SOIL SURVEY MANUAL FOR MALAYAN CONDITIONS

MINISTRY OF AGRICULTURE AND CO-OPERATIVES
MALAYSIA

DIVISION OF AGRICULTURE

BULLETIN No. 119

SOIL SURVEY MANUAL
FOR MALAYAN CONDITIONS

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1966

Published by and obtainable from
THE DIVISION OF AGRICULTURE
MINISTRY OF AGRICULTURE AND CO-OPERATIVES
MALAYSIA
KUALA LUMPUR

Price $5 or 11s. 8d.

Printed by ART PRINTING WORKS · KUALA LUMPUR

Telephone No.: 87311

MENTERI PERTANIAN DAN SHARIKAT KERJASAMA, MALAYSIA
MINISTER OF AGRICULTURE AND CO-OPERATIVES, MALAYSIA

KATA2 PENDAHULUAN

Ini-lah bagi pertama kali-nya Buku Panduan yang sa-umpama-nya mengenai Penyelidekan Kesuboran Tanah di-bawah keadaan2 hawa di-Malaya di-terbitkan. Penerbitan buku ini sekarang sunggoh kena pada tempat dan masa-nya di-waktu usaha2 pembangunan dan kemajuan pertanian sedang berjalan dengan pesatnya di-Malaysia dan tanah2 baru untok pertanian sedang di-buka dengan seluas2-nya.

Penyelidekan kesuboran tanah bagi menentukan tanah2 yang betul2 sesuai untok kegunaan2 pertanian yang sangat2 berharga ini telah mendapat sambutan yang sunggoh2 menggalakkan di-seluroh Malaysia. Sambutan ini telah mendorongkan Kementerian Pertanian dan Sharikat Kerjasama meluaskan lagi urusan penyelidekan kesuboran tanah dalam tahun2 kebelakangan ini, dan mengeluarkan peta2 kesuboran tanah dan penyata2-nya yang boleh di-jadikan dasar yang tegas kapada ranchangan memperbaiki tanah2 dan pelajaran2 di-segi agronomi.

Buku Panduan ini mengambarkan keperluan bagi menyatu dan mengeratkan penyelidekan ahli2 penyelidek kesuboran tanah bersendirian yang bertugas di-Negeri Tanah Melayu dan di-harap Buku ini akan membantu mereka mengenai chara2 dan kaedah2 penyelidekan yang digunakan dalam negeri ini. Di-samping itu, ahli2 dan peminat2 pertanian akan dapat mengetahui dengan lebeh jauh berkenaan dengan kesuboran tanah2 di-negeri ini, bagaimana kesuboran tanah2 itu di-selideki dan mutu2-nya di-nilaikan.

(HAJI MOHD GHAZALI BIN HAJI JAWI)
MENTERI PERTANIAN DAN SHARIKAT KERJASAMA,
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Kuala Lumpur,
3hb. Disember, 1965.

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MENTERI PERTANIAN DAN SHARIKAT KERJASAMA, MALAYSIA
MINISTER OF AGRICULTURE AND CO-OPERATIVES, MALAYSIA

FOREWORD

This is the first Soil Survey Manual for Malayan conditions. The publication of this Manual is particularly appropriate at the present time, when a vigorous upsurge of agricultural development is taking place within Malaysia, and new land is being brought into cultivation at an accelerating rate.

The value of soil surveys for indicating the suitability of land for agricultural purposes is widely appreciated throughout Malaysia, and increasing emphasis has been given to expanding the soil survey organization within the Ministry of Agriculture in recent years, and to producing soil maps and reports which can provide a sound basis for land development plans and agronomic studies.

The present Manual reflects the need for unifying the studies of individual soil surveyors working within the States of Malaya and it is hoped that publication of this practical handbook will further assist in systematising the methods of soil survey used in this country, and at the same time prove of interest to agriculturists and others who may wish to know more about Malayan soils, how they are surveyed, and how their qualities are assessed.

(HAJI MOHD GHAZALI BIN HAJI JAWI)
MINISTER OF AGRICULTURE AND CO-OPERATIVES,
MALAYSIA.

Kuala Lumpur,
3rd December, 1965.

FOREWORD

By Director of Agriculture, States of Malaya.

SINCE Independence, the Government has laid great stress on rural development in national planning and in this connection, land development for agriculture is accorded high priority. To help in the planning and implementing of these measures, soil resource information is necessary for deciding the best choice of areas for specific land development schemes and the Department of Agriculture is charged with the responsibility to obtain and provide the vital soil information.

To do this, schematic reconnaissance soil surveys have been conducted by the Department and in 1965, with the assistance of foreign personnel, soil survey activities reached a high level with seven field parties in Pahang, Selangor and Johore. Under the schematic reconnaissance soil survey programme, by 1967, the first inventory of Malayan soil resources will be completed. With the present number of soil surveyors possessing somewhat different backgrounds and experiences, and the prospect of this number of soil surveyors increasing as more detailed soil surveys are warranted in future, the need for standardization of soil survey techniques and nomenclature has become increasingly felt.

This Soil Survey Manual, the first of its kind in Malaya, and probably in the Tropics, is therefore a timely contribution, and should go a long way towards fulfilling this need. It will be, I am sure, a valuable companion and guide not only to soil surveyors and other soil scientists in the Department but also to others who are connected with soil management and land use.

(MOHAMAD BIN JAMIL, J.M.N.)
DIRECTOR OF AGRICULTURE,
STATES OF MALAYA.

Kuala Lumpur.
10th January, 1966.

PREFACE

THIS is a book for practising soil surveyors working in the field. It has been prepared primarily to assist in the Schematic-Reconnaissance Soil Survey of Malaya — an ambitious programme which aims to produce a stock-taking of the soil resources of the whole of the Malay Peninsula by 1967. The project has an international character provided by the Malaysian, Canadian, American, British and New Zealand personnel who are participating in it. This Manual has been compiled by drawing on their experience both in their own countries and in Malaysia.

A first approximation of this Manual was issued in cyclostyled form in mid-1965. It was circulated widely both within Malaysia and overseas, and critical comment was invited. Reaction was encouraging and many valuable suggestions were received. The Manual has now been recast and amended for formal publication. Some sections, notably the 'Descriptions of the Common Soil Series,' have been deleted because it was felt that they were out of place in a Manual devoted primarily to techniques and methods. After thorough revision these Descriptions will appear in future publications.

Free use has been made throughout of information drawn from the United States Soil Survey Manual (1951) and from Soil Survey Method: A New Zealand Handbook for the Field Study of Soils (1962), and this data has not everywhere been acknowledged specifically in the text. Such acknowledgement is tendered here. Wherever possible the standards outlined in these documents have been adhered to in order to maintain uniformity with a nomenclature that is widely understood in other parts of the world. The modifications which have been made are necessary to meet local conditions. Throughout the text, approximate metric equivalents have been given for all measurements quoted.

Grateful acknowledgement is made to other members of the Schematic-Reconnaissance Team for their participation and help, and particularly to Inche₂ Law Wei Min, Ignatius F. T. Wong and K. Selvadurai for their work on the classification of slope and terrain; to Mr. W. Null and Inche Ignatius F. T. Wong for their contribution to the soil suitability classification; to Inche Ignatius F. T. Wong for assisting with the section on landforms and Appendix 4; to Messrs. J. Dumanski and H. A. Smallwood for much of the data used in the section on horizon nomenclature; to Messrs. D. A. Libby and D. W. Ives, for contributions to discussion; to Mr. J. Wyatt-Smith for permission to quote extensively from his 1964 article on vegetation types. Thanks for criticism and helpful suggestions are also tendered to members of the staff of the Soil Science Division, particularly to Mr. G. W. Arnott formerly Senior Soil Scientist for his constant encouragement, and to the present Senior Soil Scientist, Dr. Ng Siew Kee. Thanks are also extended to Mr. C. R. Jones, Geological Survey, Dr. J. M. Strauss, Institute for Medical Research, and Dr. M. M. Guha, Rubber Research Institute for their helpful comments on Appendices 6, 9 and 12 respectively. Inche₂ Chong Toong Choong and J. Hendroff of the Survey Department are thanked for supplying information which is included in Chapter 3. The diagrams were drawn in the Soil Survey Drawing Office by Inche Raja Lob Sharuddin, to whom appreciation is extended.

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Chapter 1

INTRODUCTION

SOIL survey activity is increasing in both scope and intensity throughout the world today. This is particularly so in many tropical countries, and Malaysia is no exception. A by-product of this is the urgent need to standardise the terms and techniques associated with soil survey. Handbooks and manuals have already been produced by soil survey organisations in some countries, notably, the U.S.A., New Zealand, and the Philippines (Soil Survey Staff 1951; Taylor and Pohlen, 1962; Barrera, 1961) and although these documents have much in common it is evident that local conditions vary sufficiently from country to country to warrant the provision of a separate guide for each individual survey organisation.

The purpose of this Manual, therefore, is to provide a ready guide to the description and mapping of soils in the field in the States of Malaya. It is thus aimed primarily at the soil surveyor, and strives to outline all the information, both scientific and administrative, that he may require in order to fulfill his function efficiently and competently. At the same time, it contains much information of interest to those who use soil maps, and it is hoped that it will be accepted as the standard authority in the field of soil survey in Malaya.

Soil surveys provide a foundation for land development programmes by outlining the basic soil pattern of a region, and by identifying each kind of soil occurring there. This information on soil resources reveals a rational basis for the assessment and prediction of crop responses. Similarly, on developed land soil survey information is often helpful in explaining uneven growth patterns and in providing a blueprint for remedial trials. Although the immediate purpose of soil survey is practical, it is also a scientific exercise which is not necessarily subordinated to the needs of the moment but which results in basic information of wide application. Although the information may be interpreted in many ways for different purposes, its inherent value lies in its fundamentally scientific nature.

KINDS OF SOIL SURVEYS

Depending on the degree of detail required, soil surveys in Malaya are classed as schematic-reconnaissance, detailed reconnaissance, or detailed. The aims of *schematic-reconnaissance surveys* are; to obtain an indication of the broad soil distribution pattern over a given area; to assess the relative agricultural potentials of the dominant soils; to set up a working classification at the association and series level; and to draw up small scale soil maps showing the distribution of the main soils. Maps are compiled usually on a scale of 1 to 500,000 (or 7.89 miles to 1 inch) but also sometimes on a scale of 4 miles to 1 inch (1 : 253,440) and even 2 miles to 1 inch (1 : 126,720) by reduction from the data collected on 2 inch to 1 mile (1 : 31,680) field sheets during field traverses carried out on a reconnaissance scale. Field survey on a reconnaissance scale involves examination of soils at about ¼ mile (0.4 kilometre) intervals along pre-determined routes about 3 to 4 miles (4.8 to 6.4 km) apart and mapping these soils as series which are later grouped and shown on the map as associations of series. Geological, topographical, and any other sources of information are referred to when the actual positions of the soil boundaries are being inferred between the traversed routes.

In Malaya, schematic-reconnaissance surveys supply at least part of the answer to some very important practical questions: namely, is a certain area worth developing for agriculture, and if so, what type of crop would be most suitable. In addition, if already developed areas are also examined, the final result is a very useful initial stock-taking of the country's soil resources. Other advantages of such a survey are that a soil classification is built up in the field and this can be used as a guide in laying down certain types of agricultural experiments, thus enabling results of these to be applied in developed or potential agricultural areas where the soils are similar.

The schematic-reconnaissance survey of the Malay Peninsula is providing urgently needed information to aid investigation and planning on a regional and national scale, and at the same time it furnishes a framework within which more intensive soil studies can be pursued.

Detailed reconnaissance surveys, which are the normal method of surveying jungle soils at the soil series level, involve traversing lines cut at intervals of between 200 yards (approx. 180 metres) and 1 mile, (1.6 km) and examining the soils very closely along these lines. The maps, which are made by plotting the soil data obtained along the rentis₂* and then drawing in the positions of the actual soil boundaries by inference, are usually produced on a scale of 1 inch to a mile (1 : 63,360). This work is very expensive and time-consuming, particularly in forested areas, but if there is some definite end in view and the terms of reference have been stated in detail before the field work begins, then such surveys can be of great value in the study of local soil problems and as a basis for assembling and distributing information in the fields of agriculture and forestry.

