along with orchids, mosses, and ferns, to give the overall growth a jungle appearance.

Dry Intermediate Forest

Dry Intermediate Forest corresponds to the dry zone tropical forest described by De Silva (1952). It extends over much of the lowland or low upland, approximately from the 50 inch isohyet to the 90 inch isohyet. It grades on the low rainfall side into Dry Scrub Jungle, and on the high rainfall side into Lowland Wet Jungle, Highland Wet Jungle, Talawa, or intermediate montane types. In general, it is composed of medium height (30-40 feet), small leaved, deciduous and/or evergreen, hardwoods. Larger trees, whose crowns rise above the surrounding forest, are Satinwood (*Chloroxylon swietonia* DC.), Palu (*Manilkara hexandra* Dubard), and Halmilla (*Berrya cordifolia* Burret). These trees have wide spreading, umbrella shaped crowns and are easily discernible on the aerial photographs. Interlacing of the branches produces a dense canopy of foliage, which, by preventing the sun's rays from reaching the ground, tends to decrease evaporation from the soil surface. The undergrowth that is present, is mainly brushy, seedling growth of the parent forest, with a notable absence of broad leaved succulents and ferns.

Dry Scrub Jungle

Dry Scrub Jungle occurs in two areas, in general within the 0 to 50 inch rainfall zone. One area extends along the southeast coast from Tangalla to Pottuvil or Panama, and inland to Tanamalwila; the other, along the northwest coast from Chilaw to Jaffna and possibly almost as far south as Trincomalee, and inland to the vicinity of Tabbowa, Mankulam, and Vavuniya. The dividing line between this vegetative type and the Dry Intermediate Forest, is transitional.

Dry Scrub Jungle is characterized by the presence of thick, low, scrubby, and thorny bushes or brush, and a high percentage of xerophytic types such as cactus and euphorbia.

Talawa

Talawa is the Ceylon equivalent of savanna and is found on the upper slopes of the hills and ridges on the dry margin of the central hill country, as well as scattered throughout the central hills themselves. It is especially well developed on the east side of the Uva Bowl, in the Bibile-Lunugala-Medagama area. Rolling, grassy slopes with scattered trees or groups of trees, are characteristic (Fig. 17 and Fig. 18). Rhododendron, acacia, and patana oak are common. The grass is generally a long, coarse type.



FIGURE 17

Talawa, Balangoda Shelf



FIGURE 18

Talawa, Wekada Shelf

Patana

Patana is the montane grassland of Ceylon. It is distributed throughout the highlands as low, rolling, grassy slopes and hills (Fig. 19). This is the dry patana of Rosayro (1955), which has the limiting factors of less than 20 inches of rainfall during the southwest monsoon (from May to September), and an elevation of between 2,000 and 4,500 feet. Patana vegetation consists primarily of low grasses with occasional patches of sedge or low brush where moisture conditions are favourable. At the margins of the patanas, scattered trees, mainly patana oak, characterize the transition to Talawa or forest.

Rosayro (1955), describes a wet patana which flourishes under a southwest monsoon rainfall in excess of 40 inches, and at an altitude greater than 5,000 feet. This type of vegetation is found on Elk Plains (6,000 feet $\pm$), and their extension in the Conical Hill-Ambawela-Pattipola area (5,600 feet $\pm$); on Horton Plains (7,000 feet $\pm$) the Bopatalawa-Bogawantalawa patanas (5,000 to 5,800 feet); and the Sita-Eliya patanas including the Moon Plains near Nuwara Eliya (5,500 to 6,200 feet). The wet patanas consist of fingers of often marshy grassland extending up valleys, along water courses, and in depressions in the high plains.



FIGURE 19

Patana, Lunugala Region

CHAPTER III

LANDFORMS

Introduction

General

A description, analysis, and classification of the present landforms of Ceylon is the subject of this phase of the study. These procedures are based primarily on the analysis and interpretation of aerial photographs, supplemented where possible by selective field investigation.

Physiographic regions

For the purpose of this study, Ceylon's terrain has been divided into eight major physiographic regions. In order of their discussion these are: the Continental Shelf, the Coastal Plain, the Low Level Plain, the Central Massif, the Knuckles Massif, the Sabaragamuwa Hills, the Gal Oya Hills, and the Elahera Ridges (Fig. 20, Appendix A, in pocket). Each major region has then been further subdivided into the landforms composing it and these have been analysed and described in detail. Where possible, stereoscopic pairs of aerial photographs have been used to illustrate and substantiate the classification.

Surfaces of erosion and deposition

Of the many interesting and complex features studied, the surfaces of erosion and deposition are probably among the most important, from the point of view of reconstructing the historical development of the island. The surfaces of erosion take the form of high, medium, and low level plateaux; the surfaces of deposition take the form of high level and low level plains. The distinction between plateau and plain as used here, is that in general, the plateau is bounded on one or more sides by areas of low relief and the plain is bounded on one or more sides by areas of higher relief. Thus the plateaux are essentially erosion remnants standing, at least in part, above the surrounding terrain, and the plains are surfaces of deposition standing at or below the level of the surrounding terrain. Associated with these features are numerous fragmentary surfaces in the form of shelves or terraces and small valley bottom plains of deposition. A great many of these smaller features have been mapped (Fig. 21, Appendix A, in pocket), but have not been described in detail.

A correlation of the present elevations of the major surfaces outlined with the postulated diastrophic and geomorphologic history of the island, is contained in Chapter V.

Analysis and classification of landforms

The Continental Shelf

Ceylon is situated on an extension of the continental shelf of the Indian Subcontinent. This shelf surrounds the island and varies from five to twenty miles in width. Its outer margin follows the 100 fathom line approximately, and from there the bottom drops off rapidly to over 1,000 fathoms. In fact, the seas about Ceylon are, with the exception of Palk Strait, oceanic in nature. The Gulf of Mannar on the west is over 6,000 feet deep, the Indian Ocean on the southwest and south is over 13,000 feet deep, and the Bay of Bengal off the east coast is over 10,000 feet deep. The shelf, as shown by the hydrographic charts, is narrowest in the vicinity of Trincomalee, Batticaloa, and Panadure where submarine canyons similar to the one at the mouth of the Indus River of India may exist (Cook, 1951). The shelf is shallowest in the Palk Strait area where Adams Bridge and Pedro Banks are located.

Adams Bridge consists of a narrow chain of islands rising from a rocky ridge or causeway joining Ceylon and India, which at this point are approximately twenty miles apart. The depth of water over the submerged part of Adams Bridge averages well under 6 fathoms and this, in combination with the strong, monsoon controlled, currents, results in the formation of numerous shifting sand bars which are characteristic

of the area.

Another elevation in the continental shelf extends from north-east of the Jaffna Peninsula to the vicinity of Karikal and Calimere Point in India and is known as Pedro Bank.

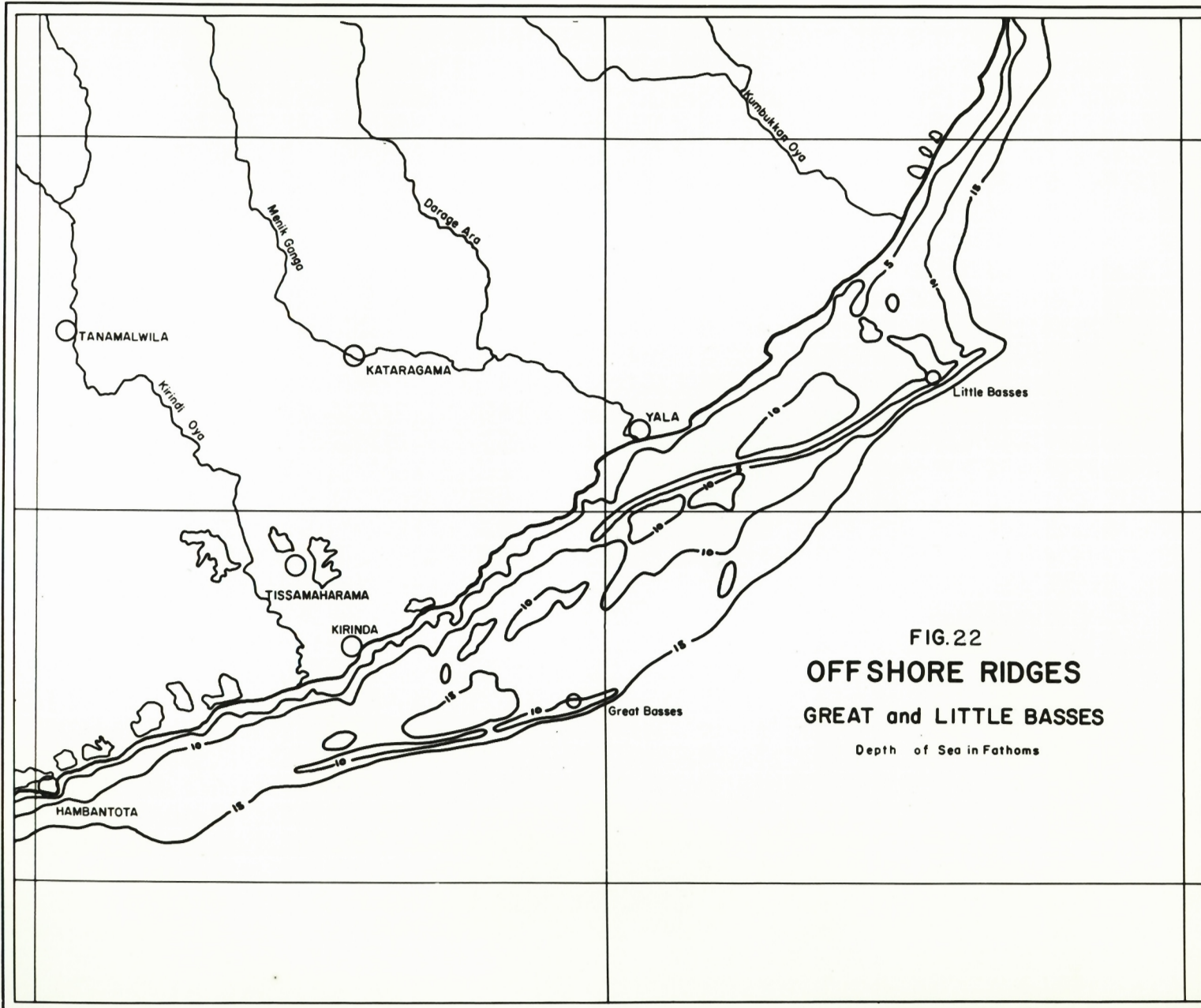
South of Adams Bridge, between Mannar Island and Karaitivu Island, a third rise in the shelf forms the once famous pearl fishing banks or paars. The surface of the shelf at this point and elsewhere in the Palk Strait area, as evidenced by fragments of rock brought to the surface by trawls operated by the fisheries research group, consists of limestone well pitted with solution cavities.

Along the southwest coast from Negombo to Dondra, strike ridges of the local rock extend at a low angle toward the shelf. Similar ridges off the southeast and east coast come to the surface as the Great and Little Basses rocks in the Hambantota-Yala area (Fig. 22) .

The Coastal Plain

General

The Coastal Plain of Ceylon has been delineated as a relatively narrow strip of land bounded on the one hand by the sea and on the other by the hundred foot contour line (Fig. 20) . In the southwest, this has been modified to take into account the Sabaragamuwa Hills, which extend almost to the coast in the vicinity of Galle and Matara.



Many of the river valleys penetrating these hills have their flood plains less than 100 feet above sea level. In general, this classification has been designed to include all the terrain characteristic of a coastal area without including unnecessary portions of the Low Level Plain inland. An additional factor was the possible upper limit of eustatic sea level adjustment.

In general, the Coastal Plain of Ceylon may currently be classed as a plain of submergence. It is true that there is evidence of emergence in the form of raised beaches, wave cut terraces and elevated coral reefs, but it is considered here that the dominant characteristics are those of submergence. The presence of broad, flat alluvial plains, virtually at sea level, behind partly silted up lagoons shut off from the sea by low sand bars and spits, is indicative of this sequence of events (Johnson 1919, Sparks 1960). The fact that most of these alluvial deposits fill depressions with a dendritic outline, and the presence of wave truncated promontories, are also indicative of a retrograding shore line.

In order to facilitate its description, the Coastal Plain of Ceylon has been subdivided into four parts; the Mannar Coastal Plain, the Trincomalee Coastal Plain, the Pottuvil Coastal Plain, and the Bentota Coastal Plain. These areas will be discussed in detail and examples of the above mentioned criteria will be indicated.

The Mannar Coastal Plain

The Mannar Coastal Plain extends from the Kelani Ganga, at Colombo on the south, to the Jaffna Lagoon on the north. It varies in width from approximately four miles at Marichchukkaddi, to eighteen in the valley of the Kelani, and twelve north of Mannar.

The inland margin of the Coastal Plain is very irregular, following as it does the topography and therefore the dendritic pattern of the various valleys crossing it. The shoreline on the other hand, is strikingly smooth with very few protuberances or major indentations. Beach drifting, and to some extent longshore drifting by littoral currents, have effectively distributed the sand, of which much of the coastal belt is composed, filling in hollows and cutting off projections. In the process of this distribution, certain features have been constructed which are characteristic of this region. Sand spits and bars are two of the most distinctive. The sand spit at Puttalam and the one at Mannar, of which Mannar Island is part, are the largest. Smaller ones occur at Negombo, Chilaw, and Vidattaitivu. The spit, which almost completely encloses Negombo Lagoon, has a core of rock which may have been responsible for initiating the deposition of sand (Fig. 4). This is apparently an extension of a bedrock ridge or "reef" called Pamunagama Reef, first noted in the vicinity of Kelaniya just north of

Colombo (Wayland and Davies 1923). The Provisional Geological Map of Ceylon (Fig. 1), also shows rock to be present in the spit at Puttalam and on Mannar Island. Configurations further south along the Bentota Coastal Plain substantiate the probability that most of the major north trending spits of the west coast of Ceylon are rock controlled. However, a great many of the minor spits are formed entirely of sand, deposited as the result of beach drifting and longshore current action.

Some of the streams flowing into the sea along this coast have been diverted along the shore by the formation of spits or bars across their mouths. There results a complex collection of anastomosing stream channels, canals, narrow lagoons and intersecting distributary channels, part of which may be deltaic in nature. An example of this type of coastal feature occurs at the mouth of the Deduru Oya north of Chilaw (Fig. 23). Many lagoons rapidly succumb to silting up and the growth of swampy vegetation.

Deltas occur along this coast, primarily where rivers flow into large lagoons. On the exposed coast, unless spit or bar forming conditions are favourable, the sediment is rapidly swept away and deltas do not form. Samples of lagoonal deltas are: the delta of the Kalu Oya in Negombo Lagoon; the delta of the Mi Oya in Puttalam Lagoon; and the delta of the Sengal Oya in Mundel Lake. An example of a delta building directly into the sea and fringed by offshore sand bars is the delta of the

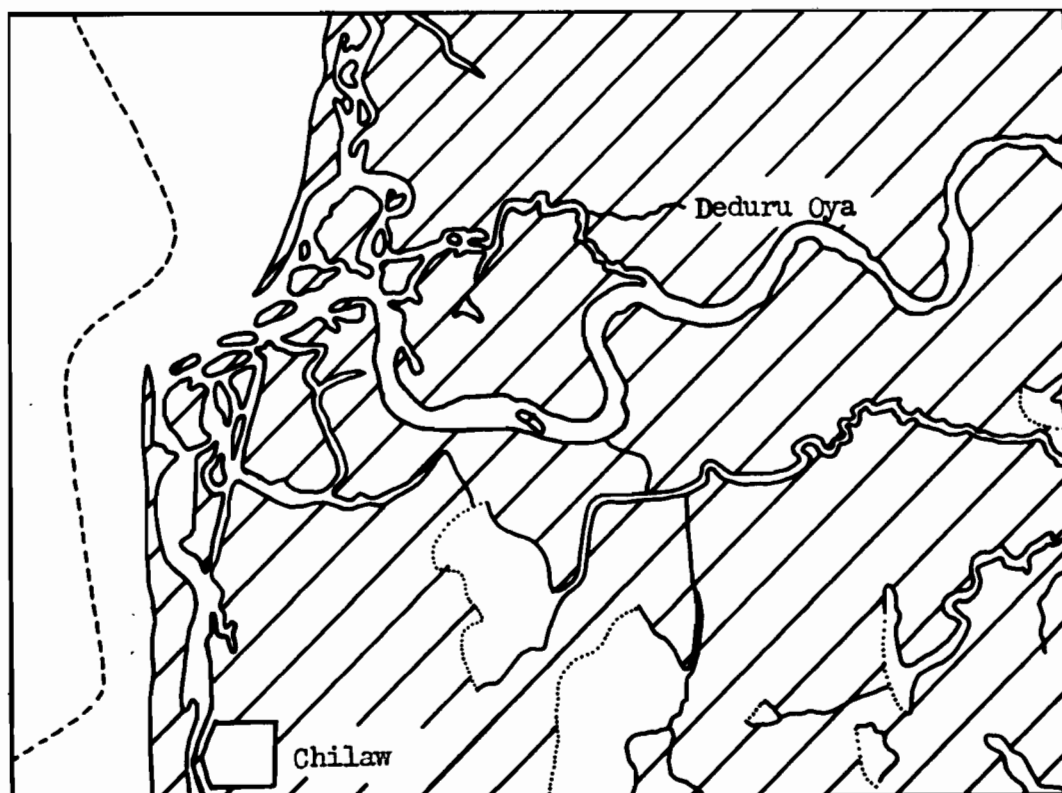


FIGURE 23

Delta at Mouth of Deduru Oya

Aruvi Aru just south of Mannar Island. In this case the magnitude of the river and its sedimentary load together with a somewhat protected position, has allowed the delta to form. In contrast, the mouth of the Maha Oya, about five miles north of Negombo, opens directly into the sea without any sign of a delta.

The islands along this coast are predominantly rock controlled, though sand deposition by local wave and current action has modified their shape to a considerable extent. Mannar Island is the largest and is part of Adams Bridge as mentioned earlier. Karaitivu Island or Islands is an elevated southern extension of the paars or pearl banks between Mannar and Kudremalai Point. Its shape is due also to the erosional and depositional effects of local wave and current action.

At the request of the Fisheries Research Department, who were studying the pearl banks, aerial photographs of this area were examined to determine if the banks could be charted beneath the shallow water. In addition to answering this question in the affirmative, it was noted that between the time that the Admiralty Charts has last been revised and the time of the aerial photography, a considerable change had occurred in the shape of Karaitivu Island. During that period, a channel had been breached directly across the south part of the main island and spits had been extended at both the north and south ends.

Further to the south in Dutch Bay at the mouth of Puttalam

Lagoon, a pattern of muddy swirls and flow lines indicates the turbulence set up when the flow from the lagoon meets the open sea. It appears probable that, at least in part, these flow lines have been modified by longshore currents around the point of the rock controlled spit enclosing Puttalam Lagoon.

Along the coast, and inland from the shore, sand dunes are common. In general, they parallel the coast and may extend several miles inland. The short duration of the strong southwest monsoon winds, coupled with the growth of a drought resistant assemblage of vegetation types to the leeward of the belt, appears to have limited its migration inland.

A final point which should be mentioned, is that much of the Mannar Coastal Plain is underlain by flat lying limestone rock (Wayland 1923, Adams 1929, and Fernando 1948). In areas where the soils are thin, or along certain river valleys, and along portions of the coast line, the bedrock is exposed. At Kolankanatta, six miles south of Kudremalai Point, the limestone forms a sea cliff about 50 feet high, and near the mouth of the Aruvi Aru a 10 foot cliff is reported. A narrow ridge of the same rock extends along the Coastal Plain from near Kudremalai, where it rises to 225 feet, south nearly to Karaitivu opposite Kalpitiya at the mouth of Puttalam Lagoon. This ridge has an elevation of 260 feet at Aruakallu and a maximum width of less than a mile.

With the exception of the above mentioned features, the Mannar Coastal Plain presents a very monotonous vista of scrub jungle and low, swampy stream valleys. The latter, since the streams have virtually reached base level many miles inland, are only eroding laterally and this occurs only when heavy rains in the headwaters cause floods. In addition, lateral erosion is limited by the dense vegetation along the banks.

The Trincomalee Coastal Plain

The Trincomalee Coastal Plain extends from the Maduru Oya, at Kalkudah on the south; to and including the Jaffna Peninsula on the north. It varies in width from a maximum of slightly over twenty-five miles to a minimum of slightly under four miles. The entire peninsula of Jaffna, including the associated islands of Velanai, Punkudutivu, Karaitivu, and Delft, is here classed as part of this feature.

The inland margin of the Trincomalee Coastal Plain follows the dendritic pattern of the numerous river valleys crossing it, in the same way as that of the Mannar Coastal Plain. The shoreline is very smooth and with the exception of Koddigar Bay at Trincomalee, the channels about the islands west of Jaffna, and Jaffna Lagoon, does not have any major indentations or projections. Minor projections occur at Elephant Point just north of Vandelooz Bay, at Koduwakattumalai about

twenty-two miles north of Trincomalee, and along the south side of the Jaffna Peninsula. The smoothness of this shoreline is due to the combined action of waves and longshore currents, caused for the most part, by the northeast monsoon. These agents apparently pick up and transport the sand, of which much of the coastal area is composed, and deposit it as bay mouth bars across the mouths of the rivers which empty at intervals along this coast. Numerous lagoons have been formed in this manner, chief of which are Upaar Lagoon, Ullackalle Lagoon, Kokkilai Lagoon, Nayaru Lagoon, Nanthi Kadal, and the complex association of lagoons, many of them unnamed, which dot and border the Jaffna Peninsula.

Spits are uncommon along this coast probably because the current hugs the shore and does not tend to carry the sand seaward. The presence of the 5 fathom line very close to shore along most of the coast is indicative of this condition. If spits were formed in the initial stages of the deposition across the river mouths, they were relatively short-lived and soon coalesced with the bars to make a continuous feature broken only by narrow channels which handle the outflow of the rivers. Jaffna Peninsula is, in effect, a large, somewhat recurved, compound spit or hook with a low, flat, limestone core. Aerial photographs of this area show very clearly the innumerable sandy beach ridges which together make up much of the peninsula and adjoining

coastal plain to the southeast (Fig. 24). At Keerimalai and Kankesan-turai, on the north coast of the peninsula, the limestone forms low sea cliffs of the order of 50 feet in height. It was not possible to visit them in the field, however, and as a result, they remain a subject of future study.

Rock is also exposed at scattered points between Mullaittivu and Kalkudah. At Trincomalee it consists of the seaward projections of the Elahera Ridges, which will be described in a later section. Koddiiyar Bay is of special interest since it is the location of the most clearly marked submarine canyon of Ceylon's continental shelf. In this bay, the 15 fathom line approaches to within 1,000 feet of the shore at the mouth of the Mahaweli Ganga (Fig. 25) . Since the lower reaches of the Mahaweli Ganga are flowing across a low, alluvial, flood plain, it is logical to suppose that this represents the filling, to the present base level, of an earlier, much more deeply incised valley, which would correspond to the existing submarine canyon topography of the bay. The eustatic lowering of sea level during the Pleistocene period would probably provide the differential in base level required to produce this feature.

Numerous minor rivers and streams cross the Coastal Plain, many of them only flowing during the rainy season. Of the more permanent rivers, the Mahaweli Ganga is by far the largest. Much of the

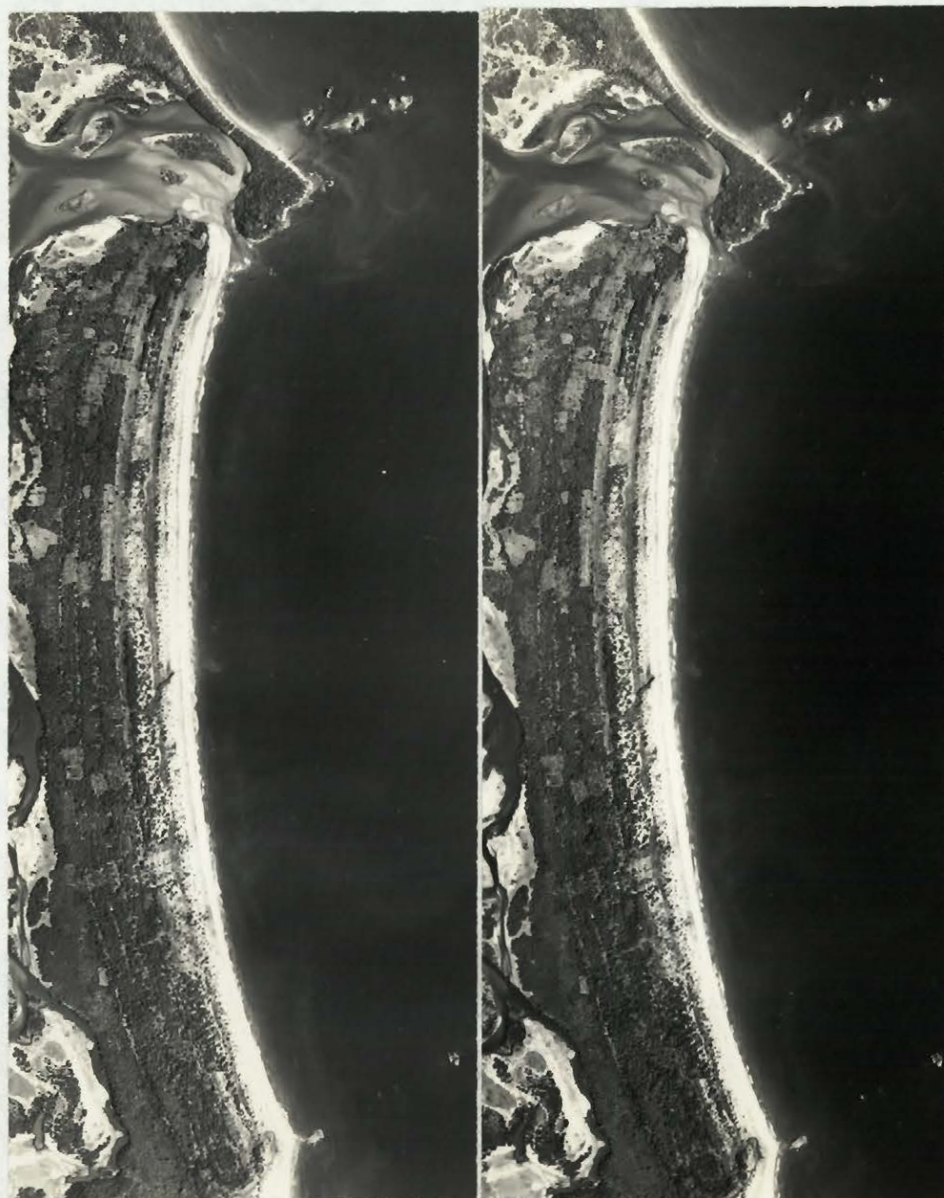
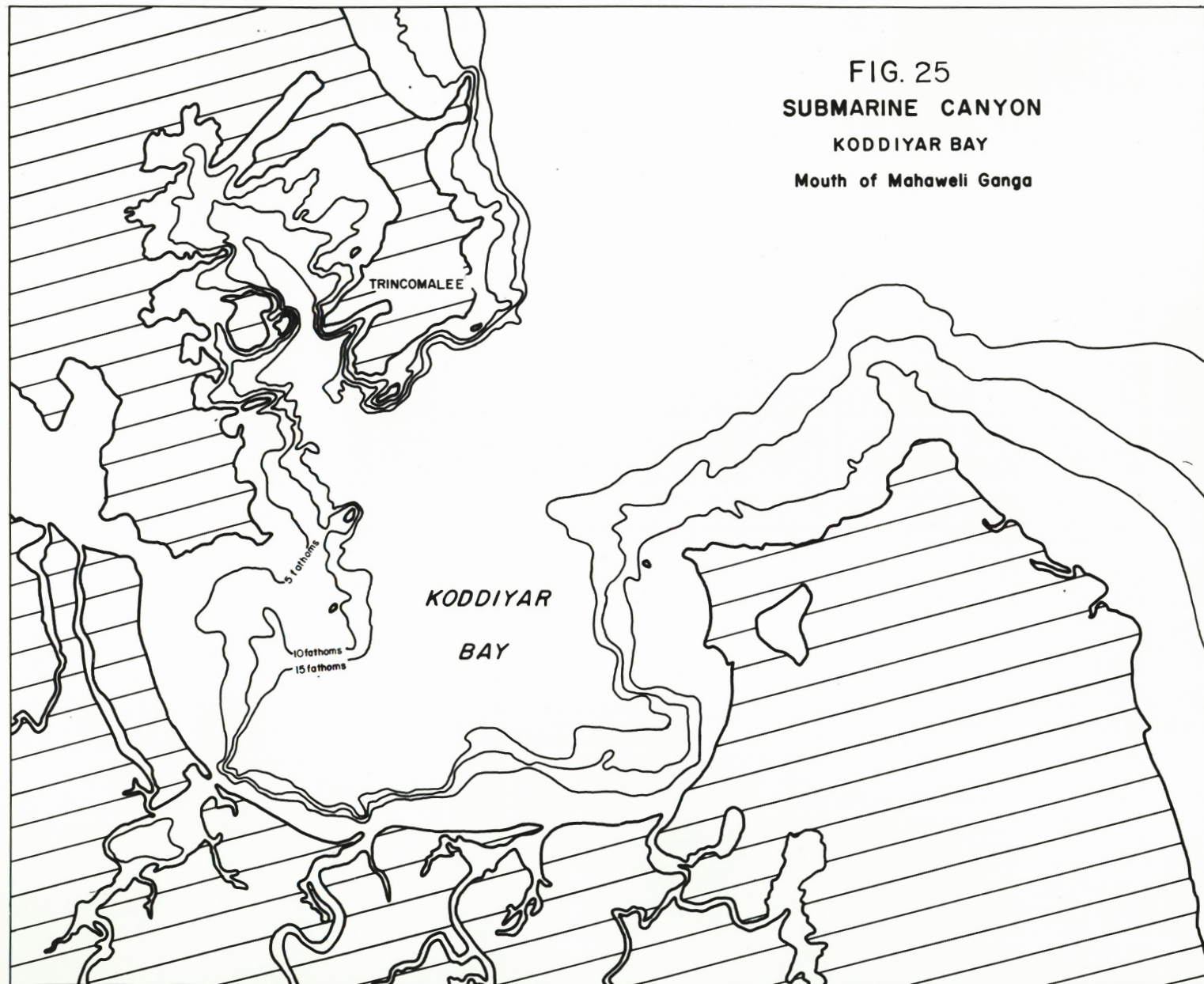


FIGURE 24

Beach Ridges, Trincomalee Coastal Plain

FIG. 25
SUBMARINE CANYON
KODDIYAR BAY
Mouth of Mahaweli Ganga



Mahaweli Ganga

plain between Kathiraveli and Trincomalee has its surface soils replenished by silt brought down by the flood waters of this river. Other rivers crossing the plain, in general, flow in low, broad valleys with little gradient.

The Trincomalee Coastal Plain is essentially a low, flat, plain, characterized by sandy wastes covered with scrub jungle in the south and palmyra palms in the north. Lagoons and silted-up, marshy lowlands are common, as are long parallel beach ridges (Fig. 26).

The geomorphologic history of this feature, as indicated by the construction of successive parallel beach ridges, the closing off of lagoons, and the planing off of projections, appears to be one of alternating prograding and retrograding conditions, probably brought on by eustatic changes in sea level during Pleistocene and post-Pleistocene time.

The Pottuvil Coastal Plain

The Pottuvil Coastal Plain extends from the Maduru Oya at Kalkudah on the north, to the Kirama Oya at Tangalla on the south. It varies in width from approximately ten miles on the north, to four miles on the south, widening in the major river valleys and narrowing at the interfluves.

The inland margin follows the dendritic valley pattern and is marked by little, if any, structural control. The shoreline is relatively

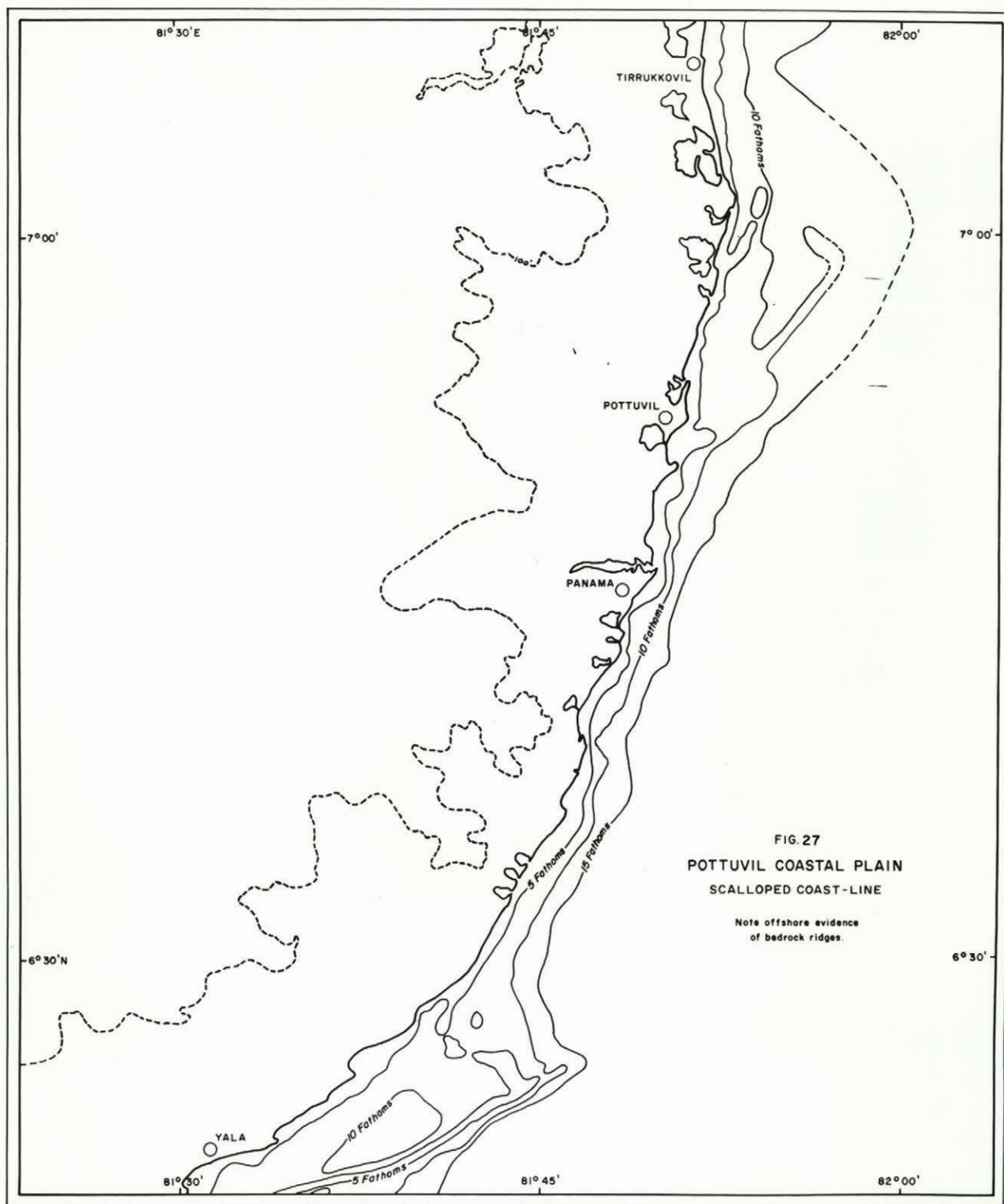


FIGURE 26

Silting of Lagoon, and Beach Ridges, Trincomalee Coastal Plain

smooth and featureless from Sangamankanda Point northward. From there south, it presents a scalloped appearance which is due to numerous small bays facing east and northeast with associated sheltering points (Fig. 27). From Tangalla to Kirinda, these points consist of rock ridges striking at approximately right angles to the coast (Fig. 28). East of Kirinda, many of the points, and parts of the coast line, are still strike ridge controlled but they generally make an acute angle with the local shoreline and trend in an east or northeast direction. The point at Panamamodaragala, about one and one half miles east-northeast of Panama, and the shoreline between Arugam Bay at Pottuvil, and Sangamankanda Point approximately six miles south of Tirrukkovil, illustrate these features.

Most of the seaward margin of the Pottuvil Coastal Plain consists of a more or less continuous series of sand bars and spits. Except for some of the major rivers, these bars and spits have been deposited across the mouths of the streams to form lagoons (Fig. 29). In Ceylon, these impondments are variously called lagoons, lakes, lewayas, and kalapuwas. In the Batticaloa section of the Pottuvil Coastal Plain, these bars have grown to a width of three to three and one half miles and consist of a series of parallel sand ridges, apparently in a prograding condition. Further south the ridges narrow, and below Pottuvil, are generally less than a mile in width.



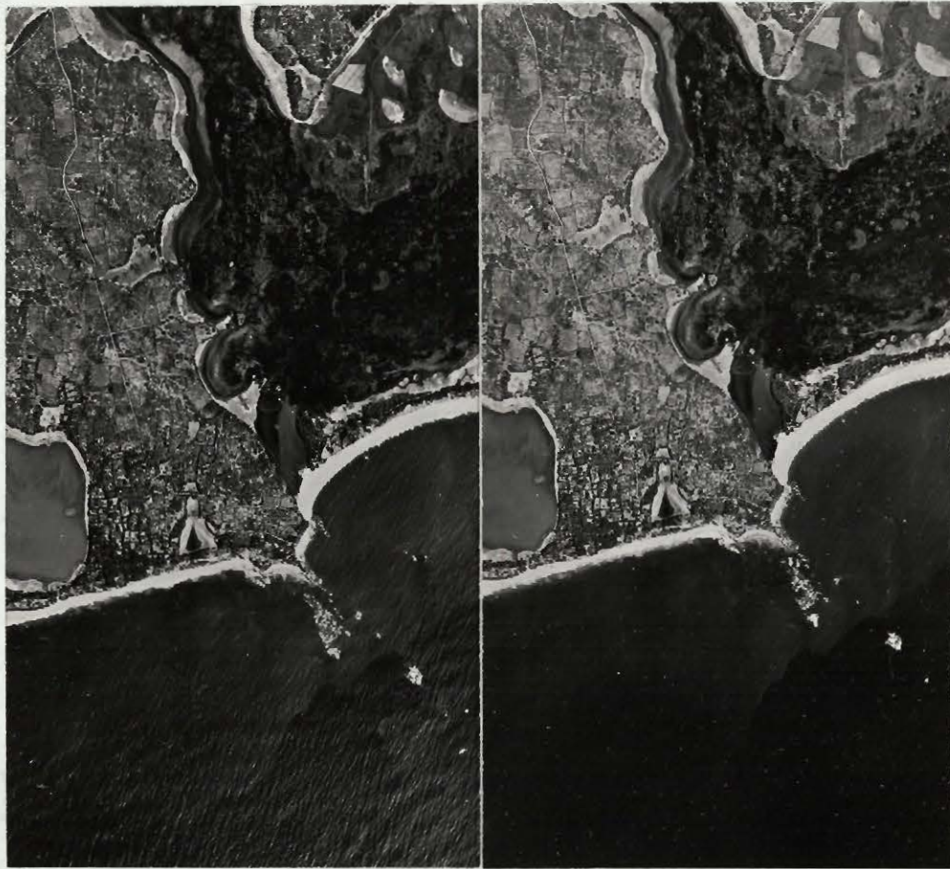


FIGURE 28

Rock Ridges Striking at Right Angles to the
Coast Line Near Kirinda

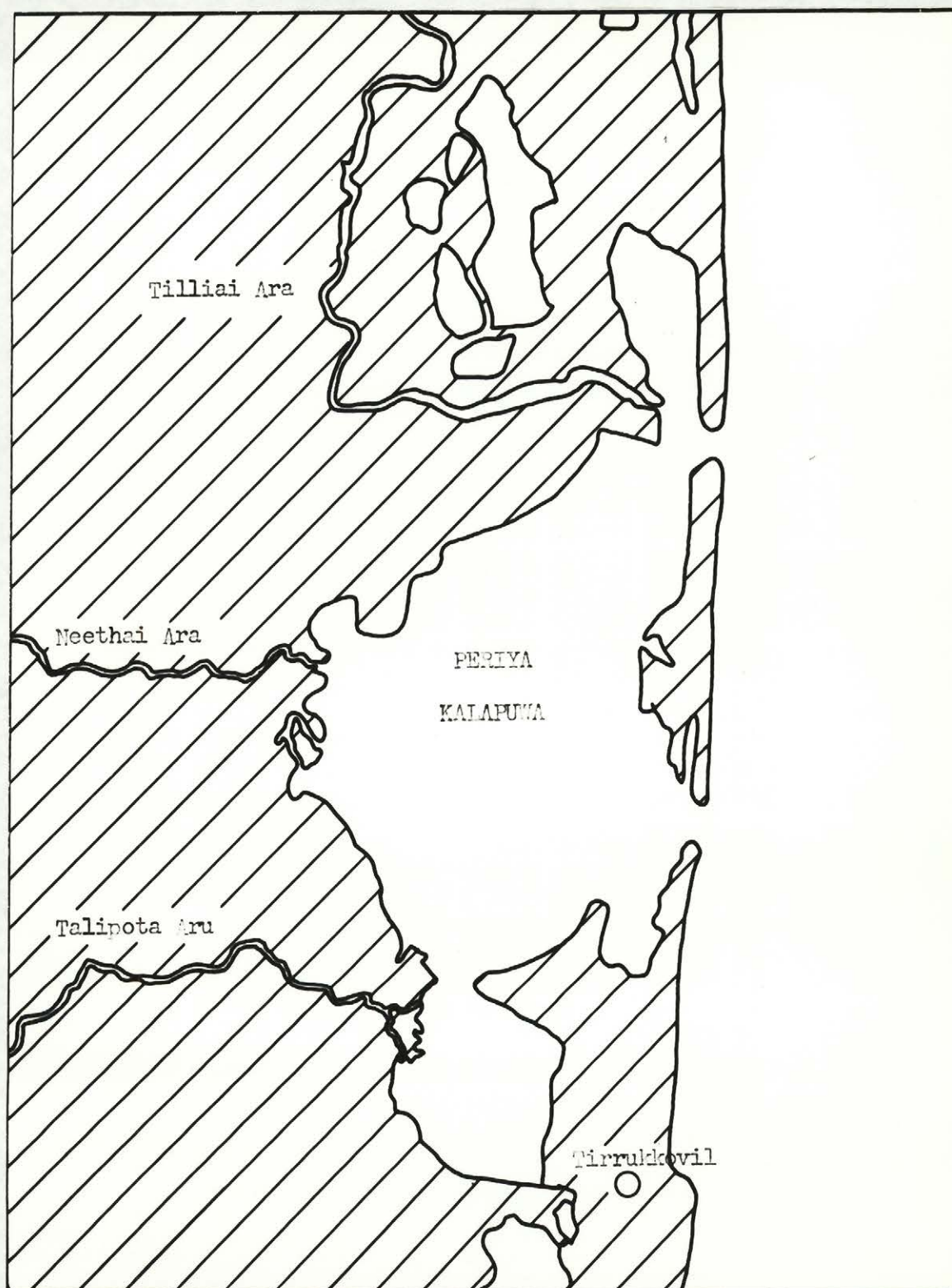


FIGURE 29

Baymouth Bar and Spits at Tirrukkovil

Along the southern part of the plain the major rivers flow directly into the sea across old lagoons silted up by the large sediment load brought down by them. The Walawe Ganga, the Kirindi Oya, the Menik Ganga and the Kumbukkan Oya illustrate this feature.

Also occurring along the south shore are steep, scalloped beaches (Fig. 30). These beaches are indicative of strong wave action and relatively deep water near shore (Lueder 1959).

In most cases, the shoreline forming bars have had their surfaces modified by wind action to form sand dunes. Along the south coast, these dunes have their long axes cutting diagonally across the trend of the bars due to the direction of the dominant southwest monsoon winds (Fig. 30 and Fig. 31). The lee side is stabilized by dense scrub vegetation consisting of low thorny bushes, euphorbia, cactus, and other xerophytic plants able to survive with little water. On the east coast, the axes of the dunes are more normal to the shoreline because of the direction of the modifying winds.

Inland, much of the Pottuvil Coastal Plain consists of the alluvium choked lower reaches of the rivers mentioned earlier. These rivers flow in very broad, flat valleys with scarcely any local relief. In the more inhabited areas, the alluvium has been cultivated and the rivers are generally confined by bunds or levees, elsewhere, they meander across the plain until stopped by the coastal bars or lagoons.

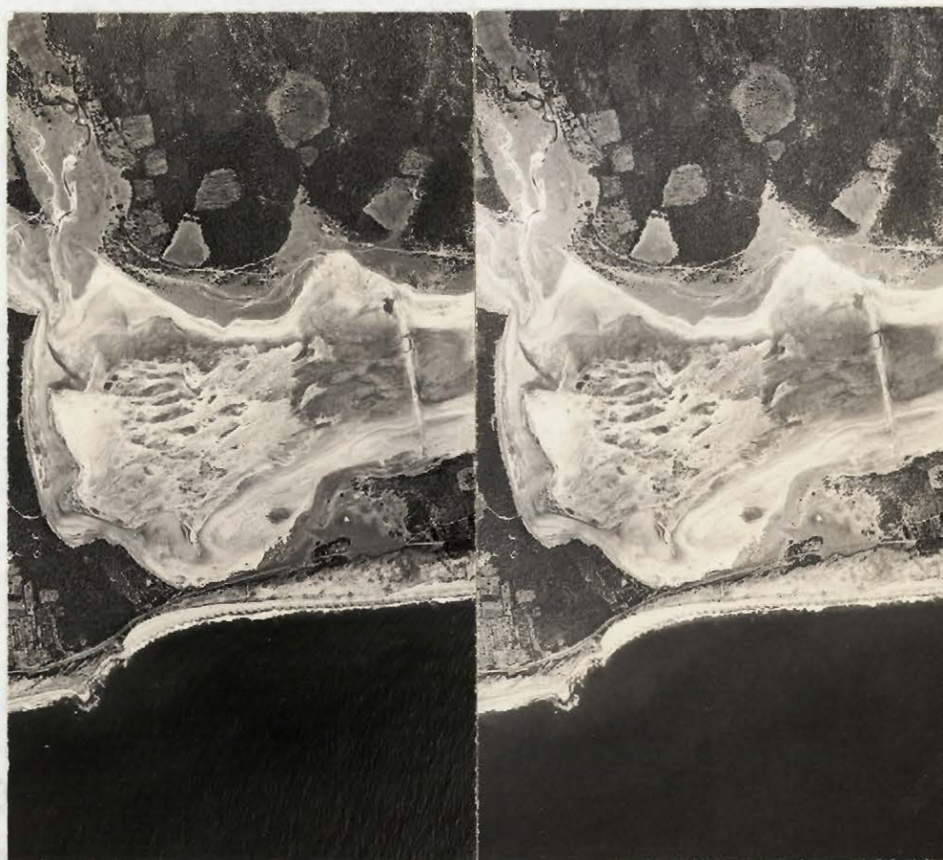


FIGURE 30

Steep Scalloped Beaches Near Hambantota



FIGURE 31

Coastal Sand Dunes Modified by Transverse Winds

In general, the interfluves of the coastal plain consist of low, rounded, bedrock rises, mantled or thinly veneered with alluvium or residual soils, and punctuated at intervals with knobs or low hills of a more resistant nature (Fig. 32). This very gently undulating rock floor is continuous with the Tanamalwila Peneplain inland.

In summary, the Pottuvil Coastal Plain consists of a relatively narrow, rock-floored, low lying strip of land, bordered on the coastal side by an almost continuous sand bar varying in width from one to three and one half miles. On the south this bar is anchored and protected by projecting rock ridges which have localized the formation of numerous bays and small crescent beaches.

The Pottuvil Coastal Plain is characterized by slightly prograding conditions in the northeast and slightly retrograding conditions in the south. The former condition is evidenced by the formation and extension of bay-mouth bars; the general widening of the main bar; and the presence of beach ridges inland from the shore. The latter condition is demonstrated mainly by the steep beaches; and the attack of the waves on the bedrock being progressively exposed at various points along the coast. The southwest monsoon produces strong wave action as well as associated east and northeast flowing current. The cumulative effect of wave action, beach drifting and current action is to pick up and transport sediment along the coast from west to east and

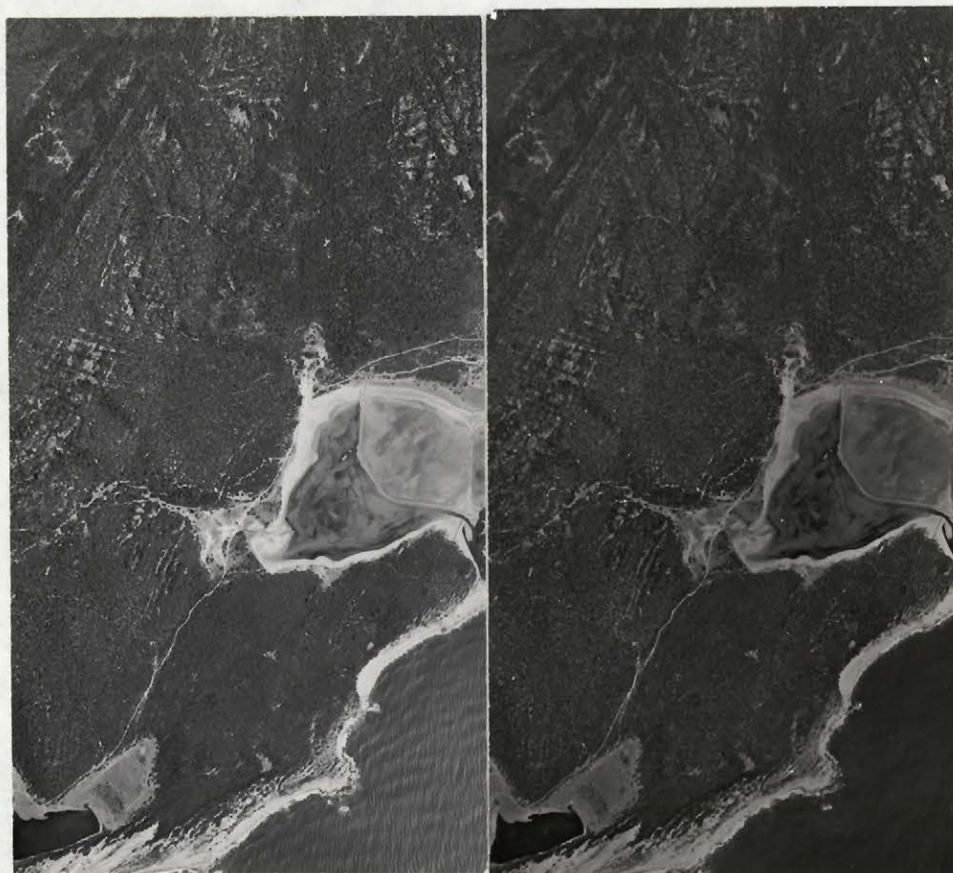


FIGURE 32

Resistant Rock Knobs and Rounded Interfluves,
Pottuvil Coastal Plain

thence northeast. This flow apparently does not have much affect north of Arugam Bay. It is possible that material carried by this flow is eventually deposited in the less active zone from Arugam Bay to Kalkudah. It is probable that the reverse of this condition exists during the northeast monsoon but to a lesser degree. Thus, the Batticaloa-Kalmunai coast may erode to a certain extent during the northeast monsoon, but not to the extent that it builds up during the southwest monsoon.

The Bentota Coastal Plain

The Bentota Coastal Plain extends from the Kirama Oya at Tangalla on the south, to the Kelani Ganga at Colombo on the north.

This section of the Coastal Plain of Ceylon differs from the Mannar, Trincomalee, and Pottuvil sections in that it consists almost entirely of drowned river valleys. The proven existence of 100 or more feet of alluvium in several of the river valleys, forty to fifty miles inland from the coast; the fact that the present bottoms of these valleys are less than 100 feet above sea level; and the innumerable, steep sided, bedrock ridges rising from flat, alluvium floored valleys which are at or within 100 feet of the present sea level (Fig. 33), indicate their drowned nature. For this reason, the width of the Bentota Coastal Plain is extremely variable. For this reason also, the inland

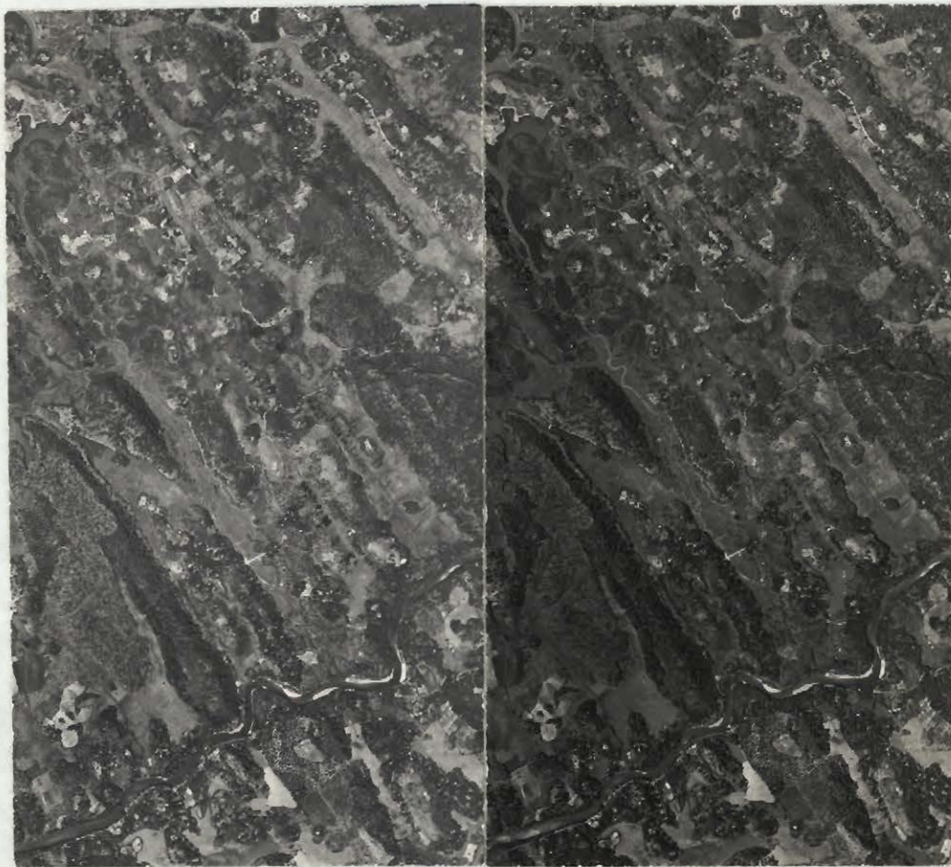


FIGURE 33

Drowned Valleys and Emergent Rock Ridges,

Bentota Coastal Plain

Eucalyptus
RECOVER BOND
25% COTTON RIBBON
USA

margin of the plain is very complex. It follows a pattern of strike-, fault-, and joint-controlled valleys rather than the dendritic pattern common to the plains already described.

The shoreline is also rather different. It is, in effect, a rock defended coast line modified by wave and current action. From Galle north, it takes the form of a series of low, bedrock, strike ridges projecting in a north-northwest direction at a low angle to the general trend of the coast. The projecting ends of these ridges are joined to the next ridge inland by sand bars which have thus blocked off the seaward outlet of the inter-ridge strike valleys. Many of the lagoons so formed have been filled with alluvium to the present base level. From Galle south and eastward, somewhat similar conditions exist with respect to the rock defended nature of the coast, but with the following differences. At Galle, the rock ridges strike south-southeast on the west side of the harbour, east-west in Gibbet Island, and southeast-by-south on the east side of the harbour (Fig. 34). At Weligama Bay the rock ridges are in line with the shore and are exposed on both sides of the bay mouth (Fig. 35). At Dondra Head, rock forms the promontory upon which the light house stands. Rock is also exposed as sea cliffs with intervening small bays eastward to Tangalla.