In both schematic-reconnaissance and detailed reconnaissance surveys, the actual position of the soil boundaries has to be inferred for most of their distance between the rentis₂ or other traverse routes and it is obviously impossible to produce an accurate map in jungle covered terrain by these methods. Such maps do, however, indicate the broad soil

*rentis — a Malay term for a track or trace cut through the jungle. Those used in soil survey work are cut on fixed compass bearings. In Romanised script the plural of rentis is written rentis₂.

pattern in spite of the inaccuracies in detail. They should be interpreted intelligently and with full regard to their limitations.

Detailed surveys produce maps normally showing series and phases on a large scale for small areas where detailed knowledge of the soil pattern will be of use in various agricultural and agronomic projects. Mapping by free traversing at close intervals can sometimes be done on estates or open areas of padi land, but in jungle or thick secondary growth a very close rentis net must be cut and very detailed notes taken of the soils along the rentis[2]. The usual spacing between the rentis lines is 4 to 8 chains, (about 80 to 160 metres) and the final maps are produced on scales ranging from 10 chains to 1 inch (1 : 7920) up to 1 mile to 1 inch (1 : 63360). It is usually impractical to produce this type of map in jungle country owing to the heavy expense involved, and such maps are normally only prepared for developed lands such as agricultural stations, development schemes and estates.

Surveys of small areas carried out at a specific request are referred to as *ad hoc* surveys. The maps are usually at a detailed scale and aim to answer an immediate agronomic problem.

Frequently a soil scientist is called upon to examine a piece of land to advise on the cropping potential or management requirement without producing a soil map. In order to differentiate this type of examination from a soil survey, which implies the preparation of a soil map, the term *soil inspection* should be used.

Chapter 2

THE SOIL SITE AND PROFILE

THE GEOGRAPHICAL SETTING OF MALAYA

MALAYA occupies the extreme south easterly portion of the Asian mainland and is part of the peninsula which extends southwards from Burma to Singapore. The distance from the northern boundary at Perlis to the southern tip near Singapore (latitude 1° 18′ N.) is about 450 miles (720 km), and the country covers an area of about 51,000 square miles. (approx. 132,000 sq. km). The central spine of mountain ranges, rising to just over 7,000 feet (approx. 2100 metres), is flanked to the east and the west by extensive coastal plains. In terms of the geographic elements of climate and vegetation, Malaya is a land of striking uniformity. The dense cover of tropical jungle is continuous in the undeveloped areas, and both the rainfall (of the order of 100 inches or 2540 mm per annum) and the mean temperature (in the vicinity of 80°F or 26.6°C) are uniformly high. Such an environment is a challenging one for soil surveyors, and athletic prowess is often almost as important as professional ability to the surveyor working in the jungle. Many of the special techniques and methods described in this Manual have been developed to overcome the difficulties of the environment.

SOIL FORMING FACTORS

All the classic soil forming factors operate in Malaya. The soils are the products of their environment — of the parent material, of the climate under which they weather, of the kind of topography upon which they are situated, and of the vegetation which grows on them, during the length of time that they have been developing. As is the case in many other regions, some factors are expressed more emphatically under Malayan conditions than are others. Thus, the broad scale soil pattern is dictated almost exclusively by the parent material. This is a reflection in part of the varied geology and in part of the uniform climate and vegetation. Differences in topography and time both produce important soil distinctions at a slightly lower level of abstraction.

PARENT MATERIAL AND PARENT ROCK

In an enviroment of deep intense weathering such as exists in Malaya, the parent material of a soil is commonly very different in nature from the original parent rock, but differences between broad rock types do persist remarkably clearly in the weathered, unconsolidated parent materials.

The more important groups of parent rocks from which parent materials of Malayan soils are derived are described below: —

1. BASALT AND ALLIED ROCKS

These are hard, dark coloured, finely crystalline rocks containing a high proportion of iron rich minerals which weather down to produce well-structured dark red or chocolate coloured soils with deep uniform profiles. Rocks of basaltic or related composition are formed by cooling and consolidation of molten magma which is injected from the interior of the earth into its outer crust, and in Malaya the resultant rocks occur mainly as dykes, which are thin sheets of rock cutting across the stratification of the surrounding country rocks: or as ancient lava flows interbedded with sedimentary strata and often folded by subsequent earth movements. Remnants of an extensive basalt lava flow of lower Tertiary age which have not been intensively folded occur near Kuantan, Pahang.

The more commonly occurring rocks in this group are basalt, dolerite, and andesite. The basalt only occurs extensively in the Kuantan area, but andesite rocks outcrop over small areas in several parts of Malaya. The soil developed from the andesite has a characteristic red colour, is deep and uniform and has a strongly developed structure.

Dolerite dykes and volcanic ash layers occur in the shales and quartzites of Central Malaya, but as they usually take the form of very narrow bands, perhaps only a foot or two in width, the soil formed from them is usually mixed with that formed from the neighbouring rock type, and the actual area of soil developed on those parent rocks is usually very small. Where a sufficient quantity of doleritic rock occurs to form a recognisable soil, this is similar to that formed from andesite, although slight differences in colour and structure can be seen.

2. GRANITE AND ALLIED ROCKS

Granites and rocks of similar composition including syenites and diorites outcrop over a very large proportion of the country, particularly in the mountainous regions. Soil differences caused by topographic and climatic influences are noticeable at different elevations, but most granite-derived soils are readily recognised by their characteristic colour and texture, and the number of series established on this type of parent material is relatively small considering the very large area involved.

Granite is an igneous rock formed from acidic magma which consolidates within the earth's crust to form large masses known as batholiths. Subsequent earth movements and removal of the overlying crust by erosion result in exposure of the granite on the surface, and this state exists over much of Malaya at the present day. On close examination, granite is seen to be a coarsely crystalline rock made up of several different minerals. The most important of these are quartz, the separate crystals of which can be recognised by their glassy and often greyish appearance, irregular outline and hardness; feldspars which are more evenly shaped and have an opaque, milky appearance; and micas which are the glittering, sometimes dark-coloured, finely-layered minerals which can be broken down into small flakes by splitting in one direction. Quartz is the mineral which forms the sand fraction in the resultant soil, while the other minerals weather down to form clay, and as the free quartz content of a granite rock varies from place to place, the texture of the resultant soil will reflect these changes. Granitic rocks of progressively lower free silica content are known as granodiorites and quartz diorites, and these give soils with a very much lower proportion of sand which is also usually of a finer grain size. The higher content of hornblende and other dark-coloured, iron-rich minerals also imparts a redder hue to these soils. The dominant colours match the 7.5YR and 5YR hues on the Munsell Colour Charts rather than the 10YR hue which is common to the soils derived from acid granites.

3. QUARTZITE

Quartzite and quartzose sandstones are hard, highly siliceous rocks formed at depth by the action of intense heat on sandstones. They are common rocks in many parts of Malaya, and can be distinguished from unmetamorphosed sandstones by their hardness and sometimes by their glassy appearance. Malayan quartzites are seldom formed from pure sandstones with the result that soils formed from quartzite show some variation depending on the amounts and nature of any clay which may have been present in the original sedimentary rock. Soils formed from quartzite normally occur on strongly ridged terrain and usually have shallow profiles with fine sandy textures and light yellowish colours, although those on gentler topography have deep uniform loamy, well-structured profiles.

4. SHALES

A shale is a soft, laminated, fine grained rock formed by accumulation of successive layers of clay, or silt and clay, under still-water conditions. A very large part of the rocks of Carboniferous age shown on the Geological Map (Geological Survey, 1948) are shales. The mineral composition is variable and this influences the nature of the resultant soils. Some types of shales, particularly those occurring along the East Coast of Malaya, are sandier than normal and these give rise to looser, more weakly structured loamy soils. Differences in lithology are very common in most shale-bearing rock formations occurring in Malaya, so that the soil pattern is generally rather complex in such regions.

5. LIMESTONE

Limestones are formed by accumulation of shells and corals, or by direct precipitation of calcium carbonate in salt or fresh water. Pressure of overlying rocks results in re-crystallisation of the calcium carbonate to form calcite or marble with the result that the original outlines of the shells disappear, as is the case with most Malayan limestones. Limestone weathers by solution, and the resultant soil is in fact formed from residual minerals other than carbonates which exist in small quantities within the original rock. The high iron content of many of these residual soils suggest that atmospheric dust may in some cases be an important constituent, while in other cases the iron may have originated by metasomatic replacement connected in some way with the granite intrusions. Limestone outcrops in Malaya generally take the form of steep-sided, rugged cliff masses almost bare of soil, and impossible to cultivate; but in a few small areas of gently rolling country, deep well-structured dark red coloured soils are developed on limestone; while in other cases laterite bands may be developed at varying depth within the profiles.

6. OLDER AND SUBRECENT ALLUVIUM

In many parts of the country, low, weakly dissected terraces of unconsolidated clays, sands, gravels and stones are an important element of the landscape. These materials rarely occur above an elevation of 230 feet (about 70 metres) above sea level and are thought to have been deposited in early Pleistocene times. They are known collectively as "Older Alluvium" (Burton 1964). It is difficult to separate this deeply weathered material from associated deeply weathered igneous and sedimentary rocks, but the resultant soils, although similar in appearance behave very differently under agriculture. Soils formed on Older Alluvium are extremely impoverished of both major and minor plant nutrients. The following criteria are used to identify Older Alluvium in the field (Null, Acton, Wong 1965). No one of these is necessarily diagnostic by itself but the presence of several of them in any one locality is regarded as sufficient evidence for Older Alluvium:

1. The presence of rounded stones and gravel.
2. Signs of stratification.
3. Absence of quartz veins.
4. Absence of mica.
5. Greater susceptibility to erosion.
6. Light yellowish red vertical mottling in the subsoil.

Flat to gently undulating terraces occur in some parts of the country, intermediate in elevation between the Older Alluvium and Recent Alluvium. These are composed of predominantly coarse textured "Subrecent" alluvium which is approximately intermediate in age between Recent Alluvium and Older Alluvium.

7. MARINE ALLUVIUM

Material eroded from the mountains of the interior is carried by the rivers to the sea where it is deposited to form new land around the mouths of the rivers and along the neighbouring coastal stretches. On the West Coast, the rivers flow very sluggishly in their lower reaches and often meander for miles through swamp land. Such rivers do not have the capacity to carry large amounts of coarse grained material so that the bulk of the detritus which reaches the sea consists of very fine particles in suspension, and this eventually settles out as mud in the shallow, relatively calm waters of the Straits of Malacca. This material is known as coastal or marine alluvium, and several extensive coastal flats including the Kedah Plain and the flat lowlying country around Kuala Selangor in West Selangor have been built up in this manner. The more recently deposited alluvium (i.e. that nearest to the coast) is usually subject to flooding by the sea with the result that the soils formed on it contain very high proportions of dissolved salts, but further inland these salts have been removed by leaching under the heavy rainfall. Chlorides are rapidly removed in this manner, but sulphates, which are often reduced to sulphides under the prevailing anaerobic conditions, may persist.

In some of the larger stretches of alluvium along the West Coast, the permanent swamp conditions in the centre prevent the total decomposition of dead plant material and this gradually accumulates to form a thick layer of peat. The peat is coarse and woody, has a high loss on ignition, and is usually between 2 and 25 feet (.6 to 7.5 metres) in depth. Shallow peat suitable for agricultural development is usually restricted to a narrow marginal zone.

On the East Coast the wave and current action of the sea, particularly during the North-east Monsoon, has caused extensive marine abrasion and the sandy residuum is transported by marine action along the coast and deposited on beaches in the more sheltered situations. On the other hand, the bulk of the finer material resulting from this erosion and the clays and silts carried down from the interior by the rivers, is apparently swept away from the shore by offshore currents (Nosin, 1965). Very extensive beach ridges have been formed in this way along the East Coast of Malaya, and the soils developed on this coarse material are very free draining and almost devoid of nutrients.

8. RIVER ALLUVIUM

Around the bases of all the mountain ranges of Malaya, usually at elevations of less than 100 feet (about 30 metres) above sea level, the rate of flow of Malayan rivers decreases very rapidly and this sudden change in the current speed reduces the carrying capacity of the stream very considerably and causes deposition of much of the coarse and medium grained material. This results in the formation of large areas of riverine alluvium, and the soils formed on such deposits are usually loamy in texture and with very variable drainage character. Near the river banks, the soils are likely to be very free draining but towards the valley sides the water-table approaches close to the surface and in some very poorly drained spots small pockets of inland peat may form.

LANDFORMS

Malayan landforms bear features characteristic of both a narrow mountainous peninsula and a tropical environment. The landscape is dominated by mountain ranges and the tectonic skeleton of Malaya consists of a series of mountain or hill ranges separated by valley troughs (Richardson 1947). Extensive coastal plains flank this mountain complex both to the east and to the west, and these are probably the second most conspicuous feature of the Malayan landscape. Between the mountains and the coastal plains, and occupying a large tract of terrain in the central and southern part of the Peninsula is a complex of undulating, rolling, and hilly land which almost certainly represents various stages of dissection of an ancient erosion surface* Besides these three major groups of landforms, i.e. the mountains, the coastal plains and the dissected erosion surface, many minor features can be recognised and are often of great value to the soil surveyor in providing supplementary evidence concerning the origin and age of the soil and its site. Short descriptions of the landform units recognised for soil survey purposes are given below: —

The *mountains* which are steep-sided, and strongly dissected by an intricate pattern of small active streams, range in elevation from about 2,000 to about 7,000 feet (610 to about 2100 metres). The larger streams flow through torrent tracts which are narrow V-shaped, steep-sided valleys, the floors of which may be completely cluttered with large boulders.

The *coastal plain* can be briefly described as a plain whose seaward margin coincides with the coast. A *beach ridge* occurs on the coastal plain and is an essentially continuous mound of beach material located behind the beach, where it has been heaped up by wave action. Ridges may occur singly or as a series of approximately parallel deposits. They are well developed along the East Coast of Malaya. Extensive *swamps* are common on the wide parts of the coastal plain where they occur behind a seaward bar of alluvium or sand. Their landward margin generally coincides with the edge of the dissected erosion surface.

A *plain tract* is the lower portion of a river course where it crosses the coastal plain. It consists, in effect, of a wide path cut across the marine alluvium of the coastal plain and filled in with typical river alluvium. A

* This feature has in the past been called a dissected peneplain, but because there is probably some room for debate as to whether downwearing (leading to peneplanation) or backwearing (resulting in pediplanation; King, 1951, p. 52) has been the dominant geomorphic process, the more neutral term "erosion surface" is preferred here.

meander belt is often a very distinct feature of these plain tracts. In some parts of Malaya, particularly Kelantan, this feature may become very extensive until the landscape is dominated by features of riverine deposition. In this case, the term *river basin* denotes the distinction between this and the smaller plain tract. A river basin is commonly almost entirely surrounded by hills. A *marine terrace* is a component of the coastal plain, and the term is used to distinguish very weakly dissected remnants of a former coastal plain at a slightly higher level. In Malaya, most marine terraces range from about 5 to about 50 feet (1.5 to about 15 metres) above the surrounding coastal plain. However, in the southern part of the country, dissected remnants of what were probably former coastal plains occur up to 230 feet (70 metres) above sea level.

A *valley tract* is most commonly associated with the dissected erosion surface landscape, and is the middle part of a stream course characterised by a moderate gradient and a fairly wide valley. *River terraces* are quite common in central and southern Malaya particularly, where they are associated with the dissected erosion surface. They occur at various levels and at various stages of dissection, but always consists of a plain and an accompanying escarpment, features which are sometimes partly obliterated by dissection. The lowest and most recent surface in a river valley is normally called the *floodplain*. A *levee* is the natural bank of a river formed during flood periods by the deposition of sediment. When the flood subsides, the sediment remains and the levee is thus the highest portion of the floodplain of a river.

The above are not intended as strict geomorphological definitions. They are included only to allow soil surveyors to describe in a reasonably consistent way an important feature of the soil site.

SLOPE AND TERRAIN

The elements of the different landforms can be described in terms of slope and terrain, that is, the angle of the single slopes in the landscape and the nature of the terrain produced by a combination of the single slopes in any one place. A single slope occurs on a tract of land which is level, or flat, or having a slope in one direction only; whereas the complex slopes occur on all tracts of land which have slopes in more than one direction. At present, no allowance is made in the classification of slope and terrain to express the amplitude of relief of the landscape. Obviously, this is an important facet of the terrain, but for schematic-reconnaissance purposes the following classification is considered sufficient: —

TABLE I

SLOPE AND TERRAIN CLASSES

Angle of Slope	Terrain Classes	
	Single Slopes	Complex Slopes
0 – 2°	Level or nearly level, A_1	Level or nearly level, C_1
2 – 6°	Gently sloping, A_2	Undulating, C_2
6 – 12°	Strongly sloping, A_3	Rolling, C_3
12 – 20°	Moderately steeply sloping, A_4	Hilly, C_4
20 – 25°	Steeply sloping, A_5	Steep, C_5
Greater than 25°	Very steeply sloping, A_6	Very steep, C_6

The above Table includes suggested mapping symbols for the various slope and terrain classes.

STEEPLAND BOUNDARY

The steepland boundary is the line which marks the sudden break between terrain which is predominantly steep and very steep and that which is level, undulating, rolling or hilly. It is an obvious topographical feature over large areas of Malaya, and is highly significant to land use for it very effectively marks the separation of land which is topographically suitable for agricultural development from land which is of questionable suitability for extensive cultivation owing to excessive steepness. The position of this change of slope boundary can be readily located on any contoured topographic map (1 to 63,360 or 1 to 25,000 New and Old Series Sheets) by noting the difference in spacing between adjacent contours. For a given topographic sheet or district, the boundary will usually be found to coincide with one particular contour. For instance, in the Kuala Lumpur district the boundary is generally about 300 feet (about 90 metres) above sea level; while in Central and North Kedah the line coincides with the 150 foot (about 45 metres) contour; and in the Kuala Lipis area it corresponds with the 600 foot (about 190 metres) contour. The change in altitude of this boundary between these different places is very gradual and takes place progressively on a regional scale. In general terms, the boundary rises gradually towards the centre of the country and this increase in altitude is most readily apparent in the State of Pahang within the catchment of the Sungei Pahang, which drains the geographical centre and is the largest river in the country. This suggests that the steepland boundary is coincident with the edge of a pre-existing erosion surface which was a general feature of the Malayan landscape at an earlier geological period and is now being dissected to give the typical undulating to rolling terrain found in most places below the steepland boundary.

In the field, either on the ground or from the air at low altitude, the demarcation of the steepland boundary is even more obvious than it is on the map, and it is seen to separate the undulating, rolling, and hilly land of the dissected erosion surface, or the level terrain of the coastal plain, from mountainous country with most slopes exceeding 25°. Above the steepland boundary, the slopes are long and continuous right to the topmost mountain ridges which may be up to 7,000 feet (2100 metres) high. Below the steepland boundary, the individual small hills seldom rise to more than 250 feet (about 75 metres) above the surrounding coastal plain and their summits are commonly accordant so that the appearance of the landscape indicates that the area in question represents a strongly dissected erosion surface. The slopes in these areas generally fall in the 5° to 20° slope category.

The steepland boundary in Malaya can thus be defined as a line separating land with average slopes less than 20°, and topographically suitable for tree-crop agriculture from land having average slopes exceeding 20° and better suited to permanent forest rather than to extensive agricultural development.

EROSION

The first distinction to be made in discussing this subject is that between *normal erosion*, which is the geological process by which the land surface is being continuously worn down, and *accelerated erosion* which occurs when the normal process is speeded up, sometimes catastrophically, and in most cases due to man's interference with the existing natural regime. In the humid tropics, the forces of *normal erosion* are operating almost universally whether they be slow mass movement on slopes, active gullying in steep terrain, or deposition on alluvial plains. Probably the only units of the landscape which are relatively immune are the level surfaces of marine and alluvial terraces which are isolated from the effects of river activity. It is important to recognise whether or not normal erosive processes are operating on any particular soil site in the tropics because under the prevailing conditions of intense weathering and leaching, the soil is rapidly impoverished unless there is a constant rejuvenation by erosion, whether it be addition to the surface, or removal from the surface with addition to the soil from the underlying rock. In Malaya, the processes of normal erosion can be categorised as water erosion and mass movement erosion. The main manifestations of water erosion are: -

1. SHEET EROSION

This is the relatively uniform removal of soil from an area without the development of conspicuous water channels. It operates to some extent on undulating, rolling, hilly, and steep terrain under jungle cover where the surface of the ground is normally exposed due to the rapid decomposition of any protective litter layer.

2. GULLY EROSION is the removal of material by streams of running water with consequent formation of relatively large channels commonly with steep sides. Gullies are common in hilly and steep terrain under jungle cover where they provide evidence of the intensity with which the land is being dissected.

3. DEPOSITION on floodplains by rivers and on the coastal plains by the sea completes the normal cycle of water erosion.

Mass movement under normal conditions is probably confined to soil creep, which is a slow movement downhill under the influence of gravity. The presence of stone lines tends to suggest that soil creep operates almost universally on rolling, hilly and steep land as well as on near level and gently undulating terrain.

Accelerated erosion in Malaya most commonly and most spectacularly occurs on steep slopes which have been cleared for cultivation. The same sub-division can be made as was employed in the description of normal erosion. The processes are essentially the same, the main distinction being one of increased speed and intensity due to the disturbance of the natural protective cover. The effects of water erosion are sometimes described as sheet and gully erosion, as have been described under normal erosion. *Rill* erosion refers to the removal of soil by the cutting of numerous small but conspicuous channels which are minor concentrations of run-off. In many ways, rill erosion is intermediate between sheet and gully erosion. Under mass movement, soil creep is accelerated so that slip or slump erosion becomes characteristic and very destructive. This is the sliding or slipping of saturated soil and underlying material upon a slip surface under the influence of gravity. Slips are relatively shallow, whereas slumps are normally quite deep and spoon-shaped with characteristic upheaval of the bottom part of the slump. The type and extent of accelerated erosion in Malaya has been assessed by Speer (1963).

These are the main types of erosion affecting the soils of Malaya. For the purposes of the schematic-reconnaissance survey, it will probably suffice to recognise the type and the approximate severity which can be described in ordinary terms. However, a comprehensive classification of erosion classes is outlined in the U.S.D.A. 'Soil Survey Manual' (Soil Survey Staff, 1951) and this may be used if more precise description is required.

DRAINAGE

In a country such as Malaya which has a high rainfall and whose soils are predominantly fine textured, drainage is a most important soil characteristic and in many cases poor drainage is the chief factor limiting agricultural development.

The problem of appraising soil drainage is far more complicated than it may at first appear. The term has two distinct connotations. Soil drainage in the active sense refers to the rate and extent of the removal by surface run-off, flow through the soil, evaporation and transpiration, of water which has been added to the soil by precipitation, seepage, etc. On the other hand, in a passive sense, soil drainage refers to the condition of the soil and implies the frequency and duration of periods when the soil is actually free of saturation or partial saturation. Both these conditions can be measured, but for soil survey purposes they are estimated in the field by inference. Among the internal characteristics of a soil that throw light on the soil drainage and its variations at different times of the year are:-

The soil texture; the soil structure; the pattern of cracking; the soil colour; the pattern of mottling; the kind and depth of organic matter; and the consistence of various horizons.

The overall concept of soil drainage is a broad one and it comprises certain narrower aspects such as surface run-off which is sometimes referred to as external soil drainage, internal soil drainage, and soil permeability.

Surface run-off is the relative rate at which water is removed by flow over the surface of the soil and it can be recorded in the following six classes:- Ponded, very slow, slow, medium, rapid, and very rapid. These classes are defined in the United States 'Soil Survey Manual' (Page 167).

Internal soil drainage is that quality of the soil that permits the downward flow of excess water through it. It is reflected in the frequency and duration of periods of saturation with water. Six classes are recognised and are defined in the United States 'Soil Survey Manual,' (Page 169). They are none, very slow, slow, medium, rapid, and very rapid.

Soil permeability is that quality of the soil that enables it to transmit water or air. It can be measured quantitatively but it may also be gauged in the field by considering structure, texture, porosity, cracking, and other characteristics of the soil horizons in relation to local experience. It is a valuable aid in predicting how much the drainage can be improved. Thus, a rapidly permeable sandy soil and a slowly permeable clay soil may both have poor drainage because of a high water-table. If the water-table is lowered, the drainage will clearly be improved much more in the one than in the other.

Seven classes of soil permeability ranging from very slow to very rapid are given in the United States, 'Soil Survey Manual' (Page 168).

By combining these aspects of surface run-off, internal soil drainage, and soil permeability, the overall drainage of the soil under the prevailing conditions of the site can be indicated by soil drainage classes derived by assessing the rate at which water is removed from the soil and the time for which the soil is saturated. The following classes are reproduced, with slight modification, from the United States 'Soil Survey Manual': -

0. VERY POORLY DRAINED

The water is removed from the soil so slowly that the water-table remains at or on the surface for the greater part of the time. Soils of this drainage class usually occupy level or depressed sites and are frequently ponded. They commonly have peaty surface layers and grey subsoil colours or other evidence of gleying. An example is the Linau Series.