The presence of Galle Harbour, Weligama Bay, and the numerous small, unnamed bays mentioned above, gives this southern section

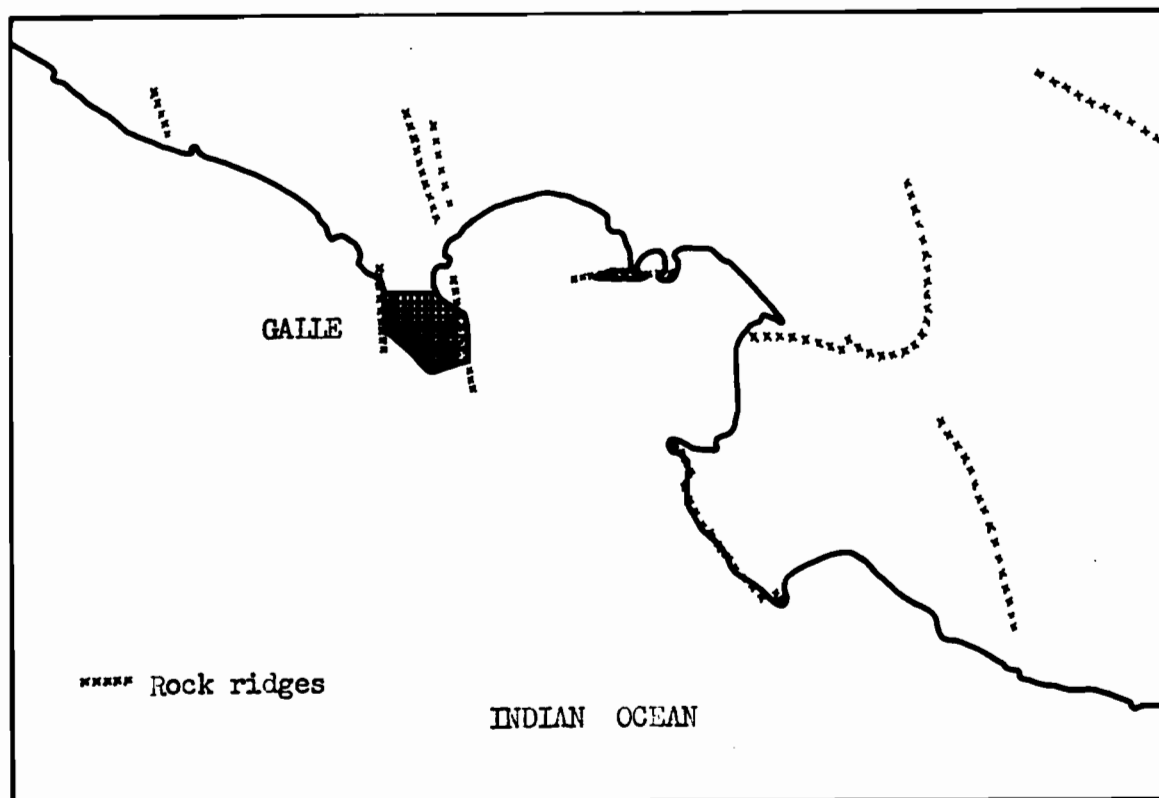


FIGURE 34

Galle Harbour and the Controlling Rock Ridges

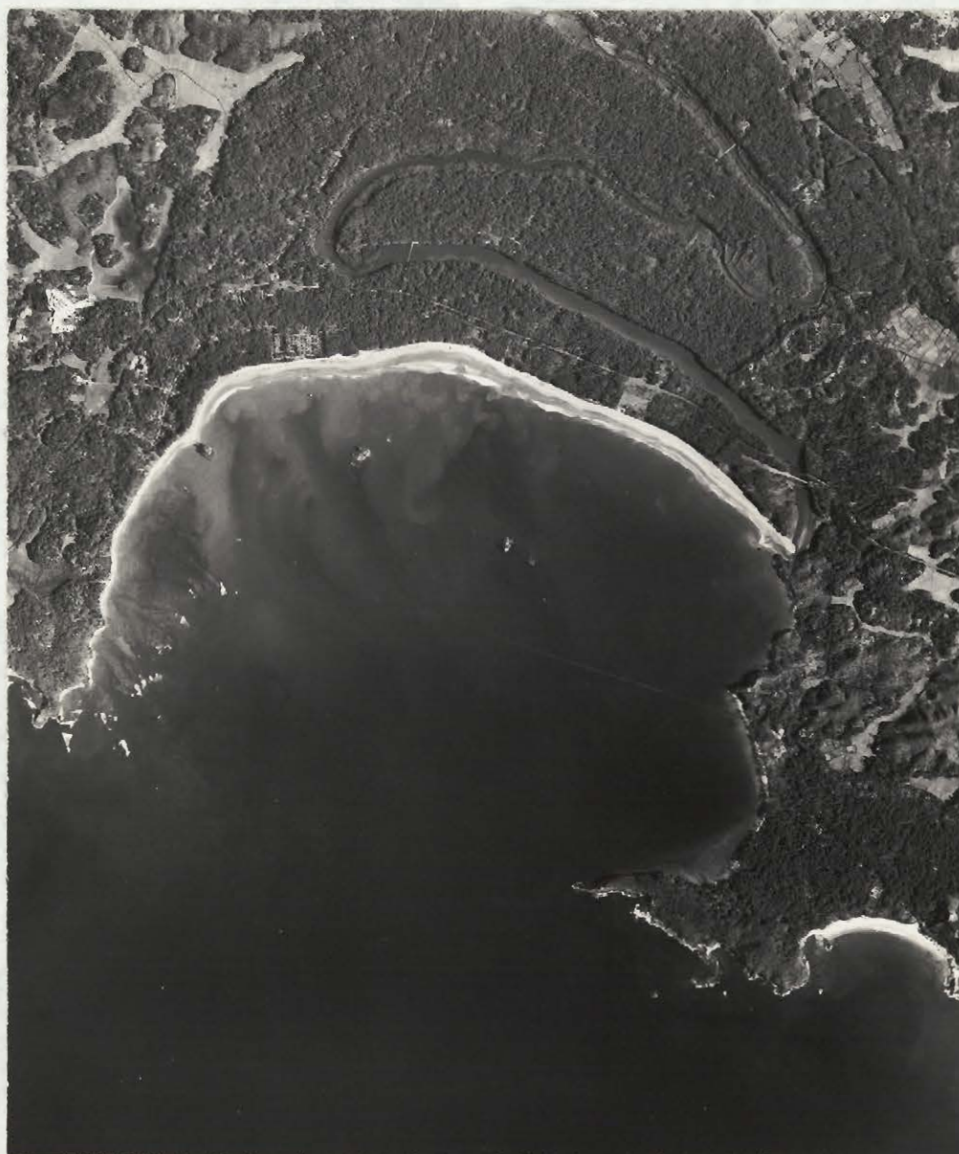


FIGURE 35

Weligama Bay

of the Bentota Coastal Plain the most irregular shoreline in Ceylon.

From Galle north, the rocky points have acted as groins and breakwaters, angled out into the path of the strong waves generated by the southwest monsoon, and the littoral current present during the northeast monsoon. As such they have induced deposition in their lee and have tended to form a fairly continuous, though somewhat scalloped shoreline. On the other hand, the rock ridges and cliffs from Galle eastward have defended the land directly behind them and allowed wave and current erosion to carve bays in the undefended gaps between them. Galle Peninsula, Galle Harbour, the eastern promontory of Galle Harbour, Weligama Bay, the shallow curving bay at Matara, Dondra Head Peninsula, the small bays east of Dondra, and Mawella Kalapuwa, all owe their existence to this process. Bay-head or crescent beaches exist in all of the above mentioned bays but only in the bays fed by major streams do they appear to be growing. The long curved path of the Polwatta Ganga at Weligama Bay appears to be the result of the re-working, by wave and current action, of sediment brought down by the river (Fig. 35). Similarly, the bar forcing the mouth of the Nilwala Ganga at Matara, to the west, is probably controlled by beach drifting and long shore currents active during the northeast monsoon.

True spits are not common along the south and southwest parts of the Bentota Coastal Plain, possibly because the strong wave and

current action resulting from the southwest monsoon has eroded most of the sandy material from this area leaving the bedrock exposed as shore cliffs. However, along the west coast, spits were noted at the mouth of the Bentota Ganga, at the mouth of the Kalu Ganga, and at the mouth of the Bolgoda Ganga. The Bentota spit may be rock controlled, since it trends northwest in line with a rock ridge inland to the southeast and a reef development offshore to the northwest. At Kalutara, a spit from the north and a recurved spit from the south, almost close off the mouth of the Kalu Ganga and do form a small lagoon. The spit separating Bolgoda Lake from the sea begins at Moratuwa and extends southward almost to Panadura, a distance of four and one half miles. It consists of a flat, low, sand bar with no apparent rock control.

Inland from the coast, as mentioned earlier, the plain consists of a very complex network of low, flat, alluvium filled, drowned valley bottoms separated by strike ridges (Fig. 33).

Near the coast, low, rounded, deeply weathered interfluves are common; further inland, where the Coastal Plain extends up relatively narrow valleys, the interfluves may be steep-sided, hog-back, strike ridges.

The rivers of the Bentota Coastal Plain drain an area with the highest rainfall on the island (Fig. 11, Fig. 12, and Fig. 13), and have an exceptionally high recorded flow. During the southwest monsoon they

frequently overflow their banks and flood the surrounding lowland.

In summary, the Bentota Coastal Plain consists of a network of drowned river valleys, distributed among bedrock ridges. It has an essentially rock ridge defended coast, containing silted up valley mouths and lagoons in the northern part; and wave and current eroded bays in the south. Little evidence of recent differential movement is visible, the drowning of the valleys being attributed to diastrophic action or eustatic changes in sea level. The presence of coral reef ridges inland from the present coast line, at an approximate elevation of 40 to 60 feet, indicates a rise in the land relative to the sea.

An interesting addition to the above discussion is the relatively recent substantiation by airborne radioactivity surveys of the existence of beaches and associated beach deposits inland from the present coastline. The results of this survey, though not available for publication, clearly outlined deposits of radioactive sand which had been concentrated as beaches during an early, higher level of the sea.

The intense weathering, the formation of lateritic soils on the interfluves of the plain, and the extensive valley bottom sedimentation to the present base level, will necessitate a much more detailed study of this area to determine the exact history of development.

The Low Level Plain

General

As defined here, the Low Level Plain of Ceylon extends from the inland margin of the Coastal Plain to the lower slopes of the Central Massif, Knuckles Massif, and Sabaragamuwa Hills. To facilitate description and because of some variations, the plain has been divided into four regional units; the Anuradhapura Peneplain, the Polonnaruwa Peneplain, the Tanamalwila Peneplain, and the Southwest Peneplain (Fig. 20).

The classification of peneplain is based on the theory that this is essentially an erosional surface cut into the well weathered, partially weathered, and more or less unweathered bedrock of the island by processes which are predominantly down-wearing rather than back-wearing. It is not intended that this discussion should solve the peneplanation-pediplanation controversy, but rather that it should put forward some observations on an area characterized by a surface which is almost a plain; which truncates varying rock types and structures; which is underlain by variable thicknesses of residual and alluvial soil; and which is surmounted by an extensive collection of monadnock-, inselberg-, and bornhardt-like erosion remnants, with and without associated jointing and tor-type rocks. This approach appears to be substantiated by the recent work of Budel (1957) and Ollier-Melbourne (1960).

Conversely, according to King (1962) this surface would probably be classed as a pediplain and the dominant process in its formation pediplanation.

The resistant ridges, which extend as a relatively narrow band from the Knuckles Massif to the coast at Trincomalee, thus separating the two northern peneplains, have been classified as the Elahera Ridges and will be discussed in a subsequent section.

The group of well marked erosion remnants or monadnock type hills and resistant ridges centred on the Gal Oya reservoir between the Polonnaruwa Peneplain and the Tanamalwila Peneplain, have been classified as the Gal Oya Hills and will also be discussed in a subsequent section.

In general, the streams crossing these peneplains appear to be at grade and only in particular cases is active vertical erosion important.

The Anuradhapura Peneplain

The Anuradhapura Peneplain is bounded on the northwest by the Mannar Coastal Plain, on the northeast by the Trincomalee Coastal Plain, and on the south, approximately by a northeast-trending line joining Veyangoda, Mirigama, Kurunegala, Galewela, Habarane and Pankulam (Fig. 20).

In general, it consists of a gently undulating surface rising from the 100 foot contour along the Coastal Plain to a maximum elevation of 800 feet at the base of the Nalanda Shelf. Over most of its area, it does not rise above 600 feet and has a very low local relief. The exceptions are the monadnocks or inselbergs and the resistant strike ridges, which extend onto the plain in the south-central part. These features vary from small rock knobs 100 to 700 feet high, such as Watershed Point in the Iranamadu area (247 feet); to steep sided ridges and peaks up to 2,500 feet in height, such as Weddakanda in the Medawachchiya area (839 feet), Sangilimalai in the Horowupotana area (1,351 feet), Mihintalekanda and Katupotakande in the Anuradhapura area (1,014 and 1,319 feet respectively), Ritigala in the same area (2,513 feet), Galgiriya and Dambulla in the Dambulla area (1,877 and 1,146 feet respectively), Beliyakanda in the Nalanda area (2,014 feet), and Kurunegala Rock with its extension Yakdessagala (1,100 and 1,721 feet respectively) in the Kurunegala area. From these monadnocks, bornhardts or inselbergs, the plain presents a picture of flat, featureless, jungle stretching for miles in all directions, and broken only by other monadnocks or strike ridges in the distance (Fig. 36).

Weathering on this peneplain appears rather intense despite the present semi-arid nature of the climate. This may be due to chemical weathering as will be discussed subsequently, or to the effects of an



FIGURE 36

Anuradhapura Peneplain from a Monadnock

Near Maha Iluppallama

earlier, more humid climate. In any event, deep residual soils occur both in the areas devoid of erosion remnants and in the valleys among them. In the northwest, where soils are developed on the Miocene limestone, reddish terra rosa soils are reported (Joachim, 1955), elsewhere on the gneissic bedrock, granular soils are common. Water wells drilled at the Maha Iluppallama Dry Farming Research Station southeast of Anuradhapura, penetrated thicknesses of residual soil of the order of 50 or 60 feet before reaching bedrock. Further south, great thicknesses of alluvial soils have been deposited over the surface of the plain by the outflow from several major valleys heading in the Central Massif. It is considered here that much of this deposition was due to rejuvenation of the north-flowing rivers of the Central Massif by tectonic uplift. The "Plateau Deposits" of Wayland (1919) are probably of this origin.

At present, erosion does not appear very active on the Anuradhapura Peneplain. This situation is probably due in part to the generally low rainfall, in part to the permeable nature of the soils with resultant low runoff, and in part to the overall low relief of the peneplain and the associated low gradient of the rivers which are at or near base level.

The erosion remnants names previously which are scattered over the plain in the form of monadnocks, bornhardts, inselbergs, rock

knobs, and strike ridges, are indicative of the long periods of time during which Ceylon has been exposed to the processes of weathering, mass-wasting, and erosion, whether one accepts the peneplanation theory of Davis (1899, 1902, 1905, and 1930), the pediplanation theory of King (1948, 1951, 1953, and 1962), or one or more of the related theories of Bornhardt (1900), Willis (1936), Freise (1938), Macar (1949), Birot (1950), Dresch (1950), Baulig (1952 and 1956), Cotton (1955), Budel (1957), or Ollier-Melbourne (1960). Sigiriya and its sister rock to the north, are excellent examples of the bornhardt or inselberg form (Fig. 37 and Fig. 38), and the hills shown in Figure 36 are fine examples of the monadnock form.

The drainage patterns of the rivers of the Anuradhapura Peneplain show only slight structural control. This occurs in the eastern and southern parts of the plain where the strike ridges are dominant. Even here, they are only confined to a minor degree and wander back and forth across the broad inter-ridge valleys without hindrance. At one or two places in the northwest, stream courses appear to follow a relatively linear path for some distance but other streams in the vicinity do not show any particular linearity to substantiate possible structural control. In view of the degree of drainage pattern control by bedrock structure throughout the remainder of the island however, it is probably that a more detailed analysis of this area would reveal

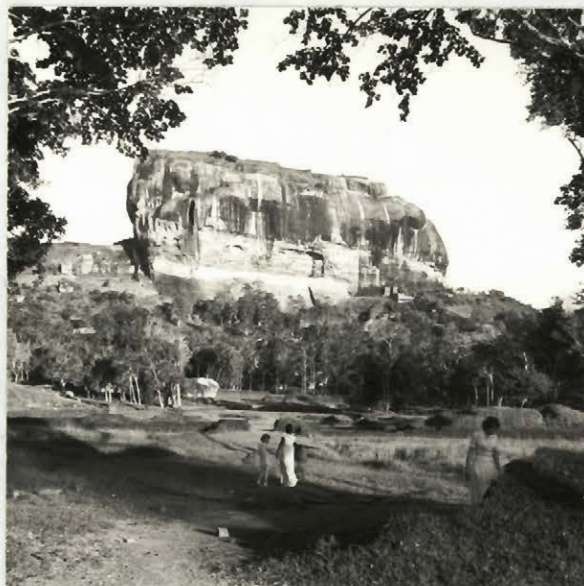


FIGURE 37

Sigiriya, a Bornhardt or Inselberg

Type Erosion Remnant

Erasmu
 PLOVER BOND
 25% COTTON FIBER
 U.S.A.

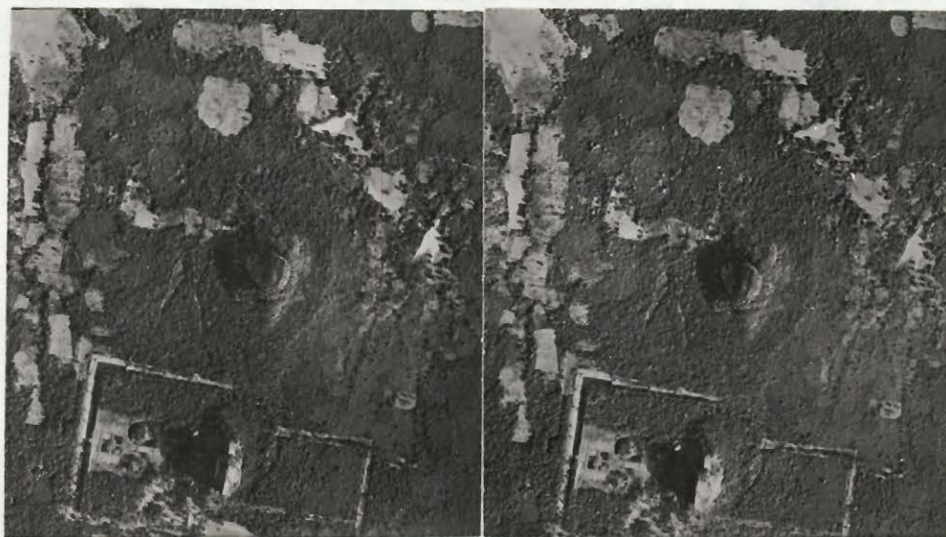


FIGURE 38

Sigiriya and Sister Rock; Bornhardt or Inselberg

Type Erosion Remnants

evidence to modify the above observations. In the southwest section of the plain, for example, the stream pattern closely follows the bedrock structure. This is particularly true in the Kurunegala area.

The vegetation of the Anuradhapura Peneplain is predominantly jungle. It varies from well developed forest in the south to poorly developed scrub jungle along the northern margins. The jungle in itself is a strong protective medium for the soils of the plain, fostering weathering but hindering erosion.

The Polonnaruwa Peneplain

The Polonnaruwa Peneplain extends from the Trincomalee-Pottuvil Coastal Plains on the east to the Elahera Ridges and Central Massif on the west and to the Gal Oya Hills on the south (Fig. 20).

It consists, for the most part, of a low, flat-to-gently-undulating, alluvium veneered, bedrock peneplain. Outcrops occur along both sides of the Mahaweli Ganga and are scattered throughout the plain. At Polonnaruwa, one of Ceylon's most famous ancient ruined cities, these outcrops have been carved into many impressive statues (Fig. 39). Some of these statues illustrate the nature of the bedrock extremely well as the head of the reclining Buddha shows (Fig. 40). Erosion remnants such as Gunners Quoin (1,672 feet), Dolagalgala (1,325 feet), Omunagala (1,685 feet), and Lindagala (1,279 feet),

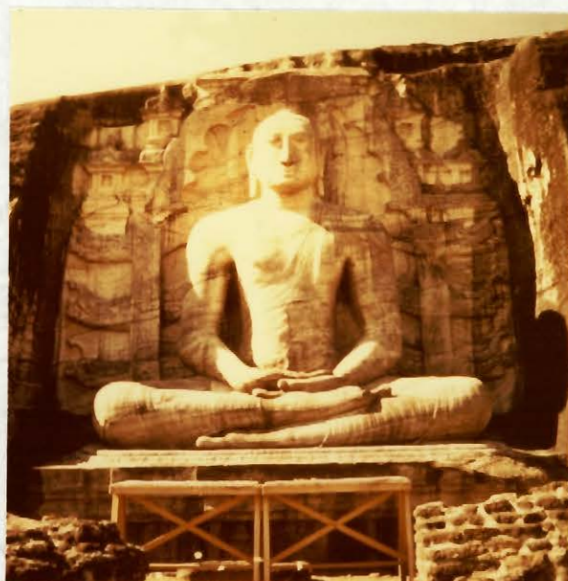


FIGURE 39

Sedent Buddha Carved from Bedrock
at Polonnaruwa



FIGURE 40

Gneissic Pattern of Bedrock, Head of Reclining Buddha,
Polonnaruwa

become more numerous as the Gal Oya Hills are approached. In the Rukam area and further south in the Maha Oya area, on the border of the Gal Oya Hills, structural control of drainage is well marked over the shallow bedrock, but in adjacent alluvium filled valleys, the streams are uncontrolled.

With respect to the erosion remnants on the plain, weathering, erosion, and mass-wasting are in many cases controlled by joints or faults. Thus, when a large mass of this nature reaches an advanced stage of decomposition and disintegration, it is often in the form of a group of isolated, steep sided, rock hills separated by enlarged joint or fault valleys (Fig. 41). It is probable that any elevation of this peneplain would result in rapid erosion of the weathered material surrounding these features and they would thus be perpetuated at a new, higher elevation.

Aerial photographs of the Polonnaruwa Peneplain give a very clear picture of the degree of control exercised by bedrock structure. They show everything from major ridges a thousand or more feet in elevation, down to insignificant, knife edge ridges scarcely projecting above the jungle growth. In some instances they show the trend of ridges by patterns in the vegetation only (Fig. 42). The general trend of these ridges and therefore the grain of the country is north-south. However, in several areas local variations and contortions occur.

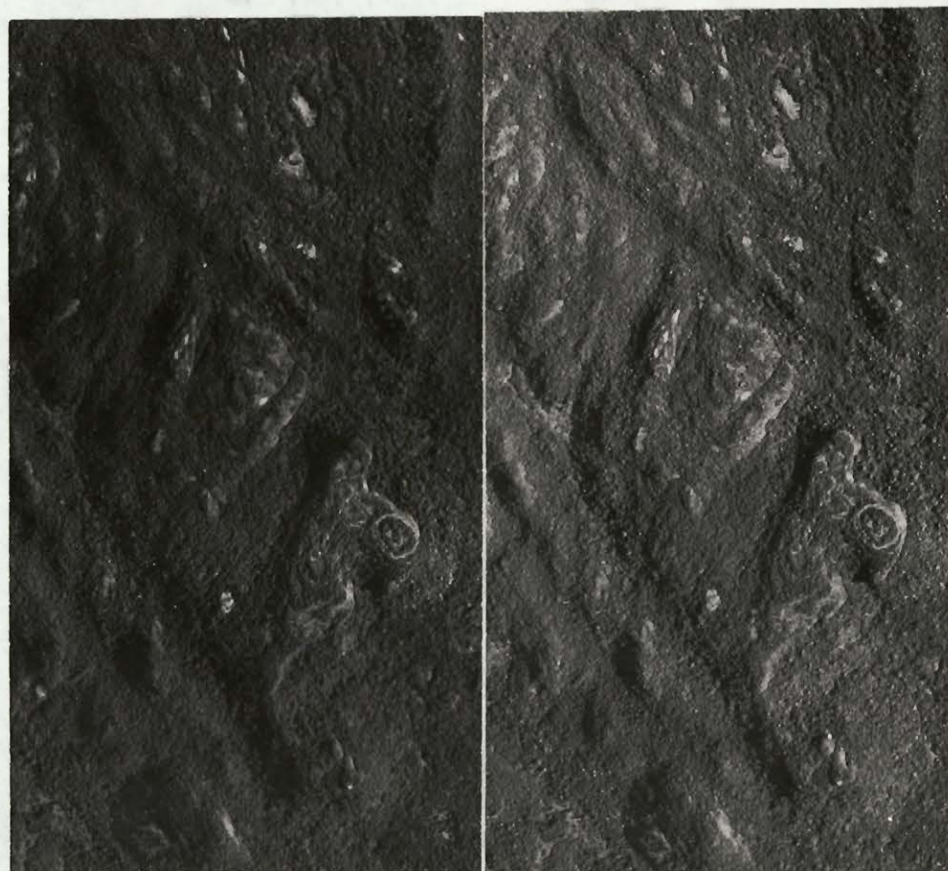


FIGURE 41

Rock-block Hills Separated by Weathered Joints or Faults,
Northern Margin of the Gal Oya Hills



FIGURE 42

Bedrock Structure Delineated by Vegetative Pattern,
Polonnaruwa Peneplain

The effect of bedrock structure on the general drainage pattern is not as marked as might be expected. Only where the bedrock is exposed or under a very thin veneer of residual or alluvial soil, is control clearly demonstrated. Elsewhere, except in a broad sense, the mantle of soil appears sufficiently thick to allow the streams to develop an uncontrolled, generally dendritic pattern.

The Mahaweli Ganga, which is the largest river in Ceylon, draining most of the Central Massif, Knuckles Massif, and Polonnaruwa Peneplain, is controlled from where it leaves the Central Massif to a bend forty-two miles downstream. Rock ridges, and outcrops on both sides of the river indicate that it is following a broad strike valley for most of this distance. It is possible that the first ten mile section is controlled by a major fault, which may be the eastern boundary fault of the Knuckles Massif. The remainder of the river below the above mentioned bend flows in a wide alluvial flood plain.

The Mahaweli Ganga is an excellent example of a river which reaches virtual base level many miles from the sea. At Ambagahaplessa in the Minipe area, where it leaves the Central Massif, it is at an elevation of 300 feet above sea level. From this point, it is one hundred and twenty-four miles to the sea at Koddigar Bay, Trincomalee (Mahaweli Ganga Profile, Appendix A, in pocket). This portion of the river, which thus has a gradient of approximately 3 feet per mile, is

subject to flooding. This is evidenced by the formation of natural levees along its banks (Fig. 44).

In summary, the Polonnaruwa Peneplain consists of a low, flat-to-gently-undulating bedrock plain, rarely rising above 400 feet, with a variable mantle of deeply weathered residual soils and alluvium. Drainage is to the north and northeast by slow moving, low gradient rivers, flowing in broad alluvium filled valleys only occasionally controlled by bedrock structure. Vegetation consists almost entirely of dense jungle with here and there patches of more open parkland. Erosion remnants in the form of strike ridges, low rock knobs, and well marked monadnocks or inselbergs provide the only relief.

The Tanamalwila Peneplain

The Tanamalwila Peneplain is bounded by the Sabaragamuwa Hills and Southwest Peneplain on the west, by the Central Massif and Gal Oya Hills on the north and northeast, and by the Pottuvil Coastal Plain on the east, southeast and south (Fig. 20). It varies in width from ten to thirty miles, being narrowest in the northeast and widest in the southwest.

The Tanamalwila Peneplain consists of a flat-to-gently-undulating bedrock plain with a moderate to thin veneer of residual and alluvial soils. The bedrock is generally uniform under most of the

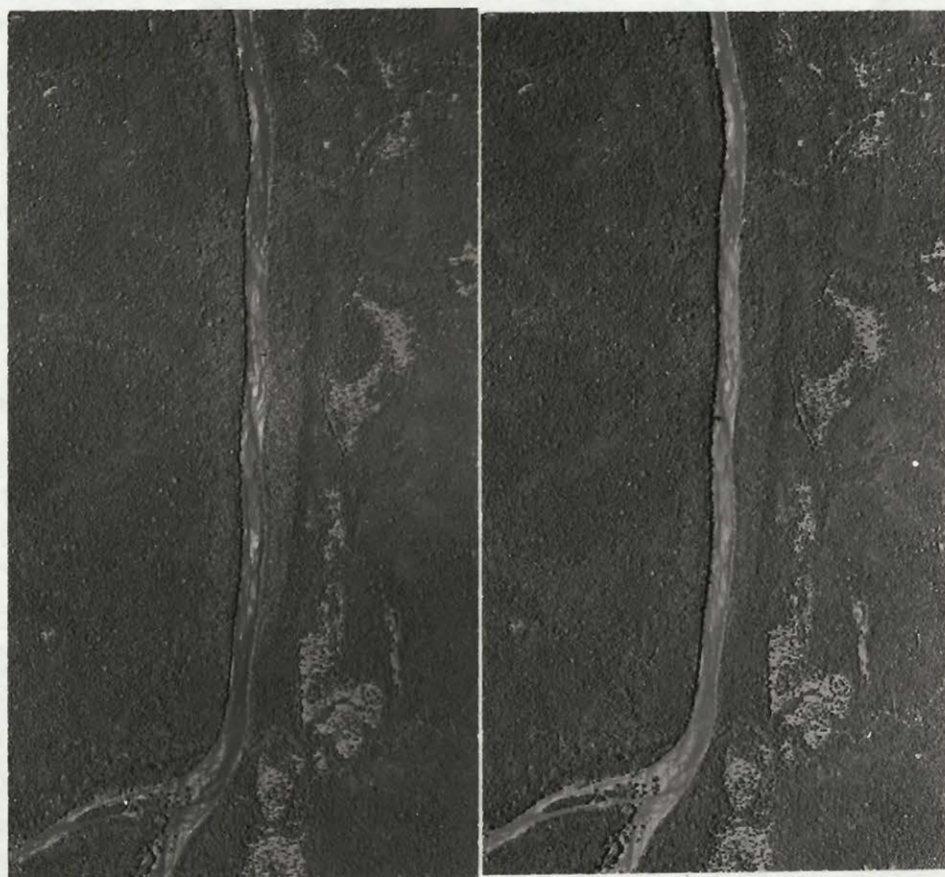


FIGURE 44

Natural Levees, Mahaweli Ganga, Polonnaruwa Peneplain

Essex
FLOWER BOND

25% COTTON FIBER

U.S.A.

plain, being essentially a biotite gneiss (Oliver, 1958). In the south-east, north of Hambantota, this rock becomes somewhat more granitized or massive. This is indicated by a change in vegetation, which is probably due to drainage conditions as well as the chemical nature of the soil. This change is further reflected by a particular pattern on the aerial photographs (Fig. 45). This pattern is the result of localized vegetative growth along the joints of the bedrock because of increased moisture. Jointing of this nature is more common in massive, granitic type rocks than in more well bedded or foliated varieties.

Elsewhere on the plain, strike ridges project from the jungle to give an effective indication of the local structure (Fig. 46). The strike ridges result from the differential weathering out of the more resistant beds. A similar process is responsible for the monadnocks or inselbergs which are common to this area. In this case the resistant rock is granitic in nature and weathers out as a peak or knob (Fig. 47). Kataragama (1,390 feet), Wadinahela (2,183 feet), and Tammitakanda (1,171 feet), are examples of this type of feature. These erosion remnants vary in size from rock knobs scarcely projecting above the jungle to prominent peaks visible for miles across the flat plain. In the south and east these remnants may be surmounted by, or composed of, large boulders or tors. Examples of this topographic form are shown in Figure 48, which is also an excellent illustration of the typical peneplain surface.



FIGURE 45

Drainage Pattern Characteristic of Granitic Gneiss,
Northwest of Hambantota, Tanamalwila Peneplain



FIGURE 46

Strike Ridges of Synclinal Bedrock Structure,
Tanamalwila Peneplain

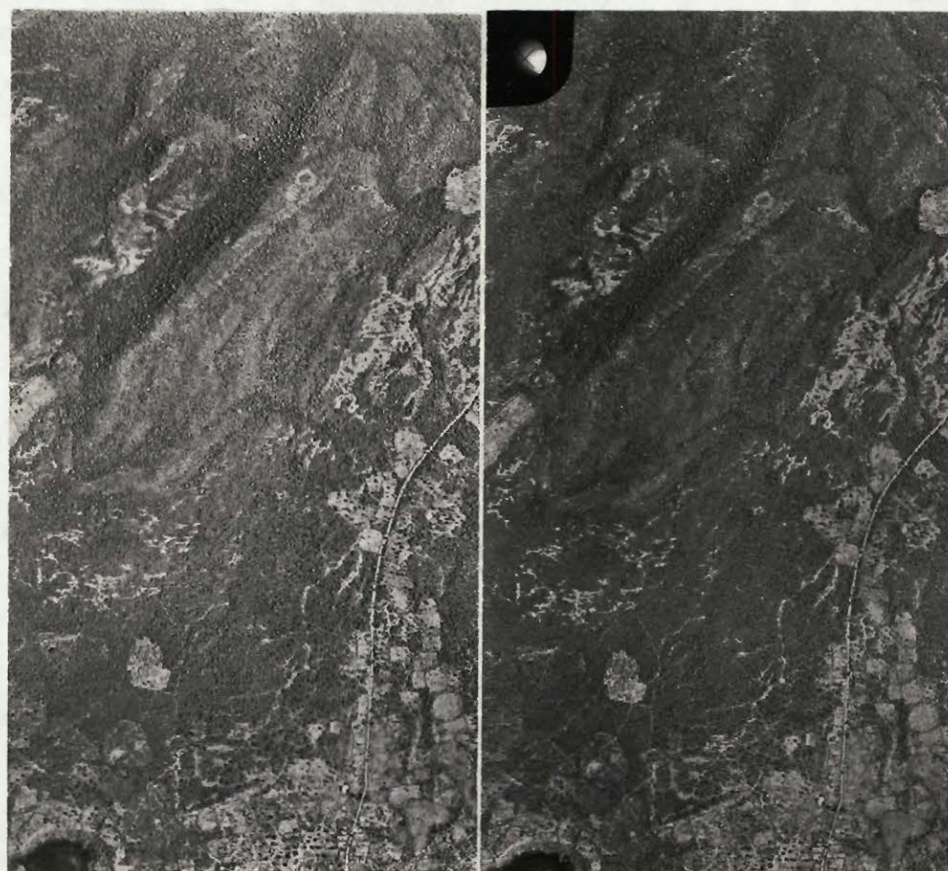


FIGURE 47

Granitic-gneiss Erosion Remnant Near Kataragama,
Tanamalwila Peneplain



FIGURE 48

Tanamalwila Peneplain, Associated Erosion Remnants, and Tors
from Magulmaha Vihare Pokuna

Weathering on the Tanamalwila Peneplain appears to be dominantly chemical in nature. The weathering of the gneissic rocks characteristic of this region to essentially granular soils, aids the infiltration of moisture bearing air and allows internal drainage to keep the water table low enough for this process. The rainfall, though not generally sufficient for agriculture, does provide moisture for the chemical decomposition processes. The heavy jungle vegetation which is present over approximately nine tenths of the plain, also aids the chemical weathering processes by contributing organic acids of decay, and protects the soil from erosion. This latter point is substantiated by the erosion developing on recently cleared land in the southwest (Fig. 49). In the northwest part of the plain, along the base of the Sabaragamuwa Hills and low hills bordering the Molamure Shelf, rocks possibly of the Khondalite System have weathered to a more clayey soil, which in addition to having a characteristic light tone on the aerial photographs, also illustrates the finely dendritic gully pattern of clay erosion (Fig. 50).

Erosion on the Tanamalwila Peneplain is, at its present stage of development, moderately weak. Most of the streams of the areas, except in their headwaters, are at or near base level, and erosion and deposition balance each other. In the southwest, as mentioned earlier, some indication of erosion is present which may be the result of a

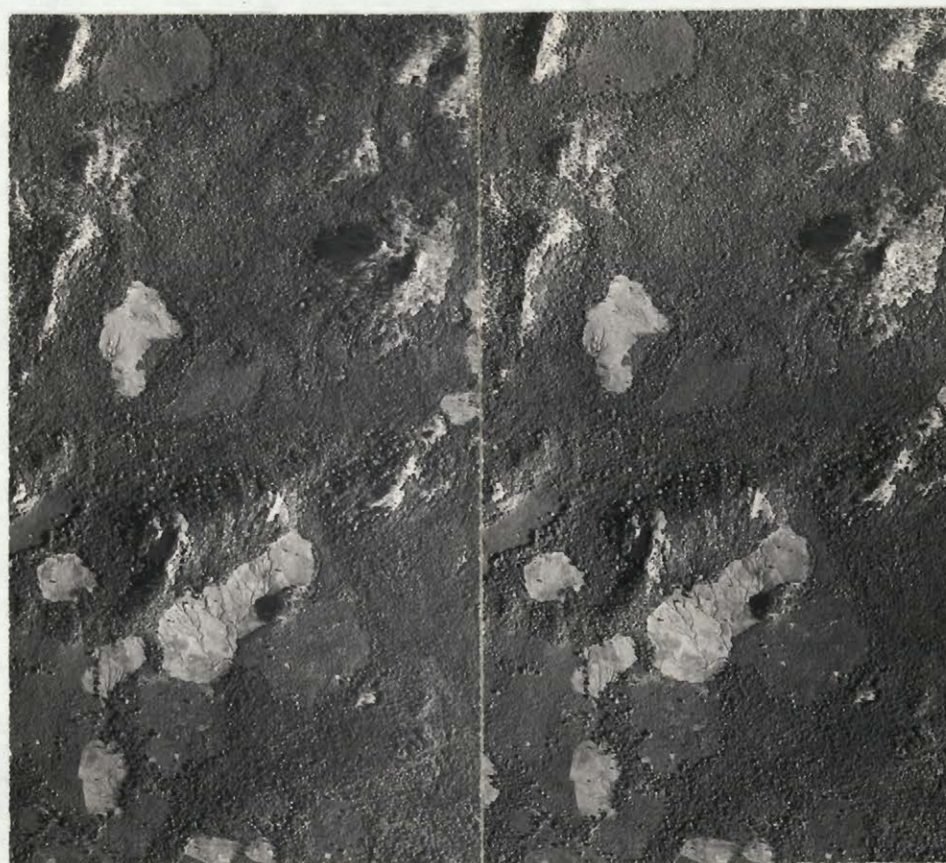


FIGURE 49

Erosion on Bared Lower Slopes of Monadnocks,
Tanamalwila Peneplain

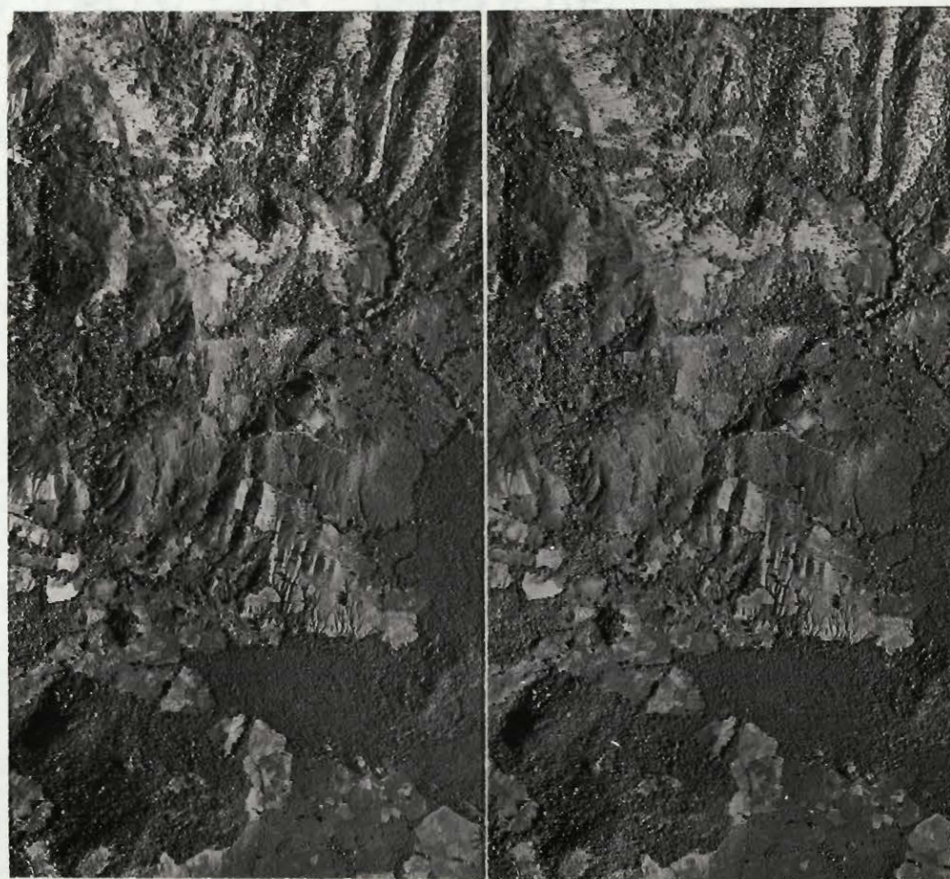


FIGURE 50

Erosion in Clay Soil, Northwest Tanamalwila Peneplain

slight rejuvenation of the entire plain. This latter interpretation is dependent on the erosion of these valleys in the southwest; on the fact that the lower course of the Walawe Ganga flows in a relatively steep sided, narrow valley; and that some streams on the plain, such as the Kirindi Oya, Kuda Oya, and some of the smaller tributaries visited in the field, all are flowing in channels roughly 10 to 15 feet below the general level. The bottom of the Kirindi Oya, except where it is broad and alluvium filled near its mouth, is on bedrock. Heavy rainfall and rapid runoff in the headwaters of these streams along the southern face of the Central Massif, has probably resulted in the formation of the narrow, incised channels characteristic of the main streams mentioned above. Certainly the flow of these rivers reflects very rapidly, heavy rains in their headwaters. The intensity of flow is also substantiated by the presence in the channels many miles out on the plain, of boulders of rocks characteristic of the Central Massif.

It is possible that, failing a slight rejuvenation of the entire plain, a small portion in the southwest may have been slightly upwarped as a marginal phase of the elevation of the Sabaragamuwa Hills. The raised, wave cut terraces near Tangalla may be the result of a movement of this nature (Fig. 51).

Another feature of the Tanamalwila Peneplain is the alignment of some of the major rivers and their tributaries along probably faults.

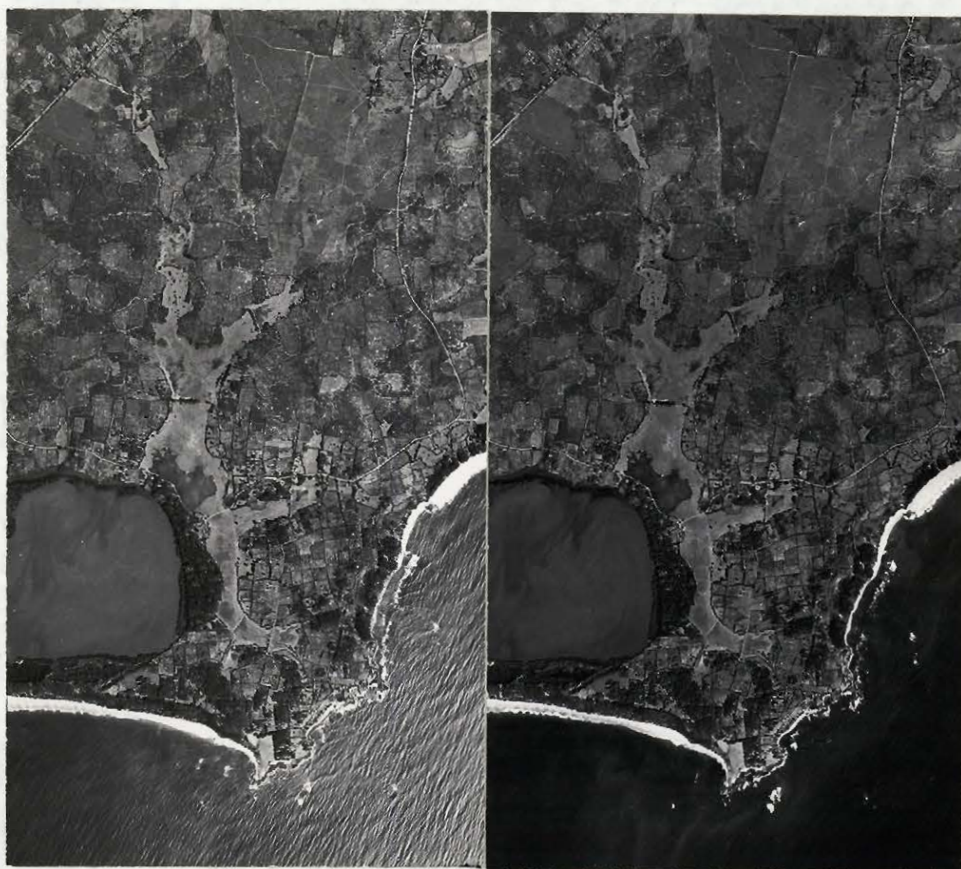


FIGURE 51

Elevated Wave Cut Terraces Near Tangalla, South Coast

The headwaters of the Walawe Gange, the Kuda Oya and Diyabetma Oya, tributaries of the Kirindi Oya, and some of the headwater tributaries of the Kumbukkan Oya illustrate this feature.

Heavy jungle is characteristic of approximately nine tenths of the Tanamalwila Peneplain (Fig. 52 and Fig. 53). It is most dense in the moister areas near the hills, but nowhere does it have the tropical rain forest characteristics. As the more arid coastal region is approached, it grades into a low scrub jungle of thorny bushes, euphorbia, and other drought resistant types of vegetation (Fig. 54).

A final interesting feature noted with respect to this area, consists of a soil profile. In quarries for road metal, in road cuts, and in pits dug for soil studies, a characteristic sequence of soil texture and composition is visible. Briefly, it consists of a variable thickness of silty loam with rounded pebbles, overlying a zone characterized by very numerous angular, quartz pebbles (Fig. 55). The break between the two horizons is abruptly and apparently fairly uniform laterally. There are places on the plain where this sequence was not observed but its absence was not proved conclusively by digging or drilling. No entirely satisfactory explanation for this feature has been advanced and it is considered here as a subject for much additional detailed study. A somewhat similar feature has been reported in Africa and South America by H. S. Scott (personal communication). Parizek and Woodruff (1957)

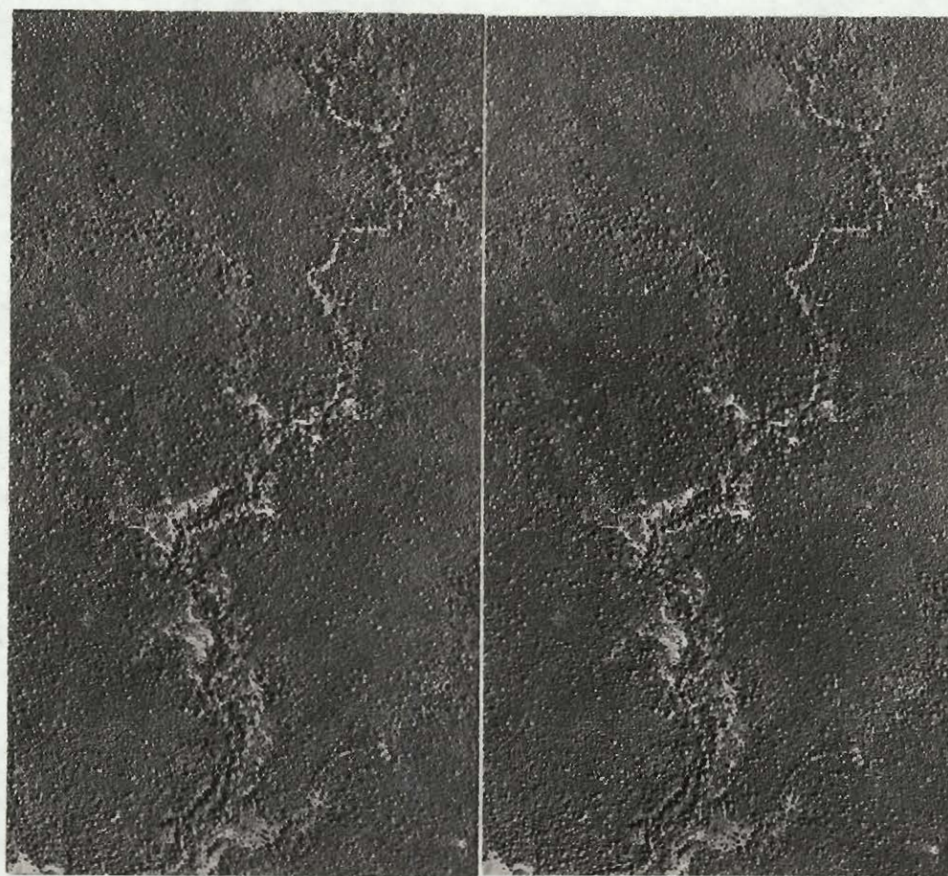


FIGURE 52

Heavy Jungle, Tanamalwila Peneplain



FIGURE 53

Jungle Surrounding Small Tank and Patches of Chena Cultivation,
Tanamalwila Peneplain, from Helicopter



FIGURE 54

Dry Scrub Jungle and "Whale Back" Outcrop
Near Tissamaharama, Tanamalwila Peneplain



FIGURE 55

Quartz-pebble Horizon in Soil
Overlying Bedrock, Near
Hambantota

have described stone layers in soils of the southwestern United States, which may be somewhat similar to these quartz-pebble zones. They have termed them carpedoliths.

In summary, the Tanamalwila Peneplain consists of a low, flat-to-gently-undulating plain of weathering and erosion, truncating rocks of several different types and structures. A veneer of residual and alluvial soils of variable thickness overlies this plain and is broken by numerous rock outcrops in the form of low, rounded "whale backs" (Fig. 56), as well as knobs, ridges and monadnocks or inselbergs. Erosion at this stage of development is apparently not excessive. Weathering is undoubtedly active down to the water table, but is most evident on the local relief forms.

The Southwest Peneplain

The Southwest Peneplain consists of a large number of separate fragments of what was once an extensive, shelf-like plain marginal to the Sabaragamuwa Hills (Fig. 20). Its present elevation of approximately 600 feet may drop to 200 or 300 feet along the Coastal Plain. Its classification as a peneplain is dependent on numerous factors among which are: the accordance of surfaces; the truncation of structure and lithologic types; and the existence of rivers with their headwaters flowing in mature valleys and their middle reaches flowing in youthful valleys.



FIGURE 56

Gneissic "Whale Backs" in Dry Scrub Jungle
Near Tissamaharama, Tanamalwila Peneplain

The deep dissection of this plain is due; in part to its age, which is considered probably equivalent to the three low level peneplains already described; in part to its location in an area of extremely high rainfall; and in part to the fact that several major river systems cross this area and drain the west face of the Central Massif and the Sabaragamuwa Hills, also areas of very heavy rainfall.

The delineation of the Southwest Peneplain was based on stereoscopic study of the aerial photographs and comparison of the areas, which appeared to have a well marked accordance of summit levels, with the one mile to one inch topographic maps. Where the topographic maps substantiated the interpretation of the aerial photographs, and where other criteria of peneplanation were evident, the area was classified as such.

The Southwest Peneplain has been developed on a very strong structural and lithologic pattern. The area, geologically speaking, consists of a wide belt of well foliated, metamorphic rocks of somewhat variable lithology. Beds of resistant rock alternate with beds of weaker rock and the whole has been tightly folded to form a series of anticlines and synclines. In some cases the anticlines and synclines are more or less open, in others, they are so tightly folded that the beds become isoclinal or may be overturned. In addition to the tight folding, faulting and/or jointing has been very active. Weathering and erosion,

acting upon this geologic base, have developed a well marked pattern of strike ridges, strike valleys, and fault or joint valleys (Fig. 57 and Fig. 58). The heavy rainfall and high temperatures have accelerated chemical weathering particularly, and the high rainfall with associated heavy runoff has intensified erosion, so that dissection and degradation of the general terrain is rapid. For this reason, it is difficult to say with any certainty, what the exact boundaries of the Southwest Peneplain were before dissection. Therefore, only the areas considered to be remnants of this plain, have been outlined on the accompanying map (Fig. 20).

Few extensive areas of low relief are visible on these peneplain remnants, however, areas consisting of a large number of low hills with accordant summits and alluvium filled valley bottoms are common. In some cases it is possible to define roughly accordant levels on both sides of deeper valleys (Fig. 59). In others, the remnants of a clearly defined erosion surface truncating present hills are visible (Fig. 60).

Another problem encountered in delineating the Southwest Peneplain is that of structurally controlled erosion levels or local base levels. These features consist, in many cases, of a group of interconnected valleys bounded by strike ridges and maintained at a certain level by lithologically resistant barriers. The valley bottoms are generally filled with alluvium to this dominant controlling level; the

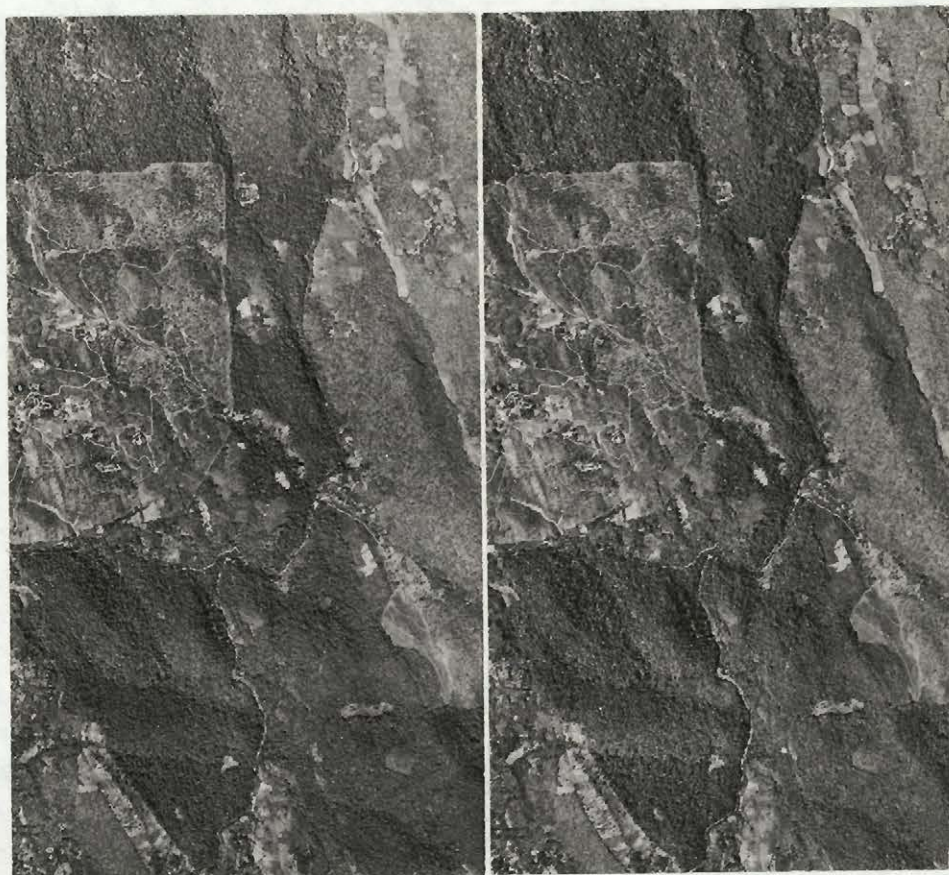


FIGURE 57

Strike Ridges, and Strike, Fault, and Joint Controlled
Valleys, Southwest Peneplain



FIGURE 58

Strike and Joint Controlled Valleys, Southwest Peneplain

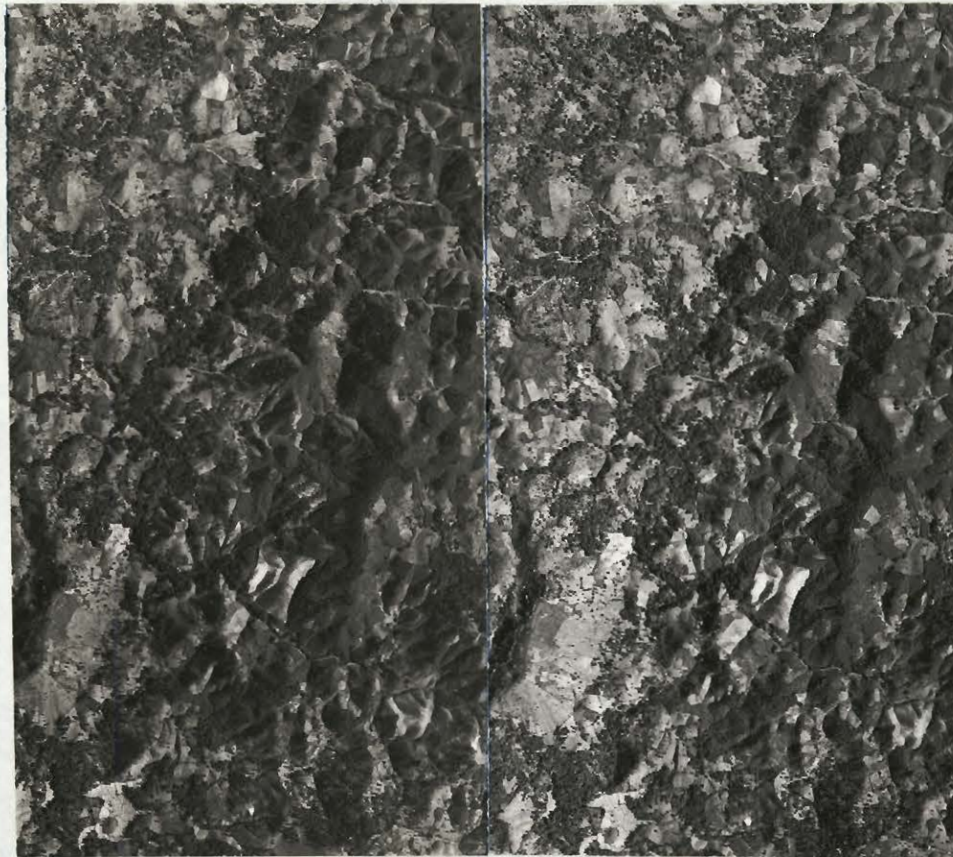


FIGURE 59

Roughly Accordant Levels in the Morawaka Area

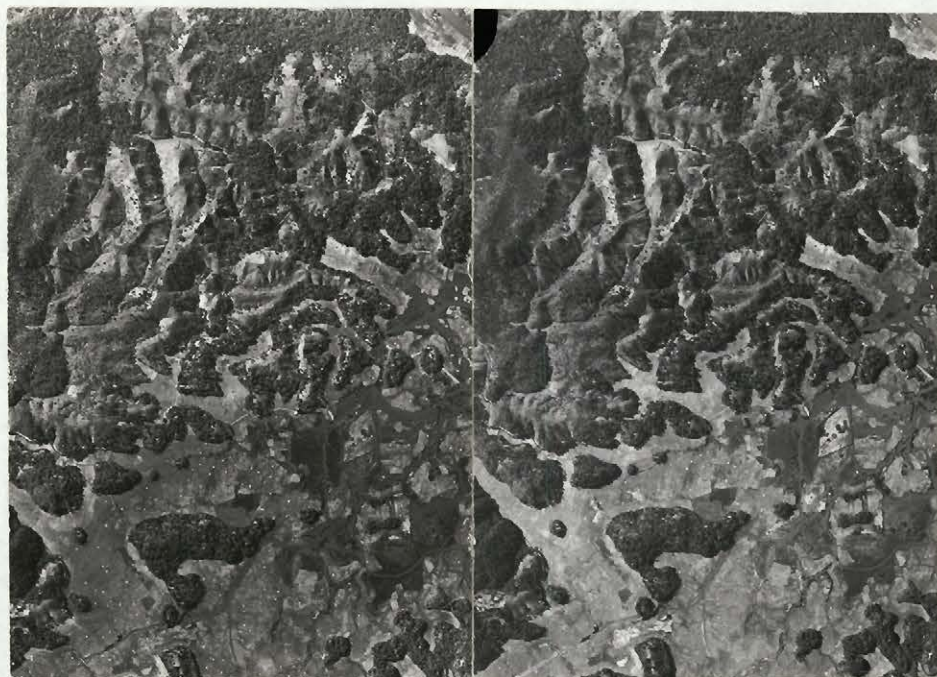


FIGURE 60

Erosion Surface Truncating Hills Near Matara,

Southwest Peneplain

slopes of the interstream hills are usually rounded; and the hills appear to have nearly accordant tops. However, by using aerial photographs which give an overall picture, it is possible to discover the control and label it as such. On the other hand, where erosion and weathering have dissected and degraded an area to the stage common to the Southwest Peneplain, very little, if any, evidence is left of the original surface or its extent.