1. POORLY DRAINED

The water is removed so slowly that the soil remains saturated for a large part of the time. The water-table is commonly at or near the surface during a considerable part of the time. Poorly drained conditions are due to a high water-table, a slowly permeable soil, seepage or to some combination of these conditions. Grey gley colours predominate in the subsoil but reddish, brownish or yellowish mottles are common in the upper horizons. Undeveloped Selangor Series provides an example of this state of drainage.

2. IMPERFECTLY DRAINED

The water is removed from the soil slowly enough to keep it wet for significant periods but not all of the time. Imperfectly drained soils commonly have a slowly permeable layer within the profile, a high water-table, additions through seepage or a combination of these conditions. Reddish, brownish and yellowish mottles normally penetrate well into the subsoil but the grey gley colours are still present at depth, as in the Briah Series.

3. MODERATELY WELL DRAINED

The water is removed from the soil somewhat slowly so that the profile is wet for a small but significant part of the time. Moderately well drained soils commonly have a slowly permeable layer within or immediately beneath the solum, a relatively high water-table, additions of water through seepage, or some combination of these conditions. Reddish, brownish, yellowish and greyish mottles are common in the subsoil. Akob Series is an example of a moderately well drained soil.

4. WELL DRAINED

The water is removed readily but not rapidly from the soils which consequently are not wet for a significant part of the time although they commonly retain near optimum amounts of moisture for lengthy periods. Well drained soils are commonly intermediate in texture although soils of other textural classes may also be well drained. Serdang Series is a good example of a well drained soil.

5. VERY WELL DRAINED

The water is removed from the soil rapidly and many of these soils have little horizon differentiation. They are sandy and very porous, as for example the Telemong Series.

6. EXCESSIVELY DRAINED

The water is removed from the soil very rapidly and little is retained. Excessively drained soils are commonly sandy and may be steep, very porous, or both. Shallow soils on slopes may be excessively drained. Jambu Series is a Malayan example of an excessively drained soil.

Confusion sometimes arises between the natural drainage of the soil under primitive conditions and the present state of drainage induced by man. In order to understand clearly the changes that are taking place, both conditions need to be considered.

For the purposes of the schematic-reconnaissance survey, indication of the soil drainage class alone is sufficient, but for detailed studies the permeability and the internal and external drainage may need to be described.

VEGETATION

Malaya is a forested land, and at first glance vegetation seems too uniform a factor to have much impact on the soil pattern. This is essentially true when the separation of soils is being carried out on a schematic-reconnaissance scale. But there is evidence which suggests that vegetation/soil inter-relations do exist in detail. (See Wyatt-Smith 1964, page 203; Libby 1964, page 10)

Furthermore, vegetation is an important environmental factor and the recording of vegetation type should be an integral part of soil survey operations. A useful description of the main vegetation types found in Malaya is outlined by Wyatt-Smith (1964), and the salient points of this are reproduced below for the guidance of soil surveyors in the field.

For ease of reference the types are arranged in three groups, namely: -

1. Lowland (dryland) vegetation.
2. Hill and mountain vegetation.
3. Swamp and low-lying vegetation.

1. LOWLAND (DRYLAND) VEGETATION

a. *Primary Forests*

The primary lowland forests are usually dense though comparative freedom of movement on the ground is possible. They are composed of many thousands of species of trees as well as shrubs, herbs, and woody climbers. The upper or emergent storey is usually about 100 to 150 feet (about 30 to 45 metres) high, though trees nearly 200 feet (about 60 metres) in height are often present. This storey is often discontinuous. The main storey or second tree layer which occupies a region of about 70 to 100 feet (about 20 to 30 metres) from the ground forms a continuous canopy, except immediately below the large emergent storey trees. The under storey or third tree layer consists of segments of the upper two storeys together with members of other families. The density of the shrub layer varies from very thick and dense to open. It contains young saplings of larger trees, shrub species, and palms. The herb layer consists mainly of young seedlings of the other layers and lianas with some ferns near streams and in moist valleys. Epiphytes are usually very poorly represented. There is usually a comparatively poor layer of litter though fallen leaves often cover the forest floor. Certain broad and rough divisions of the lowland dipterocarp forest can be made on the basis of the larger economic trees.

(1) Balau Forests

These forests are mainly found in North Johore, East Negri Sembilan, West Pahang, and North Trengganu. They are characterised by a high percentage of the Balau or heavy hardwood group of *Shorea* of which *S. atrinervosa*, *S. excelliptica*, and *S. maxwelliana* are the most common. *Dipterocarpus* spp. and species of the Red Meranti group of *Shorea* are also frequently present.

(2) Beach Forests

These form a very narrow strip of woodland rarely more than 20 to 40 yards (18 to 36 metres) wide and frequently less along the sandy or gravelly beaches of the coast above the level of all but the highest tides.

They occur along much of the length of the East Coast although often in a disturbed form, but they are comparatively rare along the muddy shores of the West Coast where mangrove forests predominate and where most of the sandy and gravelly beaches which do exist have been developed or greatly disturbed by man.

Along the accreting sandy beaches, *Casuarina equisetifolia* is the predominant species. Species of *Calophyllum, Cycas, Desmodium, Eugenia, Pandanus, Planchonella, Scaevola* and *Terminalia* also occur. Along the receding and the gravelly beaches, notably on the West Coast, the Casuarina fringe is replaced by a narrow belt of trees among which species of *Barringtonia, Calophyllum, Cerbera, Desmodium, Hibiscus, Pongamia, Scaevola* and *Terminalia* are common.

This vegetation type has been destroyed in many places along the East Coast and secondary growth is allowed to return. Owing to the demand for firewood and poles, the regrowth is very shrubby, and scrambling shrubs and woody climbers predominate. The shrub, *Rhodomyrtus tomentosa*, is particularly common.

(3) Chengal Forest

Balanocarpus heimii or Chengal characterises this forest, and is Malaya's best known hardwood, occurring in many parts of the country. However, it is absent from North-west Malaya and Malacca, and poorly represented in much of Central Malaya and Johore. The species is found in most types of lowland and hill Dipterocarp forest but is specially common in the Bukit Goh area and the Lepar Forest Reserve of East Pahang, and in most reserves of West Pahang. It is also found in some parts of the eastern foothills in Negri Sembilan, some foothill reserves of Selangor, and North-east Malaya, and in some foothill and lowland reserves in Perak apparently preferring a rich soil.

(4) Damah Laut Merah Forest

This forest is characterised by the presence of *Shorea kunstleri* (Damah Laut Merah) which is particularly common in many of the forests in foothills of South Kedah, North Perak, East Kelantan, Trengganu, and north of the Pahang River in East Pahang.

(5) Heath Forest

Along the East Coast, a clear pattern is frequently revealed of strips of high forests inter-spaced with strips of shorter vegetation, the strips running, in general, parallel to the present coast line. This high forest is growing on old sandy beach ridges occupied largely by Rudua soils (Panton, 1958, page 29).

This type of forest was formerly, it is believed, very extensive along Malaya's East Coast and of local occurrence along the West Coast but it has largely been destroyed. A small area, however, still remains in the northern part of Tanjong Hantu Forest Reserve in the Dindings on the West Coast, and two accessible areas are known to remain along the East Coast — Jambu Bangkok Forest Reserve north of Dungun in Trengganu and Menachali Forest Reserve in the Rompin District of Pahang. All three areas however have been subject to disturbance. When the forest is clear felled, the secondary regrowth is that of very open scrub. This scrub degrades to an open grassland of tufted grasses or parkland with a few scattered trees or shrubs. The commonest of these trees and shrubs are *Fagraea fragrans*, *Ploiarium alternifolium*, and *Melaleuca leucadenderon* (gelam).

(6) Kapur Forests

These forests are characterised by the presence of *Dryobalanops aromatica* (kapur) and are found in eastern Malaya usually never more than about 15 to 20 miles (24 to 32 km) inland (except in Johore) on low hills and undulating land on well drained sandy clay loam soils. The forest structure is typically three-layer but the individuals forming the emergent or upper storey are generally taller than is usual in lowland dipterocarp forests. It is usually found mixed with other dipterocarps, both *Shorea* spp. and *Dipterocarpus* spp. and, but for its presence and predominance the forest would be classified as either Red Meranti — Keruing type or Balau type.

(7) Kempas-Kedondong Forests

These forests, often of poor timber value with the tallest trees few in number and rarely exceeding 100 feet (30 metres) in height, occur mainly in the rather low-lying and flatter land between the Red Meranti-Keruing or Balau forests and the swamp forests. They are found principally in Central and Southern Perak, Selangor, and Johore where the forests appear to be associated with heavy white clays of poor nutrient status and old beach ridges. These forests are characterised by the comparative abundance of *Koompassia malaccenis* (Kempas), *Canarium*, and *Santiria* (Kedondong), *Dialium patens*, *D. reticulata* (Simpoh), *Ixonanthes reticulata*, *Madhuca spp.*, and *Palaquium* (Nyatoh) and by the relative scarcity or complete absence of Dipterocarps.

(8) Keruing Forests

On some of the less well drained land in North Johore, Central, East and South Pahang, East and West Negri Sembilan, the Kinta and Batang Padang Districts of Perak, and the northern part of Trengganu; extensive areas of forest are found characterised by *Dipterocarpus* spp. (Keruing) which are often associated with *Dryobalanops oblongifolia*, *Hopea mengarawan*, and *Shorea lepidota*. Other common species are *Koompassia malaccenis* and *Palaquium* spp. Much of the area is slightly water-logged at certain times of the year. The height of the upper tree layer is less than that in Red Meranti-Keruing forest, and this layer is frequently very discontinuous with the large trees resembling true emergents.

(9) Lowland Dipterocarp Forest

This is a general term including all the well drained primary forests of the plains, undulating land, and foothills up to an elevation of about 1,000 feet (about 305 metres) with the exception of the narrow strips of beach forests.

(10) Merbau-Kekatong Forest

This type is found in the foothills of the Main Range, principally in North Malaya, and is usually very deficient in Dipterocarps and other economic tree species. It is characterised by *Intsia palembanica* (Merbau) and *Cynometra inaequifolia* (Kekatong). *Sindora* species are also frequently present.

(11) Nemesu Forest

Shorea pauciflora (Nemesu) occurs throughout the Peninsula, except Perlis, but it is particularly common in undulating country and the foothills of North Malaya where it frequently characterises the forests.

(12) Red Meranti – Keruing Forests

These forests are mainly found in South Perak, Selangor, Negri Sembilan, Malacca, North and Central Pahang, South Kelantan, and Central Trengganu. They are characterised by a high percentage in the upper storey of species of the Red Meranti group of *Shorea*, and of species of Dipterocarpus. The shrub and sapling layer is usually open with the palms, *Eugeissona triste* (mainly west of the Main Range), and the shrub or woody scrambler, *Agrostistachys* spp. often locally common.

(13) White Meranti — Gerutu Forests

These forests have a predominantly Burmese flora and are found where there is a distinct annual dry season of about two months. They are characterised by: -

(a) the absence of the Red Meranti and Damah Hitam groups,
(b) the paucity of the Balau group, and
(c) the relative abundance of the White Meranti group of the genus *Shorea.*

Parashorea lucida (Gerutu-gerutu) is perhaps the commonest of a group of characteristic Dipterocarps. These forests occur on the flat lands of the extreme north-west of Malaya (Perlis and North-west Kedah) and at a slightly higher elevation on hill slopes, and low ridges farther south in North-west Kedah, Upper Perak, and North Kelantan.

b. *Secondary forests*

The lowlands of Malaya have been subject to much destruction by storms, floods, shifting cultivation, and rapid development during the past century. Secondary forest is often induced as a consequence of this disturbance, and the following is an outline of the commonest species which occur: -

Trema spp. are the most prominent early pioneer species on gently undulating land, deforested and cultivated for one or, at the most, two years before being abandoned. They are generally followed by species of *Macaranga, Mallotus, Ficus,* and *Glochidion*. If the land is cultivated for several years before being abandoned and the soil fertility is thoroughly exhausted, a

Melastoma-Eupatorium-Gleichenia scrub develops. This community readily burns and is soon converted into almost pure *Imperata* grassland (lallang). In South Malaya on degraded land a woody community dominated by *Adinandra dumosa* often develops, and once established it appears to be maintained by periodic ground fires. On foothill slopes banana-ginger thickets and in the valleys of the Main Range, bamboo groves commonly arise after shifting cultivation by aborigines.