In summary, the Southwest Peneplain consists of a rather poorly marked, though regionally persistent, erosion surface truncating the tops of many hills in the area. Its stage of geomorphic development may be classed as old age bordering on reduction to a new peneplain at the present base level.

The Central Massif

General

The Central Massif is bounded on the southwest by the Ratnapura-Pelmadulla Valley, separating it from the Sabaragamuwa Hills; on the west by a line approximately through Ratnapura, Yatiyantota, Kegalle, and Galewela; on the northeast by the Matale Valley and part of the Mahaweli Valley, separating it from the Knuckles Massif; on the east by a line approximately through Uraniya, Bibile, Medagama, and

Wellawaya; and on the south by the north boundary of the Tanamalwila Peneplain (Fig. 20).

The Central Massif consists of a group of structurally controlled mountain ranges and ridges, in part surrounded by, and in part surrounding an assemblage of high level, medium level, and low level plateaux. These mountains, ridges, and plateaux have been dissected by several major and many intermediate and minor rivers and streams, and in addition, have been cut by a complex pattern of faults, joints, and unclassified fractures. Because of the high precipitation, high temperature climatic regime, weathering, mass-wasting, and erosion have been intense and have resulted in a terrain often characterized by very great local as well as regional relief.

An attempt has been made here to subdivide the Central Massif into its major geomorphologic features. These will be described first and then correlated in a subsequent section.

Mountain ranges and ridges

Adams Peak Range

Adams Peak Range extends from Meriyakota (6,025 feet) in the southeast, through Doturugala (6,484 feet), Ratkanda (6,088 feet), Benasamanalagala (6,597 feet), Adams Peak (7,360 feet), Dakinarupa (5,900 feet approximately), Pidurutalawa (5,500 feet approximately),

Udalaxapanagala (5,143 feet), Peak Wilderness (3,900 feet approximately), Kiripanagala (3,472 feet), and Pallegage (2,700 feet approximately), and terminates in several unnamed peaks (3,500 to 4,200 feet), four miles northwest of Kitulgala, at the We Oya (Fig. 20).

It consists of a series of block faulted mountains in the vicinity of Adams Peak (Fig. 61); folded mountain ridges to the northwest (Fig. 62), and a broadly synclinal plateau to the south. The entire Adams Peak Range is bordered on the eastern side by a vertical scarp varying in height from 1,500 feet to 2,500 feet above the valley bottom (Fig. 63). This scarp is gently curving but maintains a marked uniformity which may indicate the presence of a fault or fault component. The south face also consists of a steep, relatively straight scarp having a definite fault nature (Fig. 64). The western margin is much less regular, being cut by numerous major and minor streams actively eroding fault or joint controlled valleys (Fig. 65).

The peaks of the Adams Peak area are generally angular in appearance with flat dip slopes to the west. They are separated from adjoining peaks by well marked fault or joint valleys which exert a strong control over the drainage (Fig. 61 and Fig. 66). In the northwest, the peaks coalesce to form a long ridge with beds dipping toward the west-southwest. South of the Kelani Ganga, a well marked northwestward plunging syncline forms the western half of the range (Fig. 67).

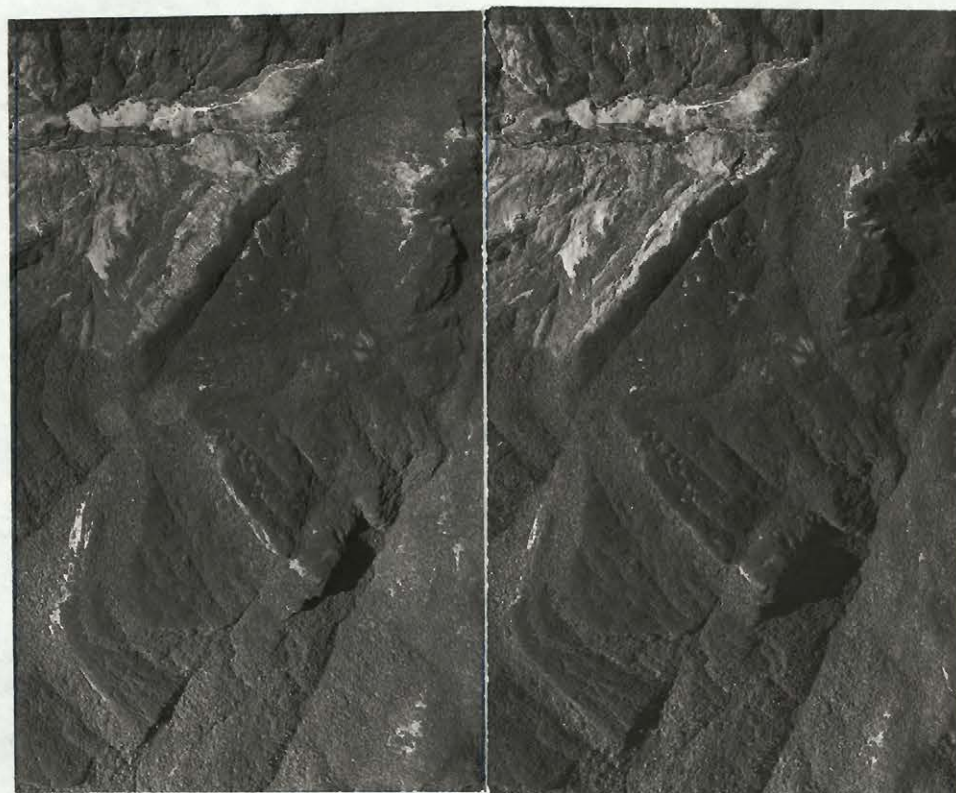


FIGURE 61

Block Faulted Mountains, Adams Peak Range

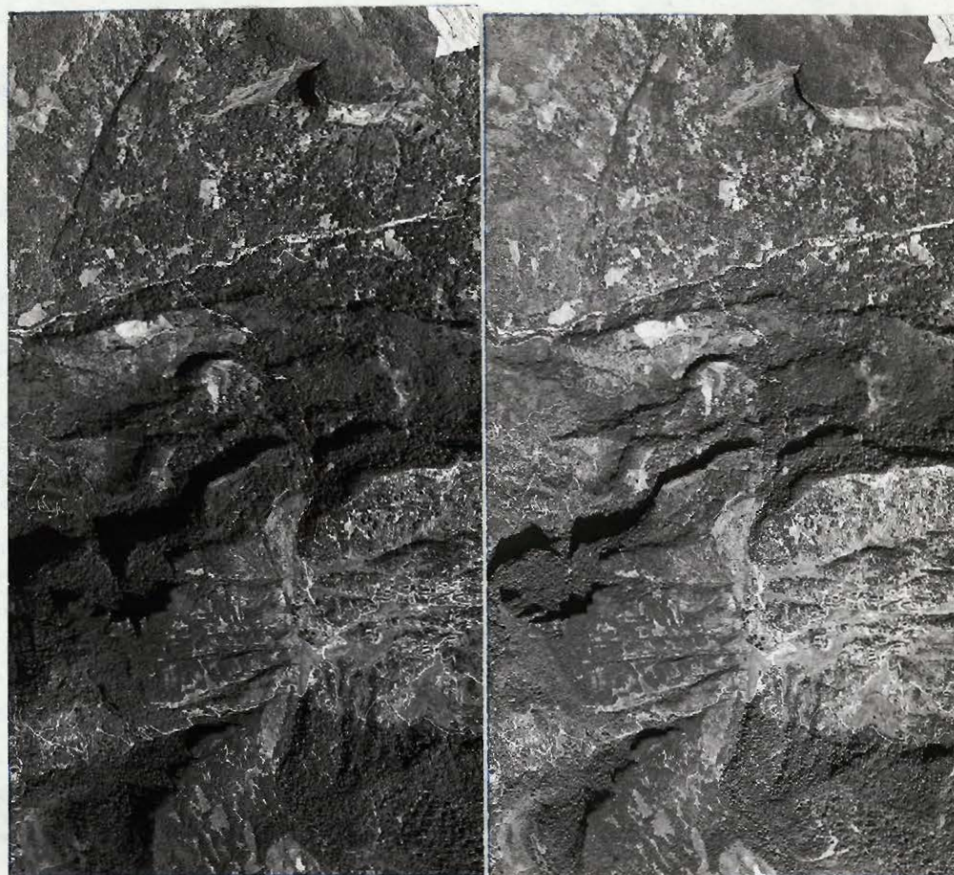


FIGURE 62

Continuation of Adams Peak Range to the Northwest as a
Synclinal Peak on the South Bank of the We Oya

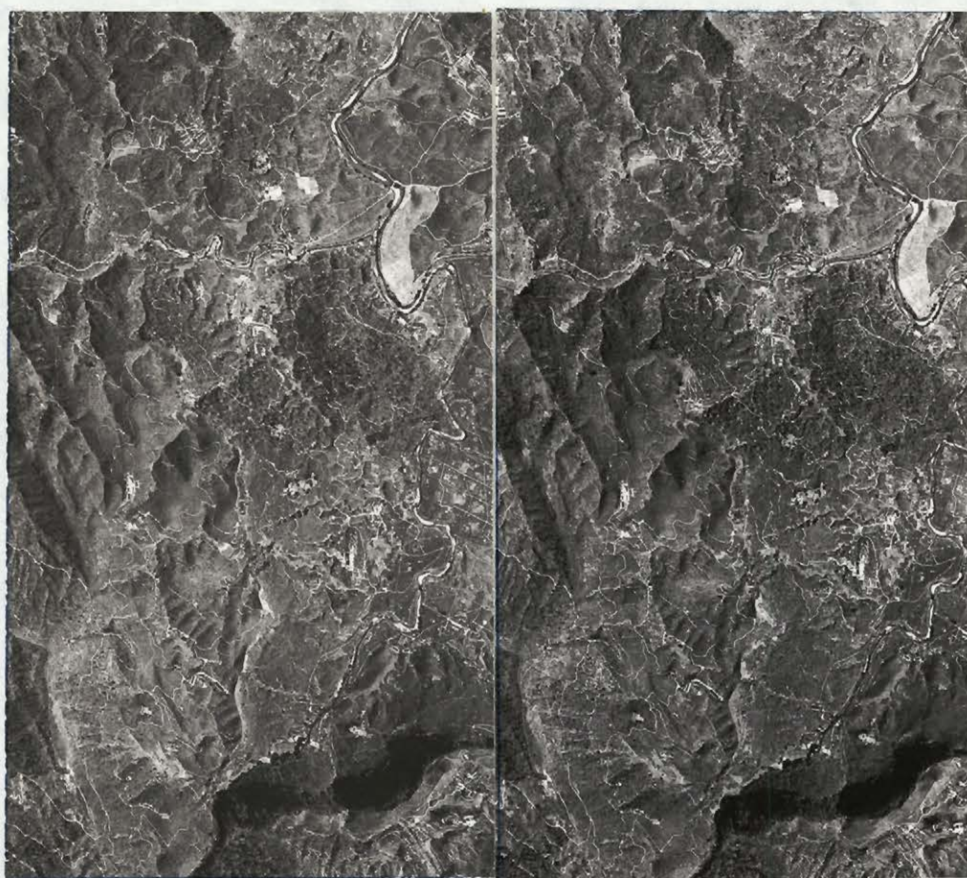


FIGURE 63

East Face of Adams Peak Scarp, Upper Maskeliya Valley

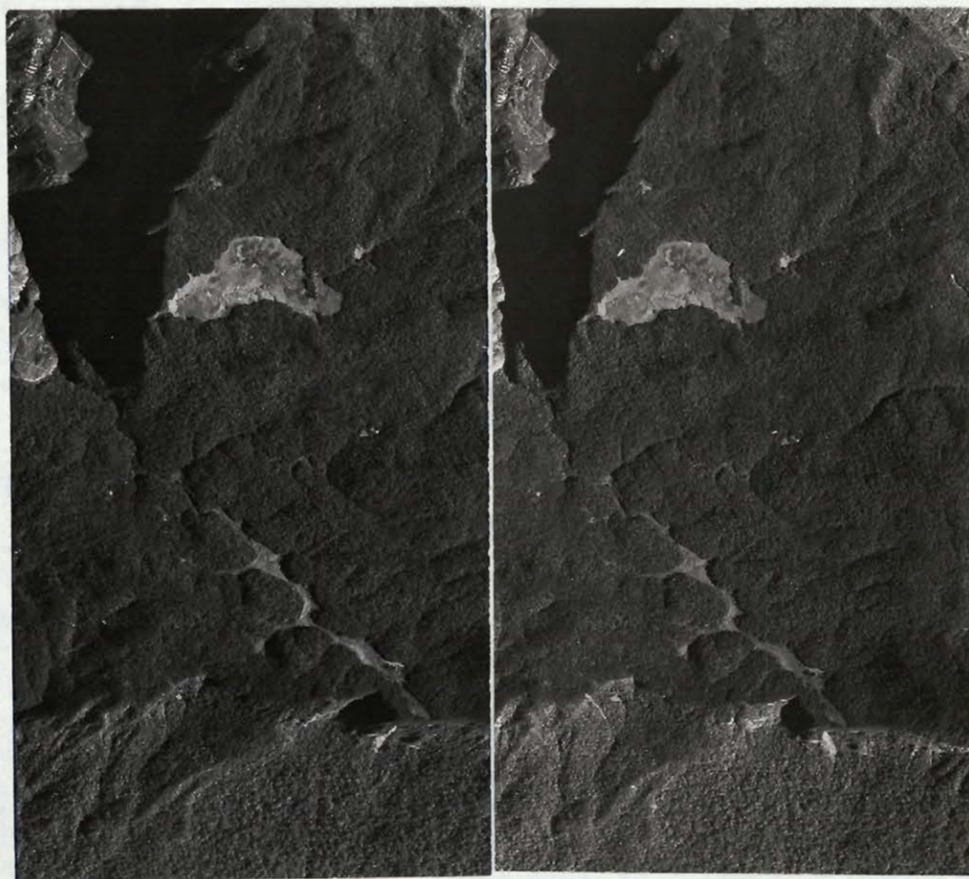


FIGURE 64

Southern Scarp Face of Adams Peak Range and
Peak Wilderness Part of Pattipola Plateau



FIGURE 65

Western Face of Adams Peak Range



FIGURE 66

Fault and Joint Pattern, Adams Peak Range

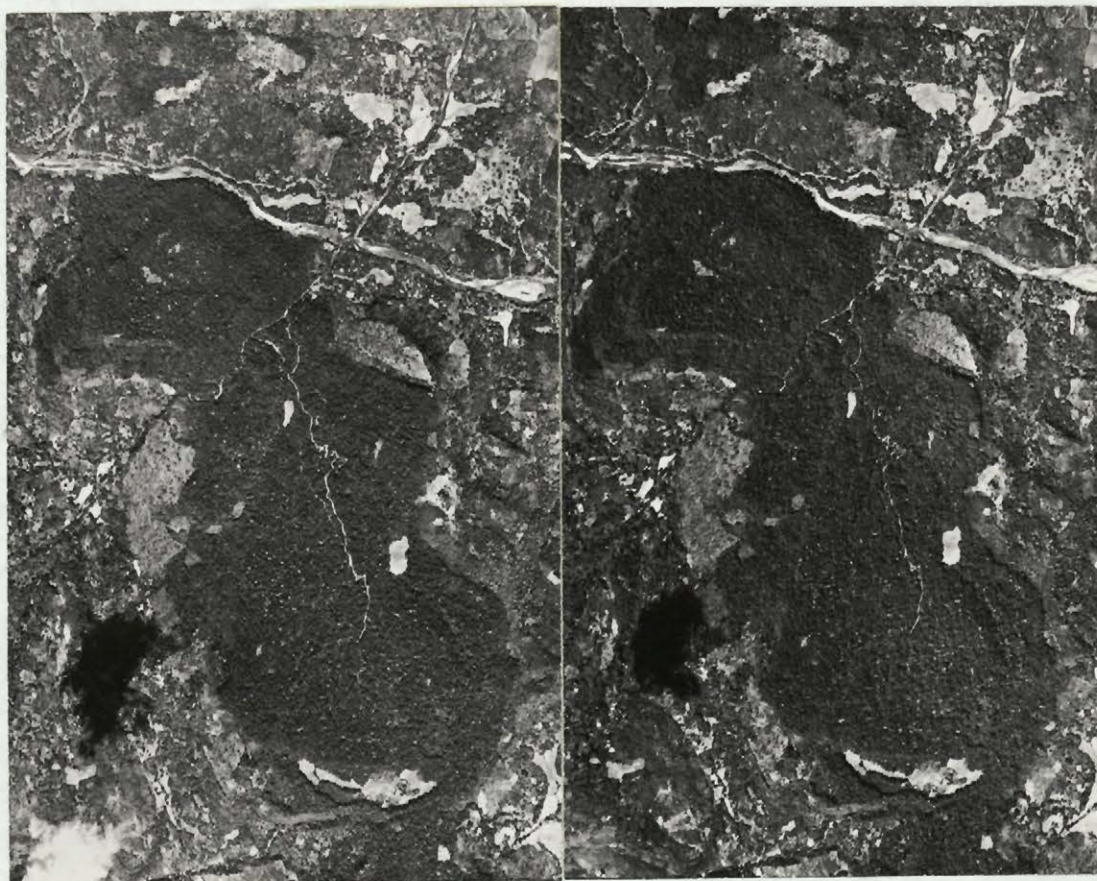


FIGURE 67

Plunging Syncline South of Kelani Ganga,

Adams Peak Range

North of the Kelani, this syncline is continued as a peak on the south bank of the We Oya (Fig. 62). Adjacent to this syncline is a tightly folded anticline which southeastward may become isoclinally folded and form part of the long marginal scarp described above. Adams Peak itself consists of a conical erosion remnant of resistant rock which is here classed as a monadnock on the ancient Peak Wilderness Plateau. South of the Adams Peak area, the range is laterally truncated by the two boundary scarps. Its surface consists of a rolling, maturely weathered and eroded plateau with what appears to be a slight inward dip to the marginal beds (Fig. 64). This forms part of the Peak Wilderness Plateau mentioned above. The whole range is cut by numerous faults and joints which are illustrated very well on the aerial photographs (Fig. 66). These structural breaks follow three main trends; north-northeast, west-northwest, and east-west. Many other fault and joint directions are present, but have not been recorded in detail.

Weathering in the Adams Peak Range is intense. Since this range forms the first major orographic barrier to the southwest monsoon winds, rainfall is very heavy, exceeding 200 inches throughout most of the area. This heavy rainfall combined with the much jointed, faulted, or fractured rock and the very heavy jungle cover, has favoured active chemical weathering. Except on the scarp faces, very steep slopes undergoing active erosion, and bare peaks, thick residual soils have been formed by this process.

Erosion is or has been very active in the Adams Peak Range.

This is partly due to the heavy rainfall, partly due to the intense weathering and partly due to the steep slopes. It is especially active where the surface has been cleared of vegetation for tea planting, but it is modified or curtailed by the heavy jungle vegetation characteristic of the undeveloped parts of this area. Bedrock structure in the form of resistant, ridge forming beds and weak, valley forming interbeds, has controlled weathering and erosion to a large extent. In addition, fault and joint traces which are usually weathered more rapidly also present easy paths for erosion. In this area, the geologic structure has been accentuated by these processes on the upper slopes, and buried by the resulting alluvium and colluvium on the lower slopes. On the heavily forested western slopes of the range, erosion has formed large concave valleys or basins with the present streams flowing in narrow steep sided, high gradient valleys (Fig. 65). The stream pattern is often modified by joint or fault control and in almost all cases the erosion appears to be cutting downward, heading into the range. Of the valleys so formed on the west slope, the most prominent are: the Kudiran Oya Valley; the Mandagal Oya Valley; the Halatura Ganga Valley; the Naye Ganga Valley; the Magal Ganga Valley; and the Kuru Ganga Valley. Most of these valleys extend across the range to the edge of the scarp forming the east margin. In fact, the Maskeliya Oya which drains the

valley immediately east of the range, as well as the upper surface of the southern third of it, flows diagonally across it at Kitulgala (Fig. 68). This transverse valley has been cut through at least 850 feet of rock at Kitulgala and 2,000 feet at Kalugala about two miles upstream. It does not appear to have the characteristics of a fault valley and, therefore, is probably either superposed or antecedent. If antecedent, the river must have followed its present course before the diastrophic uplift which raised the Central Massif in general, and Adams Peak Range in particular. The ancestral Maskeliya would then have cut down the present valley as uplift proceeded. If it is superposed, however, its course must have followed the present one but on an elevated surface correlative with the top of Adams Peak Range at this point. Under this situation, it cut its way downward as the material on both sides of the range was eroded away. A third possibility, which is a composite of the two above and which hinges on a theory of differential uplift to be treated at some length in Chapter V, is that the river flowed over a rough peneplain with Adams Peak Range as a relatively low but well marked strike ridge on it. As this surface was uplifted, the break being at or near the west face of the ridge, a major dislocation of profile was caused in the vicinity of Kitulgala. Subsequent headward erosion and incision by the river into the deeply weathered rock and alluvium of the old valley floor, reduced it to the present form. This latter



FIGURE 68

Maskeliya Oya Valley Cutting Across Adams Peak Range at Kitulgala

explanation is considered here to be the most logical. The existence of Laksapana Falls, together with smaller unnamed falls along the Maskeliya to the east, indicates that the downcutting is still in progress and substantiates this theory.

Mass-wasting is also active in Adams Peak Range. The fault scarps forming its southern margin are almost buried beneath talus, as are many sections along the foot of the eastern scarp (Fig. 63). Similarly, the basin-like concave valleys of the western face have deep deposits of colluvial material.

In the Gartmore Valley, removal of the forest cover has allowed mass-wasting and erosion to act unhindered, and the result is striking (Fig. 69). Here major slumping, aided by jointing in the bedrock, has occurred along the sides of a fault controlled valley. The deep talus deposits resulting from this slumping, have been gullied by subsequent erosion to form the present topography. The rapid headward erosion of this valley is indicated by the presence of falls on the main stream and a tributary where they flow off the upland surface of the range.

The existence of Gartmore Falls on the tributary of the Battulu Oya draining Gartmore Valley, and of Adams Peak Falls on the Battulu Oya itself (Fig. 70, Kelani Ganga Profile, Appendix A), is indicative of the differential weathering and erosion which have lowered the Maskeliya Valley below the original level postulated earlier. The existence

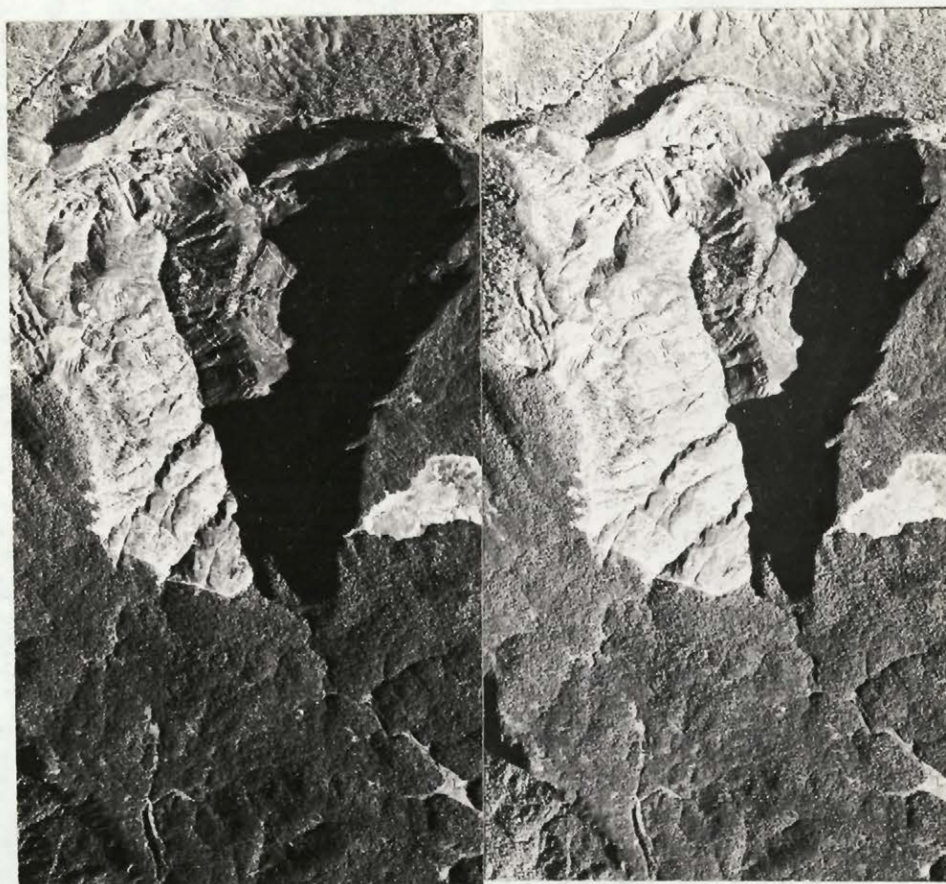


FIGURE 69

Mass-wasting and Erosion, Gartmore Valley

Adams Peak Range

of Dotulu Ella Falls Lower, and Dotulu Ella Falls Upper, on the Naye Ganga (Fig. 70, Kelani Ganga Profile, Appendix A) , and Diyanella and Uraella Falls on a tributary of the Walawe Ganga on the west and southern slopes of Adams Peak Range respectively, is indicative of the uplift which originally raised the range and the inner valleys together. Thus, the eastern scarp and consequent variation in level are apparently due primarily to weathering and erosion, and the western slope and southern scarp, with associated difference in elevation, are apparently due to diastrophism involving the entire Central Massif.

Namunakuli Range

The Namunakuli Range extends in a broad curve forming the eastern rim of the Central Massif, from Weywellakella (5,058 feet) in the south, to Alugalgekanda (2,800 feet approximately) in the north (Fig. 50). The main peaks of the range with their elevations are: Kanawerella (5,149 feet); Dataniyagala (5,043 feet); the Namunakuli Peaks (6,671 feet and 6,679 feet); Kabaragala (5,323 feet); Bandiyakanda (4,351 feet); Karalagala (4,931 feet); Beriyagala (4,538 feet); Rilaoluwa (4,556 feet); and Dorepotagala (4,964 feet). A somewhat lower subrange to the east includes: Kosgolla (3,437 feet); Mahatenna (3,259 feet); Waradola (2,636 feet); and Pallekanda (3,286 feet).

Structurally, this range consists of a series of en echelon, moderately overturned anticlines and synclines with a north-northwest

axial strike. Weathering, mass-wasting, and erosion of these beds has resulted in an extremely rough, angular topography. The peaks are generally steep sided with sharp summits, knife-edge ridges, relatively smooth dip slopes and deeply eroded scarp slopes.

The rainfall in this area is generally of the order of 100 to 150 inches, but may approach 200 inches in the vicinity of Hugaloya. This, coupled with the longer dry periods, has not allowed the growth of thick forest, as is the case in the Adams Peak Range, and as a result, erosion and mass-wasting are much more active and conspicuous. Both sides of the range are characterized by deep V-shaped gorges with extensive networks of sharply eroding tributaries. The combination of resistant ridges and weaker interbeds has resulted in down dip erosion in the weaker beds and undercutting of the resistant beds.

On the north, the crest of the Namunakuli Range is formed by a synclinal valley occupied by a tributary of the Loggal Oya (Fig. 71). This syncline appears slightly overturned toward the east-northeast and as a result, the beds forming the western rim of the valley are vertical or have a very steep east dip. The beds forming the eastern rim, on the other hand, have a moderately steep west dip. Within this basin, weathering, mass-wasting, and erosion have been active to produce thick residual soils, deep talus deposits on the lower slopes, and an alluvium filled valley bottom. Erosion, however, has cut into these



FIGURE 71

Synclinal Crest of Namunakuli Range at North End

slopes and into the valley bottom and in most cases has bared the un-weathered bedrock.

The western slope of the range in this area is marked by a series of deep V-shaped gorges cutting across the steeply dipping beds. These valleys are in part controlled by faulting, which apparently traverses the entire range, and in part are controlled by the steeply dipping beds of the western arm of the syncline. Weathering is intense and the residual soils developed tend to mantle the bedrock topography to some extent.

On the east side of the range, erosion is more active and deep V-shaped valleys are common. In this area, vegetation is thicker, but weathering does not appear to dominate erosion to the same extent. Talus deposits at the base of this slope are indicative of mass-wasting processes in action.

Headward erosion of the Loggal Oya tributary and its branches, especially along fault valleys, is cutting into this range and, in places, divide lowering is in progress. Roughly accordant ridge crests, more mature valleys, sharp breaks in stream profiles, and a general pattern of relatively low local relief in the vicinity of Rathkele and on the slopes of Dorepotagala, are considered to indicate the presence of a fragment of the Hatton-Diyatalawa Plateau. This surface is continued to the southward in the dissected Madulsima Plateau at an elevation of

approximately 4,500 feet. This plateau consists of a moderately dissected surface with accordant ridge tops and valley bottoms. The dissection is partly controlled by bedding and partly by faults and joints. Streams draining the plateau flow over the margin as falls or in very steep gorges and continue as high gradient, deeply eroding streams until they reach the valley of the Loggal Oya on the west, or the Lunugal Valley on the east. On the plateau, the streams have a low gradient and flow in open V-shaped valleys, often with alluvium filled bottoms.

Further south the Namunakuli Range is almost cut through by the headwaters of the Loggal Oya flowing north-northwest, and the headwaters of the Waradola Oya flowing south. The elevation of this drainage divide is approximately 2,700 feet as compared to the peaks on either side: Lunabissa on the north (4,438 feet); and Bandiyakanda on the south (4,351 feet). It is probable that the rapidly down cutting Loggal Oya has captured part of the drainage of the much smaller Waradola Oya, at least to the extent of the alluvium filled basin above Passara and the present divide.

The southern end of the range consists of a complex assemblage of peaks, ridges, valleys and slopes, all more or less controlled by an equally complex geologic structure (Fig. 72). Only the main features of this structure have been worked out to date, but individual examples

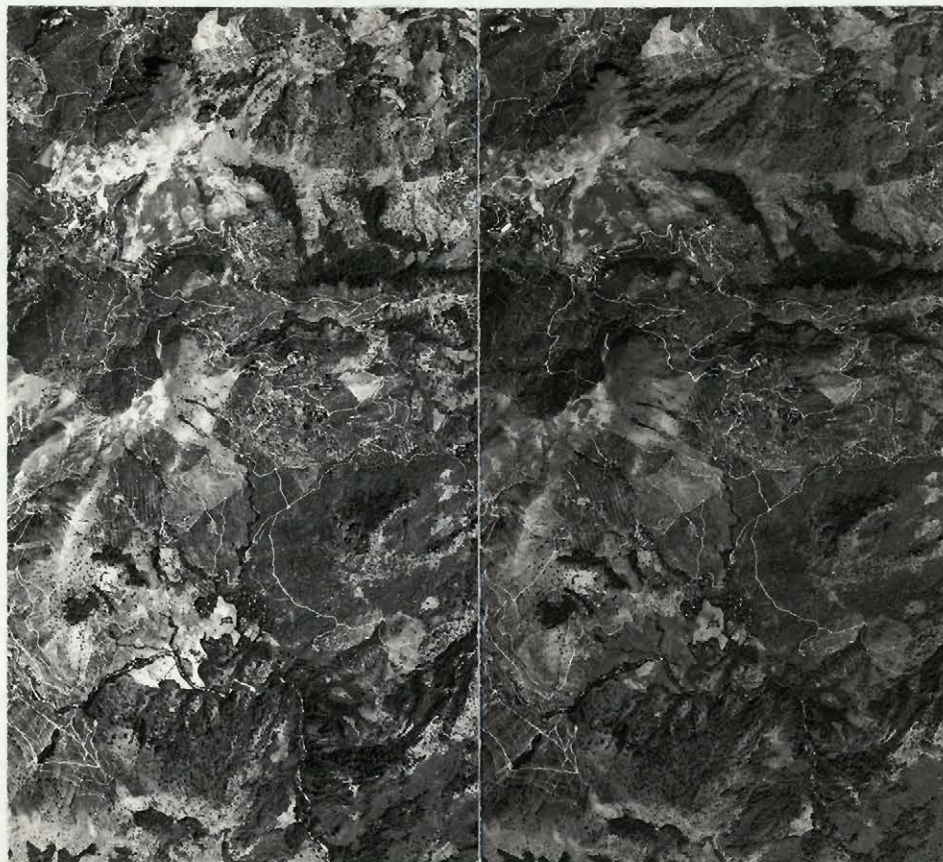


FIGURE 72

South End of Namunakuli Range Showing Complex Structure

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of its control over geomorphologic processes are numerous.

The peaks of the area are commonly resistant remnants of more extensive strike ridges. Weathering has effectively broken down much of the rock and has mantled most of the slopes with residual or colluvial soil. In the above illustration the breakdown of the resistant core of an overturned syncline has left a barchan shaped deposit of angular blocks. Also characteristic of the area are relatively smooth, deeply mantled, dip slopes alternating with nearly vertical scarps. The lower slopes of these scarps are usually buried by talus. Small valleys cutting these ridges have local base levels controlled by inward dipping resistant beds. In a similar way, the drainage pattern has been altered to conform to the structure. Streams follow strike valleys and fault valleys or have their profiles interrupted by structural dislocation.

An eastern, slightly lower level portion of the Namunakuli Range consists of a strong strike ridge, the Pallekanda Ridge, with an elevation of approximately 3,300 feet, and an associated broad alluvium filled, strike valley, the Lunugala Valley. The bedding of the Pallekanda Ridge dips westward toward the main range and thus acts as a barrier for streams flowing off its east face. This has resulted in the rapid silting up of the valley so formed and eventually the outflow of the streams across the ridge as falls. Partial erosion of this

barrier has in turn resulted in the dissection of the valley bottom alluvium and the creation of the present topography (Fig. 73).

Pidurutalagala Range

The Pidurutalagala Range might be classified as the topographic backbone of the Central Massif. It forms the main mountainous height of land from Ohiya on the south to the Gurugal Oya Fault on the north and includes the Great Western Spur on the west, the Mahakudagala Spur on the east, and the Hantane-Dotelagala Ridge as a northern extension (Fig. 20).

This range, in common with the Namunakuli Range, consists of the weathered and eroded ends of a series of anticlines and synclines which have their axes trending approximately northwest. The main peaks of the range are the eroded remnants of the numerous strike ridges which go to make up these structures. They are from south to north: Totupola (7,741 feet); Hakgala (7,127 feet); Conical Hill (7,114 feet); Waterfall Point (6,811 feet); One Tree Hill (6,890 feet); Bambarakellie (7,349 feet); Pidurutalagala (8,281 feet); and a northern unnamed ridge (6,800 feet approximately). The spurs include on the west: Uda Radella (7,026 feet) and Great Western (7,269 feet); on the north, Dotelagala (4,968 feet), Hantane No. 1 (4,387 feet), and Hantane No. 2 (3,742 feet); and on the east, Mahakudagala (6,890 feet),



FIGURE 73

Alluvium Filled Lunugala Valley, and Pallekanda Ridge

Ragala Rock (6,222 feet), and Kuraattekkanda (6,690 feet).

The southern end of the range terminates in the high level, Worlds End Plateau at approximately 7,200 feet. North of this, the central part of the range forms the Pattipola high level plateau at approximately 6,300 feet. The Kandapola high level plateau is located at the Pidurutalagala end of the Mahakudagala Spur at approximately 6,800 feet. In keeping with the overall descriptive classification, these plateaux will be described as separate features rather than as part of the Pidurutalagala Range.

The southern section of the Pidurutalagala Range is bounded on the west by a series of steep slopes and scarps, resulting from the headward erosion of strike valleys controlled by the bedding of the synclines and anticlines which form its foundation. The valley of the Agra Oya is at least partly controlled by the northeast dipping beds of the southwest limb of a major syncline whose axis forms the core of a westward extension of the Pattipola Plateau. The sides of this valley are deeply weathered and the rock structure is obscured by the residual soil. Mass-wasting is active along the steep slopes and scarps and results in deep colluvial deposits at their bases. Headward and valley side erosion is actively cutting into the residual soils of the slopes and has resulted in deep gullies with rounded interfluvies, and extensive alluvial deposits in the valley bottom. The head of the valley

is traversed by a major northeast trending fault which, in addition to controlling the local drainage and erosion, may have dislocated the synclinal structure. The head of the valley is composed of moderately dipping beds which form a broad amphitheatre. Heavy forest covers these beds and has apparently reduced erosion considerably. The present pattern of drainage on this slope is dendritic.

The valley of the Dambagastalawa Oya is a deep, almost vertically sided gorge which, from the fragmentary evidence available, appears to be controlled by a breached anticline. Mass-wasting is active along the scarp faces, in places resulting in talus deposits sufficiently large to divert the river on the valley floor. Weathering is most active on these talus deposits, reducing them rapidly to rounded hills of residual soil. These in turn are eroded by streams from the valley side above. The tributary streams which drain the plateau flow in valleys incised roughly 400 feet below the general level at the head of the Dambagastalawa gorge, that is, at an approximate elevation of 5,800 feet. The bottom of the gorge one mile downstream is at an approximate elevation of 5,000 feet. This break in profile is one of the features common to the margins of the high level plateaux and at this point Elgin Falls is located (Fig. 74).

The valleys of the Nanu Oya and its tributaries which flow along the southwestern face of the Great Western Spur are also structurally

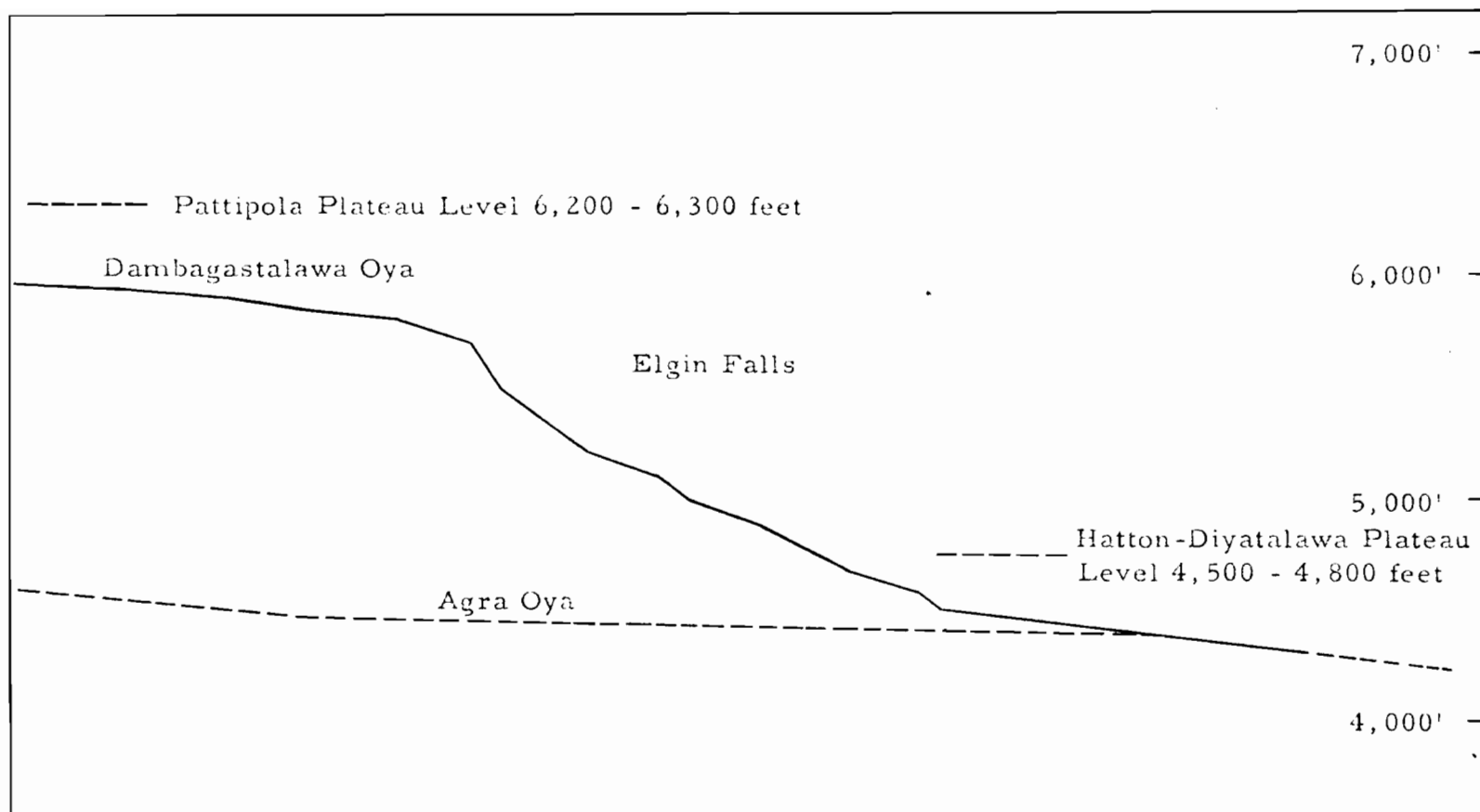


FIGURE 74

Break in Profile of Dambagastalawa Oya at Margin of High Level Plateau

controlled, partly by the strike of bedding and partly by faults. The general pattern of actively eroding, relatively deep V-shaped valleys, deep weathering, and extensive mass-wasting is followed. Local drainage patterns appear to be controlled by bedding to a large degree but faults often disrupt them. The drop from the plateau level at Nuwara Eliya to the Hatton-Diyatalawa Plateau level on the west is steep but more or less uniform because of the geologic structure of the area (Fig. 43, Mahaweli Ganga Profile, Appendix A).

The eastern face of the southern section of the Pidurutalagala Range is also being actively attacked by headward erosion. In this case however, the streams have to cut down across the west dipping beds of the noses of synclines as well as along the strike valleys formed by the limbs of these synclines and anticlines.

Deep weathering, mass-wasting, and erosion are common on this face of the range, resulting in massive talus deposits, slump scars, incised valley bottoms and, in general, a youthful appearance. Where erosion and mass-wasting are dominant over weathering, the terrain has characteristic rounded interfluvial ridges and concave valley sides. Where weathering is dominant over erosion and mass-wasting, on the other hand, the slopes or valley sides in addition to the ridges are rounded or convex. Dominantly concave slopes occur in the strike valley just south of Hakgala and dominantly convex slopes occur in the headwater valley just east of Pattipola. In these latter valleys

slump and slump scars are also well illustrated.

Pidurutalagala Peak is located just north of Nuwara Eliya and forms the core of the range and the highest point in Ceylon. Southwestward the Great Western Spur extends as a major strike ridge between the Nanu Oya valley and the Pundul Oya valley; northward the main ridge forms a divide between the Puna Oya valley and the Mul Oya valley; eastward the Mahakudagala Spur, composed of the eroded noses of a series of north-northwest trending anticlines and synclines, separates the headwaters of the Belihul Oya from those of the Halgran Oya. The Hantane Ridge is an offset extension of the main northern ridge.

The Great Western Spur is the southwest limb of a west-northwest trending syncline of major proportions. Except at the southeast end where it merges with the Pattipola Plateau, it consists of an impressive strike ridge with a wide dip slope and a narrow scarp slope. It is cut by numerous major faults which in addition to controlling weathering, mass-wasting, and erosion, may also dislocate the basic structure (Fig. 75). Proof of this latter possibility would require much detailed lithologic as well as structural field investigation. Massive blocks or erosion remnants, bounded by fault or joint scarps, which occur on this dip slope, are also indicative of the extensive degradation which the area has undergone and the control exercised by the geologic structure (Fig. 76).

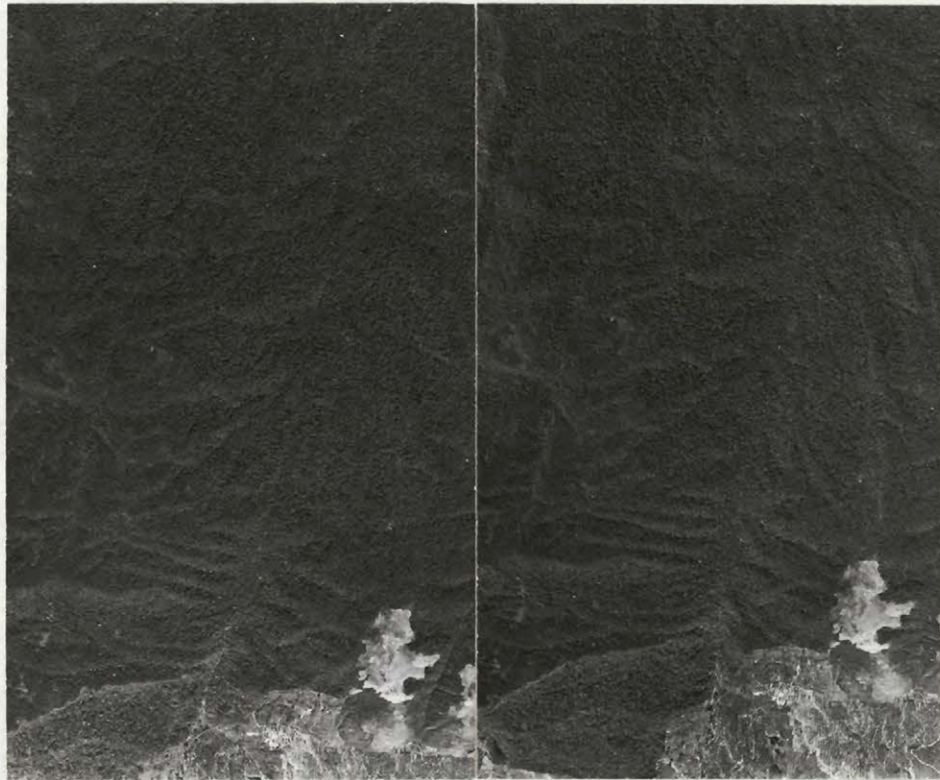


FIGURE 75

Faults Cutting Eastern End of Great Western Spur

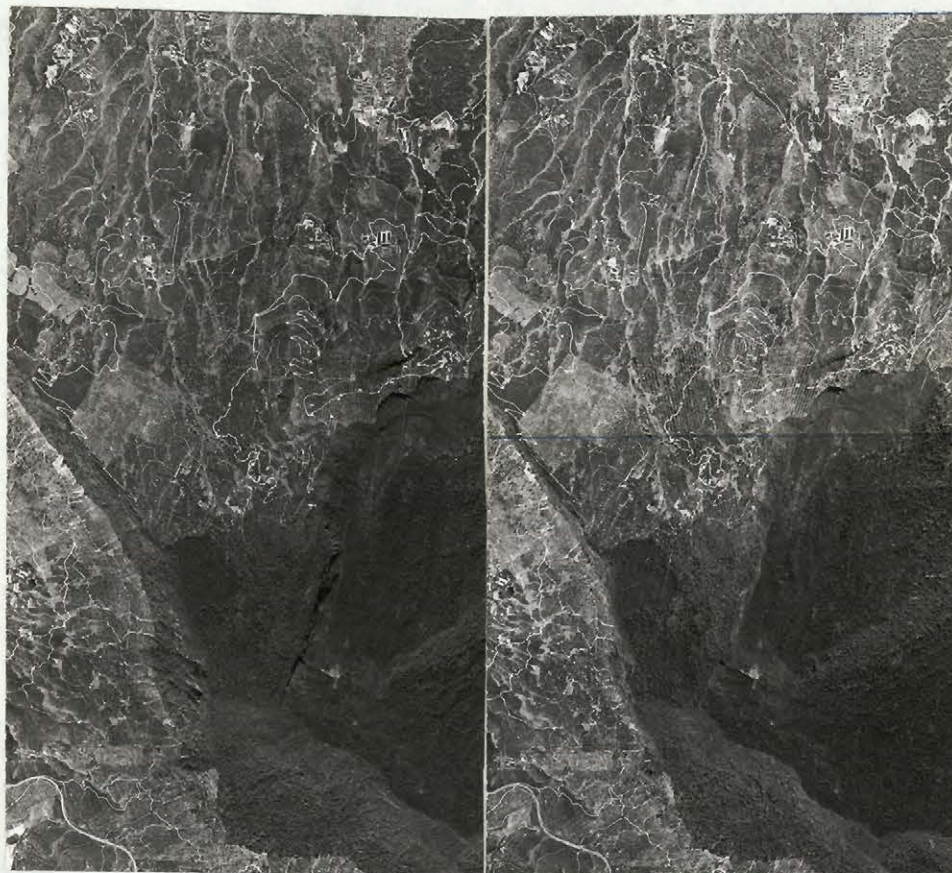


FIGURE 76

Erosion Block Remnants, Faults, Parallel "Giant Rill" Erosion
Gullies, Cuesta Scarp, and Talus, Great Western Spur

On the west end of the dip slope, deep weathering and mass-wasting have produced thick residual and colluvial deposits. These have been cut by numerous parallel gully-like valleys with rounded interfluves, which appear to incise their courses only until unweathered bedrock is reached (Fig. 76). On the eastern part of the slope where heavy vegetation is present, erosion is not as active, nor are the gullies as well delineated. Here they tend to follow the up dip margins of overlying beds and have a somewhat chevron-like pattern (Fig. 75). The Pundaluoya Syncline valley to the northeast illustrates the control exercised by faulting on erosion (Fig. 77).

The scarp face of the spur is very steep and is of the order of 1,000 to 2,000 feet in height. Its lower face is buried beneath deep talus deposits which are modified by alluvial fans and erosion. The face of the scarp is cut by numerous gullies some of which have formed moderate re-entrants. Those just west of Great Western itself are good examples (Fig. 78). The re-entrant to the east of the peak is controlled by a major fault which cuts across the entire spur. East of this fault the beds along the south slope below the crest of the ridge, dip southward. The dip slope so formed has the parallel gullies with rounded interfluves and flat, rock floors described earlier for the western end of the spur (Fig. 79). This type of weathering and erosion appears characteristic of gently dipping beds in this area.

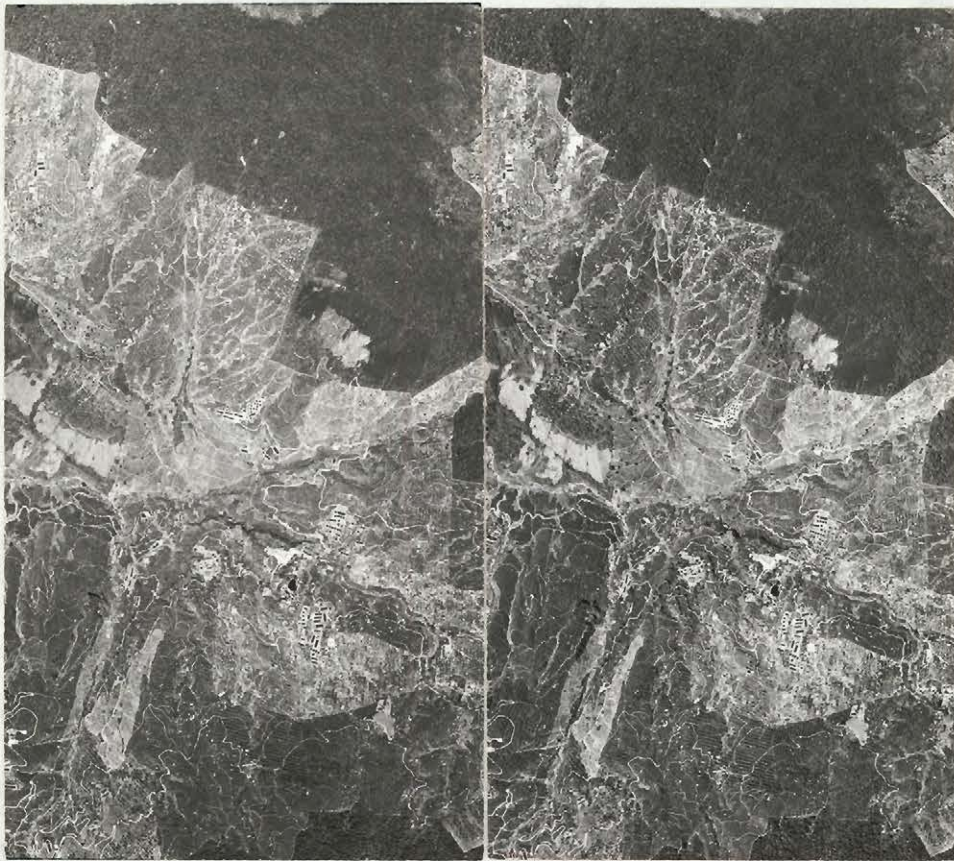


FIGURE 77

Erosion Controlled by Faults, Pundaluoya Valley Syncline

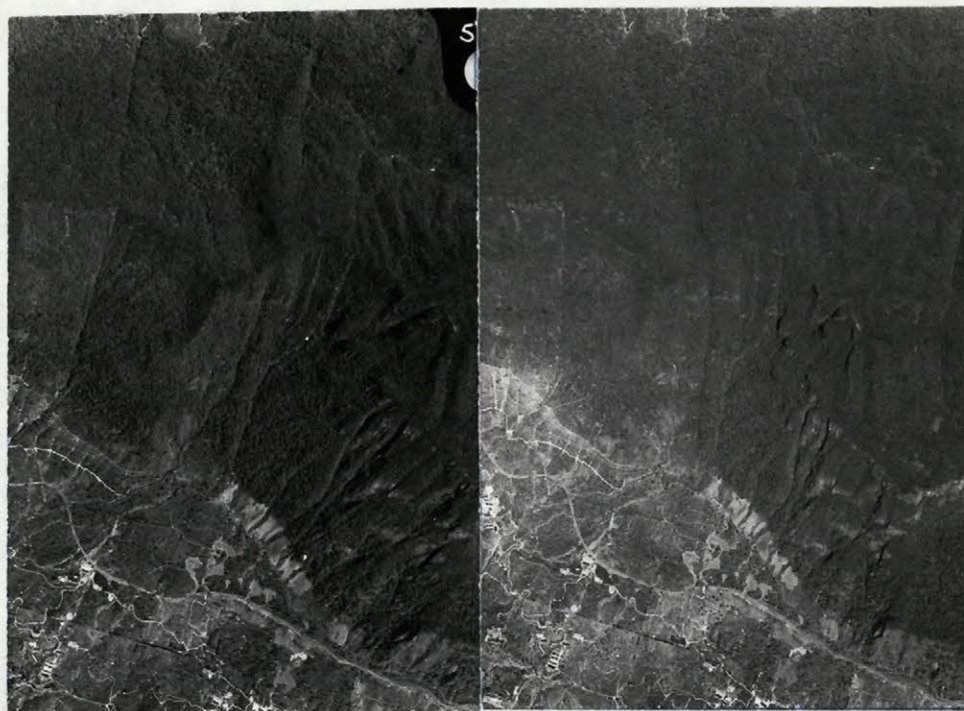


FIGURE 78

Re-entrant Gullies and Alluvial Fans, Scarp Face,

Great Western Spur



FIGURE 79

Parallel Gully Drainage, East of Great Western

The eastern end of the spur terminates in a group of peaks which form the nose of the Pundaluoya Syncline. Here, weathering and erosion have been controlled, in part by the dip of the bedding toward the axis of the syncline, and in part by a major fault which cuts across the structure from Westward Ho, just east of Bambarakellie, to a point just west of Nanu Oya.

The northern part of the Pidurutalagala Range, including Pidurutalagala Peak, consists of the erosion remnants of a syncline and an anticline. The syncline passes through the southwest side of Pidurutalagala and its northeast limb forms a strike ridge which extends from the peak, west-northwest toward Ramboda. The inward dipping beds of the nose of the syncline form a structurally controlled terrace on the east face of the peak. The anticline appears laterally continuous with the above syncline to the northeast. Thus, its southwest limb is the northeast limb of the syncline. The northeast limb of the anticline forms the southwest limb of the Nilambe Syncline, and to complete the sequence, the northeast limb of the Nilambe Syncline forms Hantane Ridge. From the above discussion, it is possible to envisage this ridge as a section across the general structure of the area.

The geomorphology of this ridge is dominated by the complex geological structure and tectonic history involved. Piduratalagala and

the northwest part of the ridge appear to be composed of very resistant rock. Soils developed on this rock are shallow in spite of a moderate forest cover. This may be due partly to the high altitude and relatively low temperatures existing in this area, and partly to the rock lithology. Weathering, in either or both cases, would be retarded and, as a result, erosion would be less effective.