In North-west Malaya, much of the area formerly covered by White Meranti — Gerutu forests has long been subject to shifting cultivation and the original vegetation has given way to a type characterised by the trees, *Schima noronhae* and *Shorea talura;* and the bamboos, *Gigantochloa latifolia*, and *G. ligulata*.

2. HILL AND MOUNTAIN VEGETATION

Vegetation types in this category occur on the inland ranges above an altitude of 1,000 feet (305 metres). Because they occur mostly on steepland terrain they are not of immediate interest to the schematic-reconnaissance survey, and this discussion is therefore confined to listing the classes separated by Wyatt-Smith on page 208, 209, 210 of the article already quoted. The classes are: -

1. Hill Dipterocarp Forests,
2. *Agathis alba*,
3. Coastal Hill Forests,
4. Limestone Vegetation,
5. Montane Ericaceous Forests,
6. Upper Dipterocarp Forests,
7. Vegetation of quartz dykes, quartzite ridges and other sterile habitats with severe drainage or lacking available moisture.

3. SWAMP AND LOW-LYING VEGETATION

1. *Fresh Alluvial Swamp or Lopak Forests*

The surface of the land covered by these forests is semi-permanently submerged in mineral-rich fresh water. Though a few inches of peat or muck may occur, they should not be confused with peat swamp forests which grow on deep peaty layers entered only by rain water, and which have a restricted and specialised flora. These Lopak forests are found throughout Malaya under a wide environmental range. Accordingly, their floristic composition and structure vary enormously. Stilt roots, knee roots, and plank-like sinuous buttresses are found in some species but are not a feature of these forests. Single species often predominate over large areas, for instance, sedges, screw pines, rattans, palms, in the Rompin District on the East Coast, the Sungei Tinggi area of Selangor, and the Tasek Bera area of South-west Pahang.

2. *Gelam Forests (secondary)*

As a result of felling, cultivation, burning or alteration of the natural drainage, many seral and sub-seral communities evolve on land that once bore swamp forest. The most important is Gelam Forest. This consists of *Melaleuca leucadendron* often associated with *Ploiarium alternifolium*, both occurring as scattered trees in the swamp forest found between old beach ridges, or more characteristically on the seasonally wet swamps of coastal flats behind the sandy beaches and mangroves of Kedah, Malacca, Negri Sembilan, Kelantan, and Trengganu.

3. *Marine Alluvial (mangrove) Swamp Forests*

These forests are confined to muddy shores, lagoons, and the estuaries of tidal rivers. They cover an overall area of about 350,000 acres (141,400 hectares) in Malaya, almost all of which is along the sheltered West Coast, mainly in the States of Perak, Selangor, and Johore. Along the

East Coast they are found within the mouths of tidal streams. Some of the principal tree species which are found nowhere outside these habitats are *Rhizophora*, *Avicennia*, *Bruguiera*, *Sonneratia*, and *Xylocarpus*.

4. *Peat Swamp Forests*

These forests are of a very special type found on peats ranging from a few feet to about 20 feet (6 metres), in thickness, immediately behind the coast, principally, of Central and Southern Malaya. These peats evolved in permanently water-logged and anaerobic habitats where the only incoming water from rain is deficient in minerals and very acid. The forests have a three-layered tree structure. This comprises a broken upper or emergent layer, often reaching a height of 100 to 120 feet (30 to 36 metres) and frequently very open and discontinuous; and a fairly continuous under storey of considerable depth usually ranging from 30 to 60 feet (9 to 18 metres) above the ground or peat surface. Where there is standing water, there is frequently a dense thicket of stemless palms; otherwise the shrub layer is, in general, rather sparse. Ground flora is comparatively poor. There are generally few species in this vegetation type and they are not normally found outside the peat swamp environment. After clearing and cultivation an almost pure stand of *Macaranga maingayi* develops as an early sub-seral stage in the secondary succession.

5. *Riparian Fringes*

Numerous vegetation types occur as narrow strips along the banks of estuaries, rivers, and streams throughout the country. Their width varies greatly depending on the terrain. Their composition and hence their structure also vary and depend on tidal influence, the rate of water flow, the elevation, the width of the river, the nature and aspect of the terrain, and the enrichment of the site by water or silt. At the mouths of rivers where saline influence is strongest are the mangroves which have already been described. Further upstream where the water is brackish, *Nipa fruticans* usually lines the banks especially those of larger and wider rivers. Still further upstream where the water is tidal but no longer brackish is found *Rassau (Pandanus helicopus).* Beyond tidal influence, occur the "gallery forests" of which those in Kelantan, Pahang, and Trengganu with *Dipterocarpus oblongofolius* are the most picturesque. In North Malaya, *Hopea odorata* plays a similar role; while in abandoned or seasonally occupied river beds of the East Coast in which heath forest grows, several species characteristic of peat swamp forest are found. In the foothills where the rivers become narrower, more rocky, and faster flowing, the characteristic component of the riparian fringes is *Saraca* species. Some bamboos *(Dendrocalamus pendulus, Schizo-stachyum gracile, Gigantochloa scortechinii)* are common in the larger valleys of the Main Range.

The following Table summarises these Malayan vegetation types: -

TABLE II

MALAYAN VEGETATION TYPES

Lowland (dryland) Vegetation	Hill and Mountain Vegetation	Swamp and Low-lying Vegetation
a. Primary Forest 1. Balau Forests 2. Beach Forests 3. Chengal Forests 4. Damah Laut Merah Forest 5. Heath Forest 6. Kapur Forests 7. Kempas Kedondong Forests 8. Keruing Forests 9. Merbau-Kekatong Forest 10. Nemesu Forest 11. Red Meranti—Keruing Forest 12. White Meranti—Gerutu Forest b. Secondary Forest	1. Hill Dipterocarp Forests 2. *Agathis alba* 3. Coastal Hill Forests 4. Limestone Vegetation 5. Montane Ericaceous Forest 6. Upper Dipterocarp Forest 7. Vegetation of sterile habitats.	1. Fresh Water Alluvial Swamp or Lopak Forests 2. Gelam Forests (secondary) 3. Marine Alluvial (Mangrove) Swamp Forests 4. Peat Swamp Forests 5. Vegetation of the Riparian Fringes.

The expression of environmental characteristics on the ody of the soil is studied by examining the soil profile — vertical section through the soil from the surface to the nderlying parent material.

"Descriptions of a soil profile should be as objective as ossible and should be supplemented by interpretations of enetics. To keep the objective and interpretative descript-ons in clear perspective, so that one is not confused with he other, is not so easy as it might seem. Even in the irst breakdown of a soil profile into horizons, the pedologist s interpreting the profile, selecting the boundaries that appear nost significant and considering the genetic relationships of he horizons. However, there is no substitute for good objective descriptions of the soil. These are the very basis of pedology. They become increasingly valuable as more and more laboratory information becomes available on col-lected samples, and without them the laboratory information loses much of its value." (Taylor and Pohlen, 1962 p. 67)

In Malaya in the past, the standard of profile descriptions has been a little uneven due, in part, to the mixed back-grounds and purposes of the people describing the soil. Many countries have faced this situation in what is still a youthful science, and have resolved it by setting up fairly rigid standards or accepting those already applied in other survey organizations, by which individual features of each horizon of the soil profile are described. In the absence of a Malayan manual, the practice generally has been to adopt the standards outlined in the United States. 'Soil Survey Manual.' Without some such standardization, there is little scientific point in indulging in the time-consuming and, in the tropics, often uncomfortable exercise of describing a soil, because the information cannot readily be correlated with other soil descriptions. This, then, is a plea to soil surveyors and to others who may feel the urge to describe soils to adhere to the standards set out in this section, because they have been set up especially to suit Malayan conditions, and they have been found acceptable by a majority of soil surveyors with Malayan experience.

1. THE SOIL EXAMINATION PIT

Ideally, full profile descriptions should be taken from freshly dug soil examination pits. Roadside cuttings may be used but should always be regarded with a certain suspicion because they may express features which have been artificially induced, and also because the drying out of the soil which usually accompanies such excavations may obliterate some natural features and accentuate others. It is rarely possible to obtain a satisfactory full profile description from auger borings because the bulk of material is not sufficient and the soil is invariably disturbed. Both roadside cuttings and auger borings are, of course, extremely valuable diagnostic tools to be used in soil mapping.

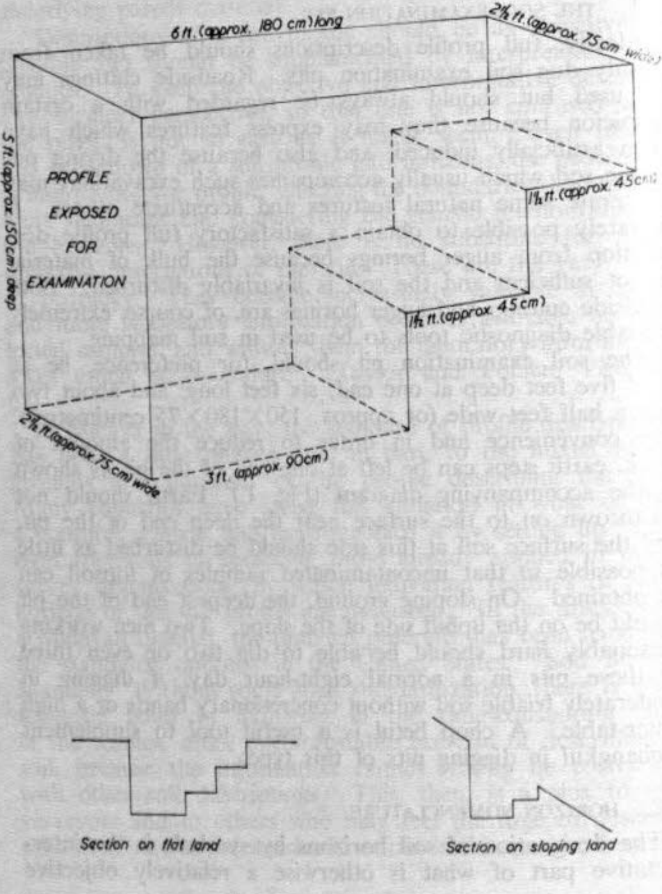
The soil examination pit should, for preference, be at least five feet deep at one end, six feet long, and about two and a half feet wide (or approx. 150×180×75 centimetres). For convenience and in order to reduce the amount of work, earth steps can be left at one end of the pit as shown in the accompanying diagram (Fig. 1.) Earth should not be thrown on to the surface near the deep end of the pit, and the surface soil at this side should be disturbed as little as possible so that uncontaminated samples of topsoil can be obtained. On sloping ground, the deepest end of the pit should be on the uphill side of the slope. Two men working reasonably hard should be able to dig two or even three of these pits in a normal eight-hour day, if digging in moderately friable soil without concretionary bands or a high water-table. A chop betul is a useful tool to supplement a changkul in digging pits of this type.

2. HORIZON NOMENCLATURE

The designation of soil horizons by symbols is the interpretative part of what is otherwise a relatively objective

FIGURE 1

SOIL EXAMINATION PIT



description. The profile description is more useful if interpretative designations are employed to indicate the genetic relationships of the horizons. It should be stressed, however, that the common designations for horizons by letters are interpretations additional to the description and are not a substitute for it. They are understood to be a matter of probability not of certainty. Many systems of soil horizon designation are in use, including those outlined in the United States 'Soil Survey Manual,' in Soil Classification (Soil Survey Staff, 1960), by Whiteside (1959) and by the Canadian Soil Survey (National Soil Survey Committee of Canada, 1963). It has been found in practice that none of these are wholly applicable to or suitable for Malayan conditions and so a new system is proposed here to cater for the salient features of Malayan soils. This system has been derived, with a little modification, by selecting pertinent features of each of the systems mentioned above. The master horizons are relatively unchanged and are essentially as outlined in the United States, 'Soil Survey Manual.' They are designated by capital letters. The sub-horizons are not designated by numbers but are identified by lower case letters selected from three sources, namely Whiteside (1959), the Canadian Soil Survey System (National Soil Survey Committee of Canada, 1963) and Soil Classification (Soil Survey Staff, 1960). This was done to escape the connotations which are probably inseparable from a system using numbers.

The following is the system employed in Malaya:-

(1) *Master Horizons*

O horizon This is a master horizon of organic material above the surface of the mineral soil.