The shoulder-like areas on the north, east, and south of Pidurutalagala are the result of silting up of strike valleys formed between the main peak and the inward dipping, synclinal beds mentioned earlier. In general, the lower slopes have thicker soils and deeper valleys resulting from mass-wasting, weathering of the thick talus deposits, and erosion. A fault just west of Pidurutalagala, controls erosion by the Belihul Oya on the northeast, and to a much lesser degree, by the headwaters of the Nanu Oya on the southwest. It is one of many northeast trending faults which cut the beds of this area into a striking pattern of tilted blocks. What is considered here as a fault scarp, strikes west-northwest along the upper Ramboda valley as a continuation of the ridge under discussion (Fig. 80). This fault line is almost normal to the general northeast trend. To the northwest, deeper weathering and very extensive mass-wasting are evident (Fig. 81). The former has produced thick residual soils which are indicative of a change in the lithology of the rock and result in more rounded interfluvies and more sharply etched V-shaped valleys. The latter has

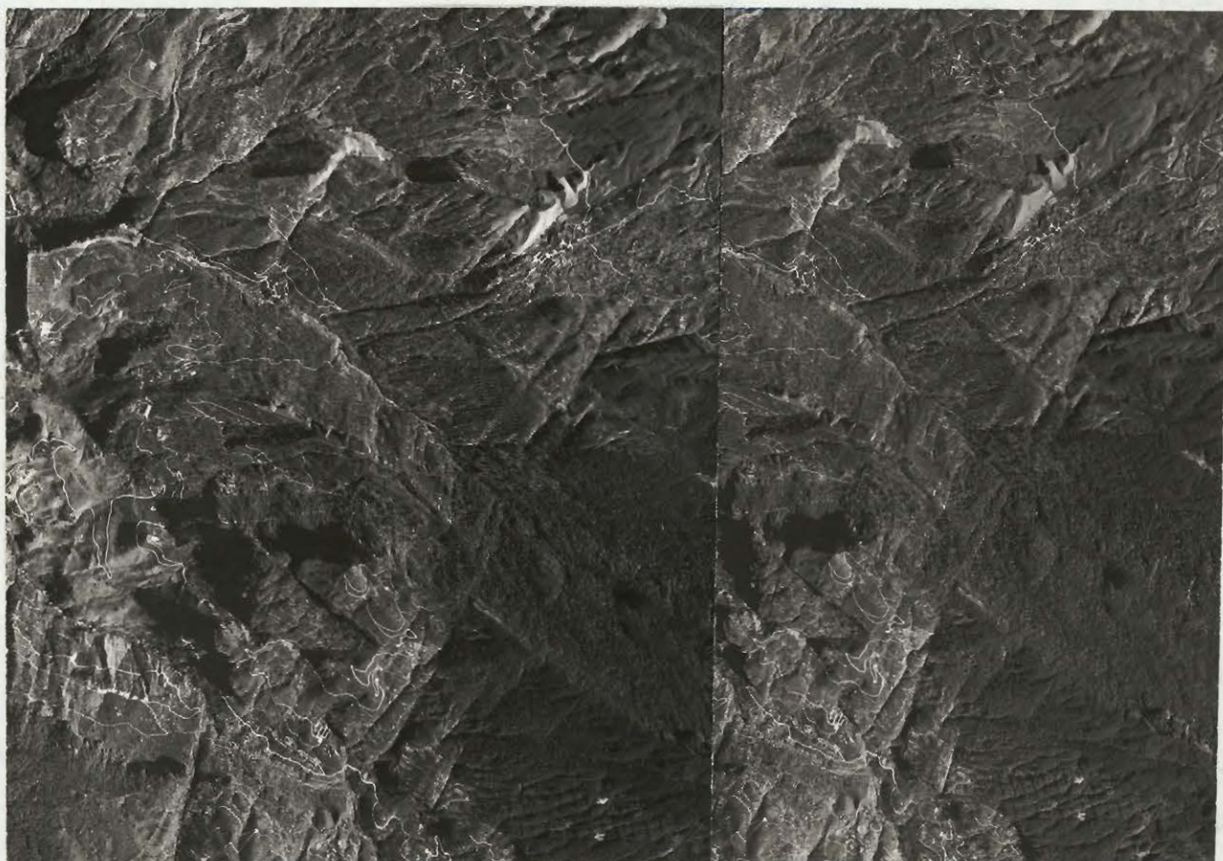


FIGURE 80

Ramboda Fault Scarp

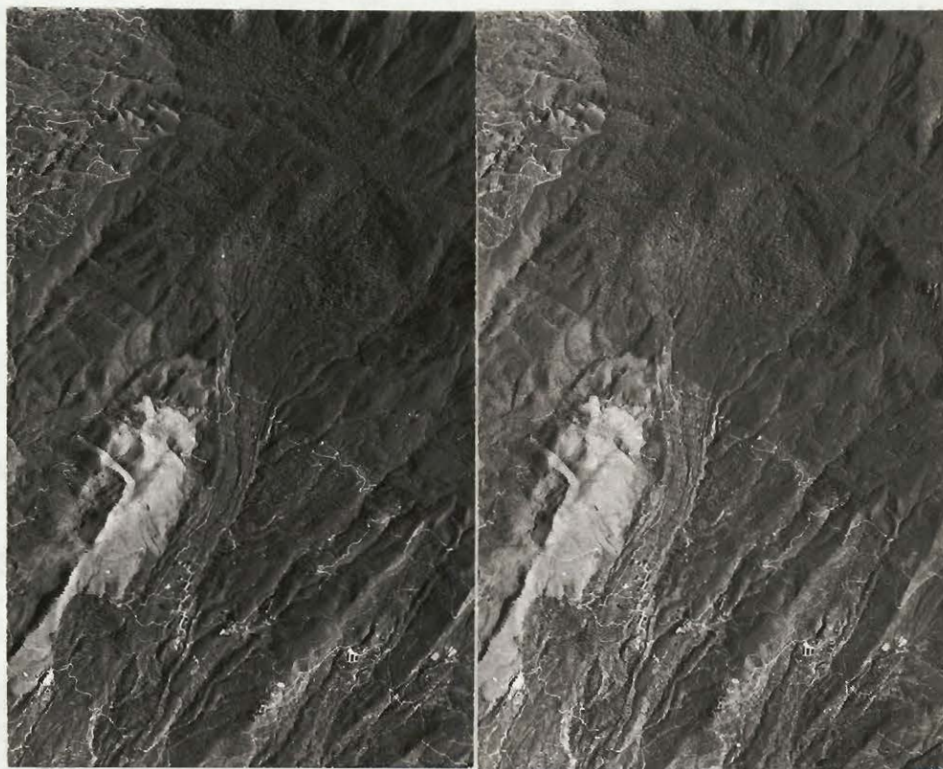


FIGURE 81

Weathering and Mass-wasting, Northeast Slope,

Ramboda Valley

produced slump or soil flowage forms which are also easily discernible on the aerial photographs. Most of the streams in the area are controlled to some extent by faults or bedding and would be classed as subsequent.

The ridge from this point northwestward is a much dissected strike ridge. Mass-wasting in the form of rockfall and rockslide has been active along the scarps of the southeast part and has resulted in deep talus deposits along the base of the scarp face. Transverse northeastward trending faults continue to affect the weathering, erosion, and general development of the ridge. In the northwest, the marked northeast dip is again evident, and divide lowering is in progress between the Gurugal Oya flowing northeast and the headwaters of the Atabage Oya flowing northwest. The Gurugal Oya flows in a fault controlled valley which cuts across structure for approximately eight miles east of the ridge.

The south end of Hantane Ridge is joined to the north end of Pidurutalagala Ridge by the beds forming the southeast nose of the Nilambe Syncline. With the exception of an eroded portion in the extreme southeast, these beds dip inward toward the northwest and form a curving strike ridge concave in that direction (Fig. 82).

At its southeast end, Hantane Ridge consists of two parallel strike ridges with moderately steep southwest dips and abrupt northeast



FIGURE 82

Nose Beds of Nilambe Syncline, Pidurutalagala Range

facing scarps (Fig. 82). These ridges lose elevation as they approach Galaha pass and northwest of this point the northeast ridge is not present. Hantane Ridge continues as a single, strong, strike ridge and after curving around to the east to form the nose of the large breached anticline which extends southeast of Kandy, ends at Hantane No. 2. Hantane Ridge is cut by Galaha pass and by numerous well marked faults. The pass, which is followed by a tributary of the Nilambe Oya, appears to be the result of faulting and subsequent erosion by a superposed stream.

Weathering has produced relatively thick residual soils along the west, or dip slope, of Hantane Ridge, and mass-wasting has almost buried the east, or scarp face, with talus (Fig. 83). The western slope has been dissected by erosion, and strike valleys have been developed along the up dip edges of the beds. Faults have also controlled the erosion, as in the Galaha area. The so-called "wine glass" valleys are common along the dip face of this ridge. On the deeply weathered talus of the eastern scarp face, erosion is cutting relatively deep V-shaped valleys. At present this pattern is modified by the drainage and erosion control carried out by the tea planters of the area.

The Mahakudagala Spur extending east-northeast from Pidurutalagala consists primarily of the high level, deeply weathered, moderately well dissected, and heavily forested Kandapola Plateau. On the north,



FIGURE 83

Deep Talus Burying East Scarp Face of Hantane Ridge

this spur is being attacked by the headward erosion of many strike valleys along the curving beds of a north-northwest trending syncline. The central trough of the syncline, by exposing only resistant dip slopes to the weathering and erosion, has partly protected this face. Eastward, another well marked syncline controls the form of the terminal peaks of the spur. Here, as in many places along the Pidurutalagala Range, the inward dipping beds of the nose of the syncline, form the peaks. Weathering in this area has produced deep residual soils which have been eroded to form V-shaped valleys with well rounded interfluves. The south face of the spur is being eroded by similar valleys which on the steeper slopes involved usually have cut down to unweathered bedrock.

In summary, the Pidurutalagala Range consists of a complex assemblage of high level plateaux, anticlinal and synclinal noses, and strike ridges, which have been cut, truncated, and differentially up-listed by faults.

Weathering in this area is generally intense and deep residual soils have been developed.

Mass-wasting is very active in this area and takes two dominant forms: one, rockfall or rockslide from exposed scarps; and two, slump or soil flowage in saturated, deep, residual soils.

Erosion is generally active, although the granular nature of some of the residual soils and the resulting good internal drainage and

low run off prevent it to some extent. Where erosion occurs on deeply weathered dip slopes, it usually incises the channel to bedrock imparting a characteristic pattern to the valleys.

Worlds End Ridge

Worlds End Ridge is a relatively short ridge extending from the southeast end of Adams Peak Range eastward to the western margin of Worlds End Plateau (Fig. 20).

It consists of the uplifted ends of a series of parallel, north-west trending anticlines and synclines which form the foundation of the Hatton part of the Hatton-Diyatalawa Plateau. This results in a situation similar to that described in the northern Pidurutalagala Ridge, that is, a rough section across these structures. The peaks of this ridge are erosion remnants of the resistant beds of the anticlines and synclines and as a result, their form depends on the particular portion of the structure acted upon. Dips varying from east, through northeast, north, northwest, west, and in some cases southwest are present. The form of the ridge is further modified or controlled by faulting and/or jointing. The major boundary fault of the central block of the Central Massif is considered here to form the south face of this ridge, and is continuous with the south face of Adams Peak Range to the west. The crest of the ridge is lowest at the western end, adjacent to the scarp

face of Adams Peak Range below Meriyakota. At this point, the crest of the ridge is at 4,900 feet approximately. Eastward, the ridge crest rises to 6,000 feet along the southern nose of the Maskeliya Syncline, and 5,100 feet to 6,300 feet along the nose of the Bogawantalawa Syncline.

Weathering in this area has been intense and deep residual soils mantle most of the features. These soils vary from moderately granular to moderately clayey depending on the local lithology. Erosion of the granular soils produces rounded interfluvies, steep sided valleys, and a more open drainage pattern. Erosion of the finer grained, more clayey soils produces a denser drainage pattern of more sharply etched valleys. Alluvium filled valley bottoms are more common in the latter case. Mass-wasting as evidenced by the deep talus deposits, the rock falls, and the slump phenomena is also important in this area.

Structural control of erosion and drainage is illustrated by the numerous strike and fault valleys. Some of the former follow the curve of bedding around the noses of the synclines, the streams having to cut across these beds via fault valleys in their general descent. The latter have a dominantly northeast trend not everywhere the same.

Although heavy forest covers the surface along the crest of the ridge, it appears that the drainage pattern and, therefore, the erosion which produced it, is very similar to that on the unforested lower

slopes (Fig. 84). This would tend to indicate that the erosion occurred prior to the growth of the present forest. In detail, however, it is possible to see that erosion is currently more active on the unforested lower slopes. This appears to substantiate the fact that forests protect the soil from such processes.

The southern face of Worlds End Ridge is much steeper than the northern face (Fig. 85). The presence of faulting along this face has partly disrupted the structure but north dipping beds still form structural terraces on the lower slopes. The steep gradient of streams traversing this face has intensified erosion in some valleys, thus hindering the development of thick soils, except on talus and alluvial deposits associated with them. On the less steep valley sides, and on their bottoms, weathering is active and does develop deep residual soils. Mass-wasting has been active along the entire face of the scarp and has produced deposits which mantle or bury the lower slopes to the extent that only prominent resistant ridges project. For this reason, the boundary fault scarp is only visible at the western and eastern ends of the ridge.

Haputale Ridge

Haputale Ridge is, in effect, the continuation of Worlds End Ridge to the east of Worlds End Plateau. It extends from the eastern



FIGURE 84

Erosion Patterns, North Face, Worlds End Ridge

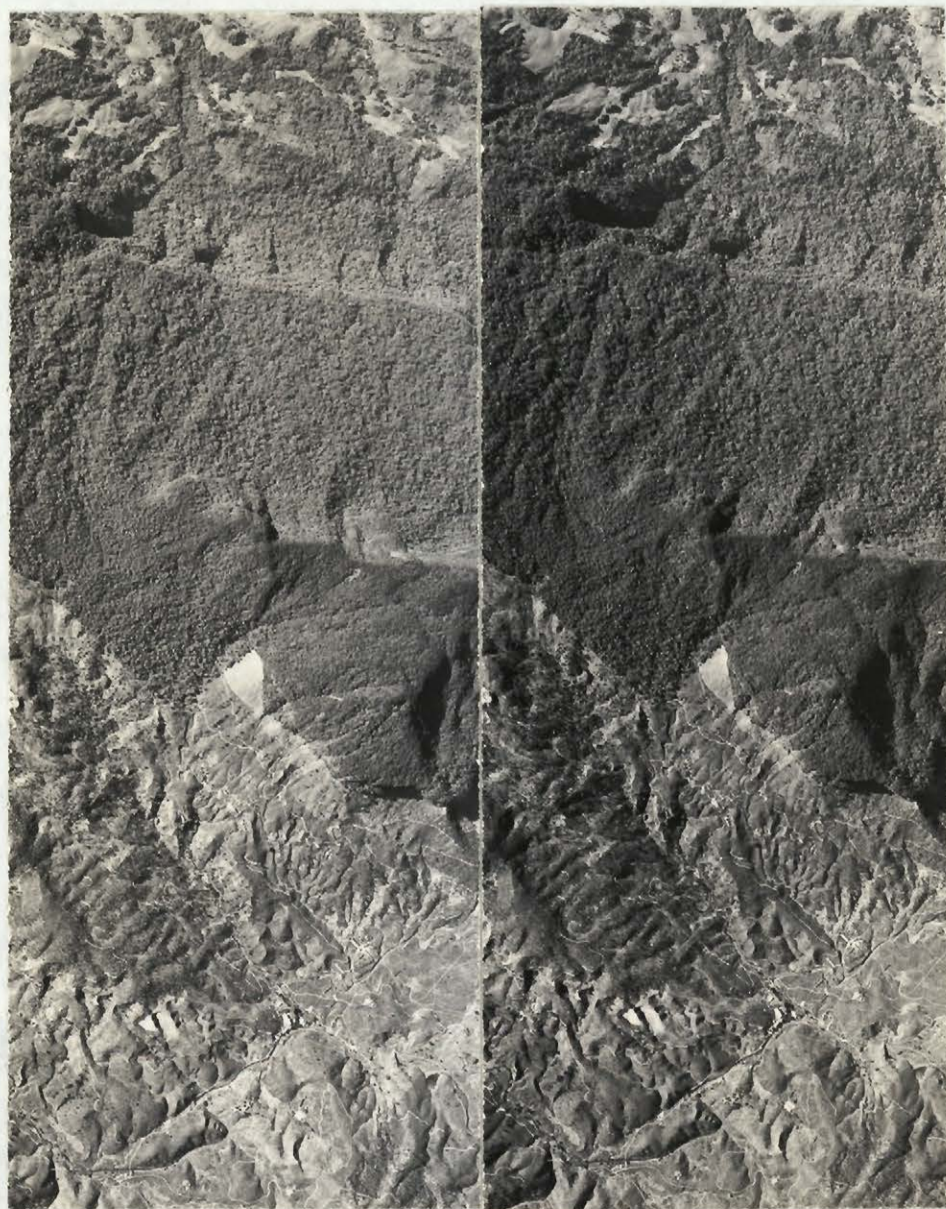


FIGURE 85

Fault Scarps, South Face, Worlds End Ridge

side of the plateau, through the following peaks: an unnamed 6,800 foot peak above Upper Ohiya; Tungoda (6,051 feet); Batgoda (5,422 feet); Berragala North (5,832 feet); Kadawatta (4,724 feet); Roehampton No. 2 (5,656 feet); and terminates in the group of peaks and ridges surrounding Bandera Eliya Plateau.

It consists, throughout most of its length, of a steep sided strike ridge, which apparently forms the southwest limb of a tightly folded west-northwest trending syncline through Ohiya. The south face is formed mainly by a continuation of the boundary fault forming the south face of Worlds End Ridge. From Haputale to Bandera Eliya Plateau this resistant ridge forms the northern rim of the Dambatenne basin. The Geologic structure of this basin has not as yet been worked out satisfactorily, but tentatively it appears to be an extension of the above mentioned syncline. The ridge forming beds in the Upper Lyegrove-Mousakellie area, dip steeply northwest; the beds in the centre of the basin dip very gently toward the south, and the beds bordering the Bandera Eliya Plateau on the east and northeast appear to dip west and southwest respectively (Fig. 86). However, the beds forming the southern lip of the basin dip moderately to the north or north-northwest (Fig. 87). In addition, a major fault, which can be traced from the Tanamalwila Peneplain on the southwest to the southern scarp face of Ella Rock on the northeast, cuts the basin roughly in half and



FIGURE 86

Bedrock Outcrop and Dip of Bedding, Dambatenne Basin



FIGURE 87

Dip of Beds, South Lip, Dambattenne Basin

controls the valley of the main branch of the Lemastota Oya. The Bandera Eliya Plateau (Fig. 88) is located at the head of the Dambatenne valley. It is cut by the same fault which cuts the valley and may be an eroded remnant of the axial beds of the syncline mentioned earlier.

East-southeast of this basin lie a series of relatively short strike ridges, the Poonagala Ridges (Fig. 89). These ridges, which consist of resistant beds having steep northwest dips, and northeast strikes, are separated by deeply incised strike valleys.

Weathering is intense along the entire length of Haputale Ridge. The northern face is mantled with thick residual soils with a more or less granular, permeable texture. These soils have good internal drainage and the fine pattern of gullying characteristic of high runoff and erosion is absent. Here, rounded interfluvies and rock bottomed valleys are common as are small, crescentic slump scars. On the southern face of the ridge, however, the soils, though well developed on the flatter areas, have been eroded from the steep rock faces. Rock-falls and rockslides have produced a very thick talus covering extensive parts of the slope. Large blocks of more or less unweathered rock are characteristic of this material and are easily discernible on the aerial photographs (Fig. 86). Slump and soil flowage are also present to a considerable extent. In general, these latter forms of mass-wasting occur in valleys or where large masses of weathered talus and alluvium



FIGURE 88

Bandera Eliya Plateau Surface

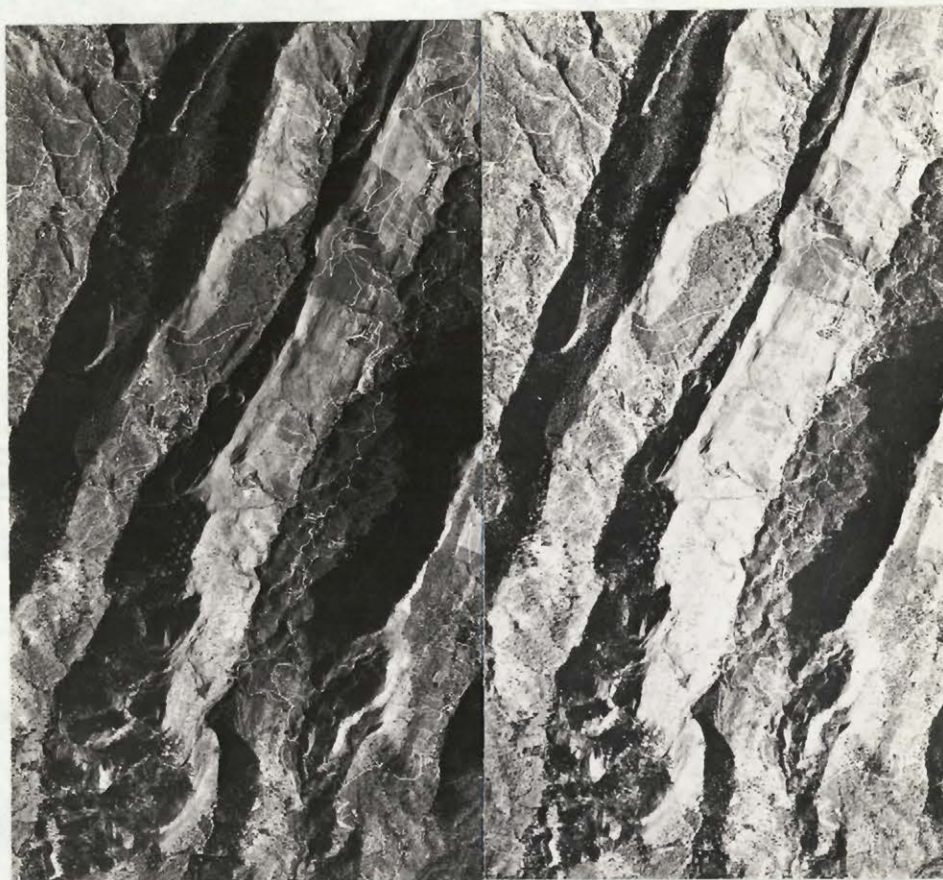


FIGURE 89

Diyaluma Falls and Strike Valleys, Poonagala Ridges

have slipped from temporary structural stabilizers such as low ridges, inward dipping beds, or changes in gradient of the slope. Erosion is active on the southern slope and has cut deep gullies in the above mentioned soil-rock complex. Some valleys are being eroded headward along well defined faults, others are controlled by the strike of bedding or foliation.

In the extreme west end of Haputale Ridge the very deep V-shaped valleys of the Belihul Oya and Kiriketi Oya are being incised headward into Worlds End Plateau along faults, which have been traced from the Rakwana section of the Sabaragamuwa Hills twenty-five miles to the southwest (Fig. 90 and Fig. 91). The geologic structure of the interfluvial ridges in this area is very complex and the pattern of drainage is controlled in part by faults, in part by bedding, and in part by the slope alone.

At the eastern end of Haputale Ridge, the slopes of the Dambattenne basin are only moderately weathered and eroded. Mass-wasting, however, is very active. So dense is the concentration of large rock fragments and blocks that the soils might easily be classed as rock-block soils (Fig. 86). The Poonagala ridges are also well weathered. Relatively thick residual soils are developed on the less steep dip slopes and thick talus and slump deposits on the scarp slopes (Fig. 89). The strike valleys have been partly filled by colluvial and alluvial



FIGURE 90

Headwaters of Belihul Oya Cutting Into Worlds End Plateau

Along a Major Fault



FIGURE 91

Active Erosion Controlled by a Major Fault,
Kiriketi Oya Valley, Haputale Ridge

deposits where debris streams or smaller gullies empty into them. Large rock fragments are also common in the colluvial deposits of this area. In the valley of the Punagala Oya, Diyaluma Falls is an example of a resistant bed arresting the downward erosion of a valley. In this case the resistant bed is quartzite (Fig. 89 and Fig. 92).

In summary, Haputale Ridge consists of a structurally and lithologically controlled ridge with a steep 3,000 to 4,000 foot scarp forming the south side, and a less steep 1,500 foot scarp or slope forming the north side. Erosion on the southern face is more intense as a result of the higher rainfall brought by the southwest monsoon and local orographic convection conditions.

High level plateaux

Worlds End Plateau

Worlds End Plateau consists, with the exception of a few small fragments south and west of Nuwara Eliya, of a well dissected 7,200 foot erosion surface, locally called Horton Plains (Fig. 21). It is located at the south end of the Pidurutalagala Range between Worlds End Ridge on the west and Haputale Ridge on the east (Fig. 20). The southern margin of the plateau has been discussed as part of Haputale Ridge.

This plateau is considered here to be a relict fragment of one



FIGURE 92

The Lip of Diyaluma Falls from Royal Ceylon Airforce Helicopter

of the earliest peneplanation stages in Ceylon's geomorphologic history. Very deep weathering of the present surface has resulted in the formation of low, well rounded hills separated by broad, rounded valleys. Meandering streams follow these valleys to produce a roughly controlled drainage pattern (Fig. 93). Erosion by these streams is only active near the margins of the plateau. Here, a moderate increase in gradient changes over a short distance to a very rapid increase in gradient (Fig. 90 and Fig. 91).

On the northwest, the headwaters of the Agra Oya are cutting into the margin of the plateau although they drain only a small part of it (Fig. 43, Mahaweli Ganga Profile, Appendix A). On the west, the headwaters of the Bogawantalawa Oya are dissecting a heavily forested part of the plateau just south of Kirigalpota (Fig. 70, Kelani Ganga Profile, Appendix A). On the south, the Belihul Oya, which drains almost the entire plateau, is incising a moderately deep V-shaped valley into its surface, and a deeper gorge-like fault valley into its margin (Fig. 90). The break between the major deeply incised valley of the scarp face and the open V-shaped marginal valley of the plateau is marked by Galgama Falls. East of the Belihul Oya valley, the Kiriketiti Oya has eroded an even more impressive gorge-like fault valley into the margin of the plateau (Fig. 91). In this case, the stream does not drain the plateau except for the extreme margin. In fact, at

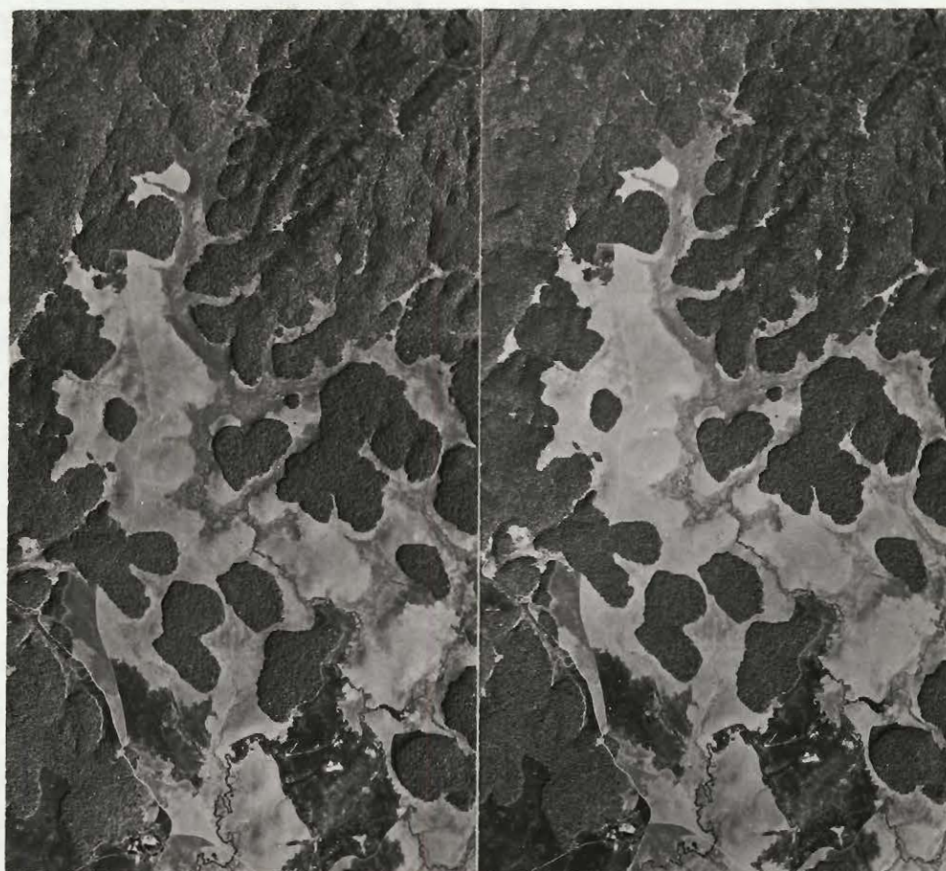


FIGURE 93

Low, Rounded Hills, Broad Valleys, and Meandering
Streams, Worlds End Plateau

several places it has truncated valleys of streams flowing into the Belihul Oya to the west without capturing their drainage. In a distance of five miles, the valley of the Kiriketi Oya drops 5,000 feet from its head in the plateau to its foot at its intersection with the Balangoda Shelf. This represents an average gradient of 1,000 feet per mile, a strong argument for the existence of a major fault along this face.

The eastern margin of the plateau is cut by the headwaters of two other streams; the Weli Oya on the south, and the Ellatotakanda Oya at Ohiya.

Neither erosion nor mass-wasting are active on the plateau at present. The soils are the result of deep weathering and apparently have good internal drainage and little runoff. The interfluves, as mentioned previously, are well rounded and have generally accordant summits. In places, a rough alignment of the long axes of these hills is the only indication of structural control; elsewhere, the structure is completely obliterated. Totupola, a 7,741 foot peak on the north, and Kirigalpota, a 7,857 foot peak on the southwest, are considered here to be structurally controlled erosion remnants or monadnocks rising above this peneplain.

The plateau fragments in the vicinity of Nuwara Eliya have a more angular, structurally controlled, erosion pattern, similar to that

of the marginal phase of the main plateau. However, the marginal disruption of drainage pattern, the general accordance of summits, and the accordance of elevations, has led to their inclusion as fragments of this erosion surface.

In summary, Worlds End Plateau represents the last remaining recognizable fragments of a once broad peneplain surface. The classification of peneplain rests on the following criteria: valleys with interrupted profiles; old age in the headwaters, youth lower down; old age interstream areas with youthful valleys cutting them; truncation of rocks of varying structure and resistance; and a general accordance of surface elevations.

Kandapola Plateau

Kandapola Plateau consists of a well dissected erosion surface just east of Pidurutalagala, and several smaller fragments in the vicinity of Uda Radella, Waterfall Point, One Tree Hill, and Mahakudagala (Fig. 21), all within the Pidurutalagala Range (Fig. 20). It consists of a deeply weathered, rather deeply dissected surface with open V-shaped valleys, well rounded, generally accordant interfluves, flat or broadly rounded, alluvium floored valley bottoms, and marginal dissection resulting in a break in the profile of the streams draining the area. The general level of the original surface appears

to be approximately 6,800 feet. Erosion on the plateau is not active, although some of the minor tributaries appear to be cutting slowly headwards into slightly higher valleys of an earlier stage of erosion. Mass-wasting is also inactive on the plateau.

Whether this surface and the accordant fragments with somewhat similar characteristics mentioned above, are the remnants of a peneplain surface or are structurally controlled plateaux with similar elevations has not been positively determined. However, this surface does appear to correlate as a high phase of the Elk Plains level to be discussed subsequently, and is classified as such.

Pattipola Plateau

Pattipola Plateau comprises three widely separated erosion surfaces with the same general elevation (Fig. 20 and Fig. 21). The main portion of this plateau forms a major part of Pidurutalagala Range between Worlds End Plateau on the south and Pidurutalagala on the north. This section comprises the Moon Plains, in the Nuwara Eliya area, and the Elk Plains, in the Ambawela-Pattipola area. At the eastern end of Haputale Ridge, Bandera Eliya Plateau is considered to be a correlative surface. Similarly, portions of the Worlds End Ridge and Adams Peak Range on the west are considered to be correlatives of the central plateau.

Geomorphologically this central plateau is very similar to Worlds End Plateau with the exception that the erosion and drainage patterns are somewhat finer. In general, it consists of a deeply weathered surface with low, rounded hills, and rounded valley bottoms floored with alluvium. Mass-wasting in the form of minor slump scarps is present but unimportant. Little active erosion is present except in the marginal areas. With the exception of these latter areas, the presence or absence of forest cover appears to have little effect. In the marginal areas, the headward erosion of the streams which are attacking the scarp faces bordering the plateau on the east and west, has provided a lowering of the local base level and this has resulted in a wave of headward erosion in the plateau streams. The sharper V-shaped valleys produced by this erosion are in places extending well toward the central area and will eventually result in a greater local relief and more angular topography. Nickpoints generally associated with rejuvenation and the resulting headward erosion, are not always present on the plateau. It is probable that, due to the deeply weathered nature of the soil, such features do not persist very long. However, almost all the streams flowing off the plateau have relatively large falls at its margin. Elgin Falls is characteristic (Fig. 74). Exceptions to this situation are the streams flowing along a strike valley where structural control has provided a steady, though often steep,

gradient. The interfluvial hills of the plateau do not, as a rule, indicate structural control but the marginal valleys and occasional resistant ridges or peaks, do. The latter, as discussed previously, are considered to represent monadnocks on the original peneplain surface. Hakgala and Conical Hill, although not included within the present boundaries of the plateau, may in fact be part of the original surface.

Peak Wilderness Plateau is a moderately to deeply dissected erosion surface, forming part of Pattipola Plateau (Fig. 21). In the Adams Peak area, it consists of a moderately eroded, heavily forested, irregular surface. The criteria which mark it as being the remnant of an earlier peneplain are the generally accordant summits, the change in gradient and form of the valleys as they leave the high level plateau, the presence of broad, flat, alluvium floored valleys and the truncation of structure (Fig. 64). This area, which lies south and east of Gartmore valley, is cut off abruptly on the south by the south boundary fault scarp. Weathering of the Peak Wilderness Plateau surface does not appear to be as intense as it is in the Moon Plains-Elk Plains area, possibly because of more resistant lithology. Erosion also appears to be limited on this surface, possibly because of the small drainage basins and less weathered soils. The plateau surface is not controlled by structure to any marked extent, although

its eastern boundary is formed by a strong strike scarp, and its southern boundary by an even more impressive fault scarp. Westward, the 6,200 foot level of the plateau is represented by three shoulder-like ridges extending radially from Adams Peak (Fig. 94). Eastward, a very rough accordance of summits in the Detanagala-New Peak area of the Worlds End Ridge may indicate a small fragment of this surface, but proof is lacking.

Bandera Eliya Plateau at the east end of Haputale Ridge, forms a small eastern correlative of Pattipola Plateau. It consists of a moderately dissected, deeply weathered surface with the drainage pattern controlled by poorly developed strike ridges and a rather complex series of faults or joints (Fig. 88). In their upper reaches, the valleys generally have open V-shaped or rounded cross-profiles, with moderately rounded interfluves. At the margin of the plateau, these valleys show an abrupt increase in gradient and become headward eroding, more sharply etched, deeper, V-shaped valleys. Falls are common features of the marginal break in longitudinal profile. The marginal scarps of this plateau show some mass-wasting in the form of rockfall, rockslide and debris slide or flow, but there is little evidence of such action on the plateau itself. The general level of the Bandera Eliya Plateau is 6,200 to 6,300 feet.

In summary, Pattipola Plateau consists of a well marked



FIGURE 94

Adams Peak and Shoulder-like Ridges Possibly Correlative

With 6,200 foot Pattipola Plateau Level

Ereable
FLOWER BOND
25% COTTON FIBER
U.S.A.

central peneplain remnant forming the major part of the Pidurutalagala Range between Worlds End Plateau on the south and Pidurutalagala on the north, and two much smaller plateaux which are considered to be correlatives; one in the Adams Peak Range, Peak Wilderness Plateau, and one at the east end of Haputale Ridge, Bandera Eliya Plateau. The general level of this surface is 6,200 to 6,300 feet above sea level. Several prominent peaks project from this plateau as erosion remnants or monadnocks.

Hatton-Diyatalawa Plateau

The Hatton-Diyatalawa Plateau as outlined by this study is the most extensive plateau of the inner block of the Central Massif. It has been divided into western and eastern parts, mainly on the basis of structural and erosional characteristics. The western part has been named the Hatton Plateau and the eastern part the Diyatalawa Plateau. Each of these plateaux has had approximately two-thirds of its area reduced to lower levels by the processes of degradation, leaving one-third identifiable as part of the original surface (Fig. 21). Scattered peaks and ridges within the central block, having summit levels which correlate with this surface, may verify its extent.

The portion of the original Hatton Plateau surface which can be delineated on the aerial photographs, consists of the area bounded

by Adams Peak Range on the southwest, Worlds End Ridge on the south, Pidurutalagala Range on the east, and a line roughly joining Laksapana Falls on the Maskeliya Oya and the western end of Great Western Spur.

The portion of the original Diyatalawa Plateau surface which can be delineated in a similar manner, consists of the area bounded by Pidurutalagala Range on the west, Haputale Ridge on the south, and a rough line from the eastern end of Haputale Ridge through Hali Ela, Welimada, Dodangolakanda, to Ragala Rock on the Mahakudagala Spur of the Pidurutalagala Range.

Hatton Plateau consists of a moderately well marked 4,500 to 4,800 foot erosion surface, deeply dissected by tributaries of the Mahaweli Ganga and Kelani Ganga. The bottoms of many of the high level valleys which have cut into the surface of this plateau in its initial stage of dissection are now at approximately 4,200 feet. In the Talawakele area, these valleys form hanging valleys over the more deeply eroding Agra Oya. The Agra Oya at the top of St. Clair Minor Falls has an elevation of approximately 3,800 feet, and its continuation downstream as the Kotmale Oya is at 3,200 feet (one-half mile below the St. Clair Major Falls). The base of the falls itself is at about 3,400 feet (Fig. 95, see Mahaweli Ganga Profile Fig. 43, Appendix A). These elevations which indicate three stages of uplift are

reproduced in roughly the same sequence in the other tributary valleys of the Mahaweli cutting this plateau, and in the profiles of the Kehelgomu Ganga, Hambantota Oya, Bogawantalawa Oya, and Maskeliya Oya tributaries of the Kelani Ganga (Fig. 70, Kelani Ganga Profile, Appendix A).

Two major northwest trending strike ridges parallel the north-eastern scarp face of Adams Peak Range; one separating the Maskeliya valley from the Kehelgomu valley, and the other separating the headwater drainage of the Kelani Ganga in the Kehelgomu valley from the headwater drainage of the Mahaweli Ganga in the Ginigathena-Hatton valley. Representative peaks with their elevations include: in the Maskeliya Ridge, Yakahaluwela (5,210 feet), Dandukellawagala (4,777 feet), and Ballapennungala (4,187 feet); and in the Dikoya Ridge, Benachie (4,193 feet). The remainder of the plateau between the Hatton valley and the Kotmale Oya valley appears to consist of a broad synclinal structure extending from the Worlds End Plateau on the southeast to Rilagala in the northwest. Representative peaks of this structure include: Relagala (5,525 feet); Kotagala (5,757 feet); Preston Hill (5,722 feet); and Elbedda (6,616 feet). These structures have been cut by numerous major and minor faults and joints. The dominant trend of faulting is northeast-southwest with a shift to east-west in the south. Any northwest-southeast faulting would be much more difficult to determine since it would parallel the strike of bedding.

Deep weathering is indicated throughout the area by the well rounded interfluvial hills and ridges and general "buried" appearance of the complex structure. Field investigation has shown that almost everywhere throughout this area at least 10 to 20 feet of well weathered soil is to be expected. This soil, in general, consists of a mixture of residual, colluvial, and alluvial materials with the dominant phase depending on the topographic location.

Erosion is most active on the steep sides of the main valleys, up their headward eroding tributaries, and on the slopes of the major hills or peaks. The generally porous and permeable nature of most of the soils does not foster the development of fine drainage patterns but on the steeper slopes, close parallel gullying is common. Alluvium resulting from the erosion described above is trapped by numerous minor, as well as major, local structural barriers and flat bottomed valleys are formed. In the Maskeliya valley, a structural barrier about one and one-quarter miles west-northwest of the village of Maskeliya has controlled the deposition of a broad, alluvium floored basin at an elevation of approximately 3,800 feet (Fig. 63). In general, the streams of the Hatton Plateau appear to be flowing in a series of bedrock floored channel segments, separated by the alluvium floored sections mentioned above. Except for these latter sections, erosion is active.

Mass-wasting is present throughout the Hatton Plateau but is most obvious on the steeper slopes of the major valleys and on the steep slopes of the peaks or high ridges. Rockfalls and debris slides are active along the scarp faces, in places resulting in deep talus deposits containing numerous angular blocks of relatively unweathered rock of all sizes. In some cases landslides have precipitated very large masses of earth and rock into the valleys below, at least partially blocking them. The large landslide one mile above Laksapana Falls in the Maskeliya Oya valley, is an excellent example of this feature. It has the typical rough, hummocky surface and rounded flow pattern and has left a well marked scar on the slope above. Elsewhere, slump and the very slow but effective process of soil creep are active. Slump scars and the bulging surface of the slumped soil are easily visible on the aerial photographs, but evidence for the less obvious soil creep is most easily seen in the field. It is considered probable that the convex slopes are, at least in part, the result of dominant weathering and mass-wasting and the concave slopes the result of dominant weathering and erosion.

The characteristics of the Hatton Plateau which are indicative of its peneplain origin are as follows: accordant, generally flat topped interstream areas; rounded mature valleys upstream, being cut into by youthful valleys downstream; the presence of abrupt changes in

stream profile; and well rounded hills of very deep residual soil on the upland surface. Resistant ridges and peaks which rise as monad-nocks or erosion remnants above the general surface and shoulders or terraces on the higher ridges are also indicative. The shoulder on Great Western Spur at Watagoda has a 4,803 foot butte-like erosion remnant on its surface, and the east face of Adams Peak Range has a well marked shoulder at 4,300 feet at the mouth of the Adams Peak tributary of the Maskeliya Oya (Fig. 63).

The remaining northern portion of the Hatton Plateau surface has been eroded away to the extent that the only possible evidence of its existence could be scattered peaks with accordant summits, and fragments of terraces on the slopes of higher mountain masses. It is possible that Rilagala, 3,981 feet, and Etapola, 4,153 feet, west-northwest of Matale, are peaks of this nature, and that a poorly defined surface at 4,600 to 4,700 feet on the Hunasgeria Ridge north of Wategama is also correlative. No well marked plateau remnants at the required elevation were noted on the west face of the Knuckles Range.

Diyatalawa Plateau consists of a moderately well marked erosion surface correlative with the Hatton Plateau west of the Pidurutalagala Range. The summits of a majority of the low, rounded hills of this surface are roughly accordant at 4,400 feet. The valley bottoms of the upper, better developed surface, are at 4,000 to 4,200

feet and those of a lower more youthful stage at approximately 3,100 to 3,200 feet. The lower valleys which are eroding headward into the upper valleys, often bypass small tributaries which cannot keep up with their erosion resulting in numerous hanging valleys and faults. Some of the larger upper valleys have been able to lower their floors to approximately 3,500 to 3,800 feet as the result of more active erosion.

Structural control of drainage and erosion is most obvious along the upper and lower margins of the plateau and in the south-central area, north and east of Banderawela. Fault and/or joint control of drainage is in evidence throughout the area, but is especially well developed, probably by the increased erosion, in the central and south-east section.

Weathering of the Diyatalawa Plateau has been intense. Deep residual soils mantle the entire area and, in general, have obscured the bedrock structure. Where erosion is active, as along the main streams and their tributaries, these soils have been partly removed and the underlying structure is exposed. Most of the larger streams have bedrock channels except where local barriers have resulted in the deposition of alluvium. The upper surface of the plateau is composed of low, rounded hills or interfluvial ridges, separated by round or flat, alluvium floored valleys (Fig. 96). In general, the lack of



FIGURE 96

Rounded Interfluves and Alluvium Filled Valleys,

Diyatalawa Plateau

active gullying is indicative of the porous and permeable nature of the soils.

Although mass-wasting is not as active as in the Hatton Plateau area, some rockfalls and debris slides have occurred along erosion or fault scarps and some slumping and soil creep are present along the valley sides.

In general, the drainage pattern is more uniform and less controlled than that of the Hatton Plateau. Profiles indicate that the streams are approaching the graded state, which may be due in part to the general structure of the area, and in part to the much lower rainfall regime (Fig. 43, Mahaweli Ganga Profile, Appendix A). Another possibility is that these streams have been flowing into the lower Mahaweli Ganga throughout their entire history, but that the Hatton Plateau streams having flowed northward into the headwaters of the Deduru Oya and Amban Ganga for a period, were re-routed into the lower Mahaweli via its present channel past Minipe. These possibilities will be treated more fully in Chapter V.

As in the case of the Hatton Plateau, much of the Diyatalawa Plateau has been eroded, leaving large areas with little or no evidence of its former extent. Isolated peaks with roughly accordant summits such as: Kitnegallakanda (4,113 feet); Odampegala (4,066 feet); and Medamahanuwara (4,394 feet), may be correlatives. Madulsima Plateau and its extension to the north along the Namunakuli Range in

the Upper Loggal Oya valley, on the other hand, have features which make them almost certainly a marginal part of the Diyatalawa Plateau. The Madulsima Plateau consists of a rough, moderately dissected surface, cut by strike and fault valleys. The rounded, well weathered interfluves have roughly accordant summits, at a level of approximately 4,400 to 4,500 feet. The valleys generally have flat or moderately rounded floors of alluvium, and open V-shaped cross profiles. As the margins of the plateau, they change abruptly to steep sided, actively eroding gorges which are cutting into the high level surface on all sides. The peaks surrounding this plateau include: Kabarabokka (4,344 feet); Beriyagala (4,538 feet); Wegala No. 2 (4,652 feet); and Madulsima (4,600 feet approximately). The northern extension consists of a flat topped ridge crest, at an elevation of 4,500 feet, along the eastern side of a well marked synclinal valley forming part of the Namunakuli Range. The correlation of the Madulsima Plateau with the Diyatalawa Plateau to the west is considered logical when based on the above facts. No evidence of correlative surfaces has been noted in the study of the Knuckles Massif to the north.

In summary, the Hatton-Diyatalawa Plateau consists of a deeply weathered, deeply eroded peneplain surface split by the Pidurutalagala Range and a line joining the Mahakudagala Spur with the Knuckles Range to the north. Elevations are similar on both the

Hatton and Diyatalawa Plateaux, but erosion appears to have been active in more well marked stages on the former. The river profiles on the west, when compared with those on the east, illustrate this feature. Structure on the west is more straightforward, consisting for the most part of northwest trending anticlines and synclines cut by northeast trending faults. Structure on the east is more complex and less easily seen, although the northeast fault trend appears to be the same.

Medium level plateaux

Ulupana Shelf

The Ulupana Shelf consists of a small, poorly marked, deeply dissected plateau which may be an upper phase of the Balangoda Shelf (Fig. 20). Its elevation, marked by roughly accordant summits, is 2,600 to 2,800 feet. This surface truncates numerous beds of differing lithology and structure which form the nose of the Maha Oya Syncline and the lower slopes of Kabaragala (4,944 feet). In general, weathering is deep and erosion is active. The nose beds of the syncline form a rough boundary between the two main lithologies and, therefore, a boundary between the two main erosion patterns. The synclinal beds have rounded tops, moderate, somewhat convex slopes, and alluvium filled strike valleys between them. Faults and/or joints cut these beds

and control weathering, erosion, and the resulting drainage pattern. The valley bottoms have different levels depending on local base level control. Headward erosion by the Maha Oya, Kuda Oya No. 1, and Kuda No. 2 (larger) is attacking this surface, and the tributaries on the plateau are incising their valleys along its margin. A marked break in profile, usually without a falls because of the strike or fault nature of the valley, is characteristic of streams traversing the margin of the plateau. The portion of the plateau outside the syncline has sharper ridges, steeper, more concave slopes, more accordant summits and valley bottoms, and a finer drainage pattern. The valley bottoms are floored with alluvium resulting from erosion by streams draining the area and cutting down into the margin of the plateau en route to the Mahaweli to the east. Mass-wasting in the form of soil creep rather than slump or rockfall is probably active in this area. In general, the Ulupana Shelf is not correlated with any other similar levels.

Balangoda Shelf

The Balangoda Shelf is a medium level erosion surface forming a well marked terrace along the south wall of the central block of the Central Massif. It extends from the Kirindi Oya valley above Wellawaya to the Alutwelawisahena-Hunuwalkanda Ridge west of Balangoda (Fig. 20 and Fig. 21).

The geology of the Balangoda Shelf is complex. On the west it consists of a series of parallel, well weathered, west-northwest striking beds between the south branch of the Walawe Ganga and the Denagan Oya. Around these beds on the south and east, a much contorted and inward dipping belt of more resistant beds is located. The boundary beds of the Balangoda Shelf are generally composed of resistant quartzite. They form prominent strike ridges and, particularly in the western part, form a scarp which separates the Balangoda Shelf from the lower Molamure Shelf (Fig. 97). North and east of the Walawe Ganga, this belt of rock broadens and the northernmost beds, which extend along the foot of the main scarp, become much less resistant, allowing weathering and erosion to attack them with ease.

The west end of the Balangoda Shelf consists of a series of plateau fragments separated by the valleys of the main streams (Fig. 98). The hills appear resistant and rise above a flat alluvial plain, having an elevation of approximately 1,800 feet. The summits of the hills are roughly accordant at 2,000 feet, and are well rounded and deeply weathered. In the area between the south branch of the Walawe Ganga and the Denagan Oya, the hills form parallel strike ridges well buried in alluvium. The contorted belt has had deep V-shaped valleys eroded between the resistant beds. In general, erosion is more active adjacent to the Walawe Ganga and its main tributaries, than elsewhere

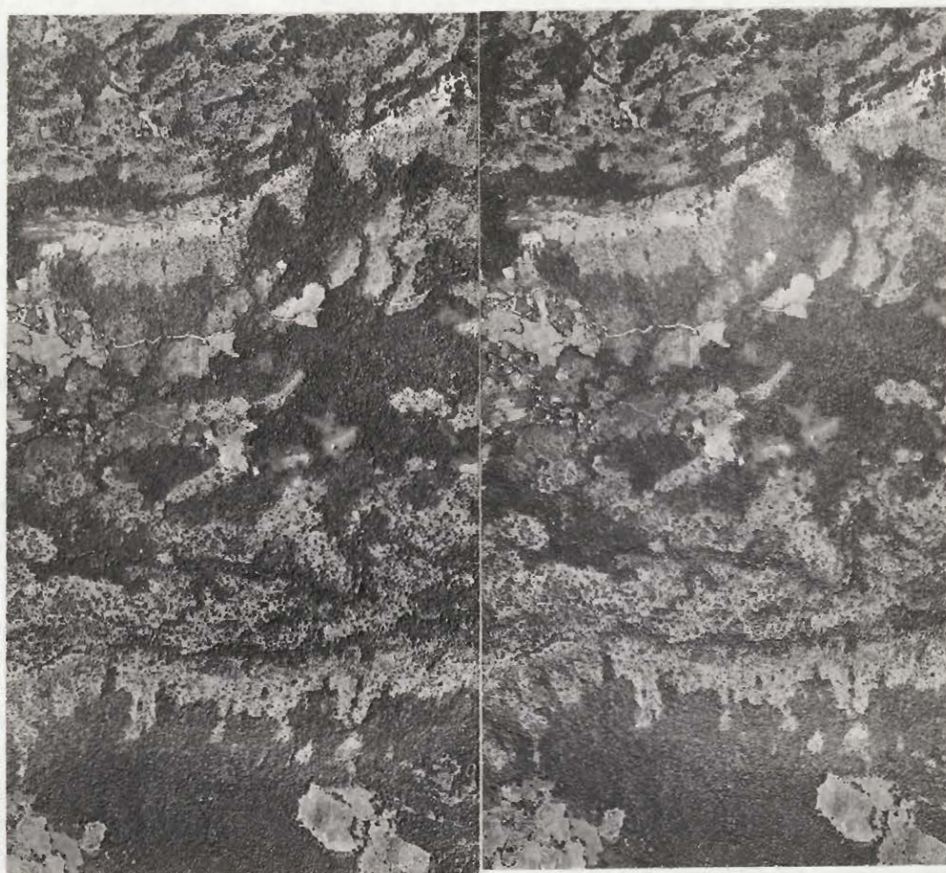


FIGURE 97

Balangoda Shelf, Molamure Shelf, and Scarps



FIGURE 98

Plateau Fragments, West End of Balangoda Shelf

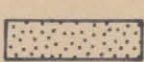
on the shelf. North of the Walawe, the folded beds adjacent to the scarp have a less resistant lithology and weather to a fine clayey soil which is subject to gullying and mass-wasting. Streams flowing down the scarp face appear to have little difficulty in cutting across these beds and in some places wander back and forth across strike ridges without any appreciable control (Fig. 99). In the area below Worlds End Plateau, the Belihul Oya and Kiriketi Oya have formed very large alluvial fans which partly bury some of the ridges (Fig. 100). Present erosion is cutting into these deposits, as it is into alluvial deposits in general on the Balangoda Shelf. Eastward, the easily weathered beds continue along the base of the scarp and are bounded on the south by more resistant beds. These are weathering to form a coarse, granular soil which is apparently more affected by mass wasting than erosion. In this area, outcrops are very common and are thinly mantled in the valleys and depressions by the granular soil described above (Fig. 101). South of Koslanda, deeply eroded gullies and a generally more angular surface appears indicative of the presence of soluble beds in the form of crystalline limestone or an easily weathered schistose rock.

On the whole, the Balangoda Shelf is composed of ridges and peaks with roughly accordant summits at an elevation of from 2,000 to 2,500 feet. Major faults cut the shelf in a northeast direction, in most cases, extending into the scarp face to the north (Fig. 91). In the southwest, faults may be the controlling influence in the alignment of

FIG. 20

CEYLON

MAJOR PHYSIOGRAPHIC DIVISIONS

CENTRAL MASSIF  KNUCKLES MASSIF 

MOUNTAIN RANGES & RIDGES

- Adams Peak Range 1
- Namunakuli Range 2
- Pidurutalagala Range 3
- Worlds End Ridge 4
- Haputale Ridge 5

HIGH LEVEL PLATEAUX

- Worlds End Plateau 6
- Kandapola Plateau 7
- Pattipola Plateau 8
- Hatton-Diyatalawa Plateau 9
- Selvakanda Plateau 18

MEDIUM LEVEL PLATEAUX

- Ulapaha Shelf 10
- Balangoda Shelf 11
- Peradeniya Basin 12
- Vellangollapatana Plateau 19
- Walpolamulla Terrace 20

LOW LEVEL PLATEAUX

- Kondesalle Basin 13
- Nalanda Shelf 14
- Molamure Shelf 15
- Wekada Shelf 16
- Mawanella Shelf 17
- Kaikawala Terrace 21

SABARAGAMUWA HILLS

MOUNTAIN RANGES & RIDGES

- Rakwana-Kiriella Ridges 22

HIGH LEVEL PLATEAUX

- Handapan Ella Plateau 23

MEDIUM LEVEL PLATEAUX

- Tangamale Plateau 24

HIGH LEVEL PLAINS

- Delgoda Plain 25
- Urubokka Plain 26

GAL OYA HILLS

ELAHERA RIDGES

LOW LEVEL PLAINS

PENEPLAINS

- Anuradhapura Peneplain 27
- Polonnaruwa Peneplain 28
- Tanamalwila Peneplain 29
- Southwest Peneplain 30

COASTAL PLAINS

- Mannar Coastal Plain 31
- Trincomalee Coastal Plain 32
- Pottuvil Coastal Plain 33
- Bentota Coastal Plain 34

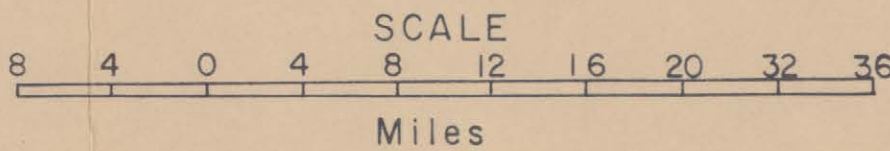
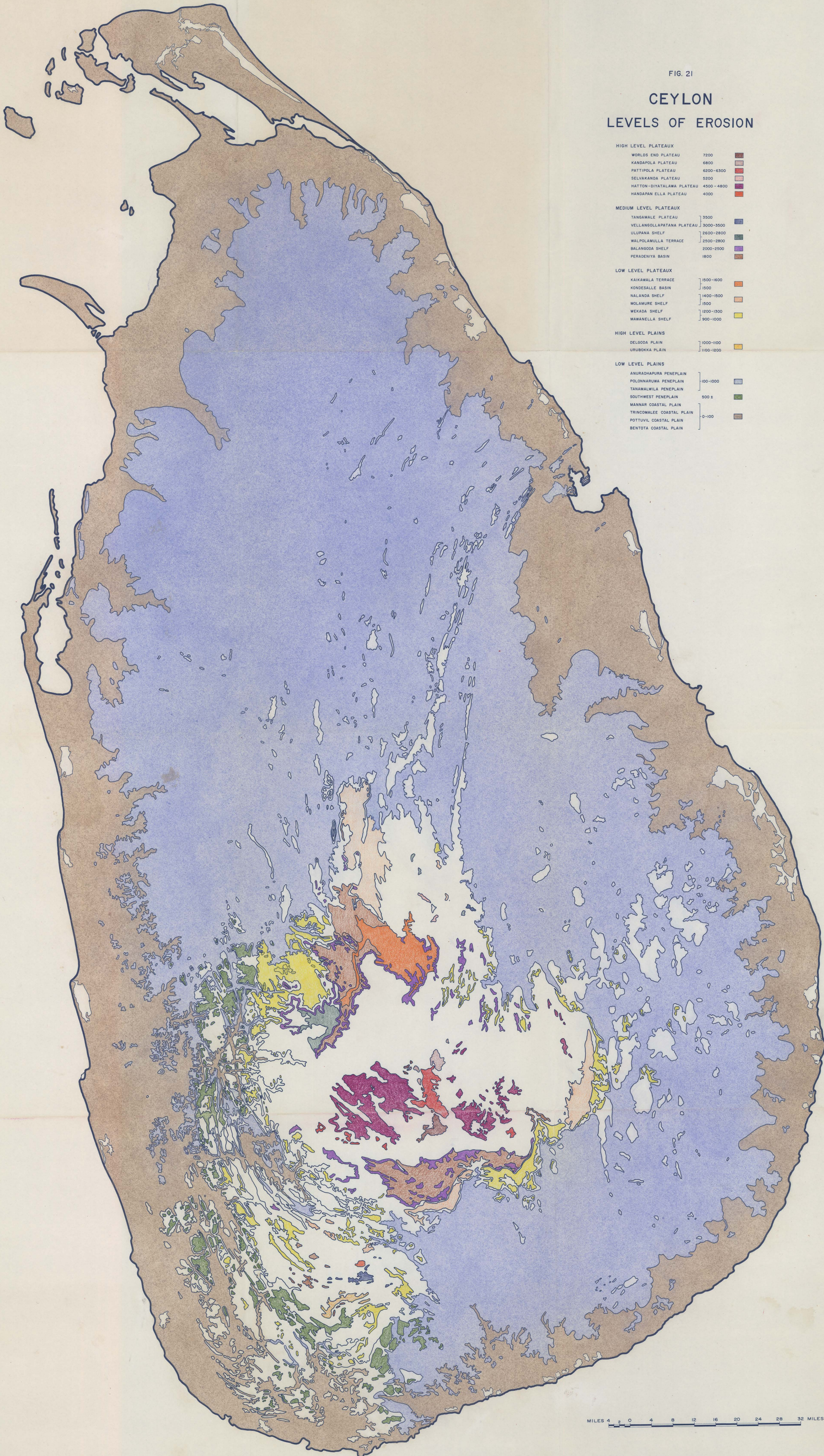


FIG. 21

CEYLON LEVELS OF EROSION

HIGH LEVEL PLATEAUX		
WORLD'S END PLATEAU	7200	
KANDAPOLA PLATEAU	6800	
PATTIPOLA PLATEAU	6200-6300	
SELVAKANDA PLATEAU	5200	
HATTON-DIYATALAWA PLATEAU	4500-4800	
HANDAPAN ELLA PLATEAU	4000	
MEDIUM LEVEL PLATEAUX		
TANGAMALE PLATEAU	3500	
VELLANGOLLAPATANA PLATEAU	3000-3500	
ULUPANA SHELF	2600-2800	
WALPOLAMULLA TERRACE	2500-2800	
BALANGODA SHELF	2000-2500	
PERADENIYA BASIN	1800	
LOW LEVEL PLATEAUX		
KAIKAWALA TERRACE	1500-1600	
KONDESALLE BASIN	1500	
NALANDA SHELF	1400-1500	
MOLAMURE SHELF	1500	
WEKADA SHELF	1200-1300	
MAWANELLA SHELF	900-1000	
HIGH LEVEL PLAINS		
DELGODA PLAIN	1000-1100	
URUBOKKA PLAIN	1100-1200	
LOW LEVEL PLAINS		
ANURADHAPURA PENEPLAIN	100-1000	
POLONNARUWA PENEPLAIN	100-1000	
TANAMALWILA PENEPLAIN	100-1000	
SOUTHWEST PENEPLAIN	500 ±	
MANAR COASTAL PLAIN	500 ±	
TRINCOMALEE COASTAL PLAIN	0-100	
POTTUVIL COASTAL PLAIN	0-100	
BENTOTA COASTAL PLAIN	0-100	



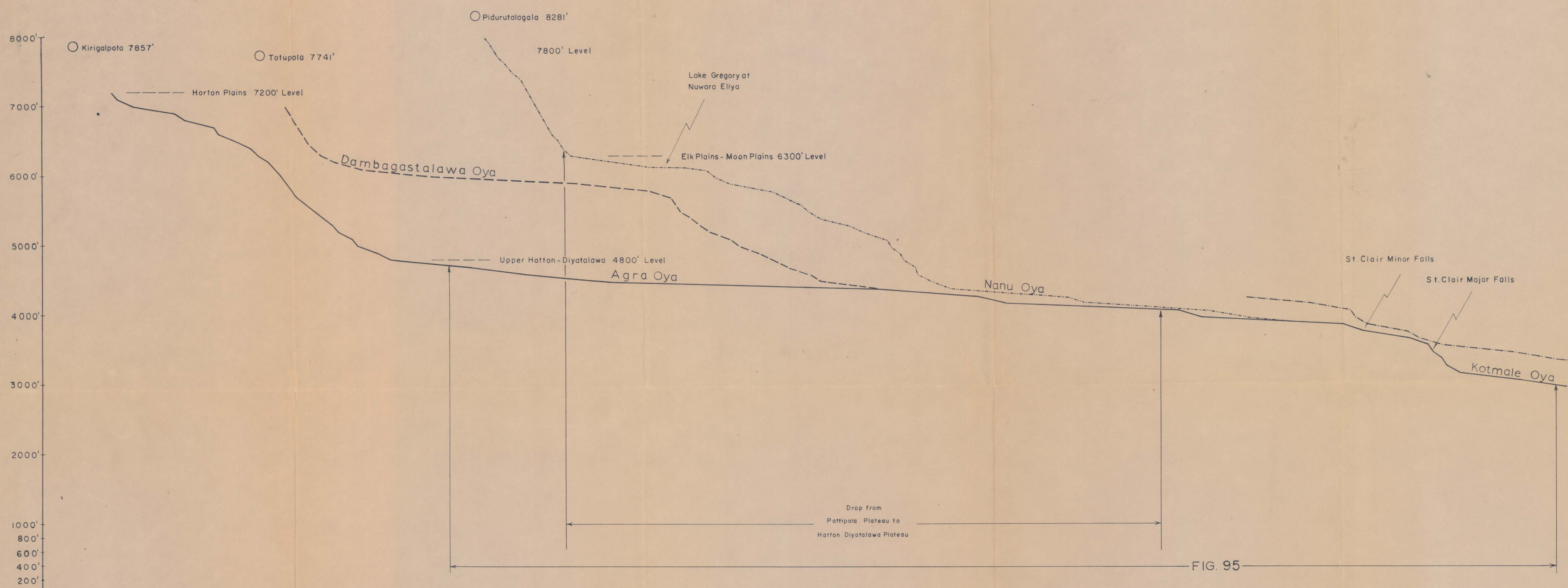
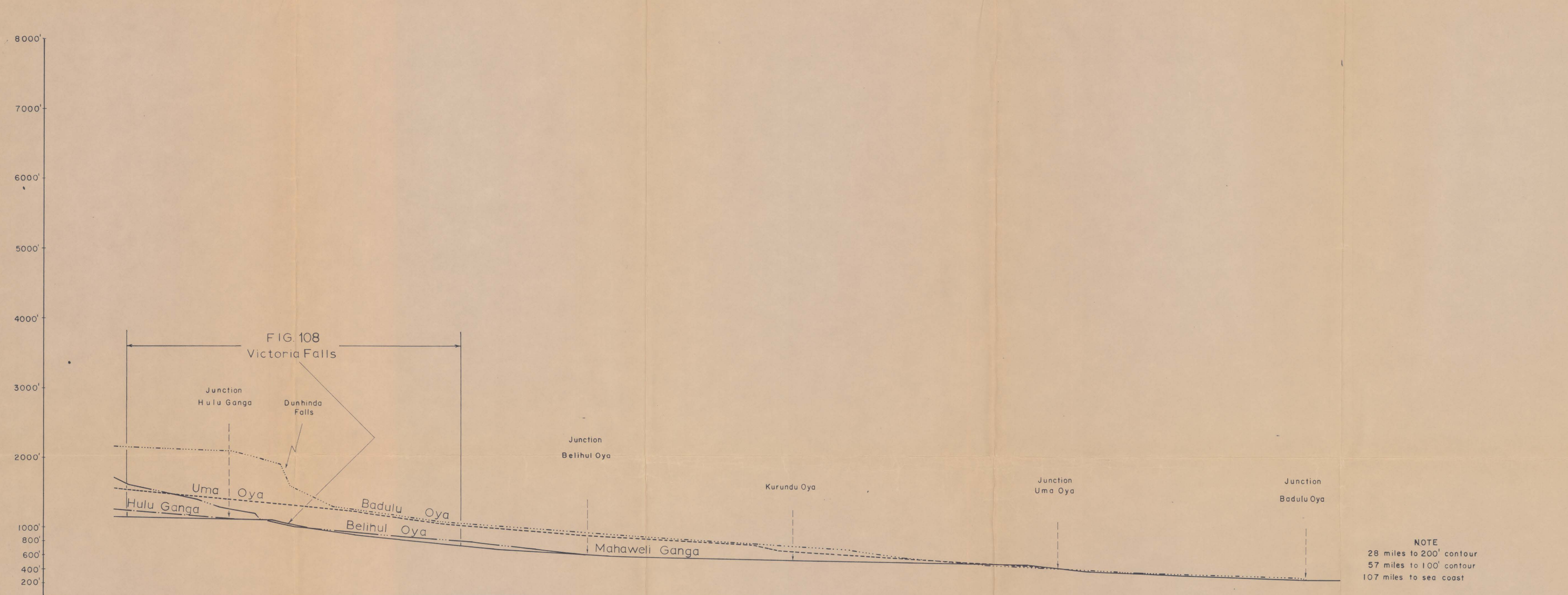
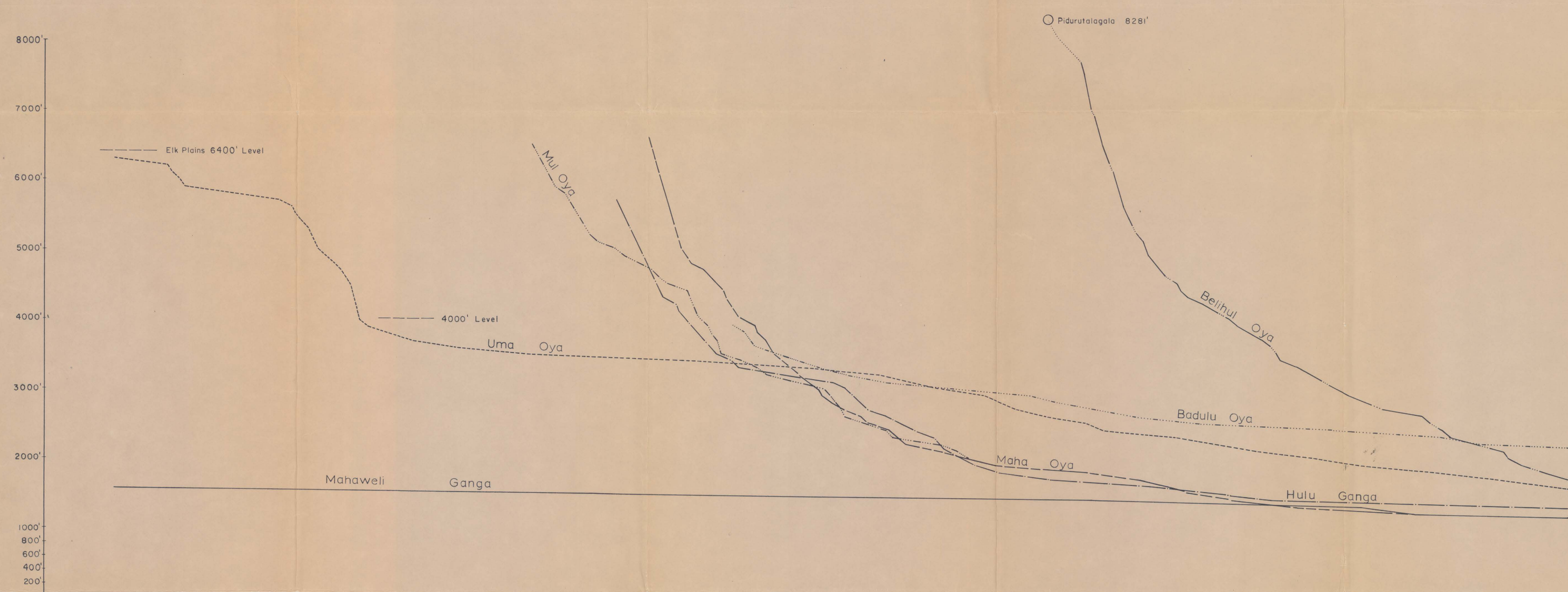
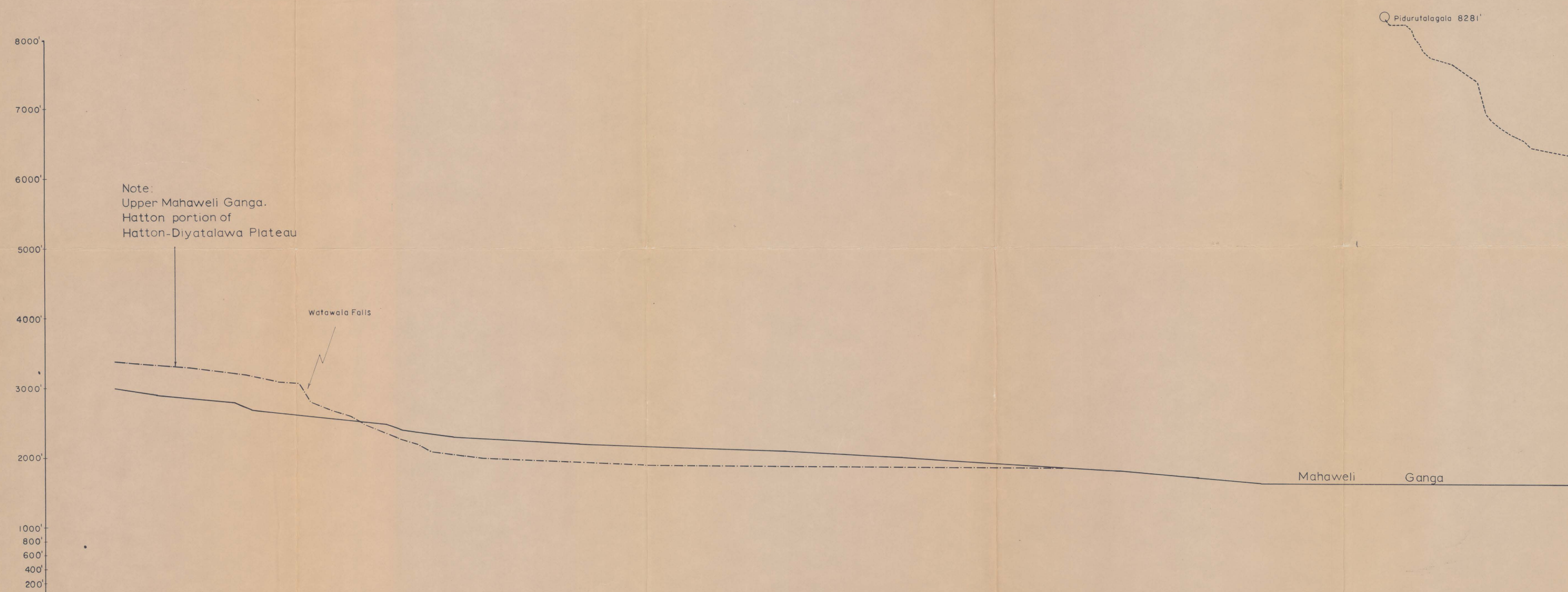


FIG. 95



NOTE
28 miles to 200' contour
57 miles to 100' contour
107 miles to sea coast

FIG. 43

MAHAWELI GANGA PROFILE

SCALE

HORIZONTAL 1 inch = 1 mile
VERTICAL 1 inch = 800 feet

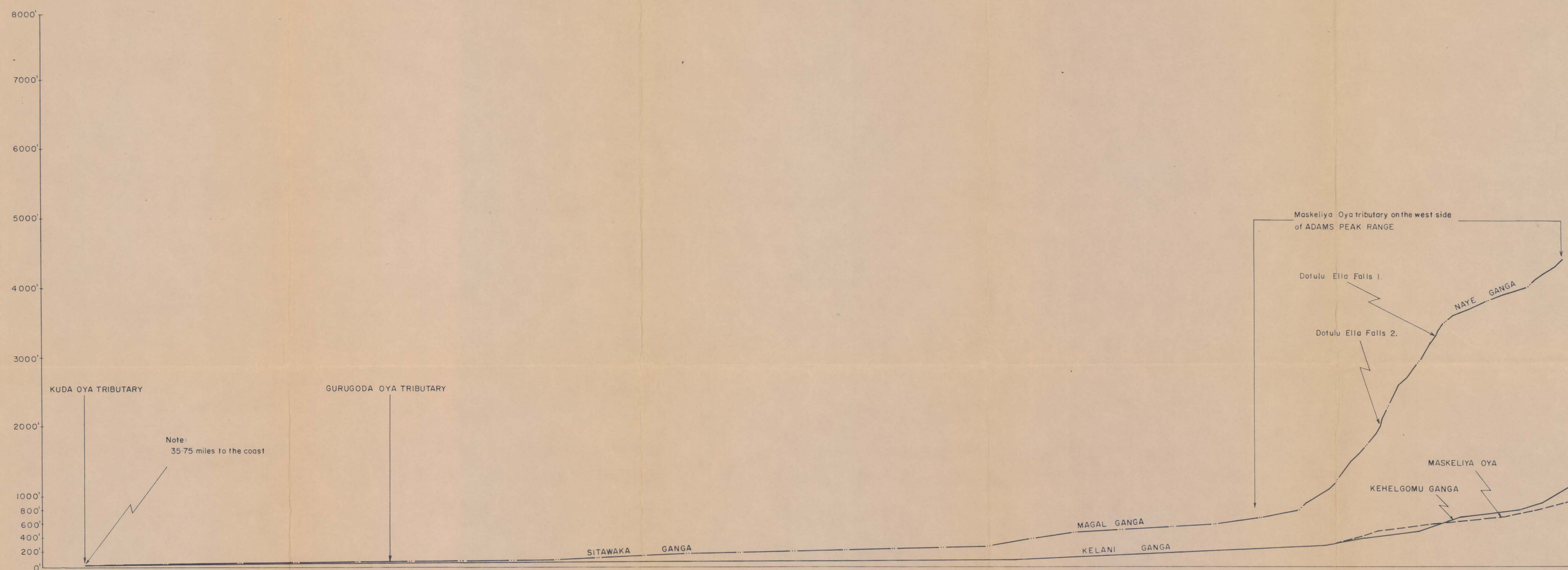
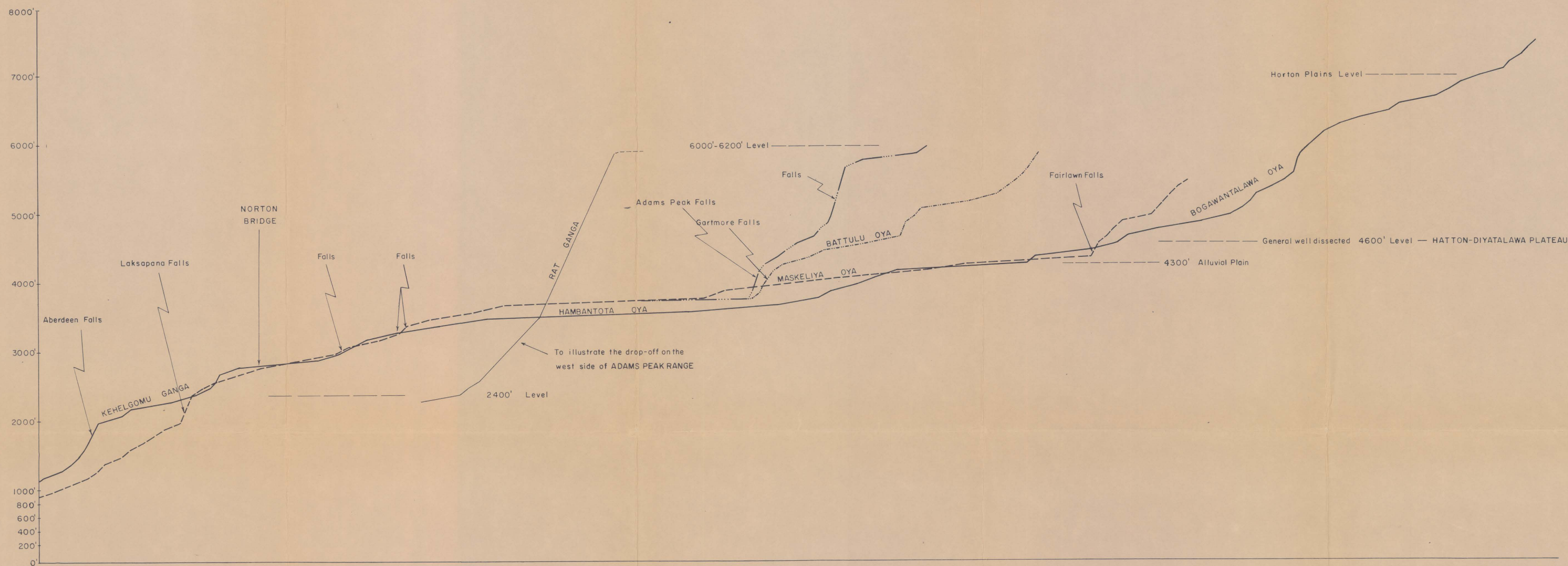


FIG. 70
KELANI GANGA PROFILE
 SCALE

HORIZONTAL 1 inch = 1 mile
 VERTICAL 1 inch = 800 feet



FIGURE 99

Streams Cutting Strike Ridges North of the Main Channel
of the Walawe Ganga



FIGURE 100

Alluvial Fan Deposited by Kiriketi Oya on Balangoda Shelf

Enoch
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FIGURE 101

Resistant, Quartzitic Rock Ridges Forming the South Margin
of the Balangoda Shelf Below Haputale

the east boundary scarp of the folded belt. Weathering is active throughout the area, but is much more effective on the less resistant rocks of the upper Walawe section and the contorted beds along the base of the scarp face of the central highlands. The quartzitic ridges weather to a granular and, in places, blocky material which has a characteristic light tone on the aerial photographs. The Kirioluahena ridge is an excellent example of this feature (Fig. 102 and Fig. 103).

Erosion is most active in association with the main rivers and in the areas of finer soils, both residual and alluvial. Where the rivers follow the strike of bedding or foliation, deep V-shaped valleys have been cut. Where the rivers cross structure, the valleys are gorge-like or have steep rocky slopes and rock floored bottoms (Fig. 104 and Fig. 105). The Walawe Ganga and its west-northwest extension, the Denagan Oya, appear to flow in a major fault valley which follows the strike of the beds upstream, but cuts across the structure downstream. In this area, the fall above Kaltota appears to be the result of a northeast fault (Fig. 104 and Fig. 106). The Weli Oya, Pataha Oya, Diyakana Oya, Kalkanna Oya, and Lemastota Oya, have eroded wide and deep valleys in the more easily weathered soils of the contorted belt, and have almost completely destroyed the original surface. In the upper Kirindi Oya valley, above Wellawaya, the Balangoda Shelf consists of small, terrace-like remnants (Fig. 21), which have



FIGURE 102

Kirioluahena Ridge, a Light Toned, Quartzite Ridge,

Balangoda Shelf



FIGURE 103

Helicopter View of Weathered, Quartz-block Surface,
Kirioluahena Ridge, Shown in Figure 102



FIGURE 104

Bedrock Channel and Structure Controlled Fall, Walawe

Ganga Above Kaltota, from Helicopter



FIGURE 105

Ground View of Fall and Gorge Shown in Figure 104,

Walawe Ganga above Kaltota

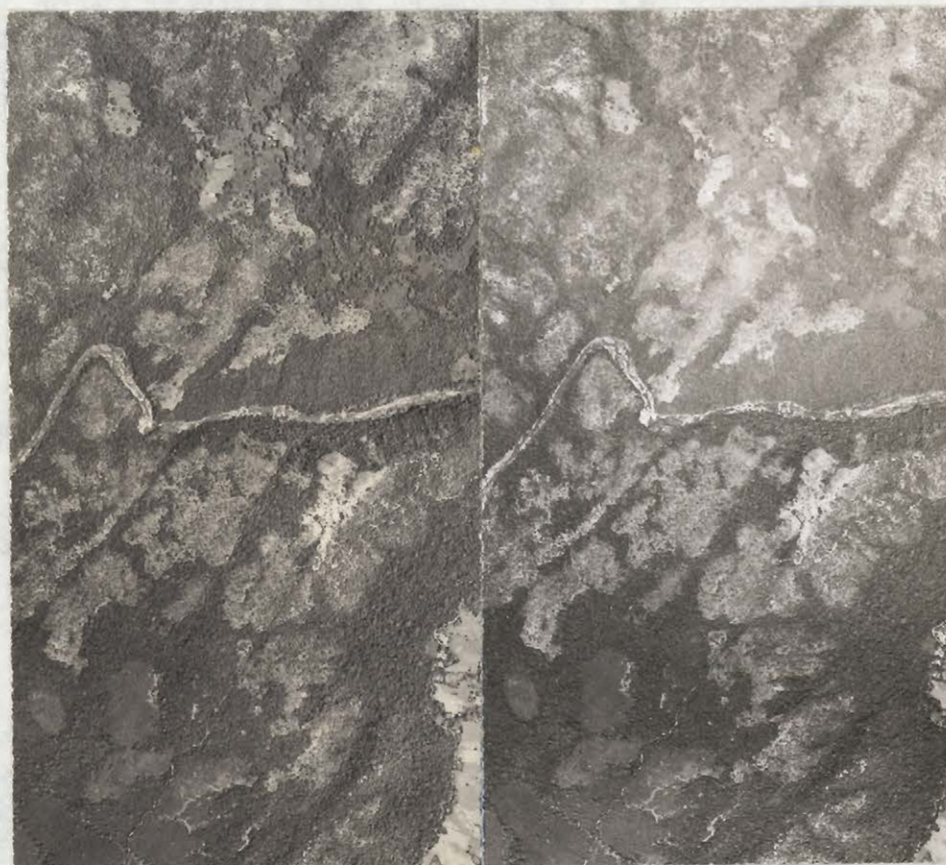


FIGURE 106

Probable Fault Control of Fall Shown in Figures 104 and 105,

Walawe Ganga above Kaltota

been left along the lower slopes by the active valley-side erosion. Mass-wasting produces fine grained talus deposits on the lower slopes and in the depressions of the resistant quartzitic ridges, especially in the southeast, and to a more limited extent, in the Iddagala Ridge area to the west. In the finer weathering soils, soil creep and slump are more characteristic.

In summary, the Balangoda Shelf is here considered to be a deeply dissected plateau surface with its drainage and erosion patterns strongly controlled by structure and faulting, and its weathering controlled by lithology. As in the other major plateaux already described, it has the general characteristics of a deeply eroded peneplain surface.

Peradeniya Basin

The extent of the Peradeniya Basin is shown on the accompanying map (Fig. 20). It consists of a relatively uniform, deeply weathered 1,800 foot erosion surface with low, moderately rounded hills, and flat floored alluvium filled valleys. These latter have a roughly accordant level of approximately 1,600 to 1,700 feet. The drainage pattern is strongly controlled by the structure and associated faulting and/or jointing (Fig. 107). The ridges are almost everywhere strike ridges and the valleys well marked strike, fault, or joint valleys. Together, they form a characteristic fine pattern, which is emphasized



FIGURE 107

Structure Controlled Valley Pattern, Peradeniya Basin

by the paddy cultivation in the alluvial valley bottoms and by the darker vegetation of the interfluvial hills. The marginal ridges of this area indicate that the Peradeniya Basin is, in effect, composed of three adjoining doubly plunging synclinal troughs with a general northwest axial trend. Weathering has reduced these synclinal beds to a relatively uniform thick residual soil which has been eroded from the ridges and deposited in the valleys to produce the present surface. The marginal beds mentioned above are the only resistant beds associated with the Peradeniya Basin and, in general, exhibit a higher elevation. Mass-wasting may be present in the form of soil creep and slump, but none is visible on the aerial photographs.

This complex of synclinal basins drains south and southeastward into the Mahaweli Ganga which flows in a slightly incised valley at an elevation of from 1,500 to 1,600 feet. Minor marginal drainage flows northwestward, northward, and northeastward into the basins of the Maha Oya, Deduru Oya, and Amban Ganga respectively. It is possible that at an early stage of its development, the entire area drained into the above named river systems. This will be discussed further in Chapter V.

Low level plateauxKondesalle Basin

The Kondesalle Basin (Fig. 20) is very similar to the Peradeniya Basin with the exception that its surface is at approximately 1,500 feet rather than 1,800 feet. It consists of two doubly plunging synclinal troughs separated by a narrow sharp anticlinal ridge. It is separated from the Peradeniya Basin to the west by a deeply eroded anticlinal saddle which is a continuation northward of the Kandy Anticline. The beds of these synclines appear to be somewhat more resistant, especially the marginal ones. The central beds of the western syncline are less resistant than similar beds in the eastern syncline. Weathering has been active throughout the area, and the less resistant beds have been reduced to low moderately rounded hills. These still retain their identity as strike ridges, but are cut by numerous faults and/or joints. Flat floored alluvium filled strike, fault, and joint valleys make a dense and characteristic pattern in the area. The eastern syncline has more resistant beds and these form steeper, more angular hills, with very well marked strike characteristics. The Hulu Ganga drains this syncline as a minor part of its normal course from the west face of the Knuckles Range to the Mahaweli Ganga. It traverses the sharp strike ridges from north to south, and is here considered a superposed stream. Erosion only appears active where main

tributaries are cutting down to the level of the Mahaweli Ganga or Hulu Ganga. The former appears to have its downward erosion controlled by a bedrock barrier in the Victoria Falls area. This barrier causes a 300 foot break in profile of the Mahaweli Ganga (Fig. 108, Mahaweli Ganga Profile, Appendix A). Mass-wasting in the Kondesalle Basin, is more active than in the Peradeniya Basin because of the greater local relief and more resistant beds. Debris fall and soil creep are probably the most important forms.

Nalanda Shelf

The Nalanda Shelf is a well marked 1,400 to 1,500 foot low level plateau forming the northern point of the Central Massif (Fig. 20). It extends from its intersection with the lower slopes of Rilagala (3,981 feet) and Etapola (4,153 feet) on the south, as a narrow, flat topped plateau, to its northern margin at Bambakanda (1,402 feet), and Getahena (1,484 feet). Its western margin is roughly indicated by a line joining the following peaks: Etapola (4,153 feet); Dahaiyagala (2,300 feet approximately); Horagala New (2,000 feet approximately); Nangala (2,848 feet); Ambokka (4,044 feet); Gedagaha (1,764 feet); Digala (1,464 feet); Dambawagama (1,472 feet); and Bambakanda (1,402 feet). Its eastern margin roughly follows the following peaks: Rilagala (3,981 feet); Asgirikanda (2,667 feet); Makulussa (3,013 feet);

Kotagala (2,200 feet); Demadoya (1,855 feet); Nalanda Rock (2,564 feet); Maratuluwa (2,207 feet); Kadigala (2,332 feet); Melegala (1,633 feet); and Getahena (1,484 feet).

Nalanda Shelf consists of the deeply weathered, flat to gently rounded, truncated summits of a belt of north striking, somewhat resistant, beds. These beds, in part, form the limbs and axial beds of a well marked syncline plunging at a low angle to the north. In places, more resistant beds project from the flat to gently undulating surface as knife-edge strike ridges. In general, however, the broad, flat, alluvial valley bottoms merge gradually into the low rounded ridges. Erosion is not well marked on the plateau. It is confined for the most part to the slopes of the higher ridges and to the valleys of the streams cutting into the plateau margin. The main stream draining this surface is the Nalanda Oya. Its headwaters are at the south end of the plateau where it is called the Dewilla Oya. The only other named tributary is the Ambokka Ganga which drains the western part. The northern part which has the best developed plateau surface is drained southward by a tributary of the Nalanda Oya. These streams appear to cross the resistant structural ridges indiscriminately and may be superposed or following a joint pattern. The gradient of all these streams is low and the major break is at the margin of the plateau just above Nalanda. The drop is across a strong bedrock

ridge and is approximately 300 feet. The marginal streams which are eroding headward into this plateau have little basin area to provide them with the runoff required, and as a result, they are only progressing slowly. In some cases along the western scarp, they have crossed the outer, nearly vertical beds by joint valleys and are eroding along the inner strike valleys, thus bringing the structure into sharp relief (Fig. 109). No major faulting is evident on this plateau, but a well developed transverse joint system is being emphasized by the above mentioned marginal erosion and the paddy fields of the plateau surface.

Molamure Shelf

Molamure Shelf is a clearly defined intermediate 1,500 foot terrace between the Balangoda Shelf and the Tanamalwila Peneplain. It extends from two miles north of Kaltota on the Walawe Ganga, south-southwest to Kalugala East, and then westward along the southern face of the Balangoda Shelf to the vicinity of Hapugastenna (Fig. 20 and Fig. 21). It is bounded on the east and south by an abrupt 1,000 foot scarp which is here considered to be fault controlled (Fig. 97 and Fig. 110). Its boundary with the Balangoda Shelf is another scarp which is also considered to be fault controlled. The rise of this scarp is roughly 500 feet. The remainder of the eastern arm of the Molamure Shelf shows little evidence of active erosion. The streams draining it have

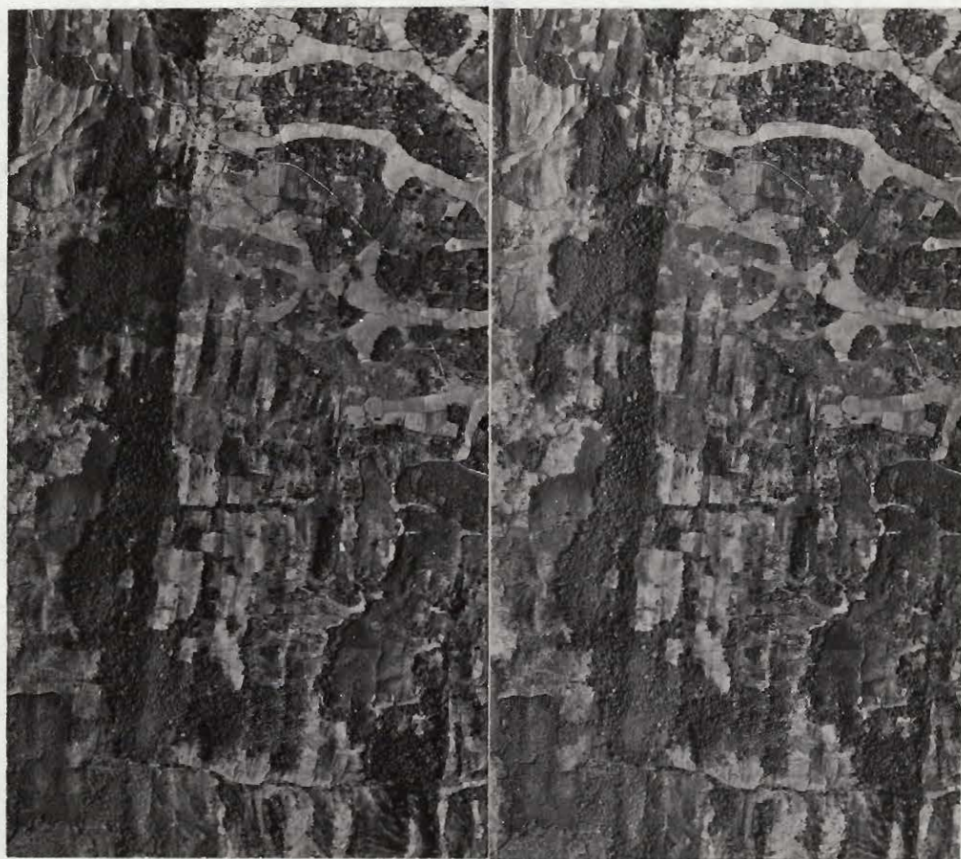


FIGURE 109

Structure Controlled Erosion, Nalanda Shelf



FIGURE 110

Eastern Scarp, Molamure Shelf, Looking South-southwest
from Helicopter

not cut into the surface except at the margins where they form narrow V-shaped valleys with falls or very steep gradients. In the north, the main stream follows a fault valley to its intersection with the Walawe Ganga above the first falls. On the east, another stream cuts across the west dipping marginal beds and drops down the fault scarp in a series of falls to the Tanamalwila Peneplain below. From the midpoint of the eastern margin, a well marked strike ridge of west dipping resistant beds rises to a maximum elevation of 1,800 feet (Fig. 111). Weathering may be of the granular or spheroidal type since talus and bare rounded outcrops are characteristic of this process and are well illustrated by the aerial photographs. Mass-wasting of the debris slide and rockfall type has buried the lower slopes of the scarp and the plateau side of the ridge with granular colluvium. Slump or soil creep does not appear active in areas with this type of rock, although field investigation along the road down the eastern scarp at its north end, indicated material which might be attributed to this process.

The beds of the resistant strike ridge mentioned above appear to change direction abruptly at Kalugala East, and from this point westward, to the west end of the plateau, strike roughly east and dip steeply to the north. The nature of the plateau's surface also changes at this corner and becomes much rougher and more deeply dissected. In fact, the valley bottoms are at 1,500 to 1,600 feet and the ridge

(Helicopter View Figure 110)



FIGURE 111

Stereo Triplet - Strike Ridge, Eastern Margin Molamure Shelf

and peak summits at approximately 1,800 feet. It is postulated that the resistant beds making up the eastern ridge, upon turning the corner, have separated and for the remainder of the distance, have formed very rough strike ridges and erosion remnants on the plateau. Erosion is more active in this section, and the streams have incised their channels into the deep combination of residual, colluvial, and alluvial soils forming the surface among the hills and ridges. The ridges and hills, as discussed above, are subject to granular exfoliation or spheroidal weathering, and much granular talus has resulted. The slopes of the ridges also reflect these processes in their steepness and tendency toward exposure of bare rock. Drainage may be controlled by bedding faults, and/or joints. Several of the streams which drain the Balangoda Shelf, cross the Molamure Shelf and then flow over its margin and down the scarp in major falls. However, the resistance of the marginal beds, or the lack of effective runoff, has prevented any deep erosion at these points. The lower slope of the scarp face is, in general, buried by talus and minor amounts of alluvium which effectively prevents the falls from undercutting the beds and causing retreat (Fig. 112). The surface of the plateau becomes somewhat smoother toward the western end, possibly because of a change in the lithology.

The Molamure Shelf satisfies most of the criteria for peneplanation that the Balangoda Shelf does and is therefore included in that classification. Its geomorphologic history will be discussed in Chapter V.



FIGURE 112

Vegetation Covered Talus, South Scarp, Molamure Shelf

Wekada Shelf

Wekada Shelf is a roughly defined 1,200 to 1,300 foot plateau bordering the Balangoda Shelf from Randeniya, in the Kirindi Valley north of Wellawaya, on the east, to the valley of the Weli Oya, on the west, and extending south to take in the group of hills between the Kuda Oya and the Damba Ara (Fig. 20 and Fig. 21).

It consists of a deeply weathered, deeply incised surface, dominated by numerous resistant peaks and ridges, especially along its southern margin. The rocks of this area are lithologically similar to the marginal rocks of the Molamure Shelf described above, and weather in a similar way. This has resulted in thick deposits of granular talus along their lower slopes and in the valley bottoms (Fig. 113). Since the Wekada Shelf surface has truncated rocks of this general type, the resultant soil is dominantly granular in nature. However, the northern margin of the shelf is formed by the much folded, more easily decomposed beds of the Balangoda Shelf and, as a result, the granular soils are modified to some extent by the alluvium from these beds. The major valleys of the Wekada Shelf are controlled by faults or joints, but the minor ones, such as the tributaries and marginal valleys, appear more or less uncontrolled. This results in a composite drainage pattern made up of dendritic sections and straight sections. Erosion has been active along the fault and joint valleys and where these carry



FIGURE 113

Resistant Ridges, Granular Talus, and Alluvium Filled
Valleys, Wekada Shelf

streams from the hill mass to the north, they are often eroded to the level of the lower plain. On the lower slopes of the ridges along the northern boundary, erosion of the more clayey soils produces a finer dendritic pattern. Field traverses in the area have indicated that many of the better defined ridges have quartzitic beds controlling them and that the more rounded, jointed hills of the southern part are more granitic in nature. They have also indicated that the stream courses are often dry or nearly dry for a considerable part of the year, and that deep coarse sand is a common bed material. On the aerial photographs, the hills and ridges with granular soils have a characteristic light spotted tone. This is due to the Savanna or Talawa type of vegetation which is apparently controlled by the excessive internal drainage and resultant scarcity of moisture (Fig. 18). The valley bottoms, and less granular soils in general have more moisture and dense, dark toned jungle results.

In the Randeniya area north of Wellawaya, the shelf becomes less dissected and is composed of gently rounded, deeply weathered hills of residual soil. A change in the lithology with fewer resistant beds may be responsible for this modification. Deep active erosion by the Kirindi Oya has cut the major V-shaped valley which crosses the shelf and reduces it to a series of low terrace-like fragments on either side.

In general, the Wekada Shelf is a somewhat broadly distributed collection of more or less separate plateau fragments with roughly accordant elevations.

Mawanella Shelf

Mawanella Shelf is a well marked, low level plateau extending roughly from Kadugannawa Ridge on the east, to the northwestern extension of Adams Peak Range on the west. It abuts the mountains and foothills of the Kabaragala-Alupota area on the south, and drops to the low level plain just south of Rambukkana on the north (Fig. 20).

It consists of a well weathered and eroded 900 to 1,000 foot surface (Fig. 21), very similar in nature to the Peradeniya, Kondesalle, and Nalanda surfaces at higher elevations. It is also "built" on truncated, doubly plunging, synclinal structures of moderate extent (Fig. 114). Faulting and/or jointing have cut these structures into a characteristic pattern of east-northeast fault or joint valleys and northwest strike valleys. In some places, the more resistant beds making up these synclinal structures project above the general surface as knife-edge ridges. In other places, resistant cores have become monadnocks on the plateau surface (Fig. 114). In the central part of the plateau, Batgala or Bible Rock (2,618 feet), and the peaks associated with Ramesarakapella (3,667 feet), form part of a massive

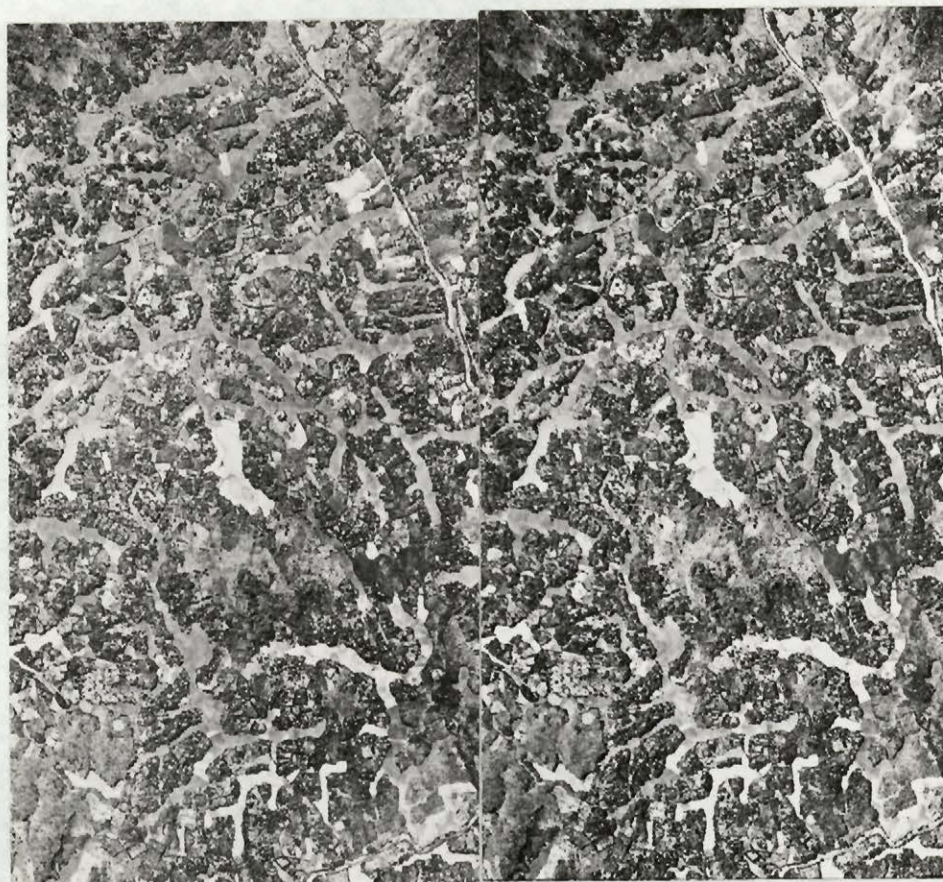


FIGURE 114

Part of the Doubly Plunging, Synclinal Structure

Forming Mawanella Shelf

strike ridge which extends northward almost to the Kegalla-Kadugannawa Road.

The valley bottoms of this plateau are floored with alluvium and show little erosion except at the margins of the plateau or where the major streams have cut into them. The valley bottoms form a roughly accordant level at 700 to 800 feet. The deep weathering of the area has produced thick residual soils which have eroded to small, rather steep sided ridges and peaks. These ridges and peaks show varying degrees of structural control. Mass-wasting is probably present, though little is visible on the aerial photographs, except along the bases of the major hills and ridges. The major streams of the Mawanella Shelf generally follow strike or fault valleys. Many of the latter, especially in the areas of major ridges as in the southwest, south, and southeast, traverse the structure in the form of deep, steep sided, V-shaped valleys or gorges.

In addition to the plateaux already described, there are many fragmental, terrace-like or shelf-like surfaces scattered throughout the Central Massif (Fig. 20). These may have levels which allow them to be roughly correlated with the more well marked plateaux, however, positive proof would require further extensive and detailed studies. Many of these surfaces have been indicated by level on the accompanying map without any attempt to assign them a name or

correlation. Undoubtedly there are also some surfaces which have not been preserved to the extent that their delineation is possible. Scattered accordant peaks may be indicative of such features.

River valleys

In addition to the points mentioned throughout the preceding discussion, the profiles of the two main streams draining the Central Massif have been constructed (Fig. 70, Kelani Ganga Profile, and Fig. 43, Mahaweli Ganga Profile, Appendix A). These streams, the Mahaweli Ganga, and the Kelani Ganga, flow toward the northeast and west respectively, and are considered to be characteristic of the area in general. The Mahaweli Ganga drains the moderately heavy rainfall, Hatton Plateau area, the rain shadow Diyatalawa Plateau area, and the lower level Peradeniya Basin-Kondesalle Basin areas, as well as virtually all of the Knuckles Range. The Kelani Ganga drains the very heavy rainfall, Maskeliya and Kehelgomu valleys, and three-quarters of the western slopes of the extremely heavy rainfall, Adams Peak Range. The Mahaweli Ganga, after leaving the hills of Minipe, flows across 107 miles of northeastern dry zone to the coast at Trincomalee, and the Kelani Ganga flows across 58 miles of low, humid plain to the sea at Colombo. These streams all have steep gradients in the Central Massif and very low gradients on the plains; they all have eroding headwaters and aggrading lower courses; and they all have numerous

waterfalls in their upper reaches and little, if any, break in profile on the plains. A final, very important point with respect to these rivers is that they all cut across major structural trends in their courses from the highlands to the plains.

The Knuckles Massif

General

The Knuckles Massif consists of the Knuckles Range, the Telambugala Spur, the Wamarapugala Spur, the high level Selvakanda Plateau, and associated valleys and minor plateau fragments (Fig. 20). It is considered here to be structurally, tectonically, and geomorphologically part of the Central Massif, but geographically it is separated from it by the relatively broad, deeply eroded valley of the Mahaweli Ganga. For this reason, it will be described as a separate unit.

Mountain ranges and ridges

Knuckles Range

The Knuckles Range extends from Dotulugala (5,164 feet) on the south, to Kehelpotamana South (3,245 feet) on the north. From south to north, the main peaks of the range are: Kabonilagala (5,098

feet); Aliyawetunaela (5,400 feet approximately); Knuckles (6,112 feet); Rilagala No. 2 (5,200 feet approximately); Selvakanda (5,300 feet approximately); Gombaniya (6,248 feet); Kirigalpotta (5,403 feet); Ratmetiya (4,832 feet); and Patanagala (4,970 feet). The range consists of what appears to be a complex assemblage of block-faulted synclines and anticlines, deeply eroded on all sides to produce a narrow, roughly flat topped ridge with very steep marginal scarps. The Selvakanda Plateau extends roughly from Rilagala No. 2 to Yakungegala, along the top of the ridge. West and northwest of Yakungegala, the ridge becomes a series of en echelon strike ridges composed of beds dipping steeply southwest and west, each segment separated by well marked, northeast faults. Weathering apparently does not attack the high ridges and surfaces to the extent that it does the lower slopes and talus deposits. Studies in the field in the course of an expedition to cross the range from Mimure, south of Lakagala on the east, to the Bambrella Estate, southwest of the Selvakanda Plateau on the west, indicated that bedrock is almost everywhere at or very near the surface (Fig. 115). Where soils have developed, they contain numerous angular to subangular blocks of rock. It is probable that under the dense forest, the dominant material of these upper slopes is colluvial and residual in nature. On the dip slopes investigated, bare rock is common. The lower slopes are generally buried under deep talus



FIGURE 115

Bedrock at the Surface, Wamarapugala

Patana, Knuckles Massif

deposits which have weathered to granular soils for the most part. Along the scarp faces, rockfall and rockslide are important destructive processes. Labulessapatana, in the Wamarapugala Spur, has had almost half of its 4,009 foot peak collapse in a major rockfall (Fig. 116). This is clearly visible on the aerial photograph, and it is interesting to note that this terrific collapse of a mountain is recorded in the legends told by the local inhabitants. Throughout the range, jointing and faulting have influenced weathering, erosion, and particularly mass-wasting. Many of the scarp faces in the Knuckles Range are undoubtedly controlled by such features. (Fig. 117).

Erosion in the area has cut numerous major valleys headward along faults or joints into the core of the range. These are particularly well developed on the east and north. The valleys of the Kaikawala Oya and Mimure Oya (Fig. 118), the Kalu Ganga, Naranatte Oya, Kuda Oya, and the Teligam Oya are excellent examples. On the southwest, the valleys of the Kota Ganga and headwaters of the Kalu Ganga are eroding into more flat lying beds and are producing amphitheatre-like basins with local, structurally controlled terraces surrounding them (Fig. 119). The heavy rainfall in the area, plus the steep gradients, has caused erosion to be active in spite of the apparent light to moderate weathering and heavy forest cover.

Too little is known of the detailed lithology and structure to substantiate the proposed block faulting, however, considering the

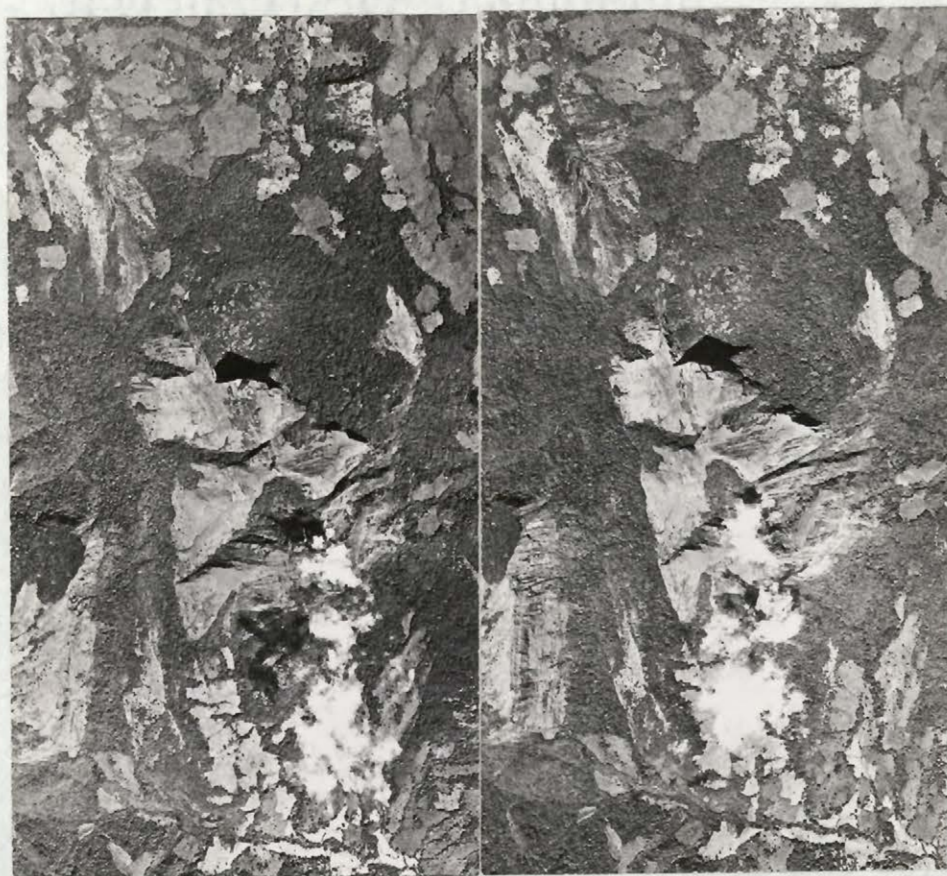


FIGURE 116

Rockfall, Labulessapatana Peak, Knuckles Massif



FIGURE 117

Fault and Joint Controlled Erosion, Knuckles Peak Area

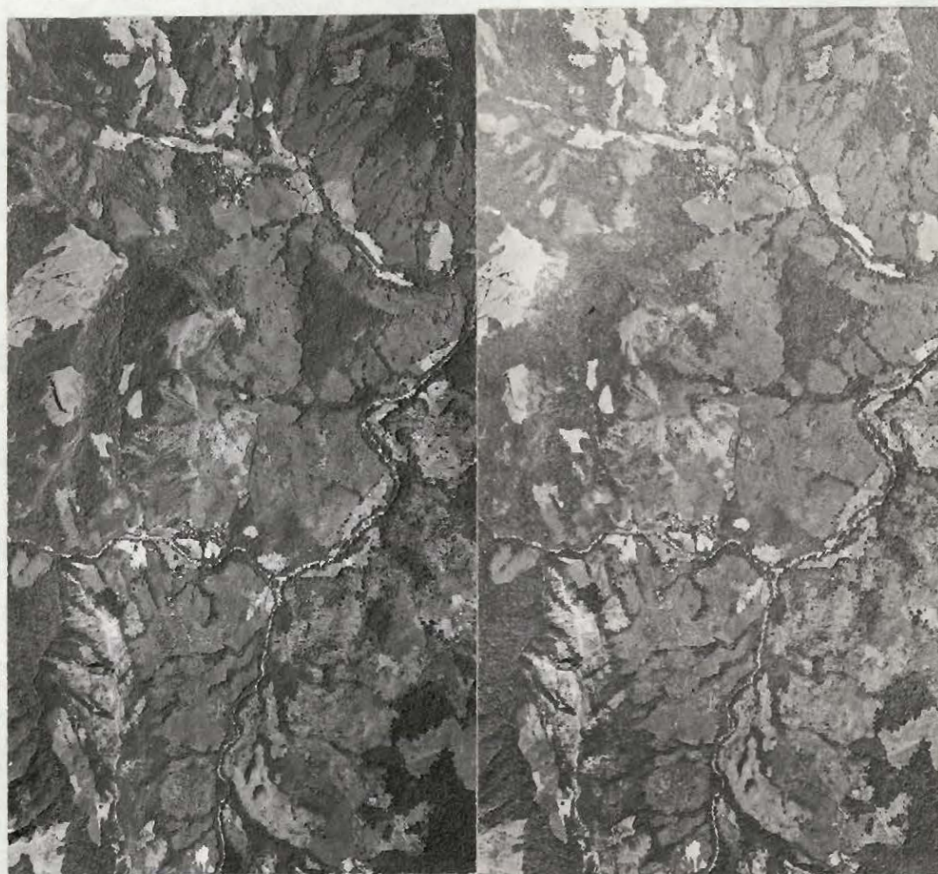


FIGURE 118

Kaikawala Terrace, and Valleys of the Kaikawala Oya
and Mimure Oya, Knuckles Range



FIGURE 119

Structurally Controlled Terraces, Upper Kalu Ganga,

Knuckles Massif

many faults visible on the aerial photographs, the many beds apparently displaced by them, the numerous scarp faces coincident with fault traces, and the general blocky appearance of the area, it is here considered to be the most logical explanation (Fig. 120). A comparison of Adams Peak Range with Knuckles Range brings out many similarities. This is not surprising if the theory assigning these ranges to marginal positions on the central elevated block of the Central Massif is accepted.

Telambugala Spur

The Telambugala Spur extends northeastward from Aliyawetunaela No. 2 and includes Dumbanagala (5,385 feet), Kehelpotdoruwegala (5,016 feet), and Telambugala (4,368 feet). Balalgiriya (3,765 feet), Dumbanagala Spur (3,784 feet), Velangala (3,871 feet), and Vellangollapatana (3,367 feet), are some of the lower level peaks associated with this ridge.

The Telambugala Spur consists primarily of well marked, southwest dipping beds in the Dumbanagala area and possibly a north trending synclinal structure in the Telambugala area. Relatively broad dip slopes alternate with steep scarp faces in the southwest, and steep scarps combine with sharp crested ridges in the northeast. Weathering in the area has produced deep residual soils on the more



FIGURE 120

Block-Faulting, Dip Slopes, Scarp Slopes, and Fault Controlled
Erosion in the Knuckles Range, Knuckles Massif

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gentle slopes and has reduced the thick deposits of talus and similar colluvial material to soils as well. On the more resistant beds, which control dip slopes and scarp rims, weathering has not been as active or if it has, the products of its action have been removed rapidly. Mass-wasting is active in the form of rockfall and rockslide along the numerous scarps, and soil creep along the less steep slopes. The rivers of the area have their channels choked with blocks of rock of all sizes, particularly along the lower gradient portions. In the headwaters, they are generally eroding into the bedrock in steep sided, V-shaped valleys or gorges. Falls and rapids are common indicators of their youth. Erosion appears much more active on the northwest side of the spur, even though this is the most heavily forested side. The northeast monsoon brings heavy rainfall up the Heen Ganga valley to this northwest or Nitre Cave area, and this apparently is instrumental in producing the erosion differential. Erosion in this area is very similar to that encountered in the Knuckles Range to the west. It produced a rather coarse drainage pattern, primarily controlled by faults and joints, but with some structural control in the southwest and northeast. In these latter areas, down dip migration of streams appears of minor importance. Divide lowering is in progress both along the main ridge and between lateral spurs.

It is considered here that the main northeast boundary fault of

the Central Massif passes along the northeast margin of this spur and may in part be responsible for the structural complexity and associated fault scarps.

Wamarapugala Spur

Wamarapugala Spur extends northeast from Selvakanda Plateau through Kalupahana (5,341 feet), to Wamarapugala (5,110 feet), Labulessapatana (4,009 feet), and Lakagala (4,324 feet). Its characteristics and relationship to the Knuckles Range are similar to the Telambugala Spur.