A horizon The A horizon is a master horizon consisting of surface mineral horizons with maximum organic accumulation; or of surface or sub-surface horizons that are lighter in colour than the underlying horizon and have lost clay minerals, iron and aluminium with consequent concentration of more resistant minerals; or of horizons belonging to both these categories.

B horizon The B horizon is a master horizon of altered material characterised by more or less block-like or prism-like structure together with other characteristics such as stronger colours which differ from those of the A horizon above or the C horizon below; or by an accumulation of clay, iron or aluminium with accessory organic material; or by characteristics of both these categories.

C horizon This is a master horizon embracing the relatively unweathered parent rock and the weathered material above this which is the parent material of the soil.

D layer This is any stratum underlying the C, or the B if no C is present, which is unlike the C, or unlike the material from which the soil has been formed. Weathered shale underlying Older Alluvium could be designated as a D layer.

(2) *Sub-horizons*

Definitions of the lower case letters used to identify sub-horizons and the source from which they were taken are given below. In some cases these definitions have been modified a little to accord more closely to Malayan conditions.

c — *c*emented, *c*onsolidated and indurated even when moist. This embraces unaltered rock (Whiteside, 1959).

cn — accumulations of *con*cretions or hard non-concretionary nodules rich in sesquioxides (Soil Survey Staff, 1960).

d — accumulation of *d*ead, undecomposed organic material in which the organic structures are clearly visible (Whiteside, 1959).

e — a horizon characterised by the removal of clay, iron, aluminium, or humus usually lighter in colour and texture than the layer below. The *e* stands for *e*luviated (National Soil Survey Committee of Canada, 1963).

f — accumulation of partially decomposed plant material (Whiteside, 1959). The *f* stands for *f*ermented.

g — a gleyed layer in which both mottles and grey gley colour are present (National Soil Survey Committee of Canada, 1963).

h — a horizon relatively enriched with *h*umus in which very few or no plant structures are recognisable (Whiteside, 1959; National Soil Survey Committee of Canada, 1963).

i — concentration of *i*ron oxide usually finely disseminated (Whiteside, 1959).

j — a horizon whose characteristics are weakly expressed, from *j*uvenile (National Soil Survey Committee of Canada, 1963). The letter will be used almost invariably with one of the other sub-horizon designations as a modifying adjective, e.g. a weakly developed Ae horizon would be Aej.

m — residual concentrations of *m*inerals from the primary material. The original rock structure is not recognisable (Whiteside, 1959).

p — *p*loughed, *p*uddled or other layers whose properties have been strongly influenced by man's activities (Whiteside, 1959).

r — a *r*eduction horizon where the characteristic colours are grey, grey-green, or grey-blue. No mottles are present. (Whiteside, 1959).

t — a concentration of silicate clay taken from the English word, *t*exture; and the German word, *t*on (National Soil Survey Committee of Canada 1963, Whiteside 1959).

u — *u*nconsolidated, *u*ncemented materials relatively *u*naltered by weathering and other soil-forming processes. The rock structure is discernible (Whiteside, 1959).

v — horizons whose characteristic properties are prominently developed. The v is derived from *v*igour. (Whiteside, 1959). This letter will be used mainly to qualify another sub-horizon designation, e.g. a strongly developed Bt horizon would be Btv.

(3) *Transitional horizons*

In many Malayan soils, horizon properties are not developed strongly enough to justify certain identification as one or other of the master horizons. In this case, the following transitional horizons may be used:-

AB — a horizon transitional between A and B having an upper part dominated by properties of the A, and a lower part dominated by properties of the B.

AC — a horizon transitional between A and C having subordinate properties of both A and C but not dominated by properties characteristic of either A or C.

BC — a horizon transitional between B and C with properties of the B dominant in the upper part, and properties of the C dominant in the lower part.

(4) *Buried horizons*

Fossil soil horizons which have been buried by colluvial or alluvial material are commonly not very well preserved in most Malayan soils. However instances do occur, particularly on recent alluvium, where such horizons can be readily identified, and in such cases the subscript letter *b* may be appended to the genetic designation to indicate *burial* e.g. the Akob Series may have an Ahb horizon between 2 and 3 feet (60—90cm) from the surface.

3. HORIZON IDENTIFICATION

The identification of horizons is one of the more demanding aspects of the soil surveyor's profession. He must use his judgment and experience to interpret the evidence before him in terms of soil genesis. He can obtain assistance in some cases from laboratory analyses, but in practice he must make the final decision in the field. The following notes on the identification of the horizons most commonly present in Malayan soils are designed to supplement the judgement and experience of individual soil surveyors: —

Od horizon — This is the upper part of the litter layer in which the original form of most plant matter is discernible by the naked eye. It consists, in Malaya, of a very thin layer of dead leaves, twigs, etc. It corresponds to the 0_1 horizon which has been used previously.

The Of horizon — This is the lower part of the litter layer which once again is commonly very thin in Malaya and consists of decomposed plant material in which the original form of the plants cannot be recognised with the naked eye. This was previously called the 0_2 horizon.

The Ah horizon — This is the humus-stained topsoil which in most Malayan soils is only a few inches thick and which in the past has been referred to as the A_1 horizon.

The Ag horizon — This is a gleyed horizon, characterised by grey, red, brown, or yellow mottling, and lying in an A horizon position.

The Ap horizon — This is a horizon which has been disturbed by man's activities and which generally has a mixed appearance.

The Ae horizon — This is the horizon of maximum eluviation which is most commonly identified by comparison with the B horizon below. It is lighter in colour and texture than the underlying B and is usually more porous, more weakly structured and has a more friable consistence, but these latter three features are not invariable. A few clay-skins may be present but they are not nearly as abundant as they are in the underlying horizon. This was the A_2 horizon. Weak development can be indicated by using Aej and similarly, strong development should be noted by using Aev.

The Bt horizon — This is the horizon of maximum illuviation which is enriched in clay and usually also in iron, aluminium or humus. Clayskin development is at its strongest in this horizon and normally structures are strongly developed or more strongly developed than structures above and below. Quite commonly, consistence is firmer than that above, and the colour is deeper. This horizon was formerly known as the B_2 horizon although the concept has been narrowed slightly and now emphasises the enrichment of clay. This horizon corresponds in most aspects to the argillic horizon defined in 'Soil Classification' (Soil Survey Staff 1960, p. 44), and the analytical criteria used there to distinguish between an argillic and the overlying eluvial horizon can be employed here. In such a horizon the ratio of the clay content of the eluvial (Ae) horizon and illuvial (Bt) horizon is 1.2 or larger, if the A has more than 15% and less than 40% clay in the fine earth fraction. If the A has more than 40% clay, the argillic horizon must contain at least 8% more clay than the A. This criterion seems to apply well to Malayan soils. For instance, the ratio of clay in the Ae and the Bt horizons of the Rengam Series (A horizon clay content about 24%) from a large number of samples is 1.4, and in this Series these two horizons are normally well developed and easily recognisable. In contrast in the Segamat Series where A horizon clay content is about 80%, the B horizon figure is the same, or only 2 or 3% higher, and in this series an illuvial B horizon is not present. In this example, the figures for clay content were taken from the arbitrary depths of 1-6″ (about 2—15cm) and 12-24″ (about 30—60 cm). Strong and weak development of the horizon should be indicated where applicable by using Btv and Btj.

The Bi horizon — This is the B horizon where the enrichment is predominantly with iron oxides, normally disseminated throughout. These oxides impart characteristic red colours, strongly developed structures, and friable and very friable consistence. Clayskins are very rare although there are some coatings which under the hand lens appear to have a metallic glint and which, in fact, may be illuvial or weathering coatings of oxides. In some respects, this horizon is similar to the oxic horizon defined in 'Soil Classification' (Soil Survey Staff 1960) and it has been identified as an A_3, B_3 or even B_2 horizon in the past. Strong and weak development can be indicated by using Biv and Bij.

The Bcn horizon — This is the horizon where concretions are common. They are normally lateritic or bauxitic, comprise more than 50% of the horizon, and vary in size, and shape and abundance.

It is possible to have an Acn or Ccn horizon because the concretions need not necessarily be formed in place, and also they may be fragments of parent material impregnated with sesquioxides.

The Bg horizon — This is a gleyed horizon in a B horizon position which is characterised by grey, red, brown and yellow mottles, and which usually has a higher content of clay and therefore a heavier texture than the overlying horizon.

The Br horizon — This is a horizon in which gleying excludes most other soil-forming processes. The characteristic colours are grey, grey-green, or grey-blue and the horizon may be sulphurous.

The Cm horizon — This is the horizon where the chemical weathering of the parent rock is dominant. It does not have features of the B horizon and is characterised normally by weak structures and lack of clayskins. Residual minerals such as quartz, and in some cases, feldspar and mica commonly occur in this horizon but these are the only vestiges of the original parent rock.

The Cu horizon — This horizon is characterised by ghost structures of the parent rock. The rock is not indurated or cemented and is normally soft and easily broken, but the original structure is readily apparent.

The Cc horizon — This is the virtually unaltered indurated parent rock.

In some cases it may be useful to combine two or more sub-horizon notations, as for instance in the case of a weakly developed illuvial B horizon with a few (less than 50% of the horizon) concretions. This could be designated Btjcn. In such instances the subscript letter immediately following the master horizon symbol always indicates the dominant sub-horizon properties.

The following hypothetical profile description illustrates the correlation between the old horizon symbols and the new horizon symbols: —

TABLE III

HYPOTHETICAL PROFILE DESCRIPTION

OLD HORIZON SYMBOL	NEW HORIZON SYMBOL	PROFILE
0_1	Od	1-0″ (2.5-0cm) dead leaves or twigs.
A_1	Ah	0-5″ (0-13cm) 2.5YR5/4 light olive brown, sandy clay loam with a weak fine crumb and subangular blocky structure, friable consistence, few fine quartz fragments, abundant animal casts, many pores, indistinct boundary.

(cont'd) HYPOTHETICAL PROFILE DESCRIPTION

OLD HORIZON SYMBOL	NEW HORIZON SYMBOL	PROFILE
A_2	Ae	5-16″ (13-41cm) 2.5Y7/6 yellow clay loam, moderate medium subangular blocky structure, friable to firm, many quartz fragments, few pores, few to many roots, indistinct boundary.
AB	Acn	16-20″ (41-51cm) yellow clay loam matix with abundant subangular to rounded laterite concretions, boundary sharp.
B_2	Bt	20-30″ (51-76cm) 2.5Y7/8 yellow clay, moderate fine angular blocky structure, very firm, discontinuous clayskins colour 2.5Y6/4 light yellow brown, few pores, boundary indistinct.
B_3	Btj	30-40″ (76-102cm) 10YR5/8 yellowish brown clay, weak fine angular blocky structure, firm consistence, infested with termites, few pores, patchy 2.5Y7/4 pale yellow clayskins, boundary indistinct.
C_1	Cm	40-56″ (102-142cm) 10YR6/6 brownish yellow clay, weak medium and fine angular blocky structure, friable consistence, few pores, patchy clayskins, many distinct vertical streaky 2.5YR5/8 red mottles, many large quartz grains, boundary distinct.
C_2	Cu	56-71″ (142-180cm) variegated coloured soft clay in which rock structure is clearly visible.
	Cc	71″+ (180cm+) hard, unaltered rhyolite.

4. MAIN MORPHOLOGICAL FEATURES

Colour, texture, structure, consistence, and mottles are the main ingredients of any soil horizon, and the method of describing them has been well standardised in the literature and is generally accepted. In Malaya the description of these properties follows very closely those outlined in the United States 'Soil Survey Manual,' and the following notes are intended to supplement these: —

(a) *Colour*

Colours are described according to the Munsell system as to hue, value and chroma. The Munsell soil colour charts, which have seven charts displaying approximately 190 different standard colour chips, are used in soil survey in Malaya, and are at times supplemented by a Japanese soil colour book which contains 14 charts consisting of more than 380 standard colour chips. As far as is possible the method by which the soil colour is compared with the colour chips should be standardised, for instance, the soil should always be moist although the colour may in addition be determined when it is dry or wet. The fragment of soil should be broken away from the rest of the soil mass with minimum disturbance although again it may be desirable at times to record the colour of the rubbed soil. Each individual will develop his own personal techniques in this matter, whether it be to record the colour comparison in the shade or with direct light or indirect light shining on the fragment of soil and the colour chip, but as long as he is consistent personal error can be eliminated as much as possible. In Malaya it is often impossible to study the colour chart in comfort in bright, direct sunlight.