It consists of a series of peaks controlled by bedding, and faulting or jointing (Fig. 121). Kalupahana has developed from relatively flat-lying beds and the remainder from moderately to steeply west dipping beds (Fig. 122). Wamarapugala forms part of a saucer-like structure with beds dipping westward at the head of Mimure valley, southwestward in the main peak, and southward in a western arm of the peak. Very heavy jungle cover in this area appears to have protected it from erosion and mass-wasting in the recent past, although topographic and drainage patterns indicate considerable deep valley cutting on the northwest face, and very deep, fault controlled, gorge cutting along the Mimure Valley on the east. Well defined down-dip migration of strike valleys along the western faces of Labulessapatana,

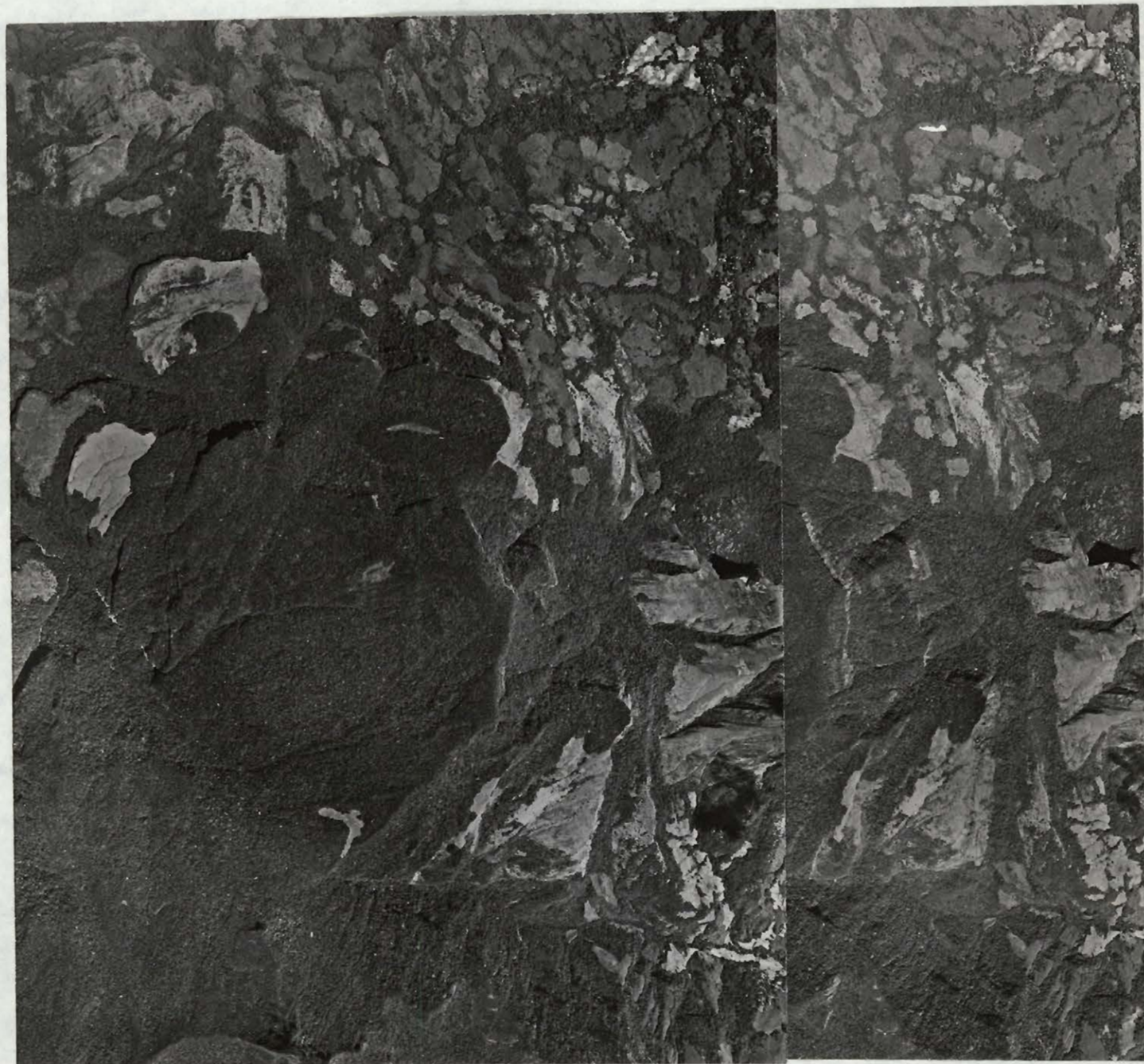


FIGURE 121

Dip Slopes, Scarp Slopes, and Associated Fault or Joint Traces,
Wamarapugala Spur, Knuckles Range



FIGURE 122

West-dipping Beds of Maratuwegala, Knuckles Range

Lakagala, Maratuwegala, and associated structurally similar peaks in the area, is visible on the aerial photographs. It is probable that a fault is responsible for the scarp from the head of the Mimure valley, northeastward along the east side of Wamarapugala and west of Labulessapatana. The heavy fall of rock which removed almost one-half of the latter peak was probably the result of this tectonic activity.

Weathering appears relatively active on the gentle slopes, but is less so on the steeper ones. Weathering of the deep talus along the lower slopes and on structural terraces is well marked. Soils produced are generally granular and have good internal drainage, thus reducing erosion. On the west, in the headwaters of the Kalu Ganga, falls and rapids indicate the active nature of erosion in this area. Throughout the upper valley of this river, several well marked structural terraces have been cut into by deep gorges in the course of general headward erosion by the streams (Fig. 119). The deep V-shaped valley of the Mimure Oya has a high gradient with associated waterfalls. The channel of this stream has boulders of varying size which, in many places, choke it completely. Mass-wasting is present along the scarp faces and is also considered active in the form of soil creep along the valley sides.

High level plateaux

Selvakanda Plateau

Selvakanda Plateau consists of a well marked erosion surface forming the central portion of the Knuckles Range between the Knuckles and Gombaniya (Fig. 123). Its maximum elevation in the Selvakanda C.P. area is approximately 5,200 feet. In general, the surface is moderately dissected. A pattern of faults and joints has controlled the erosion of several deep V-shaped valleys, especially near the margins. Weathering does not appear to be as active here as it is lower down on the adjacent scarp slopes. Field investigation has indicated rock at or near the surface and the angular topography substantiates this feature. It is probable that the faulted and jointed nature of the rock in this area assists internal drainage to reduce the overall runoff from the plateau. Erosion of the surface is thereby also reduced. The general flat lying aspect of the resistant, scarp-forming bedrock is another factor which tends to reduce active erosion on the plateau. Vegetation is relatively thick, varying from dense jungle or forest on the lower slopes in the Kaluphahana area, through stunted more open forest, to a characteristic "pigmy" forest on the upper plateau (DeRosayro, 1958). The drainage pattern is primarily fault and joint controlled with some minor bedding control on the higher surface and along the margins of the plateau.

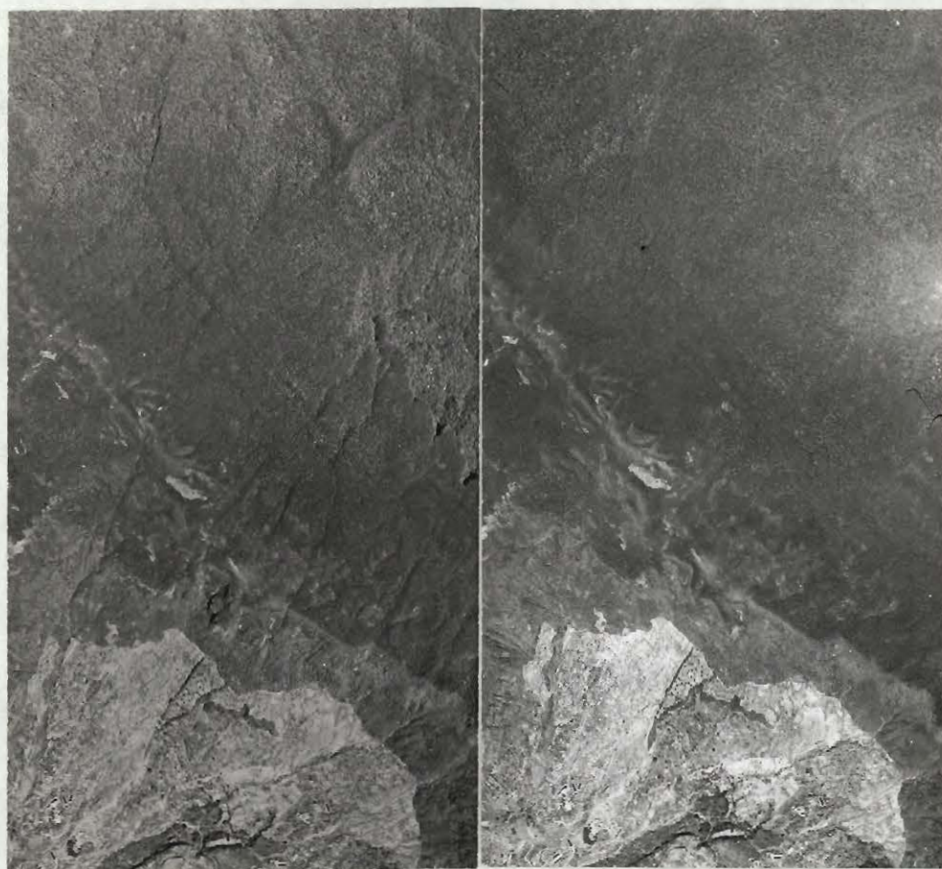


FIGURE 123

Fault and Joint Pattern, Selvakanda Plateau, Knuckles Range

South Knuckles Plateau

The South Knuckles Plateau is a small plateau which may be primarily structural in nature, located between Aliyawetunaela No. 2 and Knuckles (Fig. 124). The bedding is generally flat or dipping gently north or north-northwest and may comprise the nose beds of a synclinal structure forming part of the Knuckles Range, but separated from it by a transverse fault. This fault controls the headwater erosion of the Kota Ganga on the west and the Kurumbaketiya Oya on the east. The plateau is cut on the south by the Heen Ganga-Maha Oya valley fault and by transverse joints as well. Weathering and erosion are moderate, with the major activity concentrated along the margins in the latter case. Streams show the characteristic sharp break in profile along the margins of the plateau and the steep, headward eroding section on the scarp face.

Medium and low level plateaux

Vellangollapatana Plateau

This is a poorly marked, possibly structurally controlled erosion surface, between Vellangollapatana (3,367 feet) and Velangala (3,871 feet), projecting as a southeast extension of the Telambugala Spur. It is mentioned here only as evidence of a possible 3,000 to 3,500 foot erosion surface in this area.



FIGURE 124

South Knuckles Plateau

Walpolamulla Terrace

The Walpolamulla Terrace consists of a well marked series of 2,500 to 2,800 foot erosion surfaces cut into the spurs separating the headwater tributaries of the Kalu Ganga (Fig. 119). This river drains part of the northern slope of the Knuckles Range and the north-western slope of the Wamarapugala Spur. The terrace is structurally controlled, and has apparently formed the valley bottom at one time. At present it consists of a deeply weathered, moderately eroded surface, bounded on one side by the scarp face of a higher surface, and on the other by the scarp apparently cut by the deeply eroding Kalu Ganga. It is considered here that this surface, and those above and below it, do not indicate levels of erosion which can be correlated with particular stages in the islands geomorphologic history. They are mentioned as examples of structurally controlled features which may be confused with such surfaces and should be closely checked.

Kaikawala Terrace

The Kaikawala Terrace is a well marked erosion surface cut into the sides of the Maha Oya valley in the vicinity of Kaikawala and Mimure, by an earlier, higher level stage of the present river (Fig. 118). These terrace fragments which occur at an approximate elevation of from 1,500 to 1,600 feet are deeply weathered, and are

dissected by the streams traversing them. The Kaikawala Oya, Mimure Oya, and the stream draining the Nitre Cave area, all are incising their valleys. Little erosion is evident on the surface of these fragmentary terraces, possibly due to the granular nature of the residual and, in part, colluvial soils which provide excellent internal drainage and low runoff.

In general, the rivers of the Knuckles Massif are actively eroding their channels. Deep V-shaped valleys controlled by faults, joints, or bedding are characteristic. In their headwaters, they are attacking the higher slopes and plateaux surfaces in steep sided gorges (Fig. 117). Mass-wasting has resulted in much rockfall and rockslide in these higher reaches and the channels are often clogged with boulders and very large blocks of rock. Where the streams are cutting into the bedrock, pot holes and waterfalls are common. With the exception of the high level plateaux, they present a very youthful appearance and thus indicate relatively recent uplift and rejuvenation.

The Sabaragamuwa Hills

General

The Sabaragamuwa Hills are formed by a broad series of well marked strike ridges which are folded or curved around the southwest corner of the Central Massif. They extend roughly from Eheliyagoda

on the northwest, to Panamure on the southeast, and from the Ratnapura-Pelmadulla valley on the northeast, to a line joining Halwature and Makandura on the southwest (Fig. 20). Included in this area are the Rakwana-Kiriella Ridges, the Handapan Ella high level plateau and the Tangamale Plateau, as well as scattered fragments of other surfaces and several high level plains.

The rivers of this area generally flow in relatively deep, strike valleys or in equally well eroded, fault or joint valleys. A well developed pattern of faults and joints is clearly visible on the aerial photographs. The transverse, northeast trending faults and joints are much more noticeable than the northwest trending set, which parallel the structure for the most part. In the south, where the beds curve more tightly, the strike becomes east-west or even northeast, and the northwest trending faults and joints become more obvious. General levels in the area vary from a maximum of 4,545 feet at Beralagala, through high and medium level plateaux, including the Handapan Ella Plateau (4,100 feet), and the Tangamale Plateau (3,500 feet), to several high level plains of aggradation, the Delgoda Plain (800 feet to 900 feet), the Deniyaya Plain (1,200 feet to 1,300 feet), and the Urubokka Plain (1,000 feet).

The Sabaragamuwa Hills are subjected to a rainfall which in places exceeds 200 inches per year, but, in general, is greater than

125 inches per year. Along the eastern margin of the area, rainfall decreases as the dry zone is approached.

Mountain ranges and ridges

Rakwana-Kiriella Ridges

The Rakwana-Kiriella Ridges comprise the major part of the Sabaragamuwa Hills area, sweeping in a broad curve from Kiriella, northwest of Ratnapura, through Rakwana, to terminate at their boundary with the Tanamalwila Peneplain.

They consist of a series of sub-parallel, strike ridges which in many cases are formed by the resistant beds of tightly folded anticlines and synclines. The more northerly beds follow a smooth curve, but the southerly beds curve farther south toward Deniyaya and then swing north again giving them a somewhat sagging or festoon appearance on the map. The beds vary considerably in their resistance to weathering and erosion and this has resulted in the development of an area of strong relief. Broad valleys with low rounded hills and minor strike ridges, alternate with high, sharp crested ridges bounded by steep slopes or scarps. In some cases, these high ridges are truncated by erosion surfaces such as the Handapan Ella Plateau and the Tangamale Plateau. The stream valleys may have a locally controlled base level which results in the formation of relatively flat alluvial

plains at elevations in the vicinity of 800 to 1,000 or more feet.

Weathering of these ridges is intense. Deep residual soils are formed on the less steep slopes and are added to by large deposits of talus and colluvial material, resulting from very active mass-wasting.

Alluvium too is added to this assemblage and the resultant mixture is weathered in situ until erosion or mass-wasting processes act upon it to reduce it still further. Almost the entire lower slopes of the major ridges, and often all of some minor ridges, are buried beneath these deposits. Blocks and boulders of relatively unweathered rock form a high percentage of these deposits (Fig. 125). Major rockfalls, rockslides and soil creep are responsible for much degradation of the landscape. Steep slopes are also subject to more active erosion than the less steep ones. Faults and joints cut across these ridges in many places. Northeast faulting or jointing appears dominant and some northeast trending faults cut across the structure for many miles. Drainage of this area is mainly to the west and northwest along the strike valleys, and transverse, fault, or joint valleys. The Rakwana Ganga, the Delwala Ganga, the Koswatta Ganga, the Delgoda Ganga, and the Wewa-Kudawe-Koskulana Ganga, all are headwaters of the Kalu Ganga. The Gin Ganga and the Nilwala Ganga drain the southern part, and the Walawe Ganga the eastern margin. In the latter case, the drainage area is relatively small and being adjacent to the dry

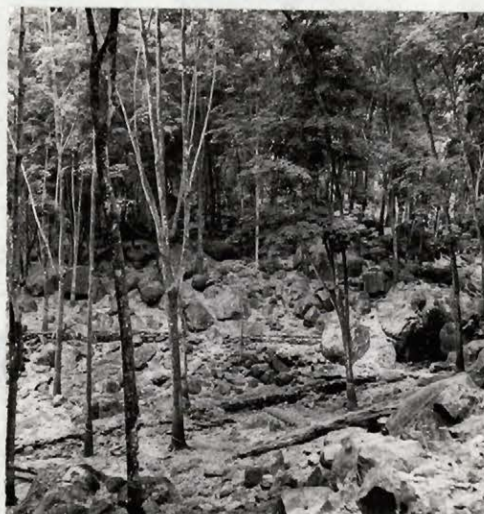


FIGURE 125

Blocks of Essentially Unweathered Rock in
Hillside West of Ratnapura

zone, does not receive as much rainfall as the hills to the west. For this reason, many of the east flowing rivers drop to the plain over falls or very steep rapids as opposed to the west flowing rivers which have cut their valleys almost to base level along much of their length. Another factor entering into this phase, is the depression and resultant drowning of the western valleys. This will be discussed more fully in Chapter V. Much of the Rakwana-Kiriella Ridge area, because of the very heavy rainfall, is covered with thick jungle vegetation. This is most noticeable on the ridge and plateau tops since the valleys are usually under cultivation.

High level plateaux

Handapan Ella Plateau

Handapan Ella Plateau occupies the top of what appears to be a synclinal ridge, about three miles south of Rakwana (Fig. 20). Four peaks roughly act as boundary markers for the plateau: Kabragala No. 2 (4,238 feet) on the north; Suriyakanda (4,300 feet) on the east; Beralagala (4,545 feet) on the southwest; and Illibe (3,911 feet) on the west.

This 4,000 foot plateau consists of a moderately dissected series of strike ridges and valleys with rounded crests and alluvium filled bottoms; the whole controlled by the apparent synclinal nature

of the basic structure (Fig. 126). Weathering is deep and erosion only moderate. A heavy forest cover protects the surface from erosion to some extent. Mass-wasting is not visible on the plateau, but the surrounding scarps and deep talus deposits attest to its presence, particularly in the form of rockfall and rockslide. There is apparently little drainage from the plateau, possibly because of porous substrata or fault aquifers which absorb much of the rainfall. A small stream flows over the margin of the plateau just east of Handapan Ella with very little indication of erosion. Another small stream drains the eastern end of the surface via a well marked fault valley. This is a major transverse fault cutting diagonally across the eastern end of the plateau and through the Bulutota pass to the northeast. No other fault traces were seen on the aerial photographs.

Medium level plateaux

Tangamale Plateau

Tangamale Plateau (Fig. 20) is similar to Handapan Ella Plateau to the north in that it is ringed with mountain peaks: Lauderdale (3,787 feet) on the north; Caledonia (3,365 feet) on the east; Abbey Rock (4,368 feet) on the southeast; Kurulugala Old (3,880 feet) on the southwest; and Hinipitigala East (3,830 feet) on the west.

Basically it consists of the truncated edges of numerous beds

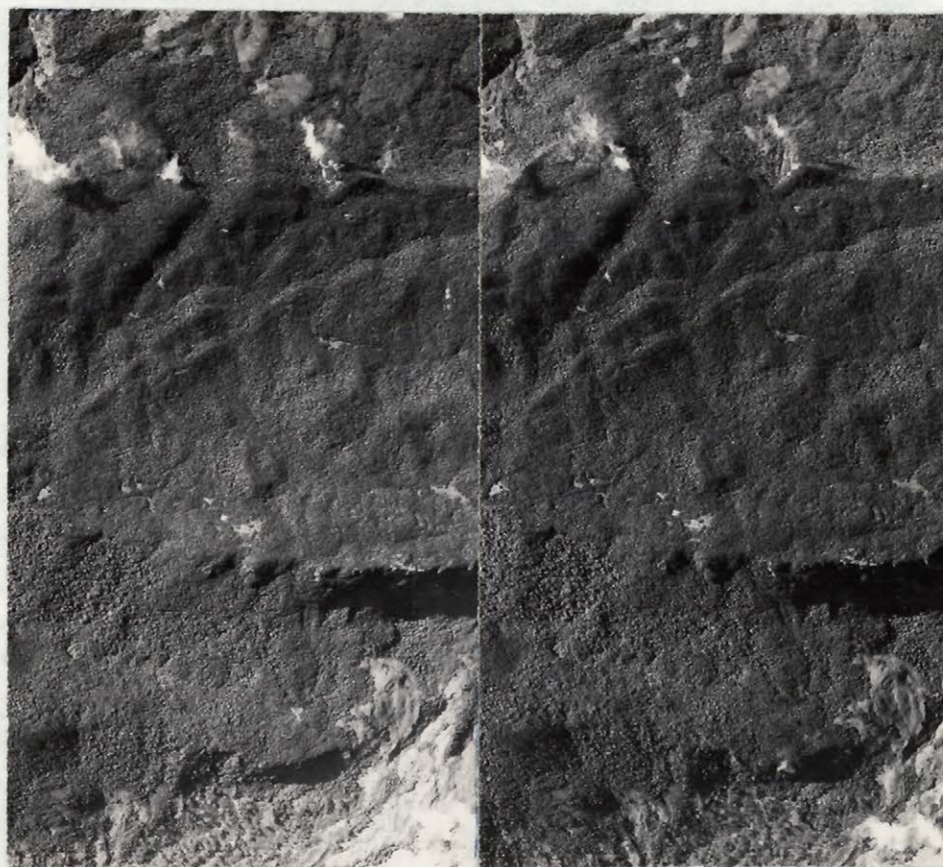


FIGURE 126

Handapan Ella Plateau

with roughly similar characteristics. The resultant deeply weathered, moderately eroded 3,500 foot surface presents a rough washboard appearance of strike ridges and valleys (Fig. 127). Slightly more resistant beds along the north and south margins at the eastern end have given the plateau a somewhat trough-like shape. Mass-wasting does not appear active on the surface of the plateau, although the surrounding valleys and scarps are dominated by rockfall, rockslide, and particularly soil creep. Numerous faults or joints cut the strike ridges of the plateau in an east-northeast to northeast direction. The drainage follows strike valleys and joint valleys, and where streams flow off the plateau, it is usually to the east or west along a strike valley, or to the north or south along a fault valley. Tangamale Plateau is covered with thick forest except at the eastern end where the Morningside and Traquarr estates are cultivating tea and cardamoms.

High level plains

Delgoda Plain

The valleys of the Koswatta Ganga, Delgoda Ganga, and the Wewa-Kudawe-Koskulana Ganga merge near Kalawana and continue as the Kukulu Ganga. The Kukulu Ganga is at present actively eroding its channel as a sharp V-shaped gorge in bedrock. The bedrock has formed a local base level for the streams mentioned above, and

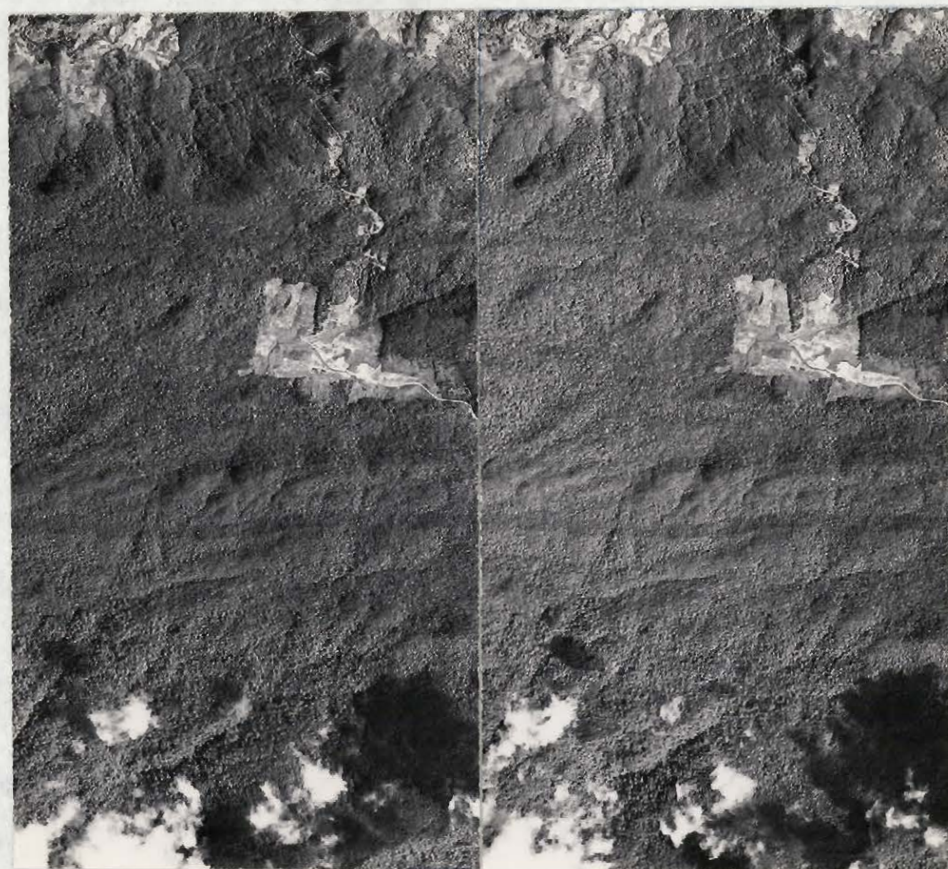


FIGURE 127

Tangamale Plateau

well marked alluvial plain has formed at the junction of the streams. This plain has an approximate elevation of 1,000 to 1,100 feet. The streams are flowing in strike valleys and the junction is controlled by a northeast trending fault.

Urubokka Plain

The Urubokka Plain is a dissected, alluvial, and possibly erosional plain, lying between the Urumutta-Ketapola-Rammale Ridge on the southeast, and the Morawaka-Dotalawakanda-Kabaragala Ridge on the northwest. A well marked, though fragmentary, 1,100 to 1,200 foot surface, is partly indicated by accordant interfluvial hills and ridges, and partly by alluvial valley bottoms. In many places, this surface is being destroyed by the headward erosion of the Urubokka Ganga and its tributaries (Fig. 128). It is considered here that this surface is primarily depositional and not a significant level in the geomorphologic history of the area.

The Gal Oya Hills

The Gal Oya Hills comprise a group of well defined erosion remnants rising from the surface of a peneplain which, if continued northward, would become the Polonnaruwa Peneplain, and if continued southward, would become the Tanamalwila Peneplain. The extent of this group of hills is shown on the accompanying map (Fig. 20). In



FIGURE 128

Urubokka Plain

general, they consist of the remnants of a series of roughly parallel strike ridges, which extend in a broad curve around the eastern margin of the Central Massif. They are cut by a well marked system of northeast trending major faults, some of which may be traceable through the southeast section of the Central Massif to the Balangoda Shelf and the Tanamalwila Peneplain beyond. Northwest faulting is present, but is often obscured by the strike of bedding which is also dominantly northwest. In the northeast, the hills have a more massive structure, and jointing rather than faulting appears dominant. The elevation of the peneplain in this area rises from 400 feet in the north, northeast, and east to 1,000 feet in the central Pitakumbura area, and drops to 500 feet in the northwest, 700 feet along the edge of the Central Massif, and 500 feet in the southwest. This variation may be due to the modifying influence of the closely packed ridges upon the erosion gradient, or may be due to a slight doming of the surface during the diastrophism which resulted in the uplift of the Central Massif. The large number of well marked major faults cutting the area, and the presence of a 700 to 800 foot valley cutting into the 900 foot surface, four miles west-northwest of Bibile, together with a clearly defined break between a 700 to 800 foot surface and a 400 foot surface in the east central section, are considered to favour the latter possibility. Weathering in the Gal Oya Hills appears to be extensive. It is generally deep on the peneplain surface and in the fault and joint

controlled depressions in the hills where moisture is concentrated and retained, and shallow on the steeper slopes and exposed surfaces of the more resistant bedrock which forms the peaks.

Mass-wasting does not appear excessive, as is indicated by the more sharply dissected nature of the terrain and lack of significant talus deposits. Relatively strong differential erosion has reduced the inter-ridge areas to a well marked peneplain with a gently undulating surface of low relief. The deep residual soils which mantle this surface, have a dominantly granular nature resulting from the relatively high quartz content of the biotite gneisses which are the basic rocks of the area. Drainage in the Gal Oya Hills region is controlled partly by foliation structure and partly by joints and faults. Structural control is most noticeable where the strike ridges are exposed and well developed; fault and joint control is more noticeable in the areas of massive rocks (Fig. 41). Some faults, as mentioned previously, traverse the entire area. Control of either type is indicative of relatively shallow bedrock and conversely lack of control is indicative of deep soils. Vegetation in this region is dominated by the generally arid climatic regime and consists of scrub jungle on the peneplain, with some heavier forests on the slopes of the hills. In places, scattered savanna type forest occurs.

Some of the peaks or monadnocks characteristic of the region

are, from north to south: Kokagala (2,252 feet); Okegala (1,089 feet); Friar's Hood (2,159 feet); Madiagala (2,867 feet); Viyanahela (2,361 feet); Udaperuwahela (2,852 feet); Yakunahela (2,031 feet); Makulassa (2,161 feet); Guruhela (2,195 feet); Gonadowa (2,364 feet); Girahela (2,277 feet); Dummalahela (2,417 feet); Kitulhela No. 2 (1,728 feet); Maragalakanda (3,646 feet); Mananahela (1,254 feet); Korathalhinna (2,124 feet); and Ulgala (1,884 feet).

The Elahera Ridges

The Elahera Ridges comprise a series of well marked strike ridges extending from the northern margin of the Knuckles Massif, in a broad curve through Ambagaswewa and Kantalai to Trincomalee (Fig. 20). The marginal ridge on the east is the Sudukanda Ridge (Fig. 3), and its continuation on a line from Giritale to Tamaraivillu, and on the west a less continuous series of ridge segments through Dambulla, Habarane, Dematawewa to Nilaveli. These ridges and ridge fragments are the erosion remnants of steeply dipping, resistant, generally quartzitic beds which are the northward extensions of the synclinal and anticlinal structures of the Central Massif. The entire structural pattern has not as yet been worked out, but the indications are that the ridges are tightly folded or compressed anticlines or synclines, and the broad valleys between the ridge groups are

relatively unfolded synclines. However, there is also evidence indicating that the ridges are simply the more resistant beds of a more or less uniform sequence of anticlinal and synclinal structures. This latter theory is favoured here.

Weathering of these beds has been intense, and all but the most resistant beds have been reduced to a low flat to gently undulating peneplain continuous with the Anuradhapura Peneplain to the northwest and the Polonnaruwa Peneplain to the east. Except for the extreme crests, the ridges are deeply mantled by residual and colluvial soils. Weathering is so far advanced and the vegetative cover so thick that little can be determined from the aerial photographs as to the nature of the soils except that they are predominantly granular and have good internal drainage. Little erosion is visible on the aerial photographs, and it is expected that little is present due to the general permeability of the soils. Mass-wasting has been active along the scarp faces of the steeply dipping beds, and here rockfall and rockslide are most important. Where less steeply dipping beds have been reduced to deep residual soils, or where the talus has been weathered to produce similar soils, soil creep may be active.

In general, the Elahera Ridges are well defined strike ridges, but locally, either changes in lithology or the complexity of folding, have resulted in the development of more massive erosion remnants

which might better be described as monadnocks (Fig. 36). The entire area is heavily forested and with the exception of the roads crossing it, is very difficult to examine in the field.

At their northeast end, the Elahera Ridges form the dominant relief of Trincomalee Harbour (Fig. 129). Here the sharp strike ridges project into the sea and have apparently controlled the flow of the Mahaweli Ganga to develop a well marked submarine canyon and one of Ceylon's few natural harbours.

Summary

The geomorphology of Ceylon described in this chapter has been based primarily on the analysis and interpretation of aerial photographs at a scale of 1:40,000. Field investigation carried out in the course of 16 months spent in Ceylon on a Colombo Plan Aerial Survey, was used to substantiate and supplement the interpretation where possible. Of necessity, at this scale, detailed investigation and description was impossible. As many stereoscopic pairs of aerial photographs as possible have been included to illustrate the terrain described, as well as the processes involved in its formation.

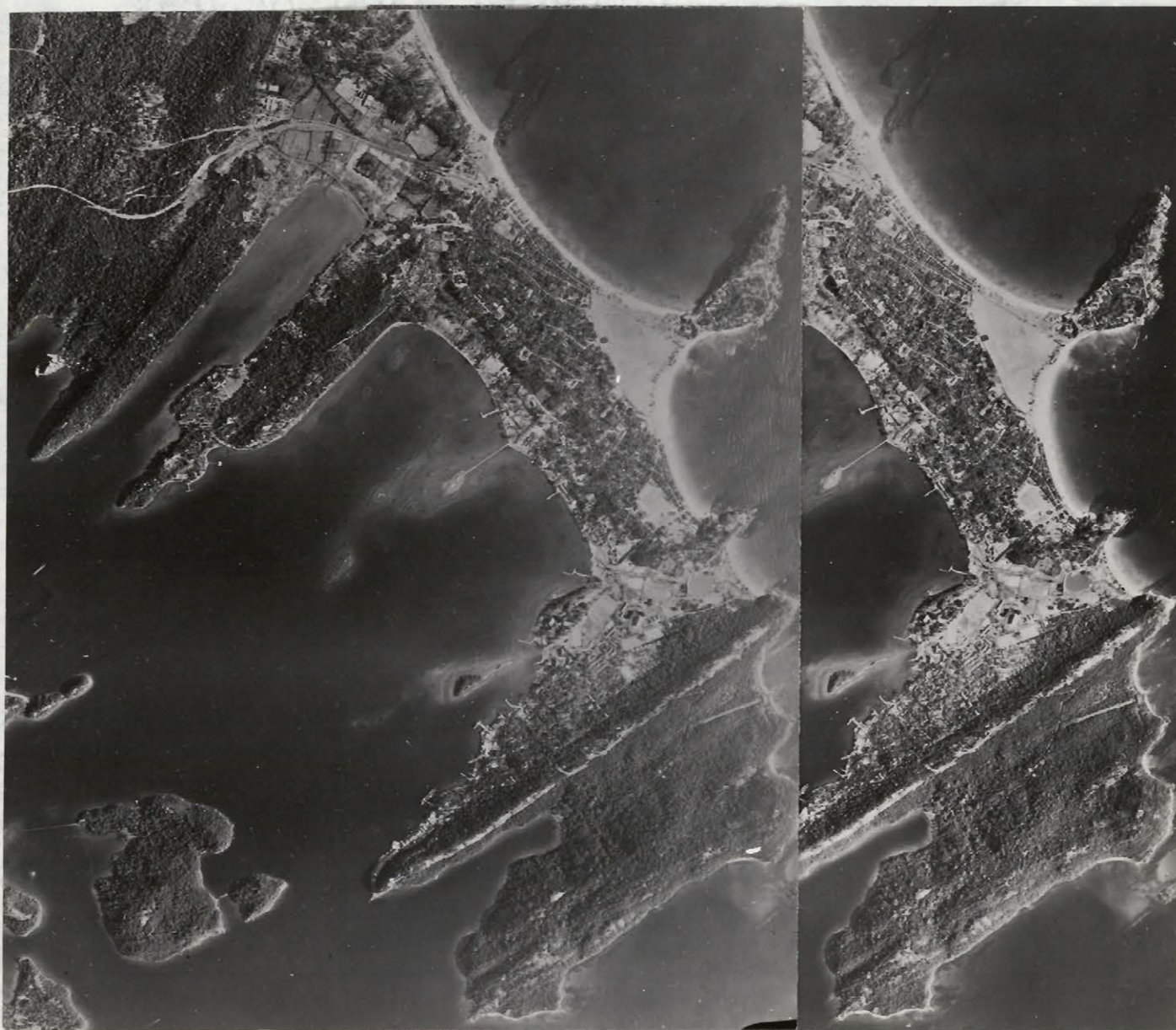


FIGURE 129

Elahera Ridges, Trincomalee Harbour

CHAPTER IV

PROCESSES

Introduction

In the following pages, the geomorphologic processes active in the formation of Ceylon's terrain, as described in the previous chapter, will be discussed.

An attempt will be made to describe the various processes and the results of their activity in terms of the landforms of Ceylon, and to illustrate these features with suitable stereoscopic pairs of aerial photographs.

Weathering

Climatically, as discussed in Chapter II, Ceylon may be classified as a warm and humid region. As such it is subject to intense chemical weathering. In certain areas, notably the Sabaragamuwa Hills, Central Massif, Knuckles Massif, and to a lesser extent the Gal Oya Hills (Fig. 20), deep weathering appears characteristic. The remainder of the island, comprising the low level plains and associated erosion remnants, exhibits less well defined evidence of this process.

In the low level plains region, bedrock outcrops are numerous and varied. They occur on the coastal plain where they may be exposed

by wave action along the shore (Fig. 28 and Fig. 51), and may rise above the surrounding soil mantle a short distance inland (Fig. 47 and Fig. 130), or they may be exposed at the base of the previously mentioned higher land (Fig. 49, Fig. 131 and Fig. 132). These outcrops may take the form of low, rounded, "whale backs" (Fig. 54 and Fig. 56); slightly higher, rounded knobs or sharp ridges barely visible above the jungle growth (Fig. 42); well defined, low peaks, both isolated, rounded, massive forms (Fig. 48, Fig. 49, and Fig. 131), as well as much jointed and dispersed complexes (Fig. 130); and much higher, monadnock or inselberg-like erosion remnants varying in elevation from 500 to 2500 feet above sea level (Fig. 37, Fig. 38, Fig. 46, Fig. 47, and Fig. 132).

Detailed studies of these features have been confined to specific areas involved in either the Colombo Plan aerial survey programme, or geological surveys carried out by the Ceylon Department of Mineralogy. Data derived from these sources have tentatively indicated the depth of weathering in the areas separating the outcrops (Vitanage, 1958), and a close correlation between the lithology of the bedrock and the degree of weathering and erosion (Oliver and Erb, 1957). Within the outcrops themselves, the degree of fracturing or jointing also appears to be related to the lithology (Oliver, 1957). Undoubtedly, more detailed petrologic and petrographic studies will have to be

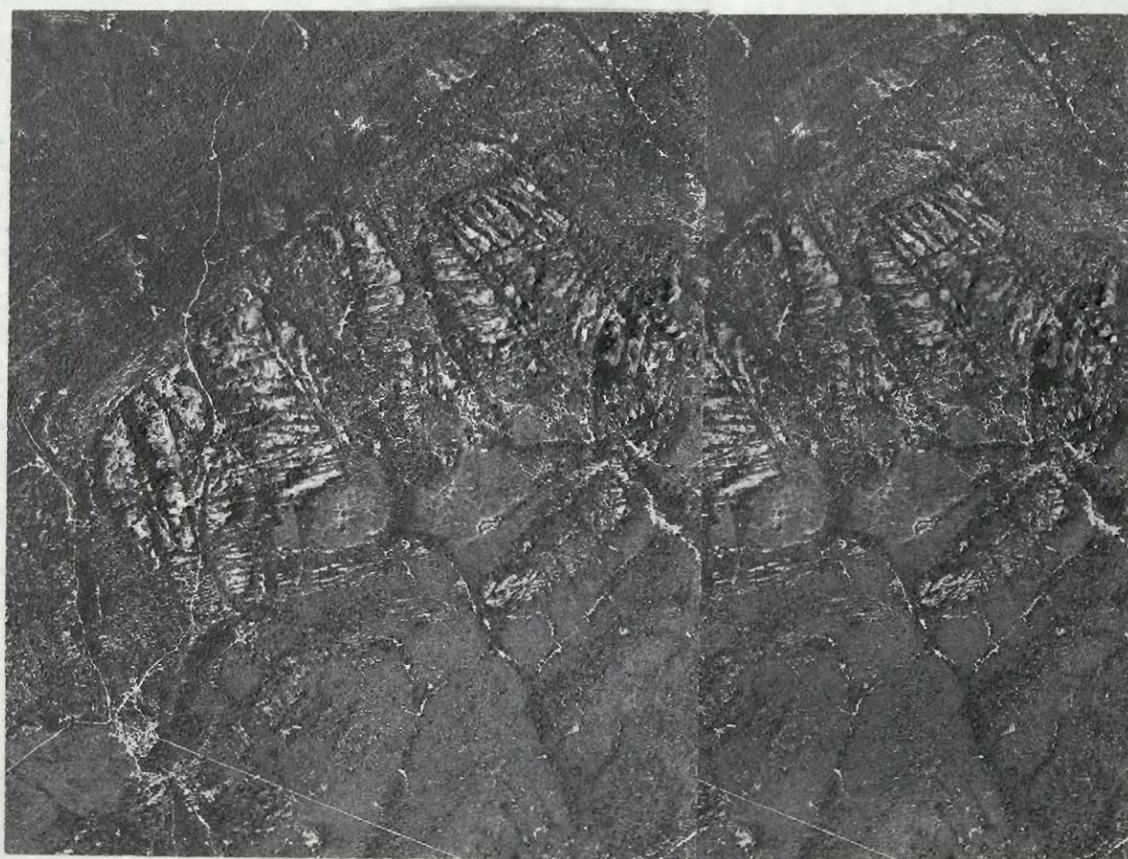


FIGURE 130

Fractured and Jointed Erosion Remnants Near Kataragama,
Tanamalwila Peneplain

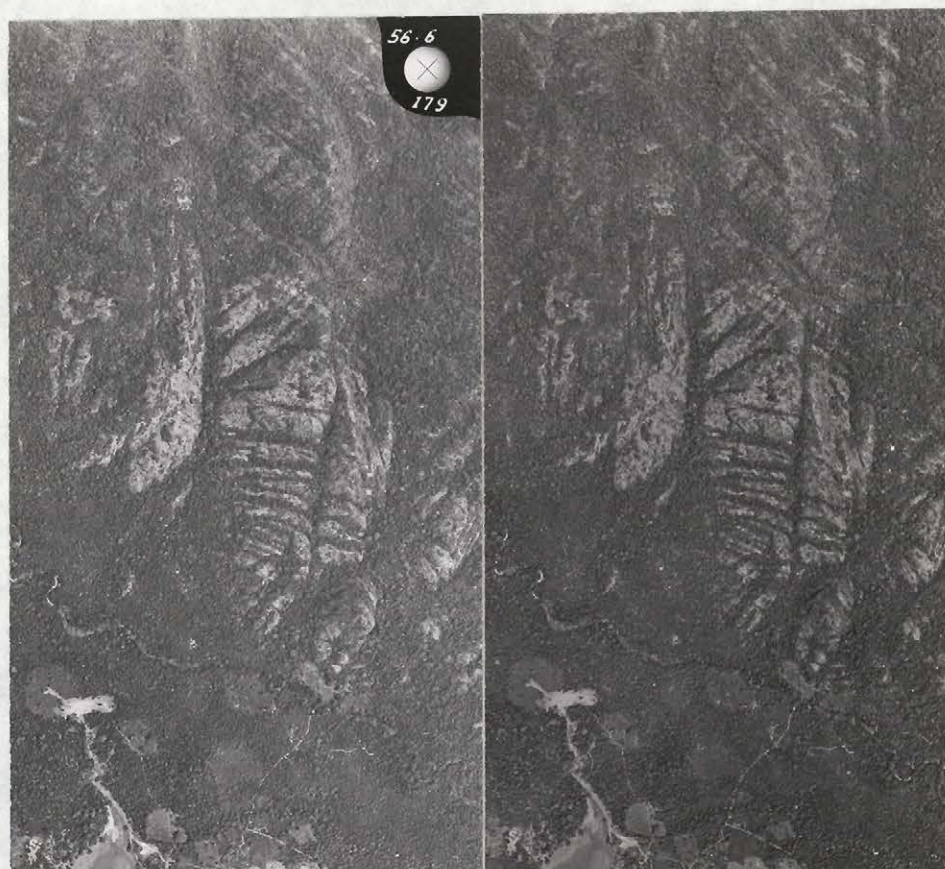


FIGURE 131

Gneissic Knobs, Upper Kirindi Oya Basin,
Southwest of Wellawaya

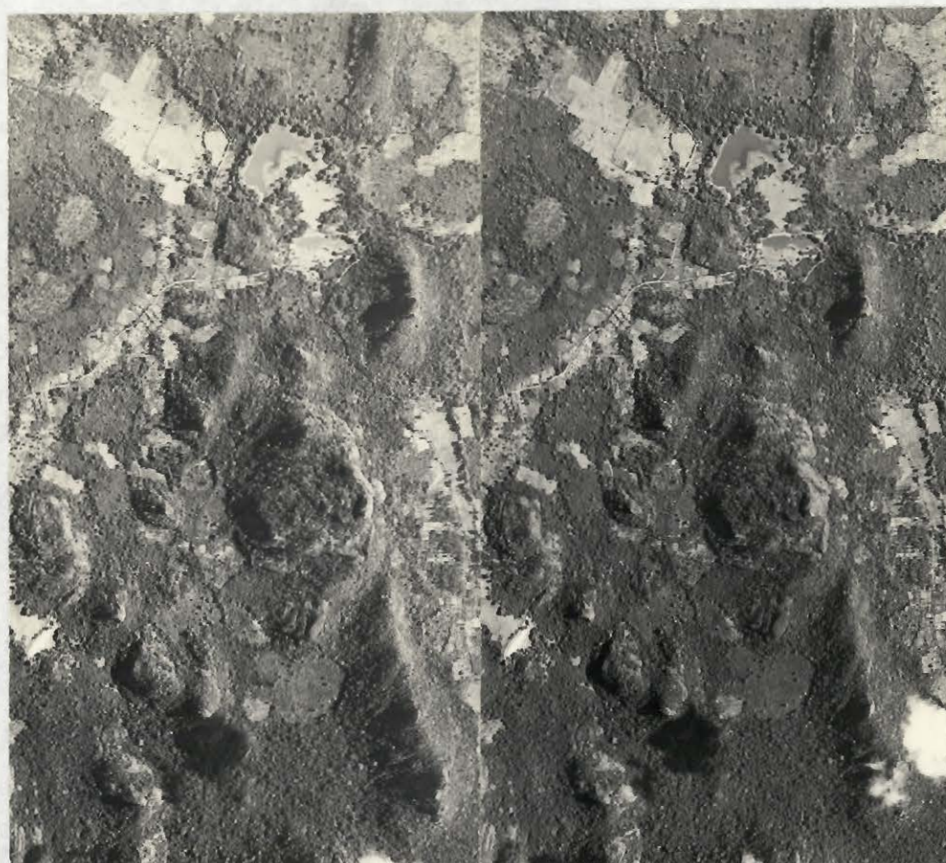


FIGURE 132

Monadnocks or Inselbergs, Kumbukkandawala Area,
East-northeast of Dambulla

carried out to enable the geomorphologist to determine the exact relationships existing among rock type, structure, lithology, weathering, and the landforms of this region. However, the data available and the observations made using aerial photographic interpretation techniques, supplemented by selected field checks, are sufficient to allow certain deductions with respect to these problems.

The depth of weathering in the inter-outcrop areas of the Polonnaruwa district (Vitanage, 1958) seems to indicate that in this region at least, the plain surface is formed partially on bedrock and partially on unconsolidated material. Evidence from the aerial photographs and from studies in the lower Mahaweli Ganga basin (personal communication) indicate that alluvial deposition has been a factor as well.

Similar surface conditions have been mapped in the low level portions of the Kirindi Oya-Walawe Ganga basins (Oliver and Erb, 1957, Kirindi Oya Report and Walawe Ganga Report 1957-1958 and 1960), but little is known regarding the maximum depth of weathering. The development of a combined erosion-deposition surface, in places truncating the essentially unweathered bedrock, and in places pierced by erosion remnants of variable form, approximates very closely the spül-oberfläche (wash surface) of Büdel (1957). Whether some of the low level plateaux which are transitional from the plains to the higher

levels of the Central Massif, may be classified as rand-spülpedimente (rim wash pediments) following the same theory, has not yet been determined. It is certain that the low level plain area does have numerous landforms which could be assigned to the various categories described by Budel (1957). For example, the low, rounded bedrock "whale backs" of the Hambantota-Tissamaharama area (Fig. 54 and Fig. 56) could be termed schildinselbergs (shield inselbergs), and the more angular single peaks or groups of peaks, usually situated near or attached to the higher land bordering the plain, as in the upper Walawe Ganga basin (Fig. 49), the Wellawaya district (Fig. 131), and the Elahera-Nalanda district (Fig. 132), could be termed auslieger-inselberg (outlying inselberg).

Budel (1957), in discussing his doppelten einebnungsflächen in den feuchten tropen (double surface of leveling in the humid tropics), perhaps wisely refrains from mentioning the pediplanation-peneplanation controversy. However, his theory which depicts the flat to gently undulating plains of the humid tropics as wash surfaces formed on the unconsolidated by products of intense chemical weathering, and explains the bedrock landforms in terms of the same weathering plus an uplift of the bedrock surface or a lowering of the surrounding wash surface, appears to approximate more closely the slow downwearing peneplanation process rather than the scarp retreat of pediplanation.

Ollier-Melbourne (1960), in his discussion of the inselbergs of Uganda, substantiates many of the theories advanced by Büdel (1957). He emphasizes the deeply weathered regolith in the inter-inselberg areas, the freshness of the rock in the inselbergs themselves, the presence of a "basal surface of weathering" between the weathered (rotten) rock and unweathered (fresh) rock (see also Büdel, 1957, and Ruxton and Berry, 1957), the formation of inselberg forms by the projection of the basal surface of weathering above the surface, and the development of "corestones" when blocks of unweathered rock imbedded in the regolith are subject to weathering from all sides. Corestones formed in this manner, if exposed at the surface by erosion, would become the tor rocks characteristic of such inselberg-dominated landscape. Tor rocks not associated with inselbergs may, however, have a similar genesis (Linton, 1955, Waters, 1957, and Ruxton and Berry, 1957).

The tors of Ceylon usually are found associated with the erosion remnants of the low level plains, especially those characterized by strong jointing. In the Magulmaha Vihare-Kataragama area (Fig. 48 and Fig. 133), the tors are perched on the rounded tops of the erosion remnants, but in the Sigiriya area (Fig. 134), they rest on the bedrock pediment or weathered mantle surrounding the bases of the remnants. Considering these two areas: Sigiriya which has an almost



FIGURE 133

Remnant Tor Rocks, Near Kataragama

Erable
FLYER BOND
25% COTTON FIBER
MADE IN U.S.A.



FIGURE 134

Tor Rocks, Sigiriya

PIPER BOND

25% COTON FIBER

U.S.A.

classic bornhardt form; and Magulmaha Vihare, which more closely resembles an inselberg, it appear logical to attribute the variations, partly to the nature of the bedrock lithology, partly to the bedrock structure, and partly to the weathering/erosion processes. However, additional detailed field studies will be required to determine the degree of influence of these factors.

In the Sabaragamuwa Hills, and Central Massif, medium (Fig. 135), and sometimes large (Fig. 136), rounded boulders, partly buried in the weathered mantle, have been observed. These are considered here to be equivalent to the corestones of Ruxton and Berry (1957), and Ollier-Melbourne (1960), and will probably weather away completely unless erosion removes sufficient surrounding material to expose them as isolated tor type rocks on a bedrock surface. The scarcity of such tor type rocks in the Sabaragamuwa Hills, Central Massif, Knuckles Massif, and possibly Gal Oya Hills, appears to be a strong argument for the dominance of chemical weathering over erosion in these areas.

In most of the examples of tors and erosion remnants mentioned above, the processes of physical weathering by exfoliation, or spalling off of layers of variable thickness, or by fracturing of the rock, are active (Fig. 133, Fig. 135, and Fig. 137). This conforms with Büdel's (1957), and Ollier-Melbourne's (1960) theories, but especially with the former. In it, he proposes that chemical weathering beneath a



FIGURE 135

Rounded Boulders Partly Buried in Weathered
Mantle, Ridges West of Ratnapura

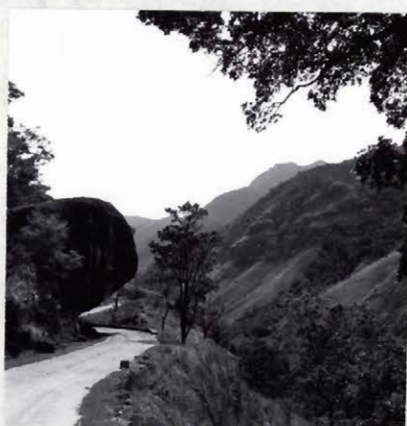


FIGURE 136

Large, Rounded Block of Rock Imbedded in
Weathered Mantle



FIGURE 137

Spheroidal Weathering and/or Exfoliation, Magulmaha
Vihare Pokuna, a Monadnock or Inselberg Near
Kataragama, Tanamalwila Peneplain

weathered mantle, changes to physical weathering, characteristic of more arid conditions, as the bedrock is exposed in the process of inselberg and tor formation. Linton (1955) and Waters (1957) are also in favour of deep weathering under tropical conditions to explain the formation of tors.

The higher, more humid regions of Ceylon, which include the Sabaragamuwa Hills, Central Massif, Knuckles Massif, and Gal Oya Hills, are subject to weathering on a more extensive scale. In these areas, the complexity of geologic conditions discussed in Chapter I, and the topography, which has evolved as a result of the geomorphologic processes acting on this framework, have determined to a marked extent the nature, degree, and distribution of weathering.

Because of the lack of significant diurnal and/or seasonal temperature variations (Tables II and III), physical weathering, by differential mineral expansion, is predominantly caused by chemical reactions. Thus, it may more correctly be referred to as physico-chemical weathering. True physical weathering is limited to root wedging, which is difficult to evaluate at the scale of this study, expansion resulting from unloading, and colloid plucking. If exfoliation domes are considered to indicate the unloading process, then its effectiveness, in the regions under discussion, appears limited. However, in some widely separated areas such as the Mawanella

Shelf (Fig. 138) and the Diyatalawa Plateau (Fig. 96), dome shaped bedrock hills do exist and may be subject to such an interpretation.

The significance of collodial plucking as discussed by Reiche (1950), has not been determined for Ceylon.

Chemical weathering is active to a greater or lesser degree throughout this area. If the bedrock surface is relatively flat, the effectiveness of this process is largely controlled by the susceptibility of the minerals, of which the rock is composed, to chemical alteration. If these conditions are accompanied by jointing or fracturing of the bedrock, or if the unweathered surface is overlain by a mantle of weathered material, or a vegetative cover, the weathering is facilitated. If the bedrock surface is steeply inclined or local relief is great, erosion and certain forms of mass-wasting actively remove the weathered material as it is formed, preventing the development of a protective, moisture holding mantle and its associated vegetative cover, and hindering chemical decomposition. All forms of transitional combinations of the above factors exist and are represented by the various physical characteristics making up the terrain being analyzed.

In the high and medium level areas, deep chemical decomposition is indicated by a number of features visible on the aerial photographs. In the unforested or partly forested patana or talawa regions

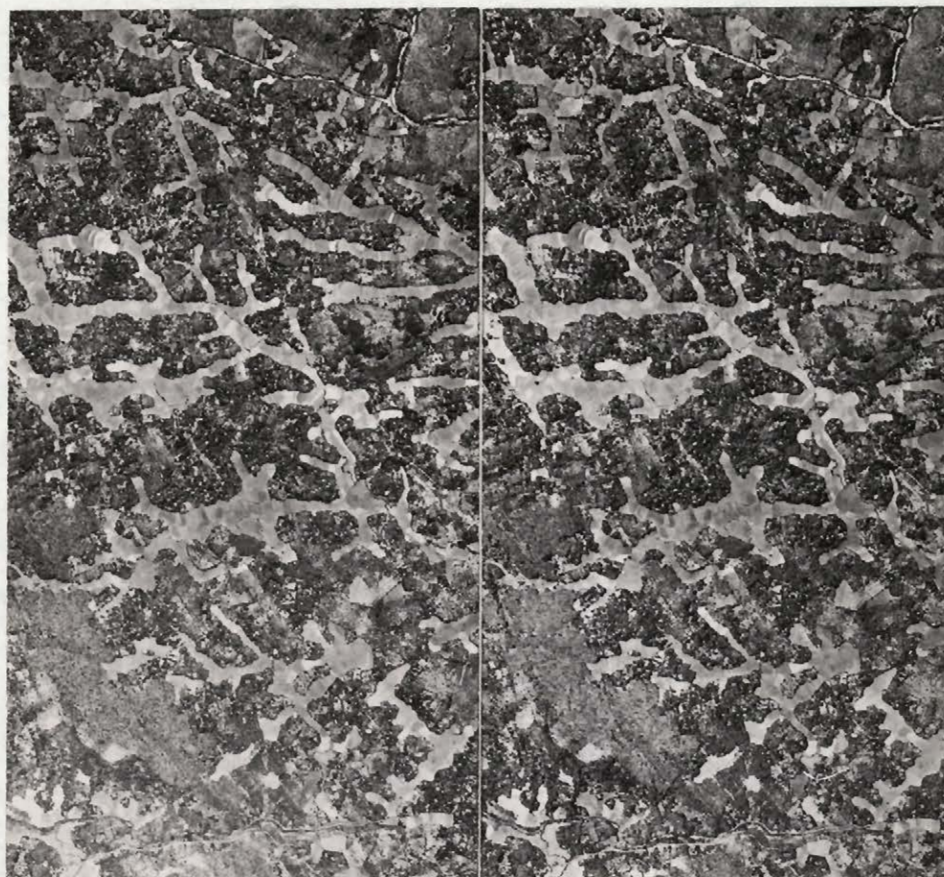


FIGURE 138

Possible Exfoliation Dome, Flat Bottomed, Alluvium Filled,
Structurally Controlled Valleys, and Resistant Ridges,
Mawanella Shelf

of the Diyatalawa Plateau and Worlds End Plateau, smoothly rounded hills, slopes, and interfluvial ridges are characteristic (Fig. 93, Fig. 96, and Fig. 139). Also characteristic is a strong tendency for the weathered deposits to obscure the underlying structure. Only where stream rejuvenation, or particularly resistant beds are present, is structural control in evidence (Fig. 96 and Fig. 139). Another feature visible in some, but not all, of the deeply weathered areas, is slump scars (Fig. 139). These are probably related to the clay content of the soil, which in turn is related to the type of rock being decomposed. In general, the rock types of the area, as discussed in Chapter I, belong to the more easily weathered Khondalite Group. Most of the exposed bedrock hills and ridges of this area are composed of the more resistant Charnockite and Quartzite.

In regions where a combination of differential resistance, steeper slopes, and increased erosion exists, bedrock control is much more obvious. The strike ridges of the upper Maskeliya Oya valley (Fig. 140) have the characteristic convex slopes and slump scars of deep weathering, but the linearity and interrupted stream profiles attributable to structure. The ridges in this region also have the well defined, reasonably dense stream patterns which are to be expected on the less porous, deeply weathered soils.

Convex hilltops of deeply weathered but more porous soils, are well illustrated in the high rainfall Sabaragamuwa Hills (Fig. 141).

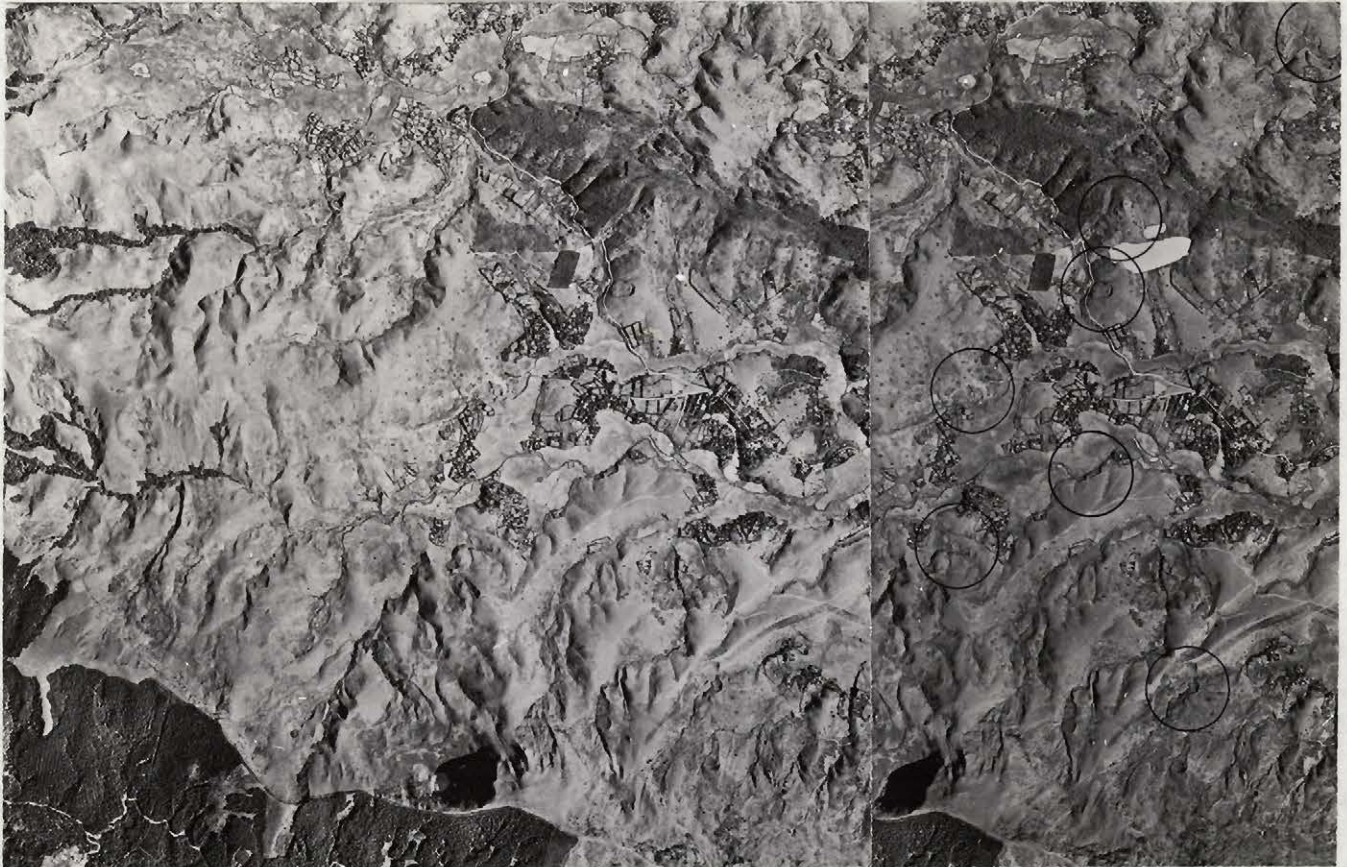


FIGURE 139

Rounded, Interfluvial Hills and Slump Scars,
Diyatalawa Plateau

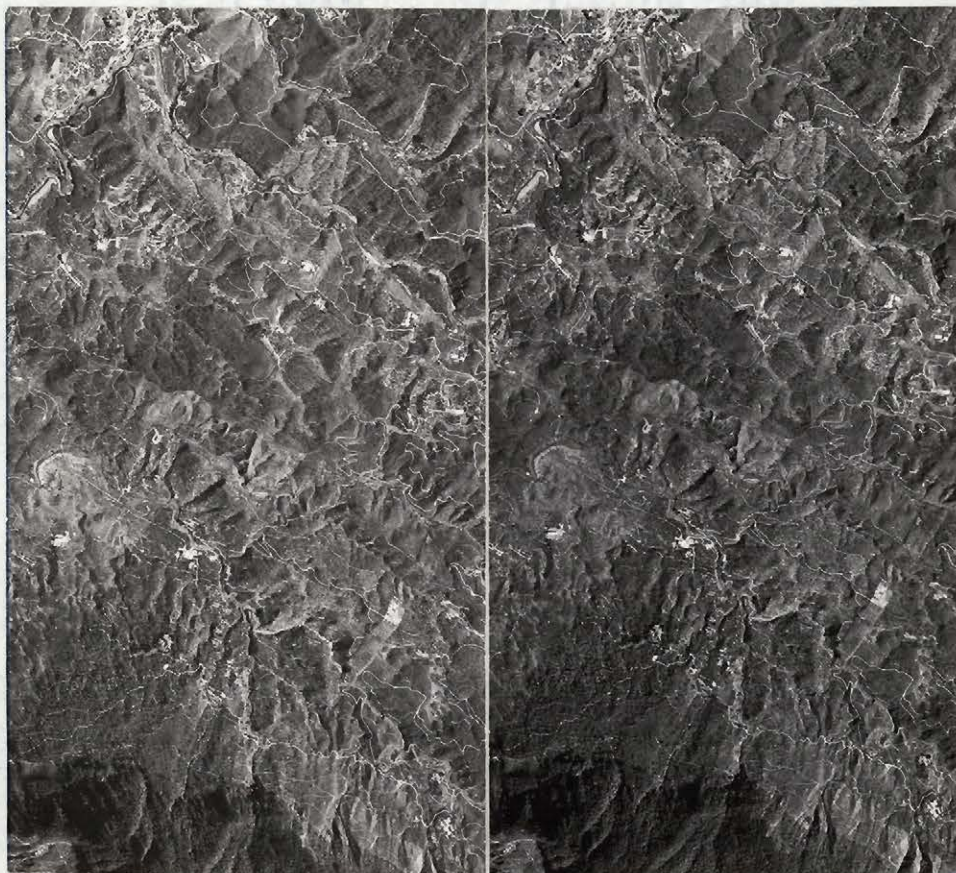


FIGURE 140

Linear Strike Ridges, Convex Slopes, and Slump Scars,
Upper Maskeliya Oya Valley

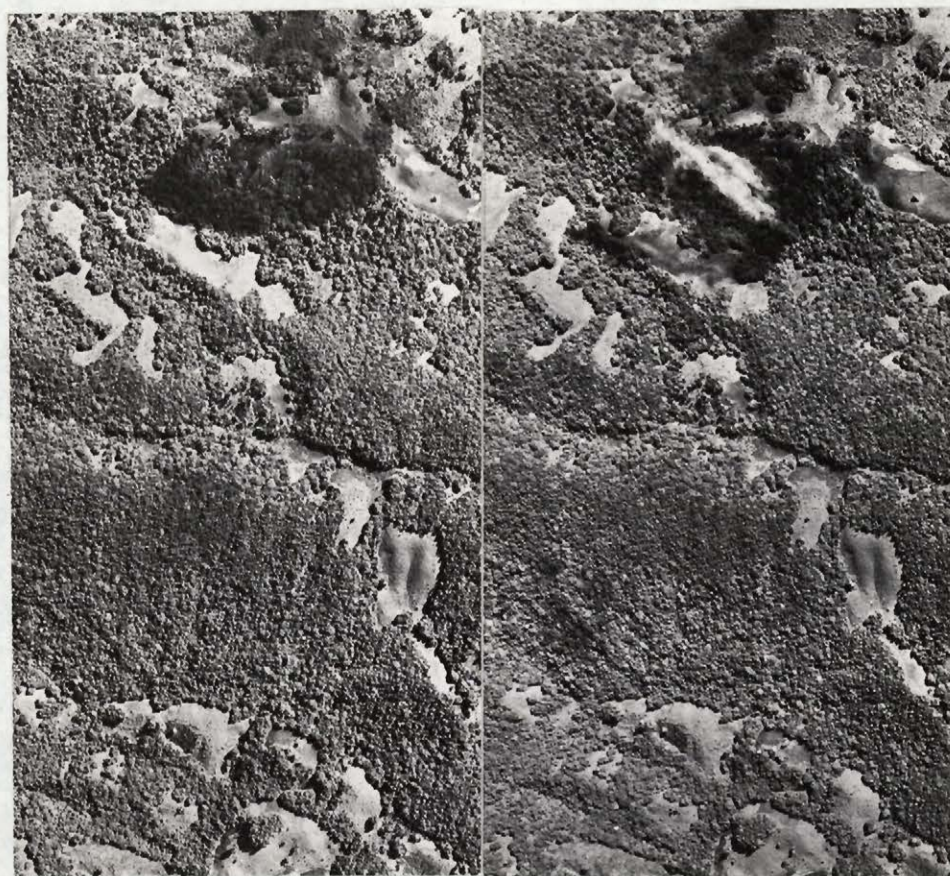


FIGURE 141

Convex Hill Tops and Possible Limestone Solution Valleys
in the High Rainfall Sabaragamuwa Hills Region

Throughout much of Ceylon, dense forest covers the terrain and it is difficult to assign a degree of weathering on the basis of the aerial photograph. However, regions such as Peak Wilderness Plateau (Fig. 64), Adams Peak (Fig. 94), Selvakanda Plateau (Fig. 123), Worlds End Ridge (Fig. 84 and Fig. 85), Worlds End Plateau (Fig. 90), Bandera Eliya Plateau (Fig. 88), and the lower, Tangamale Plateau (Fig. 127), and Handapan Ella Plateau (Fig. 126), all indicate the effectiveness of moderate to deep weathering, followed by, or concurrent with, structure delineating erosion. If erosion, as mentioned earlier, removes weathered material as it forms, the development of a moisture retaining, vegetation supporting mantle is prevented, and bare or almost bare bedrock is exposed. Labulessapatana Peak (Fig. 116), and parts of the associated Knuckles Range (Fig. 119 and Fig. 121) illustrate this situation.

As is to be expected in an area as complex as the one under discussion, all degrees of weathering from deep to shallow; all degrees of resistance from soft limestones and granulites to hard quartzites; all degrees of vegetative cover from deep rainforest to short-grass patana; and all degrees of topographic influence from almost flat to vertical, are present. Selected stereoscopic pairs of aerial photographs, supplemented where possible by stereoscopic ground photographs, or by single aerial or ground photographs, have been used to illustrate as many of these features as feasible.

Mass -wasting

Mass-wasting is most active in the medium and high level areas of Ceylon. In these areas, strong local relief combined with intense weathering and high rainfall are the factors which favour this process.

Rockfall and rockslide are characteristic of the numerous scarps, particularly in the Central Massif and Knuckles Massif. In these areas, however, rapid chemical decomposition may bury the fallen rock in a mantle of weathered soil or may even destroy it completely. In the latter case, the weathered material is removed by erosion as rapidly as it forms. The deep and rapid weathering is usually accompanied by heavy forest growth so that the lower slopes of the escarpments in such areas are often obscured on the aerial photographs. The western and southwestern escarpments of Adams Peak Range (Fig. 15, Fig. 61, Fig. 65, and Fig. 85), and the lower slopes of many escarpments in the Knuckles Massif (Fig. 117, Fig. 120, and Fig. 121), are in this category. Elsewhere in the Central Massif and Knuckles Massif, thinner vegetation, possibly larger blocks, and possibly more active erosion, or less active decomposition, have combined to make the evidence of this type of mass-wasting more clearly visible. The great rockfall of Labulessapatana (Fig. 116), is probably the most obvious, but close study of the aerial photographs will disclose many others. Among these may be mentioned: Adams Peak Range at the We Oya

(Fig. 62 and Fig. 142); Great Western Spur (Fig. 76); Pundaluoya Valley Syncline (Fig. 77); Dambattenne Basin (Fig. 86); Worlds End Ridge (Fig. 85); Ramboda Area (Fig. 80); Namunakuli Range (Fig. 72); Diyatalawa Plateau-Haputale Ridge (Fig. 139); and Nilambe Syncline (Fig. 82). Few ground photographs of the above features are available because of the difficulty of obtaining a clear view of them. The east scarp face of Hantane Ridge (Fig. 83), and the south facing scarps of the Dambattenne Basin (Fig. 143), are two exceptions. The marginal scarps (Fig. 110 and Fig. 112) of the Balangoda Shelf and Molamure Shelf (Fig. 97 and Fig. 111), were photographed from a Royal Ceylon Airforce helicopter.

In the low level plains area, the degree of activity of this type of mass-wasting is difficult to assess. In some areas, weathering and erosion appear to have kept pace and little evidence of mass-wasting is visible (Fig. 130 and Fig. 131). In other areas, because of vegetation or the scale of photography, it is difficult to determine whether the lower slopes of the erosion remnants are composed of weathered talus, bedrock, or bedrock with a thin veneer of weathered material, either transported or residual. The lower slopes of an erosion remnant near Kataragama (Fig. 47), although concave, and covered by a more or less uniform vegetative growth of the scrub jungle type, are essentially bedrock pediments. In the Sigiriya area, however, the basal slopes of the

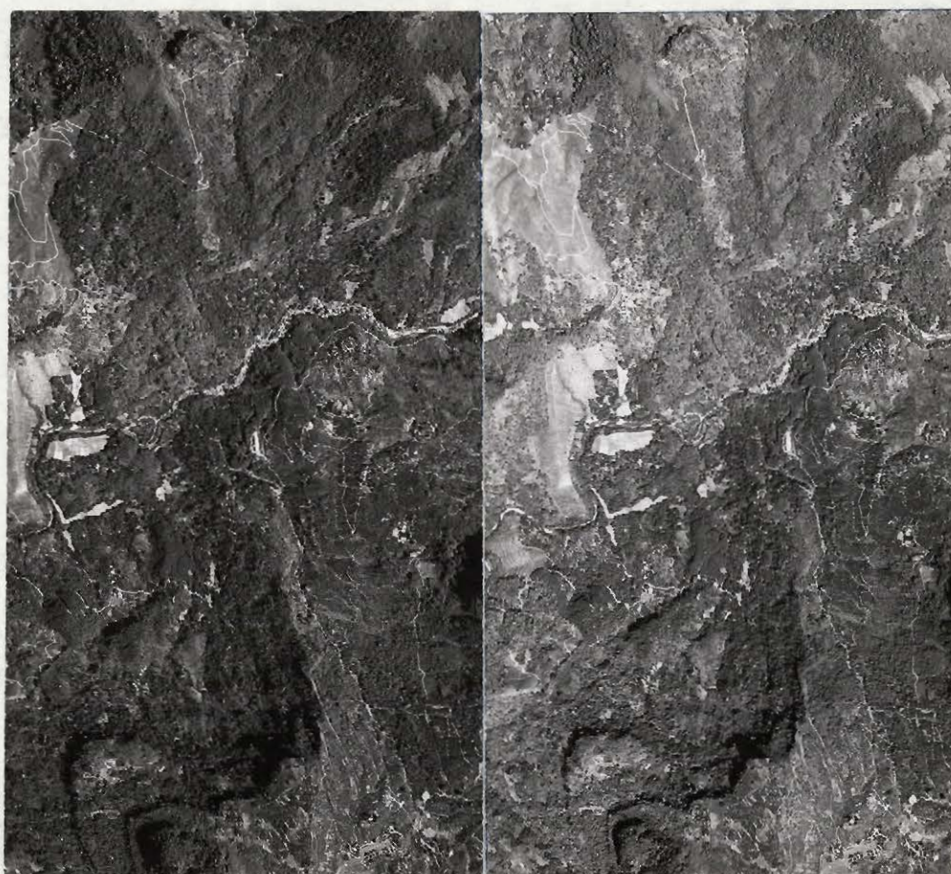


FIGURE 142

Mass-wasting, Weathering, and Erosion, We Oya Channel
and Valley, Western Margin, Adams Peak Range



FIGURE 143

Blocky Talus, South Facing Scarp,

Dambattenne Basin

erosion remnants (Fig. 38), consist of a mantle of weathered material of variable thickness, apparently formed on a presently undefined bed-rock surface, probably equivalent to the "basal surface of weathering" of Ollier-Melbourne (1960) and Ruxton and Berry (1957), "basal platform" of Linton (1955), and "base level of weathering" of Büdel (1957). As already discussed, tor type rocks or "corestones" occur in this weathered mantle (Fig. 134). In the case of some unnamed erosion remnants near Kumbukkandawala, about six miles east-northeast of Dambulla (Fig. 132), the bedrock of which they are composed can be seen to rise directly from the plain. However, other peaks in the same group appear to project above cone shaped, or rounded, lower slopes. These latter slopes, although for the most part covered by forest which obscures them, occasionally exhibit small patches of bedrock if observed closely. It is therefore difficult to determine, without detailed field investigation, if evidence of mass-wasting is present. Similar examples may be cited from the southern section of the low level plain (Fig. 46 and Fig. 49), and also from the margin of the Gal Oya Hills (Fig. 41).

Mass-wasting of the slump type is generally limited to the more deeply weathered, moderate to high relief areas in Ceylon. Slump deposits and the associated scars are clearly visible in the open patana or grassland, less so in the talawa or savanna, and very difficult, if

not impossible to see in the densely forested areas. The patanas, in certain sections of the Diyatalawa Plateau, provide many examples of slumping (Fig. 139), but in other sections with apparently similar characteristics, few if any such features are visible (Fig. 96). The explanation may involve variations in the lithology of the bedrock, local relief, moisture conditions, or factors as yet undetermined.

Elsewhere, particularly in the medium and low level plateaux such as Ulupana Shelf, Peradeniya Basin (Fig. 107), Kondesalle Basin, Nalanda Shelf (Fig. 109), and Mawanella Shelf (Fig. 114 and Fig. 138), vegetation, slope terracing, and the scale of photography make delineation of slump areas difficult or impossible. Two stereoscopic pairs illustrating features of the Mawanella Shelf (Fig. 114 and Fig. 138) do not show any evidence of this process, although small slumps have been observed in the area. In the upper Maskeliya Oya valley (Fig. 140), a more deeply dissected portion of the Hatton-Diyatalawa Plateau provides several, easily visible examples of slumping. No aerial photographic evidence of slumping was observed in the semi-arid sections of the low level plain area, or in the humid, deeply weathered, southwestern lowland (Fig. 33, Fig. 57, Fig. 58, Fig. 59, and Fig. 128) where conditions appear optimum for the process (Krynine, 1936). In the latter area, slumping is probably active, but because of the scale of the photography, is not visible under normal stereoscopic examination.

Creep, by its nature, is almost impossible to detect on small scale aerial photography. However, the combination of climatic, geologic, and topographic conditions present throughout much of Ceylon, together with the smoothly rounded, concavo-convex landforms, and the lack in many regions of dense drainage patterns, would appear to indicate its presence (Schumm, 1956, and Pallister, 1956). Detailed field investigations would be required to determine the extent and effectiveness of this process in the area under study.

Soil flowage and associated phenomena are also present in Ceylon and are gradational into debris slides and slumps, depending on the nature of the weathered mantle, the slope, the local relief, and the amount of rainfall (Cooray, 1958). As in other forms of mass-wasting, the ability to discern soil flowage forms is dependent on size, vegetative cover, and nature of the relief. One major feature considered here to be of this type, occurs on the northeast slope of the Ramboda valley (Fig. 81). Positive classification in this case would require detailed field investigation.

In summary, the deep and intensive weathering, the nature of the bedrock, the topography, the high rainfall, and the intense erosion, all combine to make mass-wasting one of the most important terrain forming processes in Ceylon.

Erosion

Erosion is active throughout most of Ceylon. In the Central Massif, erosion may be very slight on the gentle slopes of the high level peneplain remnants; moderate on the intermediate level, more deeply dissected plateaux; or intense where the concentrated drainage from these areas has been localized along structurally weak zones. In the Knuckles Massif, similar conditions exist. In the low level plateaux associated with these areas, erosion may be slight because of low, local relief, or moderately active where streams are cutting back into these surfaces. In the Sabaragamuwa Hills, the generally strong relief and well marked dissection, indicate moderate to active erosion, although the dense vegetative cover consequent on the very high rainfall, obscures detailed evidence. In the Gal Oya Hills which are also obscured by a dense vegetative cover, the overall dissection appears indicative of moderate erosion. The Southwest Peneplain provides an excellent example of differential erosion under very heavy rainfall and moderate to heavy vegetative cover. The remainder of the low level plain area, because of existing semi-arid climatic conditions, does not exhibit appreciable erosion at present, however, the general landform pattern is indicative of extensive activity during its geomorphologic history.

A comprehensive and detailed investigation of the erosive process, as it affects all of the areas mentioned in the above

generalization, is not within the scope of this study, however, the analysis and interpretation of stereoscopic pairs of aerial photographs has provided sufficient data to tentatively evaluate the process, to determine some of the significant variations from area to area, and to draw certain conclusions with respect to the geomorphological history of the region.

Worlds End Plateau (Fig. 93) is one of the high level (7,200 feet) peneplain remnants of the Central Massif. Deep weathering under 100 to 150 inches of rainfall has apparently produced a porous and permeable soil with very good internal drainage and little surface runoff. The meandering nature of the small streams draining the area indicates little vertical erosion, and the rounded (concavo-convex) form of the hills and valleys, indicates the probably dominance of creep over sheet wash on these slopes (Birot, 1949, Pallister, 1956, Schumm, 1956, and Baulig as translated by Cotton, 1957). In general, the surface configuration does not show any appreciable adjustment to structure. This is partly because of the deep weathering, as mentioned in a previous section, and partly because of the lack of active erosion which would normally etch out such structure. It may be noted that along the western margin of this portion of the plateau, streams are eroding headward along probable fault or fracture zones. Finally, the general accordance of level of the interfluvial ridges, and the areal extent of this surface as

a whole, indicate that this is a true erosion surface. The presence of monadnock-like peaks rising above this level, as shown in the upper part of the stereo pair (Fig. 93), further substantiates this hypothesis. Worlds End Plateau is the highest erosion surface mapped in the island (Fig. 21).

A lower (6,200 to 6,300 feet) erosion surface termed the Pattipola Plateau (Fig. 21), extends in scattered remnants from Adams Peak in the west (Fig. 94), to Bandera Eliya Plateau in the east (Fig. 88). The Peak Wilderness Plateau portion of the Pattipola level (Fig. 64), lies just south of Gartmore Valley at the southern end of Adams Peak Range. It is in a high rainfall (150 to 200 inches per year) area and is almost inaccessible. This surface is covered for the most part with dense forest. In areas where this vegetation has been removed (Fig. 64), the presence of flat to gently rounded valley bottoms with meandering streams is evident. Elsewhere on the plateau, especially in the area south of Adams Peak (Fig. 94), more angular topography with greater local relief and structural control has developed. The variation in erosion indicated by these features may be due to an increase in fracturing and jointing of the bedrock in the northern area, to a more resistant rock type, or to deeper weathering of the southern part.

The Selvakanda Plateau at an elevation of approximately 5,200

feet above sea level in the Knuckles Range (Fig. 123), the Handapan Ella Plateau at approximately 4,000 feet in the Sabaragamuwa Hills (Fig. 126), and the Tangamale Plateau at approximately 3,500 feet, also in the Sabaragamuwa Hills (Fig. 127), are other examples of this type of terrain.

The Hatton-Diyatalawa Plateau (4,500 to 4,800 feet) is a deeply weathered and deeply dissected surface extending over much of the Central Massif (Fig. 20). The Hatton portion lies between Adams Peak Range on the west, and Pidurutalagala Range in the centre; the Diyatalawa portion between the latter range and Namunakuli Range on the east. In the Hatton area, the presence of a geological foundation comprising resistant and weak beds folded into a complex series of anticlines and synclines, many of the former with breached crests, the whole cut by an intricate network of faults and joints, has influenced the process of erosion significantly. In sections of more homogeneous, less resistant bedrock, as in the upper Maskeliya Oya valley (Fig. 140), erosion has produced a rounded, uniform topography. In sections having steep dip slopes, resistant beds and extensive faulting and/or jointing, erosion has varied from gullying and sheet wash on the low gradient surfaces, to deep and active incision along structurally weak zones in higher gradient areas. These latter conditions tend to be most active in the upper, headward eroding portions of the streams crossing

the areas. Profiles of the three major rivers, which drain the area and form the headwaters of the Mahaweli Ganga; the Nanu Oya, Dambagastalawa Oya, and Agra Oya (Fig. 43, Mahaweli Ganga Profile, Appendix A), illustrate the gradient changes.

In the Diyatalawa area, less resistant rock types generally of the Khondalite group, and less positive structural control, have resulted in more uniform, dendritic drainage patterns; rounded, more smoothly developed topography; and very little evidence of the old erosion surface in the stream profiles. The profiles of the Uma Oya, and Badulu Oya (Fig. 43, Mahaweli Ganga Profile, Appendix A), although they traverse part of the area, do not give any indication of the Diyatalawa level.

The higher remnants of this erosion surface are generally of such small areal extent that the action of headward eroding streams is easily visible on the margins (Fig. 96). With the exception of such scattered hill tops and very small plateau remnants, evidence of the surface is confined to the margin of the basin adjacent to the surrounding mountain ridges (Fig. 139). In the area as a whole, vertical erosion accompanied by uniform, valley side retreat, has produced an almost mature terrain. The base level toward which the streams of the area are working at this stage, is the level of the Mahaweli Ganga at Minipe. This is also true for the streams draining the Hatton portion of the Hatton-Diyatalawa Plateau as well.

The Mahaweli Ganga as shown by its profile (Fig. 43, Mahaweli Ganga Profile, Appendix A), has reached an elevation of approximately 300 feet above sea level at the mouth of the Badulu Oya, a distance of one hundred and seven miles from the sea at Trincomalee which indicates a gradient over this portion of approximately three feet per mile. This point is therefore considered to be at a level which is essentially base level insofar as the upstream segments of the system are concerned.

Associated with the Mahaweli Ganga in the Central Massif (Fig. 20), are four medium to low level erosion surfaces: the Ulupana Shelf (2,600 to 2,800 feet); the Peradeniya Basin (1,800 feet); the Kondesalle Basin (1,500 feet); and the Mawanella Shelf (900 to 1,000 feet). Although their elevations vary, these surfaces have similar weathering, erosion, and morphologic characteristics. In general, weak and resistant beds of synclinal structures have apparently been truncated by an earlier period of erosion at a particular level as mentioned above. Subsequent erosion has etched out the more deeply weathered, less resistant beds and has, thereby, delineated the original geologic structure (Fig. 107, Fig. 114, and Fig. 138). Finally, whether under the influence of alluvial deposition controlled by a local base level, or under the influence of local agricultural practices (terracing), or under a combination of the two, the valley bottoms have become

flattened, and vertical erosion has apparently ceased. Very few large streams are visible in these areas, but those that are follow the above pattern. In addition, little evidence of erosion is visible on the slopes of the interfluvial ridges when they are studied on the aerial photographs. Whether this is due to the scale of the photography or to the fact that the erosion processes do not produce obvious physical evidence subject to detection, or whether the weathering processes have resulted in porous and permeable soil, not susceptible to erosion, will require more detailed studies in the field. Two characteristics are common to all of these areas, however: first, the delineation of geologic structure by the valley bottoms (and associated ridges) as is shown by the Mawanella Shelf (Fig. 7 and Fig. 107); and second, the presence of erosion remnants in the form of monadnock or inselberg-like hills rising above the surrounding level (Fig. 114 and Fig. 138). It is considered here that these forms are developed by essentially the same process active in the formation of similar features on the semi-arid low level plain, that is, deep weathering of all but the more resistant rocks, followed by erosion of the weathered mantle and exposure of these remnant forms.

Nalanda Shelf (1,400 to 1,500 feet) (Fig. 109), at the northern end of the Central Massif is an erosion surface very similar to those described above. However, in this case, the central part of the plateau

is either an old erosion surface undergoing marginal dissection, or a surface formed by a weathered mantle resting on and partially obscuring the local bedrock structure. If the latter set of circumstances obtained, the surface of the plateau might be considered equivalent to the "wash surface" and the bedrock weathered mantle contact, the "basal surface of weathering", of Büdel (1957), and Ollier-Melbourne (1960). Similar theories to explain the formation of residual features such as occur on this plateau (ridges, monadnocks, inselbergs, tors, etc.) were advanced by Ruxton and Berry (1957), and earlier by Linton (1955) and Waters (1957).

At the margin of this flat to gently undulating surface, active vertical erosion is cutting headward along transverse joints or fractures and less resistant interbeds and will eventually etch out the structure and reduce the plateau to the level of the adjacent plain.

Lying along the base of the south facing scarp of the central highland mass, are three other medium and low level plateaux: the Balangoda Shelf (2,000 to 2,500 feet); the Molamure Shelf (1,500 feet); and the Wekada Shelf (1,200 to 1,300 feet) (Fig. 20 and Fig. 21). These surfaces are within the 100 to 125 inch rainfall zone and are moderately well dissected by the associated heavy runoff. The lithology of the well bedded or foliated, steeply dipping rocks composing these features, varies from resistant quartzites to weak sillimanite-garnet-

graphite schists (Khondalite rocks), and crystalline limestones. The quartzitic rocks are exemplified by Kirioluahena Ridge (Fig. 102 and Fig. 103), by the ridges forming the south margin of the Balangoda Shelf (Fig. 97 and Fig. 101), and by ridges in the Wekada Shelf area to the south and east (Fig. 113). The less resistant Khondalites and limestones have been more deeply weathered and eroded to form many of the strike valleys characteristic of these surfaces (Fig. 97, Fig. 98, and Fig. 99). This etching out of resistant bedrock structure by vertical erosion, has left only scattered plateau remnants and accordant ridge tops as evidence of the original 2,000 to 2,500 foot Balangoda level (Fig. 98 and Fig. 99), but extensive, only moderately dissected portions of the lower 1,500 foot Molamure level (Fig. 97, Fig. 106, Fig. 110, and Fig. 111).

The Wekada Shelf (1,200 to 1,300 feet) (Fig. 113), although not as well defined, is still mappable.

The control exercised over erosion by geologic structure in this region is clearly shown on the aerial photographs. Kirioluahena Ridge (Fig. 102 and Fig. 103) demonstrates the affect of dip slopes, scarp slopes, and to some extent variable resistance; a portion of the south margin of the Balangoda Shelf below Haputale (Fig. 101), illustrates the affect of variable resistance; and a portion of the Molamure Shelf west of Kaltota (Fig. 106), is an excellent example of fault

control. In the latter case, the Walawe Ganga makes several abrupt changes in direction under the influence of a major fault pattern. The fall, shown in the aerial photograph (Fig. 106) is apparently localized by faulting and associated fracturing. The fracturing is clearly visible in the low altitude helicopter photograph (Fig. 104), and in the ground photograph of the gorge below the fall (Fig. 105).

In addition to the extensive, relatively low relief plateaux or erosion surfaces, the Central Massif and Knuckles Massif contain large areas of dominantly mountainous terrain. In these latter areas, high, local relief, steep slopes, marked lithologic variations, and complex structure are combined. Erosion under such conditions is usually active and well defined.

In Adams Peak Range (Fig. 61 and Fig. 66) the high level dip and scarp slopes are subject to sheet wash, and the fault zones to more active incision. On the west facing slopes of the range (Fig. 65), heavy vegetation obscures the surface, but deep gullying of the talus and weathered rock deposits is indicated by the topography. Erosion throughout this area is commonly localized by fault zones which often traverse the entire range (Fig. 61 and Fig. 66). An example of intense erosive activity under strong structural control is given by the We Oya as it traverses the northern part of the range (Fig. 62 and Fig. 142).

In the Pidurutalagala Range and associated marginal transition

areas (Fig. 20), very active erosion has cut deep canyons or gorges along fault or joint zones, in places exposing block-like bedrock remnants on otherwise almost denuded slopes (Fig. 76, Fig. 77, and Fig. 80). In the Pundaluoya Valley (Fig. 77), this form of erosion has been active along a major synclinal structure. On the moderately to deeply weathered dip slopes of the structure, what has here been termed "giant rill" erosion is active (Fig. 76 and Fig. 77). In this type of erosion, the more or less parallel drainage channels under the influence of moderate to steep slopes have been incised through the weathered mantle to the relatively unweathered bedrock surface beneath. Thus, the depth of these gullies or "giant rills" appears to be indicative of the depth of weathering, and the deeper, less controlled channels in the southern and eastern parts of the area would, therefore, indicate deeper weathering.

Great Western Spur (Fig. 76) illustrates the "giant rill" type of erosion on its western dip slope; the deeper V-shaped or gorge-like erosion on the more deeply weathered mantle to the east; and structurally controlled erosion on the large block shown in the southeast part of this stereo-pair. The eastern end of Great Western Spur (Fig. 75), illustrates a bedding controlled, "chevron" drainage (erosion) pattern, as well as the significance of trans-mountain faults in localizing erosion.

The relative ability to see surface detail on the aerial photographs is demonstrated by comparing the heavily vegetated portion of this stereo-pair (Fig. 75) with the bare, light-toned portion visible in the lower right hand corner.

Even a brief study of the Ramboda area, as illustrated by the aerial photograph (Fig. 80), is sufficient to demonstrate the complexity of terrain formed under the varying controls characteristic of this section of Ceylon. Fault scarps or fault line scarps, fault controlled erosion, structure controlled weathering and topography, areas of slumps, rockfall, soil flowage, and other forms of mass-wasting, and the generally youthful stage of terrain formation, are a few of the features to be observed on this small portion of a single stereoscopic pair of aerial photographs.

Other stereo-pairs showing: the nose of the Nilambe Syncline (Fig. 82); the scarp face of Great Western Spur (Fig. 78); differential erosion in the Kurunegala-Matale region (Fig. 6); possible soil flowage in the Ramboda Valley (Fig. 81); block faulting in Adams Peak Range (Fig. 61); and probably in the Knuckles Range (Fig. 120 and Fig. 121); variations in terrain across Worlds End Ridge (Fig. 84 and Fig. 85); the joint controlled, marginal dissection of the Knuckles Peak area (Fig. 117); and the unusual erosion pattern of Gartmore Valley (Fig. 69) also substantiate the complexity of this region.

The last area in the Central Massif to be discussed specifically is the great 4,000 foot south boundary scarp which separates the central highland (Worlds End Ridge, Worlds End Plateau, and Haputale Ridge) from the Balangoda Shelf. In this area, major trans-massif faulting has controlled erosion, which in turn has been intensified by high orographic rainfall (100 to 200 inches per year), and very steep slopes. The valley of the Kiriketi Oya (Fig. 91) which is cutting headward into the Worlds End Plateau, illustrates the linearity of such fault controlled erosion features. The associated, transverse, fault controlled tributary valleys; the vertical scarp faces controlled by resistant caprock and mass-wasting processes; the marginally truncated, high level erosion surface with characteristic rounded, deeply weathered topography; the existence of alluvial fan-type deposits at the mouths of the gully-like valleys cutting this scarp face; and the ability of vegetation to get a foothold, even on the steep slopes of this V-shaped valley; are also well illustrated by this stereo-pair.

The Belihul Oya Valley stereo-pair (Fig. 90) which adjoins the Kiriketi Oya Valley stereo pair (Fig. 91) on the west, illustrates similar conditions, but also shows the main east-west scarp face (along the lower part of the stereo-pair), and the continuation of the north-east trending major faults across a more deeply dissected portion of the Worlds End Plateau. In this case, the fault is being incised by the headwaters of the Belihul Oya.

Further east, the south boundary scarp is probably represented by the lip of Diyaluma Falls (Fig. 89). Another view of the lip of the falls was taken from a Royal Ceylon Air Force helicopter (Fig. 92).

West of the Belihul Oya, the south boundary scarp may be obscured by irregularities of the face due to erosion and mass-wasting (Fig. 84), or may be clearly exposed in spite of the activity of these processes (Fig. 85). In the latter stereo-pair, the two parallel, linear scarps may be indicative of a zone of faulting, or "step" faulting which, in general, would be more probable than a single major fault.

Solution as a process of chemical erosion (Sparks, 1960), is of relatively unknown importance in Ceylon. With the exception of Nitre Cave in the Knuckles Massif (Fig. 144), no evidence of the removal of material in significant quantities was observed, however, many of the limestone areas of the island were not visited in person. Caves and tunnels were reported by a tea planter from the Matale area, and inter-ridge depressions which may be limestone solution valleys were noted in the Sabaragamuwa Hills (Fig. 141). Detailed field investigation would be required to substantiate the latter illustration.

P. G. Cooray in his paper, "Geological Foundations of Ceylon's Scenery", (1956), describes limestone caves caused by wave action along the Jaffna coast of Ceylon as well as the existence of subsurface channels in the Miocene limestone of the northern part of the island.

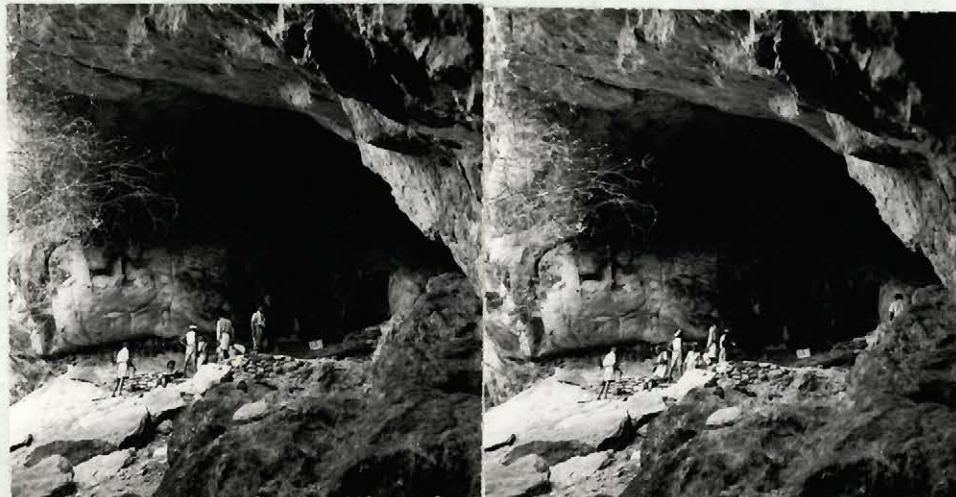


FIGURE 144

Nitre Cave, a Limestone Solution Cavern, West Face
of Telambugala, Knuckles Massif

Erreola
PLOVER BOND
25% COTTON FIBER

The Gal Oya Hills area (Fig. 20) is characterized by a moderate to heavy vegetative cover. This cover in much of the area obscures the surface of the ground or rocks and thus makes it difficult or impossible to determine the current erosion conditions from the aerial photographs.

In general, the area appears to be transitional between the partially dissected plateaux of the Central Massif, and the almost completely eroded surfaces of the low level plain. In both of these cases, geologic structure and, in particular, faulting and/or jointing, has played a very important role in localizing the weathering and erosion processes. In the Gal Oya Hills, joint or fault controlled weathering and erosion have produced a terrain composed of block-like rock remnants rising from a more or less flat plain (Fig. 41). If the hills shown in this illustration were stripped of vegetation and the soil and weathered material of the fault or joint valleys and lower slopes were removed by a period of active erosion, the features remaining would be virtually identical (morphologically) with numerous erosion remnants of the low level plain.

This, then, appears to further substantiate the theories of Büdel (1957), Ollier-Melbourne (1960), and earlier authors (mentioned previously) who believed that deep weathering under warm, humid conditions along structurally weak zones followed by erosion under

slightly more arid conditions, resulted in the formation of inselberg or monadnock-like features rising from an essentially flat plain.

The low level plains of Ceylon are here considered to be the end product of such a sequence of events. This erosion surface, although obscured over large areas by dense vegetation, has clearly truncated geologic structure almost indiscriminately. In parts of the plain, little or no evidence of bedrock is visible on the aerial photographs (Fig. 52). In other more arid areas, bedrock may be exposed as large, well defined erosion remnants (Fig. 47, Fig. 48, and Fig. 130), low, rounded, "whale backs" (Fig. 48, Fig. 54, and Fig. 56), or structure patterns outlined by vegetation (Fig. 32, Fig. 42, and Fig. 45). In the more humid areas, bedrock may form more or less isolated hills in the vicinity of the central highland (Fig. 49), or strikingly etched out examples of geologic structure (Fig. 46). In the Polonnaruwa-Elahera Ridge-Anuradhapura section, bedrock outcrop can be observed with difficulty in some areas, with less difficulty, especially in the river channels, in others (Fig. 44), and without any difficulty in still others. In the latter areas, the bedrock may be in the form of well exposed, monadnock or inselberg-like erosion remnants such as Sigiriya (Fig. 37 and Fig. 38), and Kumbukkandawala (Fig. 132), in the form of hog back ridges of resistant quartzite such as Sudakanda Ridge (Fig. 3), or may only be evidenced by vegetative

patterns in the jungle (Fig. 42). The flatness of these plains is illustrated best by a ground photograph taken from a monadnock or inselberg at Maha Iluppallama in the Anuradhapura region (Fig. 36), and by a panoramic photograph taken from another such erosion remnant at Magulmaha Vihare Pokuna near Kataragama, in the Tanamalwila region (Fig. 48).

Aggradation

Alluvial deposits, colluvial deposits, and aeolian deposits, are all well represented as evidence of the process of aggradation in Ceylon.

Alluvial deposits vary from fine clay and silt-sized particles characteristic of intense chemical weathering; through sand and gravel sized particles, which result from the decomposition and disintegration attributable to a combination of chemical and physical weathering; to coarse gravel, boulder and block-sized fragments, which with few exceptions, result from physical weathering. The rounded, residual boulders or "corestones" formed by deep weathering over a long period of time, are probably the main example of this exception.

Colluvial deposits, in view of their mode of origin, usually contain material of all sizes in a heterogeneous mixture, however, certain location factors may determine the nature of the constituent materials if not their grain size. A deposit in this latter category would be the blocky talus at the base of a bare rock cliff.

The last classification, aeolian deposits, consist primarily of uniform, sand-size material having its origin in alluvial beach deposits. This material is reworked by wind action and deposited, usually as the result of a local decrease in velocity, in the lee areas immediately adjacent to the source.

In Ceylon, much of the finer grained material resulting from the weathering and erosion previously described, is transported in suspension by the numerous rivers rising in the Central Massif, Knuckles Massif, and Sabaragamuwa Hills, and is deposited in the sea. Strong currents then carry it either along the coast or out across the narrow continental shelf, to the deeper water beyond. These littoral currents, combined with wave action and long shore drifting, subsequently deposit the coarser fraction in the form of beaches, or beach ridges (Fig. 24, Fig. 28, Fig. 30, Fig. 31, and Fig. 51), or as off-shore bars in the shallow water bordering the shore. Deposition of this type is also responsible for the baymouth bars and spits formed at the mouths of some of the larger streams, especially along the east and southeast coast (Fig. 29 and Fig. 30), and for the tombolos joining the rock ridges of Trincomalee (Fig. 129), and the east coast (Fig. 24), to the mainland. Lagoons formed behind the above mentioned bars, are rapidly filled with the silt and sand brought down by the rivers which can no longer escape to the sea (Fig. 26, Fig. 30, and Fig. 32).

Inland, alluvial deposition usually results from decrease in the velocity of the rivers and streams due to changes in gradient dependent on local base levels; to obstructions in the channels; or to hydrologic laws associated with curves in the channels. Such deposition is responsible for the flat bottomed valleys so characteristic of the dissected plateaux and lower surfaces of Ceylon. Peradeniya Basin (Fig. 107); the valleys of Nalanda Shelf (Fig. 109) and Mawanella Shelf (Fig. 114 and Fig. 138); an unnamed valley near Carney (Fig. 145), and a valley bottom near Ratnapura (Fig. 146), all illustrate this type of alluvial deposition. The drowned valleys of the Bentota Coastal Plain (Fig. 33 and Fig. 147) are in a similar category except that in this case sea level was the controlling factor.

In various sections of the many streams draining the central highland area, the material transported and subsequently deposited, may grade from fine sand and silt, through medium gravels, and into coarse gravel, boulders, or large blocks of rock. The grade of material is dependent on the nature and degree of weathering of the terrain through which the streams pass; on the position of the deposit relative to the profiles of the streams; and also on the topographic opportunity for the various weathering products to reach the channel. Thus, in some areas where weathering is intense and the terrain consists of low, rolling hills, the stream load and local deposition is



FIGURE 145

Alluvium Filled Valley Near Carney on Western

Approach to Adams Peak



FIGURE 146

Flat, Alluvium Floored Valley Bottom Near Ratnapura

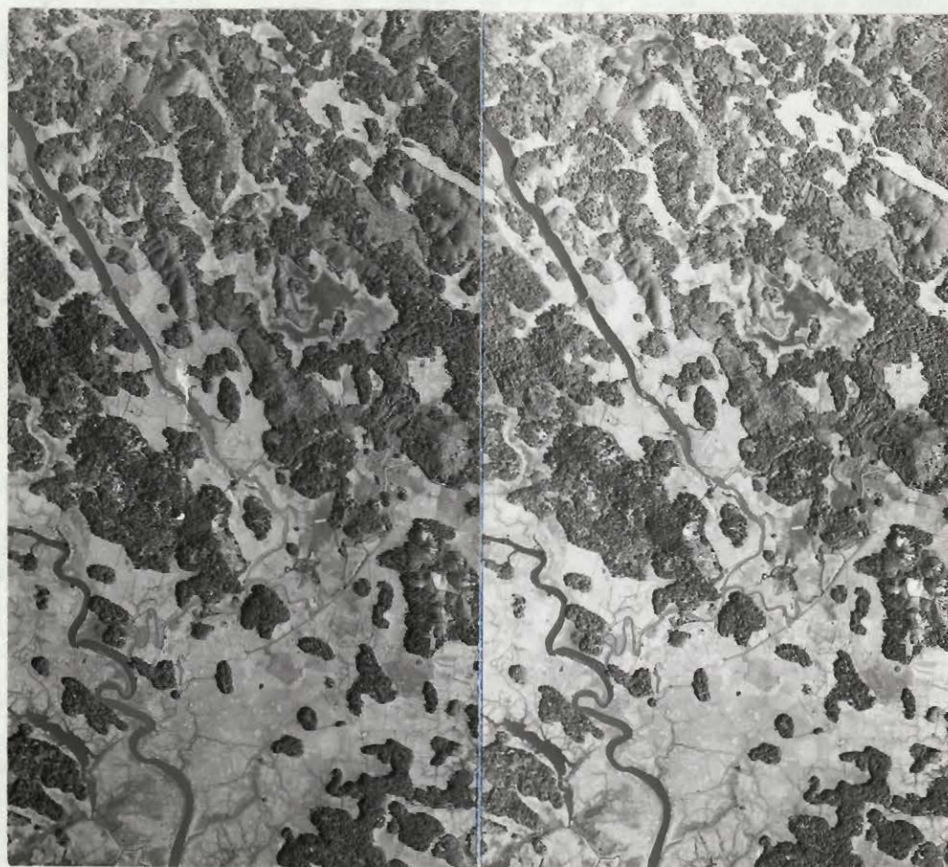


FIGURE 147

Drowned Valleys of the Bentota Coastal Plain

confined to sand-, silt-, and clay-sized particles. In other areas, where the streams have reached base level on the low level plain, the load available for deposition consists of similar materials, but in this case because coarser materials have already been deposited. In such areas, deposition is in the form of sand bars, which may form at bends in the stream (Fig. 148), or in slack water on the inside curve of meanders within a definite stream channel (Fig. 149). In the higher gradient reaches, however, steep scarps are common, physical weathering is active, and the streams flow in channels, incising their way through bare bedrock. In such sections, the load may be predominantly coarse, angular blocks of rock, which are transported only during periods of very high water, and which, in the interim, choke the channel effectively (Fig. 150). Streams having such boulder-choked channels include the Mimure Oya, Kaikawala Oya, and an unnamed stream in the Nitre Cave valley, Knuckles Massif; numerous streams in the Hatton section of the Hatton-Diyatalawa Plateau; segments of the Maskeliya Oya, particularly where it crosses bedrock structure as at Kitulgala, and the tributary Kehelgomu Ganga west of Ginigathena, Adams Peak Range; and the Punagala Oya below Diyaluma Falls, to mention a few.

Colluvial deposits have their greatest development in the high relief areas of Ceylon. If the relief is dependent on bedrock scarps or



FIGURE 148

Sand Bars in Kelani Ganga, Southwest Peneplain

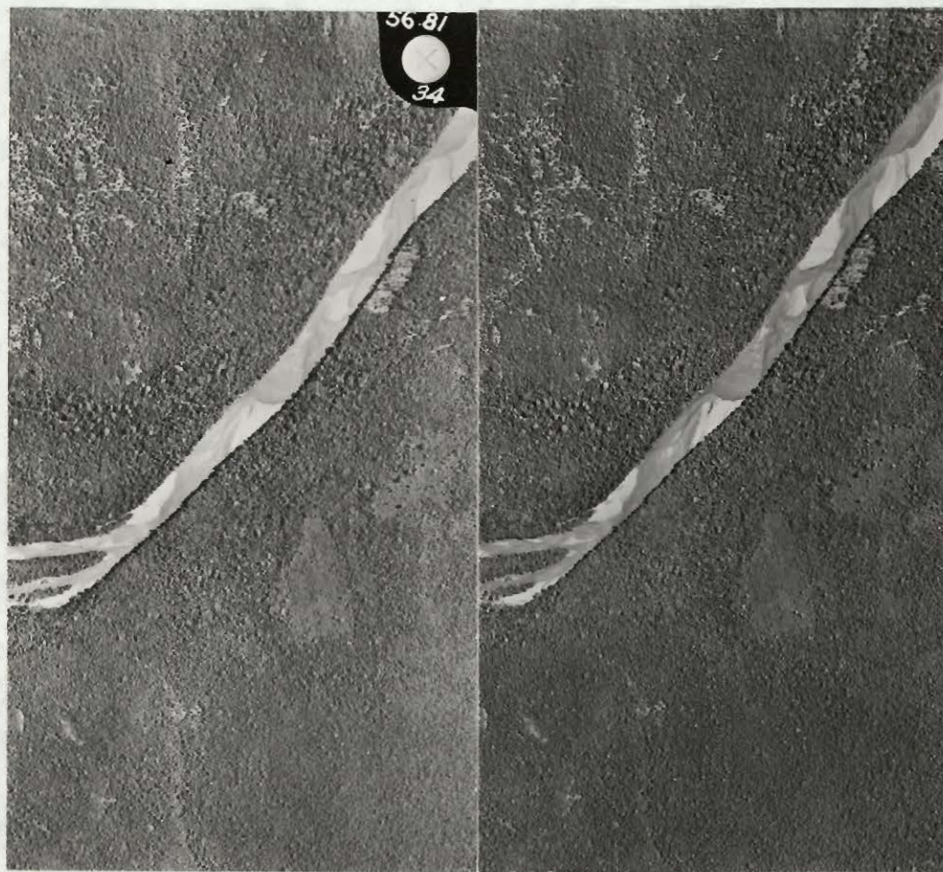


FIGURE 149

Sand Bars in Mahaweli Ganga, Polonnaruwa Peneplain

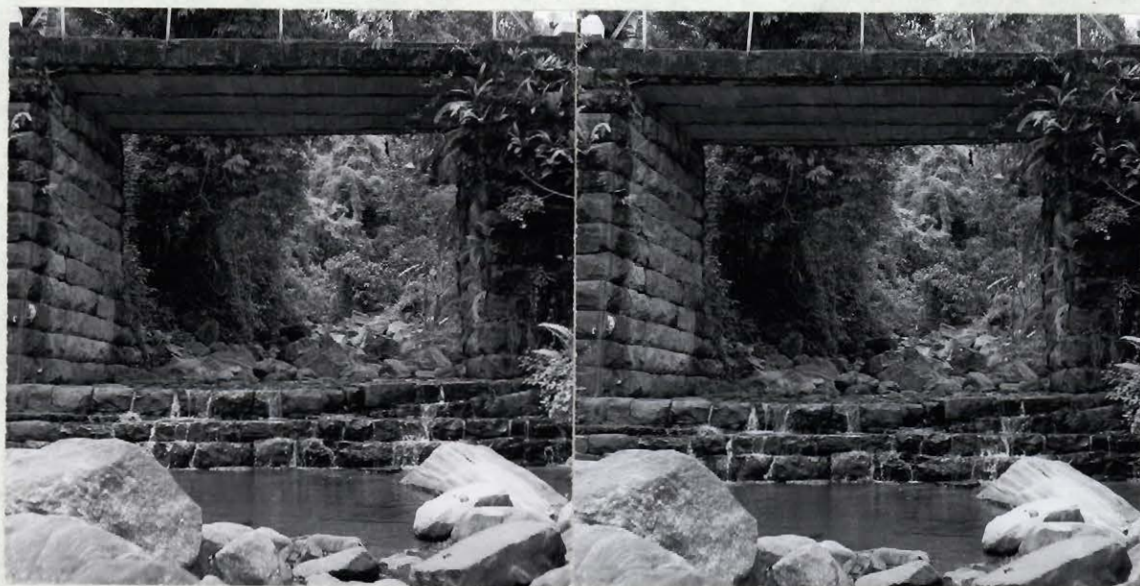


FIGURE 150

Blocks of Rock Choking a Stream Channel on the
Western Face of Adams Peak Range

ridges, the deposits are usually in the form of blocky talus resulting from rockfalls or rockslides; if the relief is dependent on deeply weathered but well defined hills and valleys, the deposits are usually in the form of heterogeneous mixtures of weathered soil, partially weathered boulders, and possibly unweathered rock fragments resulting from slumps, earthslides, or similar phenomena; or if the relief is more moderate, as is the case in the deeply weathered, rolling sections of the oldest erosion surfaces, the deposits may consist primarily of the fine grained products of soil flowage or creep. All of these deposits have been discussed, and illustrated where possible, under the various mass-wasting processes responsible for their formation and will not be reviewed here.

Aeolian deposits in Ceylon are consequent on the strong and persistent action of the southwest and northeast monsoons. They consist of well defined sand dunes, usually paralleling the coast and extending a short distance inland. At present they appear moderately well stabilized by a growth of scrub vegetation on their leeward slopes (Fig. 31). In some areas, especially along the south coast near Hambantota, they are modified by transverse ridges due to the angle at which the prevailing wind strikes them (Fig. 31 and Fig. 32). Sand dunes are present along the northwest, northeast, east, and southeast coasts of Ceylon. No evidence of aeolian deposits was noted elsewhere in the island.

Summary

The preceding discussion has emphasized the extent and complexity of the geomorphologic processes active in the formation of Ceylon's terrain; significance of aerial photographs in studying such terrain and processes; and the scarcity of data upon which to base detailed evaluations of these processes. The discussion is also indicative of the need for more advanced study in this field, and in this area.

CHAPTER V

THE GENESIS OF CEYLON'S TERRAIN

General

In the preceding chapters, the geological foundation upon which the landforms of Ceylon are based; the climatic environment in which these landforms are now situated; the extent and nature of the vegetation growing over much of their surface; the varied characteristics of the landforms themselves; and the geomorphological processes which have been active in their formation; have all been studied, described, and discussed.

In the present chapter a possible explanation of the sequence of events responsible for the formation of the existing terrain will be presented. This explanation is based primarily on an analysis and evaluation of the erosion surfaces described earlier (Fig. 21), and the landforms associated with them.

A number of observations which are basic to the formulation of this thesis may be summarized as follows:

(1) The island of Ceylon is geologically an old island consisting primarily of gneisses, metamorphosed sediments, and granitic rocks of Precambrian age;

(2) Roughly three quarters of the island can be classed as a peneplain;

(3) From the central part of this peneplain, there rises abruptly a spectacular assemblage of mountains, hills, ridges, and plateaux;

(4) This central mass is arranged in a series of step-like levels which are correlative throughout the area in general, and are bounded in part by impressive mural scarps;

(5) The higher levels have the most actively eroding streams, the youngest (geomorphologically speaking) topography, and the largest number of waterfalls. Lower levels have more subdued topography, rounded hills, less active erosion, and fewer waterfalls;

(6) The upper levels are crowned by small areas of senile topography which, in most cases, show evidence of peneplanation. These surfaces are being eaten away by young, headward eroding streams at their margins;

(7) The entire island, with the possible exception of the northern, limestone covered portion, exhibits a well marked pattern of major faulting and fracturing cutting an equally or even more well marked pattern of geological structure;

(8) The southwestern portion of the island is characterized by an intricate system of structure and fault controlled, drowned valleys; and

(9) There is evidence of oscillation of the general level in the

form of buried, alluvial gravels, elevated wave-cut terraces, and elevated coral reefs, well inland from the present coastline.

Method

Approximately 4,000 vertical aerial photographs at a basic scale of 1:40,000 provide complete stereoscopic coverage of the roughly 25,000 square miles comprising the island of Ceylon. These photographs were analysed and interpreted stereoscopically to yield data on geology, landforms, geomorphologic processes, and associated erosion surfaces, making up the island's terrain. This information was then transferred to one mile to one inch, Ceylon Government topographic maps. In particular, the surfaces of erosion were delineated, correlated with low relief areas on topographic maps, and assigned their respective elevations. If these areas appeared significant as to size or areal distribution, they were transferred to a composite, four mile to one inch, topographic map and subsequently reduced to a scale of eight miles to one inch (Fig. 21). In addition to the surfaces of erosion, the primary physiographic features were also delineated, simplified, and transferred to a smaller scale composite (Fig. 20). These surfaces and features were assigned names on the basis of local geographic nomenclature. Seventy-two, one mile to one inch, map sheets, each complete sheet covering approximately 472 square miles, were involved in this phase of the study.

Also forming part of the study, but not recorded herein, was the construction and evaluation of twelve topographic profiles across the island at a horizontal scale of one mile to one inch, and a vertical scale of eight hundred feet to one inch; the listing of mountain peaks and an evaluation of their elevations with respect to the erosion surfaces and the stages of development of the terrain; the listing of waterfalls and an evaluation of their relationship to the various erosion surfaces; and an analysis of the drainage patterns of the island.

The above information forms the basis of the following explanation of the development of Ceylon's terrain. Although the sequence of events was evolved by working backward from the present terrain, the events are presented here in the order of their occurrence. The reasoning to support this sequence will be discussed at the close of the chapter.

Stages of development

Stage I

The original height of the island and its relationship to peninsular India is not known at present. However, the type of bedrock, of which most of the island is composed, is indicative of the existence at one time, of much greater thicknesses than are currently present. Presumably this rock has been removed by normal processes of degradation.

In this study, the first surface described is that of a broad, island-wide peneplain surmounted by scattered erosion remnants (Fig. 151). The climatological and vegetative conditions obtaining during this segment of Ceylon's history, are unknown. The major erosion remnant of this stage is here considered to have been the ancestral Pidurutalagala. Other erosion remnants of equivalent elevation probably existed, but none have been determined as yet. According to the method of calculating elevations during the various stages of this sequence, Pidurutalagala's was approximately 1,681 feet. The surface of the peneplain surrounding Pidurutalagala Stage I is considered to have had an elevation varying from 600 feet at its base to zero at the coast.

This figure is considered logical, since the present low level graded surface, as exemplified by the Tanamalwila Peneplain, reaches an elevation of 600 feet above sea level at the base of the Central Massif. If the dimensions of the island are assumed to have remained more or less constant, a graded surface of erosion would reach roughly the same elevation regardless of the geologic period in which it was formed. The peneplain which surrounds Pidurutalagala Stage I is considered to be the ancestral Worlds End Plateau.