(b) *Texture*

Soil texture is the particle size distribution of the solid inorganic constituents of the soil. It refers specifically to particles under 2 mm. in diameter. The presence of large particles and organic constituents is recognised by qualifying the textural name accordingly. The particles are classified by diameter into four main fractions according to the International Scale as follows: —

Coarse sand	0.2 — 2 mm.
Find sand	0.02 — 0.2 mm.
Silt	0.002 — 0.02 mm.
Clay	less than 0.002 mm.

Each of these fractions imparts particular physical qualities to the soil; the sand fractions are gritty, the silts are smooth, and most clays are plastic and sticky. By judging these qualities and making allowance for differences due to the kind of clay, the amount of organic matter, and other contributory factors the soil surveyor is able to assess the relative portions of each fraction and arrive at a close approximation of the texture of the soil as determined by mechanical analysis in the laboratory.

The textural terms used to describe the results of mechanical analysis in Malaya closely follow those outlined on the textural diagrams shown on pages 84 and 85 of 'Soil Survey Method' (Taylor and Pohlen 1962) with the addition of fine sand and coarse sand. The common textural names used in the field in Malaya are gravel, very coarse sand, coarse sand, sand, fine sand, very fine sand, loamy coarse sand, loamy sand, loamy fine sand, sandy loam, fine sandy loam, very fine sandy loam, gravelly sandy loam, loam, gravelly loam, stony loam, silt, silt loam, clay loam, silty clay loam, sandy clay loam, fine sandy clay loam, very fine sandy clay loam, coarse sandy clay loam, stony clay loam, sandy clay, fine sandy clay, very fine sandy clay, coarse sandy clay, silty clay, clay, organic clay, muck, peat, mucky peat, and peaty muck. Textures that are distinctly more sandy or clayey than average for the class may be indicated by the terms light and heavy respectively.

Useful descriptions which may aid in the field identification of some of the main textural grades are given by Clarke (1957 page 64, 65). They are as follows: —

Sands

Soils consisting mostly of coarse and fine sand and containing so little clay that they are loose when dry and not sticky at all when wet.

Loamy sands

Soils consisting mostly of sand but with sufficient clay to give a small degree of plasticity and cohesion when moist.

Sandy loam

Soils in which the sand fraction is still quite obvious but which mould readily when sufficiently moist without sticking appreciably to the fingers.

Loams

Soils in which the fractions are blended so that the soils mould readily when sufficiently moist and stick slightly to the fingers. The sand fraction can still be readily appreciated.

Clay loams

The soils are distinctly sticky when sufficiently moist but the presence of sand fractions can still be detected with care.

Sandy clay loams

These soils contain sufficient clay to be distinctly sticky when moist but the sand fraction is a more obvious feature than in the clay loams.

Sandy clays

These soils are plastic and sticky when moistened sufficiently but the sand fraction is still an obvious feature. They are essentially soils in which clay and sand are dominant and the intermediate grades of silt and very fine sand are less apparent.

Clays

Soils which are very sticky when sufficiently moist and very hard when dry. In some cases the sand fractions are scarcely represented or entirely masked by the dominance of the clay, whilst in other cases a small proportion of sand can be detected with care.

Silts

Soils in which the smooth soapy feel of silt is dominant. This texture is not common in Malaya.

Silty clays

Soils which are composed almost entirely of very fine material but in which the smooth soapy feel of the silty fraction modifies to some extent the stickiness of the clay.

Silty clay loams

These are less sticky than the silty clays or clay loams but contain subordinate amounts of sand and sufficient silt to confer something of a smooth soapy feel.

Silt loams

Soils in which the fractions are blended to give moderate plasticity without being very sticky and in which the smooth soapy feel of the silt is the main feature.

A high content of organic matter tends to make both sandy soils and clay soils feel more loamy. Organic matter feels rather like silt but whereas silt leaves a smooth soapy surface when smeared between finger and thumb, organic matter tends to give a frayed appearance. The determination of textural grade is made by thoroughly working a small amount of moistened soil between the fingers and thumb. Many rough field tests are employed by individuals to provide clues to textural grade and although none of these is entirely reliable they can provide useful supplementary evidence as to the texture of the soils. Some of the better known tests are: —

(i) Small amounts of sand can be heard as well as felt if the soil is worked close to the ear.

(ii) Loams (including sandy loams, clay loams, and silt loams) will usually mould into a ball if rubbed vigorously between the palms with a circular motion.

(iii) A clay, as distinct from a clay loam, can be formed into a long thin rod when rubbed between the palms and this rod should not break easily when bent to form a ring.

(c) *Structure*

Structure is described according to the grade, size, and shape of the aggregates. These features are well defined in both the United States 'Soil Survey Manual' (Soil Survey Staff, 1951), and 'Soil Survey Method' (Taylor and Pohlen, 1962, page 93). A useful distinction can be made between a ped — a natural soil aggregate which is the basis of the soil structure — and a clod, which is a transient mass of soil moulded by disturbance such as digging.

In Malaya the commonest structural shape seems to be angular and subangular blocky with some prismatic, granular and crumb structures. Many granular structures can be described as cast granular, that is, spheroidal aggregates which are the result of animal activity in the soil, particularly earthworms. Crumb structures are not as common as may have been thought in the past. The term crumb was formerly used with a very broad meaning, but since the more specific definition of structural aggregates has become available it is restricted to describe porous peds similar in appearance to crumbs of bread. In most Malayan soils such structures are confined to the top few inches where the crumbs cling to roots. Many of them appear to consist of clusters of very tiny granules loosely bound together around roots or root hairs.

The simplest method of assessing soil structure in the field is to take a clod of soil and gently disrupt it by crushing between the hands. The grade or degree of development of the structure can be measured approximately by determining the amount of material which remains aggregated, compared to the amount of material which breaks down completely to single grains or unidentifiable clods of small size. The shape of the structure can be determined from the aggregated material and the size can be measured by picking out a well aggregated ped. The strength of individual peds is, strictly speaking, a property which is separate from the grade of structure. This can be described by using the normal consistence terms. For instance, it is possible to have a strongly developed structure, the peds of which when pressed between fingers and thumb are friable. Structureless horizons can be further qualified as either massive, if the material coheres together but does not form aggregates, or single grain as in many sandy soils which break down completely to individual sand grains.

(d) *Consistence*

Consistence is a measure of the resistance to deformation or rupture of the soil. It is described under different moisture conditions according to whether the soil is wet, moist or dry. The terms used are outlined in both the United States 'Soil Survey Manual' (page 231 ff.) and in 'Soil Survey Method' (Taylor and Pohlen, 1962 page 89 ff.) On page 234 of the United States 'Soil Survey Manual,' and page 93 of 'Soil Survey Method' cementation classes are defined. These could well be used to indicate the consistence of concretionary horizons in Malaya. In many soils the consistence of the soil mass when disturbed is different from the undisturbed consistence and may also differ from the consistence of the individual aggregates. To express fully consistence in this case, it may be necessary to determine not only the consistence of a clod removed from the soil; for example, friable, firm, etc.; but also the consistence of the mass in place. For describing this feature the terms weakly compact, moderately compact, or strongly compact may be used and they are usually assessed by digging or boring into the soil. Furthermore, the consistence of individual structural aggregates may need to be described separately, for example, peds firm.

(e) *Mottles*

Streaked, spotted or variegated* colour patterns in soil horizons are usually referred to as mottles. They are commonly but not necessarily an indication of retarded drainage. They can be described according to abundance, size, contrast, and colour as well as by shape. Standards for such descriptions are outlined in the United States 'Soil Survey Manual' (page 191ff.) and in 'Soil Survey Method' (Taylor and Pohlen, 1962, page 78 ff.). The terms used to describe texture, structure, consistence and mottles in Malaya are summarised in Appendix 2.

5. OTHER IMPORTANT MORPHOLOGICAL FEATURES

(a) *Pores and Channels*

Many tropical soils are characterised by the presence of cavities of various sizes. Most of the larger passages are probably biological in origin and mark the activities of burrowing insects and animals or channels previously occupied by tree roots. The abundance of smaller cavities

* It has been found useful in Malaya to distinguish variegated horizons from mottled horizons. A variegated horizon consists of an intermixture of two or more colours, often strongly contrasting, where no single colour is dominant so that it is difficult to nominate a matrix colour. The strongly weathered material forming the C horizon of many shale-derived soils is commonly variegated. A mottled horizon, on the other hand, commonly has a dominant matrix colour containing patterns of one or more subsidiary colours.

seems to increase directly with an increasing basicity of the parent material and is important supplementary evidence in classifying the soils.

An arbitrary size of 8 mm (most pencils are about 8 mm in diameter) is suggested here to distinguish the smaller cavities (pores) from the larger ones (channels), so that soil pores as used in Malaya are the visible cavities 8 mm. or less in diameter, and soil channels are crevices or passages greater than 8 mm. in diameter.

In future more detailed work it may be necessary to describe pore sizes with more precision, and in this case it is suggested that the standards outlined by Johnson et al. (1960, p. 319) for diameter classes (ranging from micro — less than 0.075 mm through very fine, fine, and medium, to coarse — over 5 mm) be used.

These workers also classified soil pores according to five other criteria — shape, location, orientation, continuity, and abundance. At present the attention of soil surveyors in Malaya is confined to recording the relative abundance of pores with reference to an exposed surface. The standard for this is taken from 'Soil Survey Method' (Taylor and Pohlen, 1962, page 99) and is as follows: —

Few pores — 1 to 3 per square inch (about 6.5 sq. cm)
Many pores — 4 to 14 per square inch.
Abundant pores — more than 14 per square inch.

Soil channels usually have obvious shapes and characteristics and can best be described in simple terms. Many of them are very large and in this case, the actual measured diameter and extent should be recorded.

(b) *Roots and Casts*

The presence of plant roots throughout the soil and any distinct concentration of roots in a particular horizon should be noted in the profile description. The relative abundance of roots can be described by using the terms, few, many, or abundant. It may also be useful to distinguish large roots from small roots and root hairs.

Casts are masses of soil material which have been processed by soil-dwelling animals during burrowing or in the course of normal feeding. Different animals produce distinctive casts and some of these are outlined in 'Soil Survey Method' (Taylor and Pohlen, 1962, page 51). The following is a summarised description of some of the commoner casts: —

Earthworm casts are smooth, rounded globules of intimately mixed organic and mineral matter, which are frequently aggregated together into a porous spongy mass. Amphipods, Isopods (woodlice), and Collembola (springtails) deposit small cylindrical pellets of finely divided plant debris. Some insect larvae deposit masses of long, narrow, cylindrical, humus-rich casts near the surface. Mites deposit very small, short, cylindrical pellets which are often found in small cavities or are scattered on the top of the soil. Ants roll soil into small compact balls. Wasps carry out soil and scatter it fairly widely over the surface. In normal profile descriptions it is sufficient to identify casts without specifying the animals responsible. Their relative abundance should be noted.

(c) *Clayskins*

Clayskins are films of translocated clay of varying thickness which coat structural aggregates and line pores and channels in the soil. They provide evidence of the movement of clay within the soil and can be an important criterion in classification. Under the microscope clayskins are recognised by the orientation of their particles. In the field they can, with experience, be detected with a hand lens or, in extreme cases, with the naked eye. Characteristically they are smooth coatings which may differ from the interior of the peds in colour as well as texture. Pores emerging on the lower side of a ped often have irregular lips where the clay protrudes. The surfaces of the clayskins often have an irregular shape with channels and apparent flowlines formed by running water, and if the clayskins on ped surfaces are thick the tracings of roots are often visible. Uncertainty of recognition increases if the clayskins are thin or if the matrix material has a clay texture, both conditions which are very common in Malaya. Furthermore, in soils rich in swelling clays, as many alluvial soils in Malaya are, they may be difficult to distinguish from smooth ped surfaces generated by pressure as the clay swells on wetting, and in soils rich in iron oxides thin coatings of predominantly oxide material may be confused with clayskins.

It has been found in Malaya that most clayskins are very thin and that they are most commonly found in pores, channels, and coating the faces of peds so that the description of them is made according to their continuity and to their position. The following standards are suggested: —

Weakly developed clayskins	:	Patchy clayskins on few peds and in some pores.
Moderately developed clayskins	:	Discontinuous clayskins on some peds and in many pores.
Strongly developed clayskins	:	Almost continuous clayskins on most peds and in most pores.