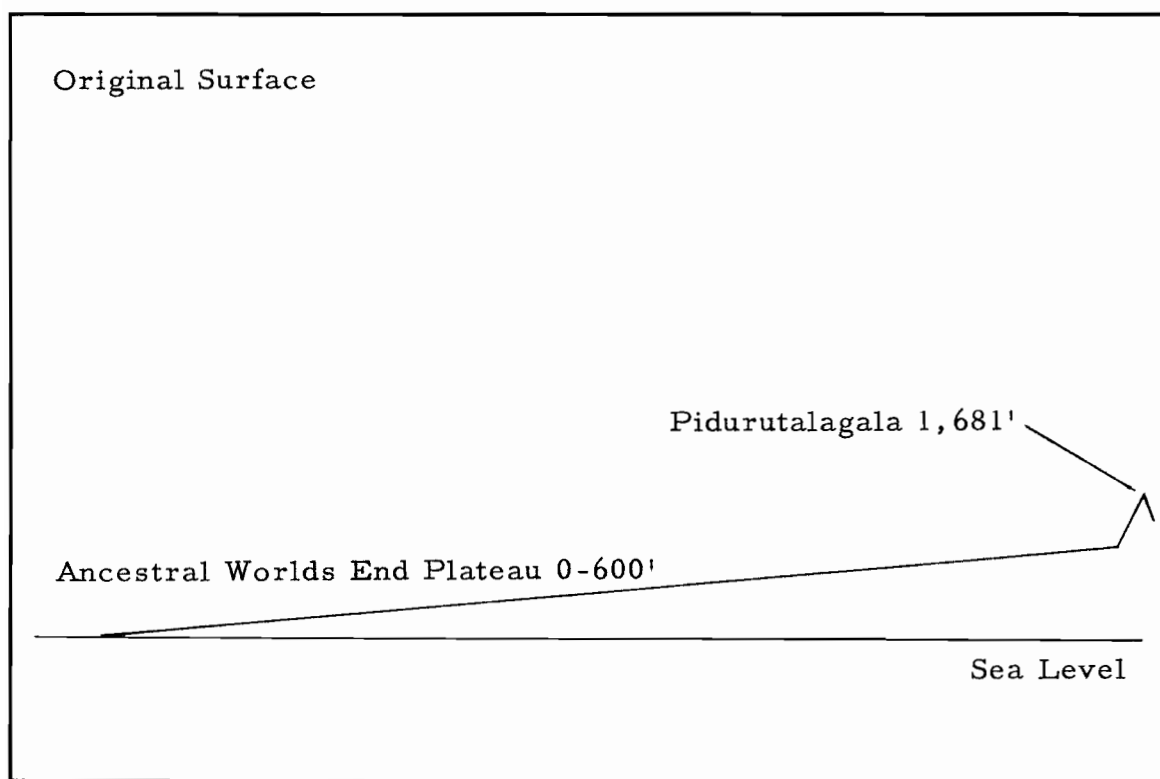


FIGURE 151

Genesis of Ceylon's Terrain, Stage I, Zone 1

Diagrammatic Section Pidurutalagala to the Sea

Stage II

Stage II was initiated by an epeirogenic uplift of 400 feet. This raised Pidurutalagala Stage I to an elevation of 2,081 feet above sea level (1,681 plus 400), and the other erosion remnants by a similar amount (Fig. 152). The original peneplain then became an uplifted surface of erosion grading from 1,000 feet (600 plus 400) at the base of Pidurutalagala, in the central part of the island, to 400 feet (0 plus 400) at the coast. This ancestral Worlds End Plateau and associated erosion remnants was then subjected to a long period of weathering and erosion which reduced the surface to a new, low, plain, graded from an upper level of 600 feet, to the sea. Remnants of the Worlds End Plateau surface were left in the central "mountainous" area only. These remnants were surmounted by Pidurutalagala Stage II and other lower peaks. The low level peneplain of this stage is considered to be the ancestral Kandapola surface.

Stage III

Stage III was initiated by a second epeirogenic rise of 500 feet. This raised Pidurutalagala Stage II to 2,581 feet (2,081 plus 500); Worlds End Plateau Stage II to 1,500 feet (1,000 plus 500); Kandapola Plateau Stage II to 1,100 feet (600 plus 500); and the associated erosion remnants by similar amounts (Fig. 153). Kandapola Plateau

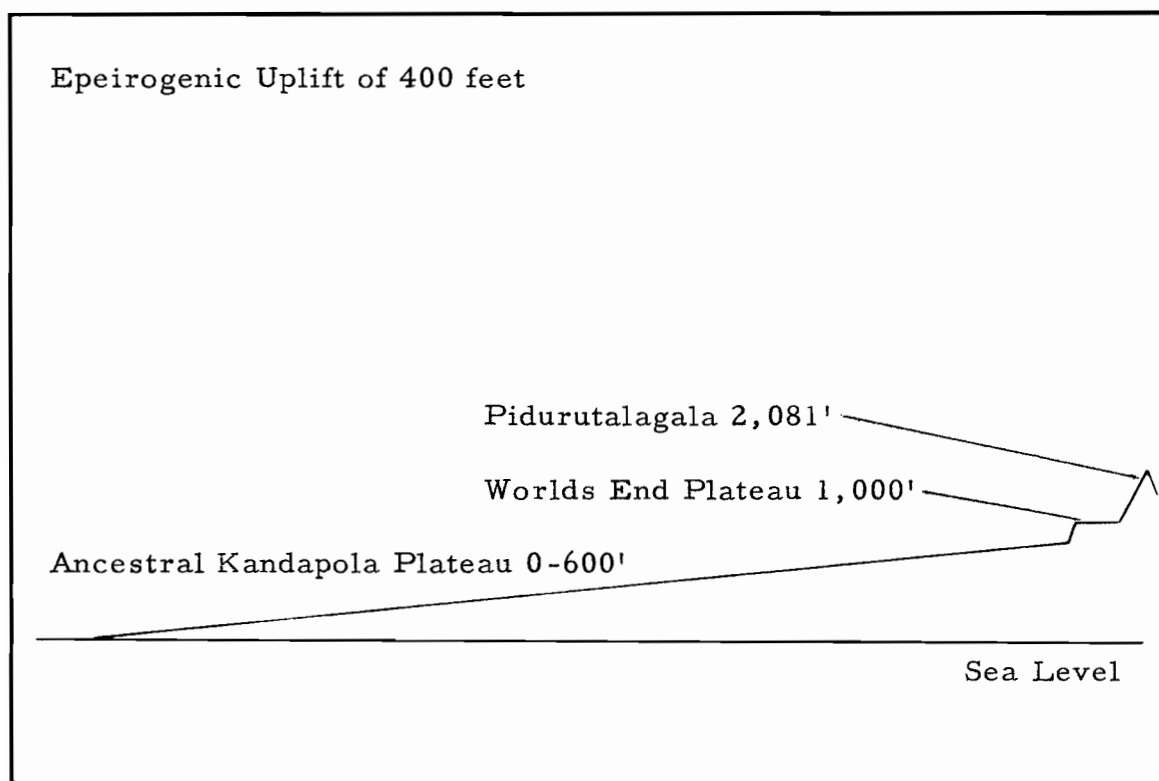


FIGURE 152

Genesis of Ceylon's Terrain, Stage II, Zone 1

Diagrammatic Section Pidurutalagala to the Sea

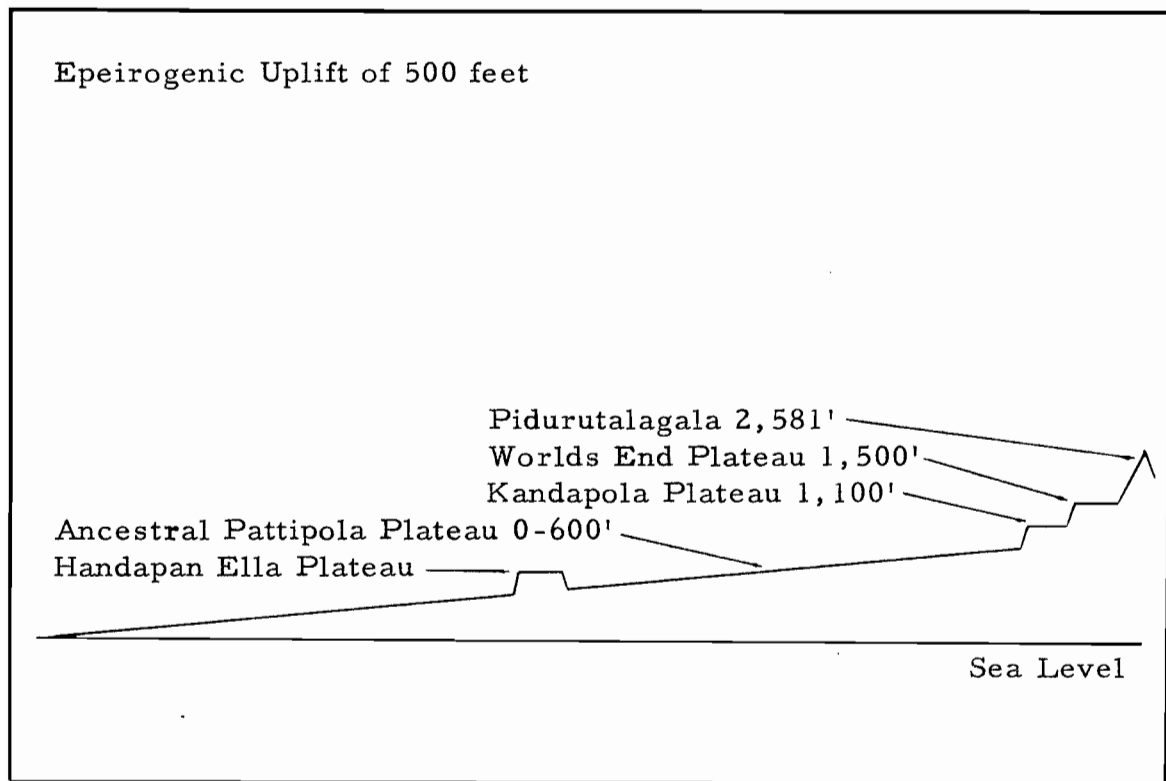


FIGURE 153

Genesis of Ceylon's Terrain, Stage III, Zone 1

Diagrammatic Section Pidurutalagala to the Sea

Stage III, which graded from 1,100 feet above sea level in the central area, to 500 feet at the coast, now underwent a long period of degradation which left only very small remnants of this surface surrounding Pidurutalagala Stage III. The resultant low level surface, grading from 600 feet above sea level in the central region to zero at the coast, is classified as the ancestral Pattipola Plateau.

Stage IV

A third epeirogenic uplift initiated the Stage IV period, and raised Pidurutalagala Stage III 1,100 feet to an elevation of 3,681 feet (2,581 plus 1,100); Worlds End Plateau Stage III to 2,600 feet (1,500 plus 1,100); Kandapola Plateau Stage III to 2,200 feet (1,100 plus 1,100); and the low level peneplain, Pattipola Plateau Stage III to 1,700 feet (600 plus 1,100) (Fig. 154). Processes of weathering and erosion again reduced the lower plain to a graded surface from zero to 600 feet in elevation. This was the ancestral Selvakanda Plateau surface. Remnants of the Pattipola Plateau Stage IV remained in the central and southwestern highlands only.

Stage V

Stage V, according to the theory presented here, was the last well marked epeirogenic uplift in the geomorphologic history of Ceylon.

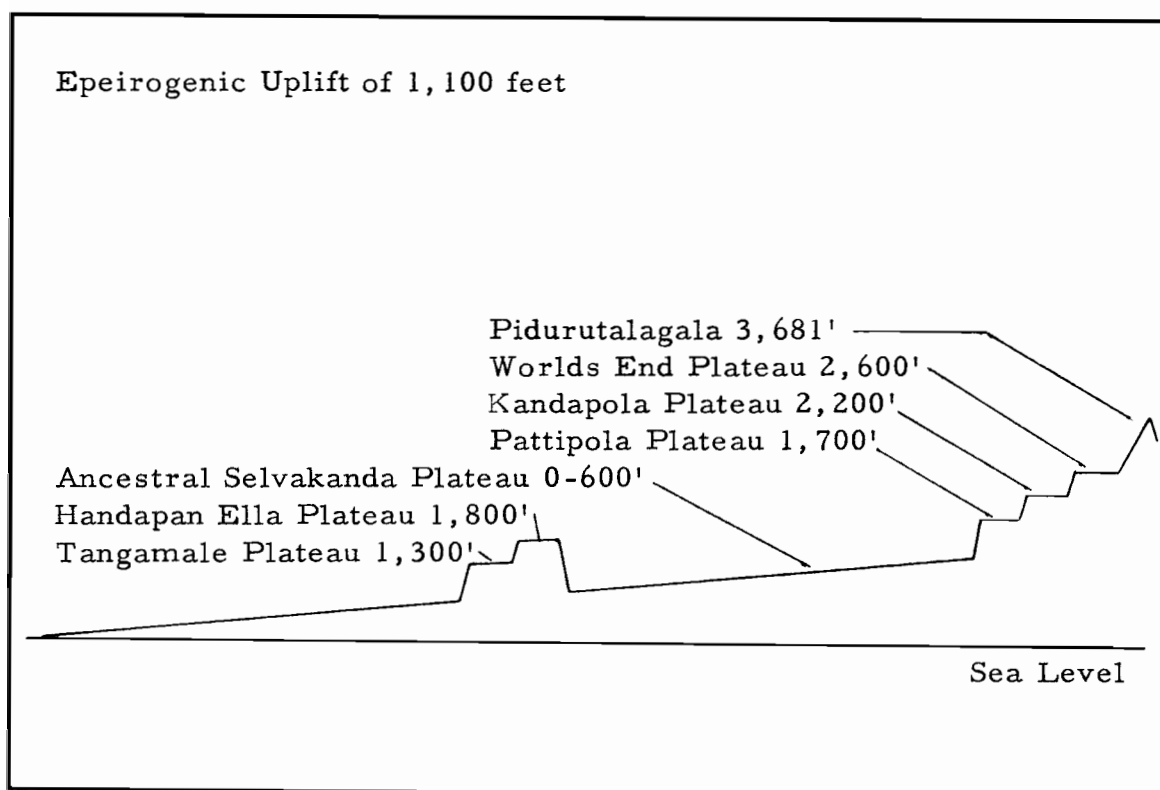


FIGURE 154

Genesis of Ceylon's Terrain, Stage IV, Zone 1

Diagrammatic Section Pidurutalagala to the Sea

This uplift raised the island a further 500 feet and resulted in the following changes in elevation: Pidurutalagala Stage IV from 3,681 feet to 4,181 feet; Worlds End Plateau Stage IV from 2,600 feet to 3,100 feet; Kandapola Plateau Stage IV from 2,200 to 2,700 feet; Pattipola Plateau Stage IV from 1,700 to 2,200 feet; and Selvakanda Plateau Stage IV from 600 feet to 1,100 feet (Fig. 155). As in the previous stages, the island was subjected to a long period of weathering and degradation and the lower Selvakanda surface was reduced to a new peneplain grading from 600 feet in the vicinity of the central erosion remnants to zero at the coast. This surface comprised the following: the Hatton-Diyatalawa Plateau Stage V; the Balangoda Shelf Stage V; and the present circum-island peneplain.

It is considered here that at this period in the development of Ceylon's terrain, the northwest section of the above mentioned low level plain, was warped beneath the adjoining seas and sediments of Jurassic age were deposited on its surface. The presence of these Jurassic rocks both on, and downfaulted into, the northern peneplain surface as discussed in Chapter I, appears to confirm this sequence of events.

Stage VI

Stage VI was initiated by block uplifts of the central and southwest highlands. According to the theory presented here, the magnitude

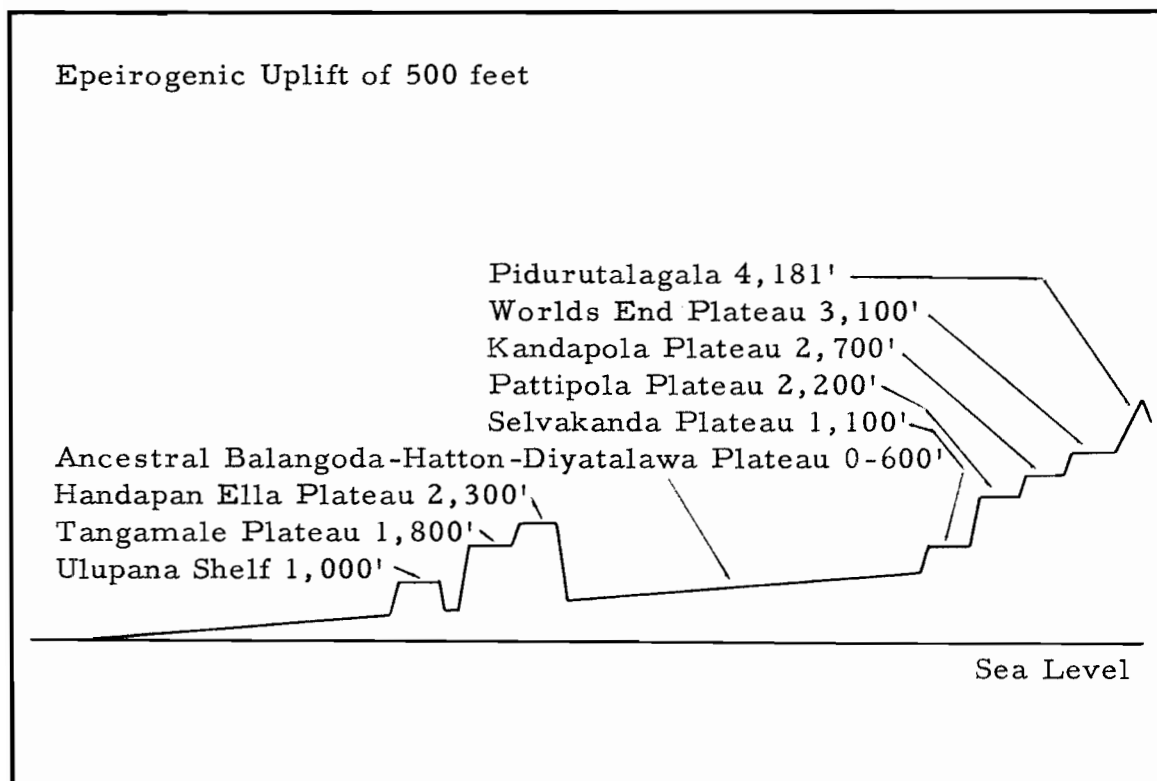


FIGURE 155

Genesis of Ceylon's Terrain, Stage V, Zone 1

Diagrammatic Section Pidurutalagala to the Sea

of the uplift was 1,700 feet. The area of uplift included within the boundary faults, or fault zones, has been described previously as the Central Massif, Knuckles Massif, and Sabaragamuwa Hills (Fig. 20). At least partly contemporaneous with this uplift, the Jurassic sedimentary rocks of Tabbowa and Andigama areas, were downfaulted into the underlying metamorphic basement.

Ceylon's terrain at this point, consisted of an epeirogenic zone, classed as Zone 1, which included Stages I through V, and an orogenic zone, classed as Zone 2, which included Stage VI.

In Zone 2, Pidurutalagala Stage VI was then at an elevation of 5,881 feet above sea level (4,181 plus 1,700); Worlds End Plateau Stage VI at 4,800 feet (3,100 plus 1,700); Kandapola Plateau Stage VI at 4,400 feet (2,700 plus 1,700); Pattipola Plateau Stage VI at 3,900 feet (2,200 plus 1,700); Selvakanda Plateau Stage VI at 2,800 feet (1,100 plus 1,700); and the combined Hatton-Diyatalawa Plateau Stage VI and Balangoda Shelf Stage VI at 2,300 feet (600 plus 1,700). The circum-island peneplain, comprising the Anuradhapura Peneplain, the Polonnaruwa Peneplain, the Tanamalwila Peneplain, and the Southwest Peneplain, because it was unaffected by the block uplift, remained at an elevation of from zero to 600 feet above sea level (Fig. 156).

It is probable that there were areas of significantly less, and areas of significantly greater uplift associated with the main rise, but

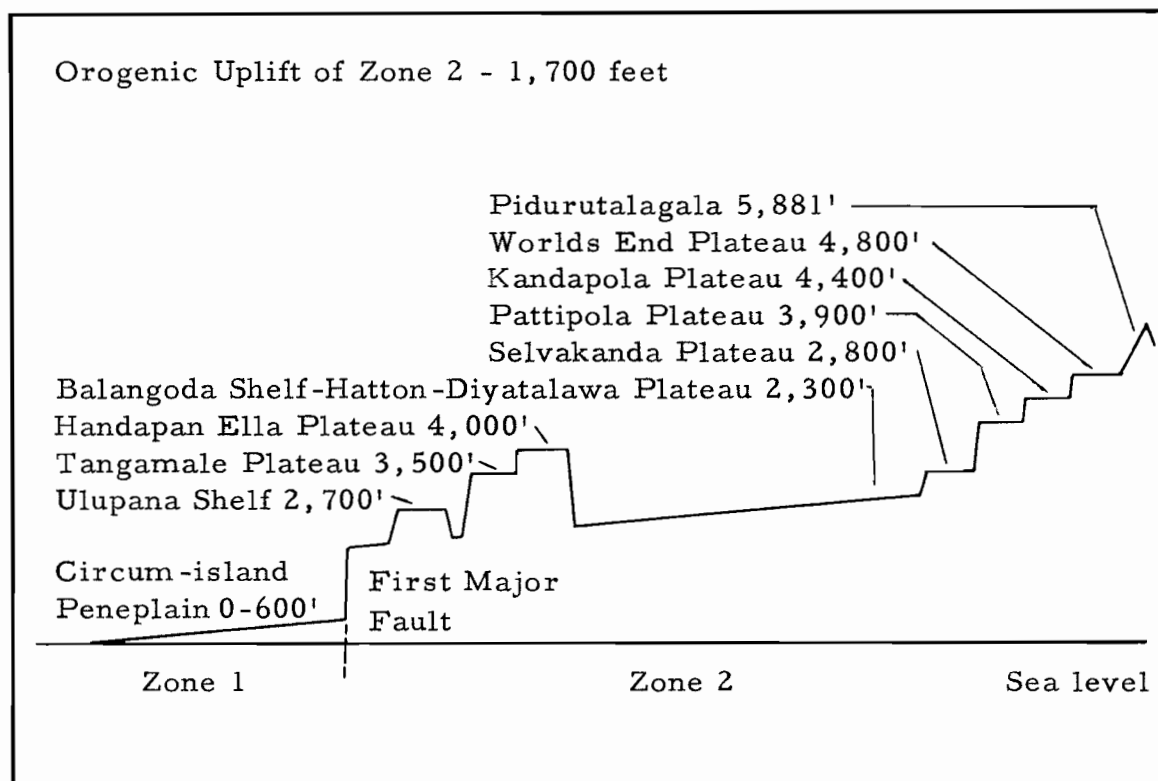


FIGURE 156

Genesis of Ceylon's Terrain, Stage VI, Zones 1 and 2

Diagrammatic Section Pidurutalagala to the Sea

except insofar as they are delineated on the map of erosion levels (Fig. 21), these have not been specifically worked out as yet.

In Zone 1, erosion remnants and remnants of erosion surfaces remained essentially unchanged. Thus, the uplift of the Central Massif, Knuckles Massif, and Sabaragamuwa Hills had rejuvenated the drainage and erosion of these areas, but had left the remainder of the island to continue relatively unaffected. This latter area, Zone 1, having virtually reached the terminal stage of the fluvial geomorphic cycle, was not subject to the active erosion in effect in the uplifted areas. It was however, still subject to the processes of degradation, and although these continued to decrease in effectiveness with decreasing relief, they were present. The gradual lowering of the interfluvial rises, the slow destruction of the erosion remnants, the deep weathering of the inter-remnant lowlands, and the wearing back of the margins of the remaining erosion surfaces, is still progressing.

During this stage, Zone 2 appears to have been drained primarily toward the north and west, with minor marginal drainage to the south and east. It is considered here, that the rivers and drainage patterns developed at this time, are with minor modifications, the rivers and drainage patterns of the present. It is also considered probable that the slight tilt to the north and west which may have controlled the direction of drainage, particularly in Zone 2, resulted in,

or from, the depression or down warping of the northern part of Zone 1 beneath the sea and the ensuing deposition of the Miocene sediments. The deposition of sediments of similar age along the south coast at Minihagalkanda, may indicate a tilting of the southern plain toward the south contemporaneously with the uplift.

The uplift of these blocks to an elevation of 2,300 feet at the boundary fault zone, and the corresponding elevation of the mountains, hills, and plateaux within this boundary to a maximum of 5,881 feet, must have had a strong affect on the climatology of the island. Orographic rainfall must have been intense, even if the monsoons as we know them, did not exist. It is, therefore, logical to expect active erosion and deep dissection of the Balangoda-Hatton-Diyatalawa surface. Further, since the geologic structure of this area is dominated by an extensive series of northwest and north striking anticlines and synclines, characterized by interbedded resistant and weak rock strata, it is logical to expect the weathering and erosion to have been controlled to a considerable degree by it. Similarly, the complex system of faults and joints cutting these structures, may be expected to have exerted a strong influence on these processes.

The landscape of the Central Massif, resulting from the above sequence of events, consisted of two deeply eroded basins, separated by the Pidurutalagala-Knuckles axis. The western basin drained

northward, via the Matale Valley; northwestward, across the Mawanella Shelf and Peradeniya Basin area, to the Deduru Oya Valleys; and westward, via the valleys of the Maha Oya and Kelani Ganga. The eastern basin drained primarily northward, via the valleys of the Loggal Oya, Badulu Oya, Uma Oya, and the Mahaweli Ganga.

Although deeply dissected, this Zone 2 area had not begun to approach maturity when Stage VII was initiated.

Stage VII

Stage VII was also initiated by block uplifts. In this case, the central block of the Central Massif including Adams Peak Range, Pidurutalagala Range, Namunakuli Range, the Knuckles Massif, and the intermontane plateaux and valleys, was raised 2,400 feet to form Zone 3 (Fig. 157). This uplift resulted in the Stage VII elevations as they are at present: Pidurutalagala, 8,281 feet (5,881 plus 2,400); Worlds End Plateau, 7,200 feet (4,800 plus 2,400); Kandapola Plateau, 6,800 feet (4,400 plus 2,400); Pattipola Plateau, 6,300 feet (3,900 plus 2,400); Selvakanda Plateau, 5,200 feet (2,800 plus 2,400); and the Hatton-Diyatalawa Plateau, 4,700 feet (2,300 plus 2,400).

The unaffected portion of the Central Massif now forms the Balangoda Shelf at 2,300 feet, the Peradeniya Basin at 1,800 feet, the

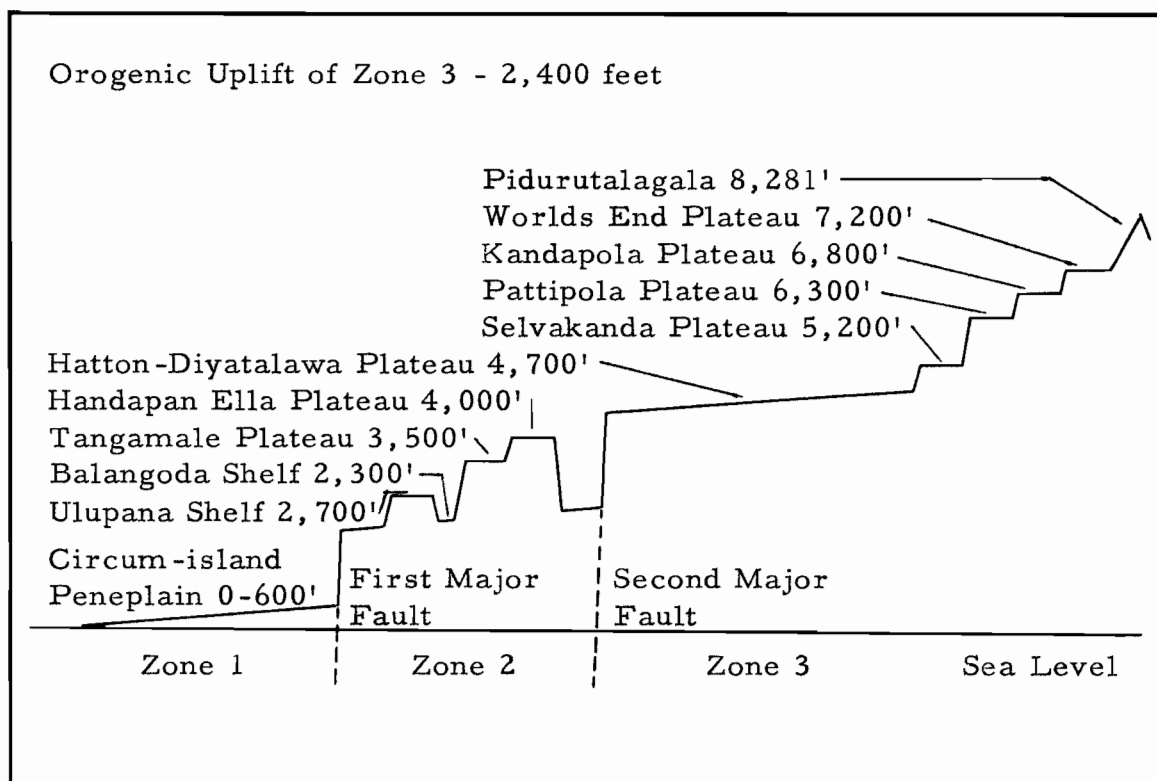


FIGURE 157

Genesis of Ceylon's Terrain, Stage VII, Zones 1, 2, and 3

Diagrammatic Section Pidurutalagala to the Sea

Nalanda Shelf at 1,400 to 1,500 feet, and the Mawanella Shelf at 900 to 1,000 feet. In the Sabaragamuwa Hills which were not affected by this uplift, the Handapan Ella Plateau is at 4,000 feet and the Tangamale Plateau at 3,500 feet. Their correlation, and that of other surfaces of erosion and erosion remnants in Zones 1 and 2 will be discussed subsequently. From the relative position of large alluvial fans on the Balangoda Shelf at the mouths of the Belihul Oya and Kiriketi Oya valleys, and from the deep alluvial valley-filling in the north facing valleys of the Matale area, as mentioned previously, and from the extent and nature of the surficial material of the north central plain, it is considered probable that the Stage VII uplift occurred during late Pliocene or early Pleistocene time. Post-Pleistocene weathering and erosion have been active as the Stage VII cycle continues.

Summary and conclusions.

To summarize, the denudational chronology of Ceylon as postulated here, involves five stages of epeirogenic uplift, each separated by very long periods of time, followed by two major orogenic uplifts.

The end product of the epeirogenic phase, in addition to scattered high level relict surfaces within Zones 2 and 3, was the Zone 1 peneplain with its associated monadnocks, inselbergs, or bornhardts. Zone 1 at present includes the Mannar Coastal Plain, Trincomalee Coastal Plain, Pottuvil Coastal Plain, Bentota Coastal Plain,

Anuradhapura Peneplain, Polonnaruwa Peneplain, Tanamalwila Peneplain, Southwest Peneplain, Elahera Ridges, and Gal Oya Hills of Chapter III.

The end product of the orogenic phase of this development was an assemblage of mountain ranges, ridges, hills, plateaux, and plains, all concentrated in the central and southwestern parts of the island. Zone 2, the oldest of the uplifted blocks, at present includes all of the Sabaragamuwa Hills region with its associated Handapan Ella Plateau, Tangamale Plateau, Rakwana-Kiriella Ridges, and the Urubokka and Delgoda Plains, and the part of the Central Massif region comprised of the Ulupana Shelf, Balangoda Shelf, Peradeniya Basin, Kondesalle Basin, Nalanda Shelf, Molamure Shelf, Wekada Shelf, and the Mawanella Shelf (Fig. 20). Zone 3, the youngest of the uplifted blocks, at present includes all of the Knuckles Massif with its associated Knuckles Range, Telambugala Spur, Wamarapugala Spur, Selvakanda Plateau, South Knuckles Plateau, Vellangollapatana Plateau, Walpolamulla Terrace, and Kaikawala Terrace, and the remainder of the Central Massif comprised of Adams Peak Range, Namunakuli Range, Pidurutalagala Range, Worlds End Plateau, Haputale Ridge, Worlds End Ridge, Kandapola Plateau, Pattipola Plateau, and Hatton-Diyatalawa Plateau as shown on the accompanying map (Fig. 20).

If the deductions presented in the body of this chapter are correct, it should be possible to assign any topographic feature of

Ceylon's terrain to a certain Stage of the developmental sequence described (Table VI). However, it would only be possible to assign a feature to one of the last three Stages or to correlative Stages in different Zones.

For example: The Handapan Ella Plateau, at an elevation of 4,000 feet in the Sabaragamuwa Hills of Zone 2, may be classed as a Stage VI Pattipola Plateau surface, that is, if it were raised by the 2,400 feet attributed to Stage VII, it would correlate with the present Pattipola Plateau level of 6,300 feet. Conversely, the same surface if correlated downward to Zone 1, would be represented by peaks or erosion surfaces in the 2,300 foot category. Tittawelgolla, nine miles northeast of Galewela, at 2,133 feet, Friars Hood 24 miles southwest of Batticaloa at 2,159 feet, and Unakirigala, 18 miles west-southwest of Maha-Oya at 2,252 feet, are some of the erosion remnants which would approximate this category. In a similar manner, the Ulupana Shelf at an elevation of 2,600 to 2,800 feet in the Central Massif of Zone 2 would be classed as a Stage VI Selvakanda Plateau surface and would be correlative with peaks or plateaux in the 5,000 to 5,200 foot range in Zone 3 and with erosion remnants in the 900 to 1,100 foot range in Zone 1. In Zone 3, Weywellakella, approximately 2 miles south of Namunakula, 5,158 feet, and Dixon's Corner on the flattish interfluvial ridge between the Halgran Oya Valley and Obada Oya valley,

TABLE VI
STAGES IN THE GENESIS OF CEYLON'S TERRAIN

					Zone 1	Zone 2	Zone 3
Stage	I	II	III	IV	V	VI	VII
Feet of Rise	400	500	1100	500	1700	2400	
Feature							
Pidurutalagala	1681	2081	2581	3681	4181	5881	8281
Worlds End Plateau	600	1000	1500	2600	3100	4800	7200
Kandapola Plateau	0	600	1100	2200	2700	4400	6800
Pattipola Plateau		0	600	1700	2200	3900	6300
Selvakanda Plateau			0	600	1100	2800	5200
Hatton-Diyatalawa Plateau				0	600	2300	4700
Balangoda Shelf					600	2300	2300
Circum-island Peneplain					600	600	600

2 miles east of Ragala, at 5,011 feet, would be correlatives. In Zone 1, correlative peaks or surfaces might include Kandurakanda No. 1, 32 miles southwest of Trincomalee in the Elahera Ridges, at 960 feet, Sigiriya, 16 miles west of Polonnaruwa at 1,193 feet, and Sitarama Peak, 7 miles west-southwest of Kataragama, at 951 feet. If the latter erosion remnant was selected initially, it would be classed as a Stage V Selvakanda Plateau surface and would be correlatable with the Ulupana Shelf in Zone 2 as above.

Other representative examples of similar correlations are: Watagoda, 24 miles east-southeast of Wellawaya in Zone 1, at 1,478 foot erosion remnant classed as the remains of a low peak on the Stage V Selvakanda Plateau surface. It would be correlatable with peaks having altitudes in the vicinity of 3,200 feet in Zone 2 or peaks or surfaces with altitudes in the vicinity of 5,600 feet in Zone 3. Maragalakanda, 2 1/2 miles east of Monaragala in the Gal Oya Hills of Zone 1, has an elevation of 3,646 feet. This is one of the highest, if not the highest erosion remnant of the epeirogenic zone. It is classed as a degraded Stage V Pidurutalagala surface or an erosion remnant on the Stage V Worlds End Plateau surface, and would be correlatable with 5,400 foot peaks in Zone 2, and with 7,800 foot peaks in Zone 3. A final example should clarify the classification. Adams Peak at an elevation of 7,360 feet is within 160 feet of Worlds End Plateau Stage VII at 7,200 feet,

but Kirigalpota at 7,857 is 657 feet above the average and only 424 feet below Pidurutalagala Stage VII. This indicates that Kirigalpota is either a major erosion remnant on the Worlds End Plateau surface, or in the same category, is an eroded correlative of Pidurutalagala.

The accuracy or lack of accuracy of the above correlations is directly attributable to the reconnaissance nature of this study and the broad correlations necessitated by this approach. It is accepted here as unavoidable when erosion surfaces, themselves rarely either horizontal or perfectly developed, are determined by correlating surfaces delineated by aerial photograph interpretation with one mile to one inch topographic maps. However, considering these limitations, it is felt that the results are sufficiently well defined to warrant their acceptance and use in further correlations. As more detailed studies are made, more accurate correlations should be forthcoming and the method or thesis itself, should be proven or disproven. Similarly, it should be mentioned here that the levels of erosion delineated in Figure 21 are those mapped for the individual surfaces and will not always correspond exactly to the range of elevations given in Table V which have been deduced from the relationships existing among the various surfaces.

The various changes in elevation resulting in Stages I to VII have been determined in the following manner. The island's geomorphology, as outlined in Chapters I to IV, has indicated the presence of

a central highland area surrounded, at least in part, by a well marked topographic and structural break. This central highland comprises the Hatton-Diyatalawa Plateau and everything above it, as well as the associated Knuckles Massif. It is surrounded by an intermediate area, which in turn, is bounded by a well marked topographic and structural break. This intermediate area includes the Sabaragamuwa Hills, the Balangoda Shelf and the associated medium level plateaux. The remainder of the island comprises the extensive low level peneplains, coastal plains, Elahera Ridges, and Gal Oya Hills. From the characteristics studied, the breaks separating these three regions are considered to be major fault controlled features.

The erosion levels associated with each region have been considered, first as they are related within the region, and second, as they are related between regions. It has been determined from this study that the difference in elevation between the highest point in Ceylon (Pidurutalagala at 8,281 feet above sea level) and the first well marked erosion surface (Worlds End Plateau at 7,200 feet), is 1,081 feet, and similarly, the difference between Worlds End Plateau and Kandapola Plateau is 400 feet, between Kandapola Plateau and Pattipola Plateau, 500 feet between Pattipola Plateau and Selvakanda Plateau 1,100 feet, and between Selvakanda Plateau and Hatton-Diyatalawa Plateau 500 feet. This means that if the central region (Zone 3) has been uplifted

as a block during the genesis of the island's terrain, these differences in elevation have to be the result of epeirogenic movements prior to the orogenic activity. On further study, it has been found that the differences in elevation between the Handapan Ella Plateau and the Tangamale Plateau, the Tangamale Plateau and the Ulupana Shelf, and Ulupana Shelf and Balangoda Shelf, of Zone 2 correlate, within the limits of the method, with the differences existing in descending order among the Kandapola, Pattipola, Selvakanda, and Hatton-Diyatalawa Plateaux. Also, the Hatton-Diyatalawa Plateau level is 2,400 feet above the Balangoda Shelf level. It has been deduced, therefore, that the throw of the major fault system outlining Zone 3 is of the order of 2,400 feet, and to re-create the terrain as it was prior to this elevation, requires a lowering of Zone 3 by that amount. When this procedure is followed, an extensive region results, having the relative elevations indicated in Stage VI of Table V.

The elevation of the Balangoda Shelf, as established by the study, is 2,300 feet above sea level, and the elevation of the peneplain surrounding Zone 2 is 600 feet above sea level. The difference in elevation of 1,700 feet occurs across the boundary fault zone of the combined Balangoda Shelf-Hatton-Diyatalawa Plateau region, that is, Zone 2 plus the depressed Zone 3. Therefore, if the combined Zones 2 and 3 are dropped by this amount at the fault, they should correlate

closely with the existing peneplain surface of Zone 1. The relative elevations given for Stage V in Table VI are the result.

Since the remaining relief consists of the differences in elevation described for Zone 3 earlier, and since these have been ascribed to epeirogenic uplifts, it only remains to depress this surface in succeeding stages equivalent to these differences, that is, 500 feet, 1,100 feet, 500 feet, and 400 feet. The last drop thus results in the original peneplain surface with Pidurutalagala as a 1,681 foot erosion remnant on its surface.

Within the limitations of the study, it is considered that this approach provides the most logical sequence of events established to date to explain the geomorphologic evolution of the island of Ceylon.

It should be repeated, however, that further study must involve more detailed evaluations, possibly on a statistical basis, of the various erosion levels, of the levels of various peaks, and of the relationships existing among these data, if the theory is to be accepted and applied to other areas.

In addition, it should be pointed out that a great many well marked, but areally minute, surfaces of erosion were discernible but not delineated on the aerial photographs. In a more expansive study, these too must be taken into consideration.

CHAPTER VI

THE APPLICATION OF AERIAL PHOTOGRAPH ANALYSIS AND INTERPRETATION TO GEOMORPHOLOGICAL STUDIES

General

Geomorphology is much more than a study of the form of the land, as the name implies. It not only involves a description of the landforms, but also an investigation of their geological foundation, an evaluation of their climatic and vegetative environment, an analysis of the processes active in their formation, and a synthesis of their history of development.

The application of aerial photograph analysis and interpretation to such studies is the subject of this chapter. In view of the complexities of the photo-interpretive technique, discussed in several texts on the subject (Lueder, 1959, and Manual of Photographic Interpretation, 1960), and the scope of the study, only a brief resume of the various phases will be presented.

Aerial photography

Although virtually any type or form of aerial photograph may be of significant value in a geomorphological study (MacFadden, 1949, Wikkramatileke, 1956), the most commonly uses is the vertical format.

Vertical aerial photography is normally taken with a specially designed, high precision camera, which is mounted in a specially designed mount, and carried by an aircraft modified specially for the purpose. As a rule, ordinary commercial or military aircraft are modified for this type of operation.

The photographic scale of commercial photography varies with the focal length of the lens and with the altitude at which the pictures are taken. With a six inch focal length lens, for example, the photographic scale, quoted as a representative fraction (ratio of a unit on the photograph to similar units on the ground), is two times the flying height. Thus, a photograph taken with a six inch focal length lens at 20,000 feet, has a scale of 1:40,000. The significant factor here is the flying height or height above the ground. If the aircraft flies at an altitude of 20,000 feet above sea level, and the terrain being photographed is at an altitude of 4,000 feet above sea level, the effective flying height is 16,000 feet, and the photographic scale will be 1:32,000 rather than 1:40,000.

This situation is particularly evident in Ceylon where flight lines crossing the island from west to east traverse the Central Massif. The topographic rise from the Southwest Peneplain to the top of Adams Peak Range is of the order of 6,000 feet, and the descent from the top of Namunakuli Range to the Low Level Plain in the Gal Oya Hills region, of the order of 4,500 feet. In this case, these factors made it

necessary to fly one strip of photography for each major change in elevation, and resulted in longitudinal flight line overlaps and major problems in mosaic production, and in interpretation.

Many other factors affect the production and usability of aerial photographs. Among these are colour sensitivity of film, resolving power film, atmospheric haze, shadows, high local relief, parallax, vertical exaggeration, cloud cover, printing paper characteristics, and the technical ability of the personnel involved.

Analysis and interpretation

Equipment

Equipment necessary for the analysis and interpretation of aerial photographs may be very simple or very complex. Actually, with practice, the photographs may be examined with the naked eye, but this method is tiring and does not permit magnification of the image.

The instrument most commonly employed in the application of this technique is the pocket stereoscope having approximately two power magnification. More refined reflecting stereoscopes employ binocular attachments, which may yield three power or eight power magnification. Larger precision stereo-plotting instruments used in photogrammetric mapping, because of their extremely high cost,

are rarely used for interpretation, although they provide an excellent, highly magnified (ten power) view of the terrain.

Stereometers (parallax bars) to measure the relative height differential of features being studied are available for both the pocket and reflecting stereoscopes, and are integral parts of the larger instruments. Instruments designed to measure slope or dip are also available for the smaller stereoscopes.

Technique

The technique of aerial photograph analysis and interpretation involves the application of basic concepts in the fields of geology, geomorphology, hydrology, pedology, climatology, and vegetation in general. These concepts are applied to the corresponding features as viewed stereoscopically on the aerial photograph. Thus, a unit of terrain depicted by one stereoscopic pair of aerial photographs may involve all of the above factors, or less commonly, only one.

Two of the most significant attributes of this technique are: the ability to study the terrain in three dimensions; and the ability to study it from a unique and unobstructed viewpoint. This allows an immediate appreciation of the general morphology of the surface under examination; an appreciation of the regional development and pattern of the drainage network; and an appreciation of the nature and extent

of vegetative cover. These preliminary observations are normally followed by a detailed evaluation of the various factors contributing to the development of the area as a whole, and local features in particular. These factors include the geological foundation of the area, the climatological environment, the vegetative cover, and the geomorphological processes active under such conditions.

Geological factors determinable by stereoscopic analysis of the aerial photographs include the rock type; whether it is massive, foliated, or bedded; the degree of fracturing, jointing, or faulting; the general susceptibility of the rock to weathering and the nature of the soil produced; the bedrock structure; and the degree of control exercised by these features on the existing landforms.

The climatological environment is determined by a study of existing literature and statistics and, except insofar as it has a controlling influence on the nature and degree of emphasis of the geomorphological processes, the nature and distribution of vegetation, and the moisture available for runoff and thus for stream development, is not subject to this approach.

Vegetative factors discernible on the aerial photographs include the type of vegetation; whether grass, low brush, stunted trees, intermediate forest, or dense jungle; the areal distribution of the various types of vegetation; and the relationships existing among the

vegetation, topography, rock type, moisture conditions, and local climatic controls.

The varied geomorphological processes active under the influence of the factors mentioned above, are subject to analysis and interpretation, in many instances, to a greater extent than would be possible using ground-based techniques only. The unique viewpoint and three dimensional image of the terrain permit a detailed study and evaluation of valleys and stream channels; slopes and slope characteristics; micro erosion features; slumps, landslides, rockfalls, and soil flowage phenomena; and depositional forms, all from the point of view, not only of the landforms themselves, but also of the geomorphological processes active in their development. Usually, the surfaces of erosion which are often associated with these features and processes, are more easily and more accurately definable by this technique than by the ground-topographic map approach. Similarly, the identification of local base levels and their controlling factors, is relatively simple on the aerial photographs.

Since the collection of the above data, and its transfer via an aerial photograph mosaic to a suitable base map, is essentially a mechanical procedure, it will not be treated here.

Example

As an example of this technique, a stereoscopic pair of aerial photographs (Fig. 158) was selected and subjected to analysis and interpretation. The following information was derived from this study:

Area: Talawakele, on Kotmale Oya, Hatton-Diyatalawa Plateau.

Geology: From field investigation, the bedrock of the area has been classified as quartzo-feldspathic Charnockite and Charnockitic gneiss with some beds of quartzite. The strike of the bedding or foliation is visible in the channel of the Kotmale Oya below the town of Talawakele where the beds form well defined interruptions in the stream profile. St. Clair (Minor) Falls (1) and St. Clair (Major) Falls (2) are formed by these beds.

Description: In general, the area illustrated is deeply weathered, deeply dissected, and well cultivated. Several levels of erosion exist and are marked by accordant interfluves, topographic shoulders or terrace-like features on the slopes, and various stream levels. Changes in elevation, significant in the history of development of this terrain, are marked by the above mentioned features and by breaks in the profiles of the streams. Specifically, the upper erosion surface at (3) has an elevation of approximately 4,400 to 4,500 feet (topographic

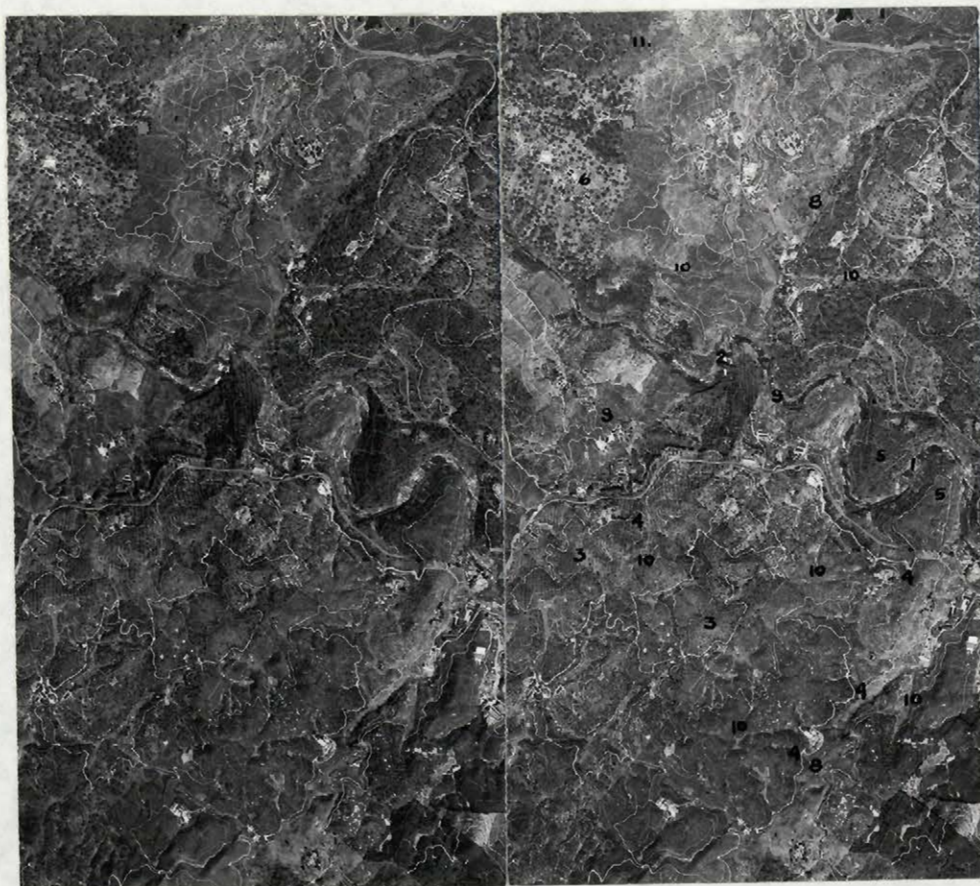


FIGURE 158

Sample Aerial Photograph Interpretation,
Talawakele, Hatton-Diyatalawa Plateau

map). It is a deeply weathered gneissic or quartzo-feldspathic rock. The angular pattern of much of the drainage on this surface is the result of fracture or joint control. The stream valleys generally overhang the next lower valleys as at (4). The simplicity of the drainage pattern, and the smooth, convex hilltops and slopes indicate good internal drainage and the probably dominance of creep as a geomorphic process. The next level down, at an elevation of approximately 4,100 feet is marked by shoulders on the spurs (5), a moderately well marked terrace at (6), and dissected valleys at (7). Conditions are generally the same as described above with the exception that the streams are more deeply incised (8).

The third erosion level is marked by the level of the Kotmale Oya above the major falls at an elevation of approximately 3,500 to 3,900 feet. The terrace remnants (9) south of the river, below St. Clair (Major) Falls, are probably part of this surface. It is possible that Kotmale Oya, because of its size and volume of flow, has incised its channel downward from the second level, and that this third level is actually a transient stage resulting from more resistant rock in the river's channel. The meandering pattern above the major falls and the interlocking spurs might support this possibility.

The lowest level in the area is represented by the bottom of the gorge-like lower valley of the Kotmale Oya, at an elevation of

approximately 3,000 to 3,200 feet.

Well marked joint or fault control of erosion and stream channels, is illustrated at many points (10). Evidence of slump or soil flowage is absent, and rockfall is illustrated only at the base of Hunuketiyagala (4,803 feet) at the top of the stereo-pair (11).

This example illustrates the amount of information obtainable from a small segment of a single pair of aerial photographs. Much additional information in the form of slope measurements, detailed drainage mapping, detailed correlation of hill tops, river cross-profiles and longitudinal profiles (all supplemented by photo-directed field investigation where possible) could be obtained if required.

Supplementary terrestrial stereoscopic photography

Aerial photograph interpretation as applied in the body of this thesis is normally supplemented by field investigation where possible. An important adjunct to such investigation, and an additional supplement to the stereoscopic pairs of aerial photographs used to illustrate the features discussed, are terrestrial or ground stereoscopic pairs of photographs (Fig. 14, Fig. 19, Fig. 87, Fig. 144, Fig. 145, and Fig. 150). These provide a three dimensional picture of the features discussed from what might be called a more normal point of view. In addition, they provide an opportunity to study the features in much

greater detail and with much greater realism than the ordinary monoscopic photograph. If the enlarged photograph of a Ceylonese farmer's home and environment (Fig. 159) is compared with a smaller scale stereoscopic pair of photographs of the same site (Fig. 160), the advantages of the latter are striking. The enlarged photograph is actually one half of this stereoscopic pair so that the detail is exactly the same in both cases. In another example, the termitaria (Fig. 161) not only illustrates the effectiveness of termites in reworking the soil and providing channels for moisture infiltration, but also the effectiveness of this type of photograph in illustrating such features. Finally, the illustration of a roadway and steps cut in a thick laterite deposit near Colombo (Fig. 162) not only depicts the characteristics of such soils, but also the effectiveness of ground stereoscopic photography in the study of geomorphology.

Conclusions

The above discussion and the illustrations accompanying it have been presented in an attempt to emphasize the importance and scope of the technique of aerial photograph analysis and interpretation in the study of geomorphology. It is felt that although much has been done in this field in the past, its utilization as a major geomorphological tool is still to come.

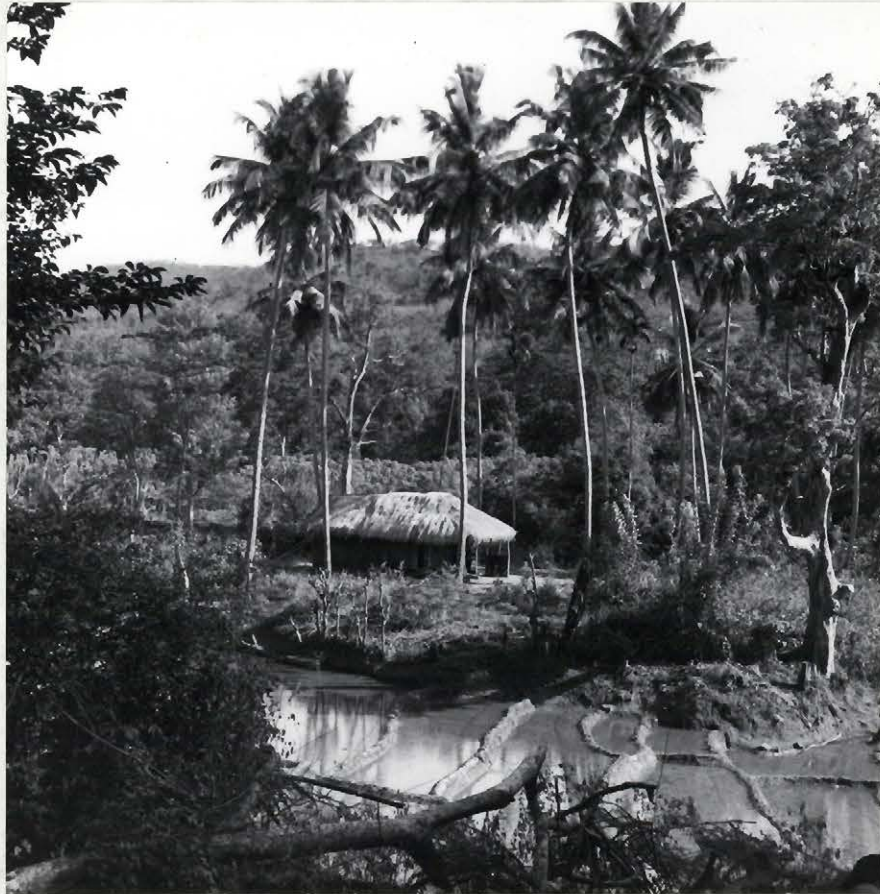


FIGURE 159

Sample Monoscopic View of Ceylonese Farmer's House
and Land, Near Ratnapura



FIGURE 160

Sample Stereoscopic View of Ceylonese Farmer's House
and Land, Near Ratnapura

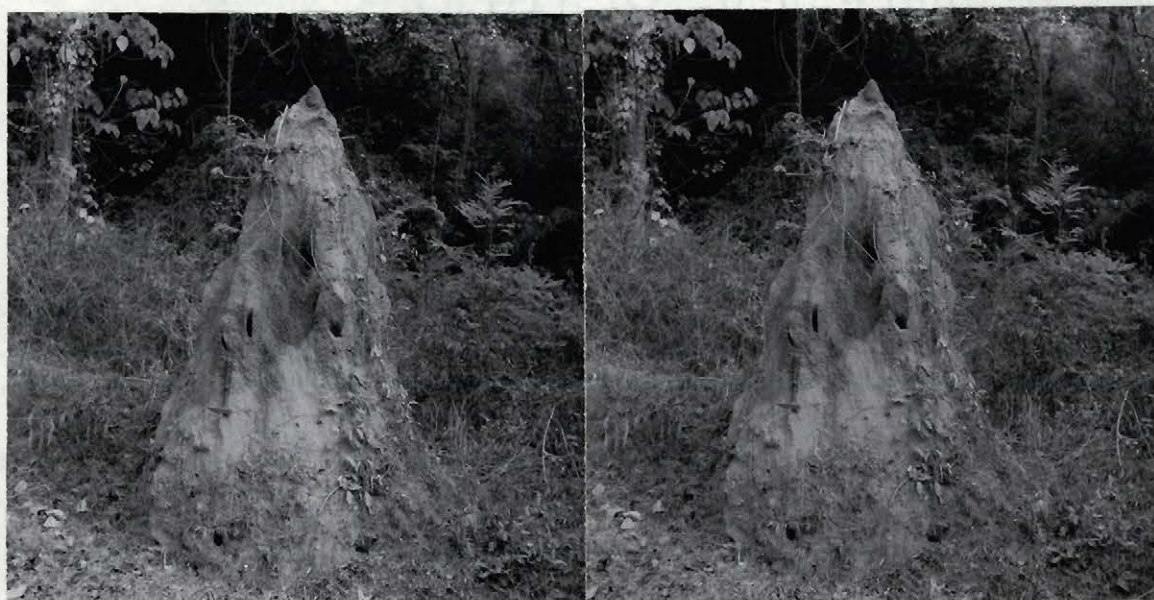


FIGURE 161

Termitaria, Near Wellawaya on Tanamalwila Peneplain



FIGURE 162

Roadway and Steps Cut in Thick Laterite,
Near Colombo on Southwest Peneplain

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