This provides three classes for describing the incidence of clayskins in any horizon. Clayskins are an important characteristic of illuvial horizons but are not necessarily confined to such horizons. Structureless or massive soils obviously cannot have clayskins on ped surfaces since they have no peds. The clays in the illuvial horizons of these soils are usually found as coatings on the individual sand grains. Occasional pores in these horizons persist long enough to have patchy or continuous clayskins with flowlines. Because of the turbulent flow of water down wide cracks and large channels such as are quite common in Malayan soils, clayskins might be formed by a single rain in a soil having no significant illuviation. For this reason, a Bt horizon should have clayskins on most of the structural aggregates as well as in pores and channels. It is possible also to have clayskins in the surface horizons of many Malayan soils and this probably indicates a fairly rapid rate of erosion at that particular site, the clay-skins being relics from a former illuvial horizon. Brewer (1960) has given a comprehensive description of colloidal coatings and related features, which he calls cutans.

(d) *Stones and Concretions*

Gravels, stones, and boulders of geological and pedological origin are common in Malayan soils. They should be described according to shapes, (rounded, angular, subangular, etc.) identification, size, and abundance. The following standards are suggested for size and abundance: —

Size

Gravel — Individual particles are less than 10 mm. (2/5 of an inch) in greatest diameter. A ready field test is provided by the fact that it is easier to throw a handful rather than individual particles.

Stones — The diameter of stones ranges from 10 mm. to 200 mm. (2/5 of an inch to 8 inches) and it is easier to throw a single stone than a handful of stones.

Boulders — The diameter of a boulder is greater than 200 mm (8 in.) and it is not at all easy to throw a boulder.

Abundance (modified after Taylor & Pohlen, 1962, p. 88)

Slightly stony, gravelly or bouldery.........Less than 10% of exposed area consists of stones, gravel or boulders.

Stony, gravelly or bouldery.........10—30% stones, gravel or boulders.

Very stony, gravelly or bouldery.........More than 30% stones, gravel or boulders.

(e) *Laterite*

Laterite in one form or another is a very common feature of Malayan soils. If is, of course, an extremely well documented substance(e.g. Sivarajasingham et al. 1962; Panton, 1956) but these notes are intended to standardise the methods of describing laterite in the field. A detailed discussion concerning its origin and genetic significance is considered inapproporiate to this Manual.

The term laterite is widely used in Malaya, as in many other parts of the tropics, particularly by agriculturists and engineers, as well as by soil surveyors, and in view of the different connotations given to the simple definition that laterite is a hard, iron-rich material found in soils, it is necessary to define further what is meant by this term when used in soil surveys. In brief, it is equivalent to indurated, or hardened plinthite as defined in 'Soil Classification' (Soil Survey Staff, 1960, p. 62).

Plinthite, according to the American definition, is "the sesquioxide rich, humus poor, highly weathered mixture of clay with quartz and other diluents, which commonly occurs as red mottles......" Red mottles conforming to this definition are very common in the lower horizons of many Malayan soils, particularly in the heavier textured sedentary soils, where the mottled or plinthite horizon may also contain, or be overlain by a horizon containing, small laterite (indurated plinthite) concretions.

Gradations between profiles conforming to the above description and profiles having massive laterite (indurated plinthite) horizons which are underlain by strongly mottled or variegated horizons, and which have a diffuse boundary between the two horizons are extremely common, and a genetic relationship between mottles of this type (non-indurated plinthite) and laterite (indurated plinthite), which forms as a result of a gradual increase in iron content within and around the mottle nucleus, is suggested by the field evidence.

Some of the forms of laterite found in Malayan soils, and suggested terms for them are given below: —

1. **Nodular laterite** — This consists of rounded or subrounded individual concretions which are not cemented together. They are mostly hard and brittle

and occur most commonly in B horizons although they are found in A horizons and in some places on the surface. Individual pieces of nodular laterite in the A horizon are commonly corroded into essentially rounded but irregular shapes.

2. **Massive laterite** — This consists essentially of nodular laterite cemented into a coherent mass. It most commonly occurs in the B horizon but in many places occupies the whole profile from the surface to depths as great as 15 to 20 feet (about 4.5 to 6 metres).

3. **Laterised parent material** — This comprises the underlying rock which is impregnated or coated with iron. The structure and texture of the rock can still be discerned. This material is normally confined to the C horizon.

4. **Fragmental laterite** — This includes angular or subangular fragments of laterite or laterised parent material which probably originated as one or other of the three forms described above. It occurs indiscriminately throughout the profile and has almost certainly been transported away from the place where it was formed.

The cementation of lateritic horizons is a very important property in terms of plant growth and should always be described. The following scale can be used: —

Weakly cemented — The cemented mass is brittle and hard but can be broken in the hand.

Strongly cemented — The cemented mass is brittle and too hard to be broken in the hand, but is easily broken with a hammer.

Indurated, very strongly cemented — Brittle and is so extremely hard that a sharp blow with a hammer is required to break it and the hammer generally rings as a result of the blow.

Other features of laterite which should be recorded are the thickness of the horizon containing laterite, the depth below the surface at which it occurs, (these two particularly apply in the case of massive laterite), and the presence of bauxite which can be distinguished by its yellowish white or pink colour.

(f) *Stone Lines*

Layers of stones within the soil profile are a common feature in many Malayan soils, and the characteristics of many of these lines suggests that they are not residual features of the rock from which the soil is derived, but are pedologic in origin.

These lines normally consist of angular or subangular fragments of vein quartz, quartzite, iron-stained shale, granite, or rounded concretions of laterite (limonite), or mixtures of two or more of these components. The fragments can vary in size from small pebbles to medium-sized boulders, and considerable differences in size and angularity of the stones can occur in any one stone line. They are normally only a few inches in thickness, and not uncommonly consist of only one layer of stones. In some cases the stones may be several inches apart so that the line is broken and discontinuous. Stone lines may occur from within a few inches of the surface down to depths of several feet, but they are not found in the parent material horizons. They normally run parallel, or nearly parallel, to the surface, and in rare instances can be seen to outcrop on the surface.

The soil above and below the stone line is usually similar in general appearance, but a close examination often reveals slight differences in colour, texture, and consistence, indicating that the line marks a boundary between two genetically different horizons of the profile. It is not unusual to find that the horizon below the stone line is coarser in texture and firmer in consistence than the horizon above, and that the change takes place suddenly at the line itself.

If it is accepted that these features are of pedogenic origin, which certainly appears to be the case, then two possible modes of origin can be postulated, namely that they are either layers formed as a result of soil creep along the frictional boundary separating the static from the moving part of the soil mass, or alternatively that they represent former surface accumulations which have been subsequently covered by colluvium. Ruhe (1959) has suggested that a process similar to the latter is responsible for the formation of stone lines in parts of Africa. It is possible that stone lines in Malayan soils could have formed as a result of either process.

Soil creep could explain the presence of stone lines in the more steeply sloping areas of the country; while the colluvial explanation appears to be more applicable in the less steeply sloping lowland areas, and more particularly where sedentary soils on undulating terrain and Older Alluvial soils developed over dissected terraces, occur in close association. In such areas the low slopes would preclude intensive soil creep, while the higher sea level conditions during the interglacial ages of the Pleistocene would have led to extensive alluvial and colluvial accumulation and sheet wash, interspaced by periods of erosion during the glacial ages, when climatic conditions may have been unfavourable to dense forest growth. It is of interest to note that stone lines are commonest in such low-lying sedentary soil areas below the 250 foot contour and the balance of evidence appears favourable to the colluvial explanation.

Similar stone lines occurring in the south-eastern states of the U.S.A., which are explained in similar manner, are termed carpedoliths, (Parizek and Woodruff 1957) and this name may prove acceptable in time to Malayan soil scientists.

(g) *Identifiable Minerals*

The presence of relatively unweathered minerals in the soil can be an important indication of the age of the soil and of the relative reserve of plant nutrients. In most cases, these mineral remnants reflect the mineralogy of the parent rock. Such minerals should be identified with the aid of a hand lens and recorded. The following brief notes may be of assistance: —

Identification can be assisted by separating colourless minerals (including pale coloured) from coloured (mainly dark coloured) minerals. The commonest colourless minerals will be quartz (which cannot be scratched with a pocket knife), feldspar (which can be scratched with a pocket knife and can usually be crushed between the fingers because of the semi-decomposed condition in which this mineral often occurs in Malayan soils) and the lighter coloured micas (which have a characteristic glitter and a platy shape). The coloured minerals will be mainly ferro-magnesian minerals and separate identification is probably not necessary apart from noting biotite, the dark coloured mica which is easily recognised by its tabular form and by the striated character of the crystal edges. The degree of decomposition of mineral fragments should also be noted.

(h) *Horizon Boundaries*

The boundaries between horizons vary in distinctness and in shape. The distinctness of boundaries depends partly on the contrast and partly on the thickness of the transition between the horizons. It is expressed by the thickness of the transitions, and the following standards can be used: —

Sharp — almost a line.
Distinct — less than one inch (about 2.5 cm.)
Indistinct — one to three inches (about 2.5 to 7.5 cm.)
Diffuse — greater than three inches (about 7.5 cm.)

Most horizon boundaries in Malayan soils are smooth so that the shape need not be specified unless it is unusual such as wavy, irregular, or broken. Definitions of these terms can be found in United States 'Soil Survey Manual' (page 187).

Chapter 3
SOIL SURVEY

BASICALLY soil survey is one of the many manifestations of man's attempt to satisfy his natural curiosity about his environment, but at the same time it is a scientific exercise carried out for severely practical purposes, and the techniques of unravelling and recording the soil pattern must be as effective as resources of time, finance and manpower permit. They must also be reasonably standardised so as to avoid accumulating fragments of information which are difficult to correlate.

The main components of soil survey are the mapping of the soils in the field, the classification of the soils, and the production of soil maps and soil reports.

UNITS OF MAPPING AND CLASSIFICATION

The grouping of like soils into units for mapping and classification purposes provides an essential framework for the survey. Art becomes entwined with science in this aspect of the profession because the analysis of the soil landscape, and the subsequent synthesis into significant soil units which can satisfy the twin demands of land use and technical taxonomy depends in considerable degree on pedological "intuition" — a distillation of learning, skill, and experience which imparts a flair for making the right choice more often than not, from a number of alternatives.

The difference between mapping units and classification units is often confused. Ideally the units of the soil classification are simple and uniform, becoming more embracing and comprehensive but still within sharply defined limits as the higher categories of the classification are approached. Much of the confusion probably arises from the fact that this ideal is seldom realised in practice, but a broad distinction on the basis of uniformity can be made between the mapping unit and the classification unit. The basal unit of both mapping and classification is the same, and in the schematic-reconnaissance survey of Malaya this is the soil series. Series are recognised and mapped in the field and they also represent the individual bricks by which the technical classification is built up. Mapping units other than the series are units of convenience to enable a practical soil map to be assembled. Because of the many differences within a soil landscape they allow for considerable variation, variation which in some cases is greater than would be permitted within one classification unit. But whereas such mapping units are a reasonable and practical way of depicting a complex array of natural objects on a map, they are rarely precise or uniform enough to satisfy the requirements of a technical classification, and so classification units, which are closely related to but more strictly defined than the mapping units, are erected.

In brief, the soil mapping unit is used to analyse the soil landscape to show what is there and where it occurs; whereas the purpose of the unit of classification is to synthesise this information and to arrange it into a logical and orderly system. The mapping units most commonly used in Malaya are the soil series, the soil phase, the soil variant, the soil complex, the soil association, and miscellaneous land units. The classification units which are most commonly recognised in Malaya are the soil series, the soil family, and the great soil group.

1. MAPPING UNITS

(a) *The Soil Series*

In the present state of soil survey in Malaya the soil series is regarded as the unit basal to mapping and to classification, and it thus forms the link between them. This situation differs from that pertaining in many other countries, where the soil type is accorded this distinction. No realistic criteria for soil type distinction have so far emerged from mapping done in Malaya. The original concept for type separation, namely different topsoil textures, does not apply in a country where topsoils, i.e. A_1 or Ah horizons, are only a few inches thick and are commonly modified by erosion, so that textures are considerably coarser than those throughout the rest of the profile. It is interesting to note that the series also tends to supplant the type as the basal unit in other parts of this region, e.g. in Sarawak, (Andriesse, 1964, p. 21).

The soil series is a grouping of soils with similar profiles, similar temperature and moisture regimes, and the same or very similar parent material. It is used on occasions as a mapping unit by itself, but is more commonly replaced by associations of series, particularly in the schematic-reconnaissance survey. The series name however provides a ready key to most of the characteristics of the soil it embraces. It is most important that series be erected on valid and uniform criteria. It is much easier to draw attention to differences than it is to stress similarities but a distinct series should satisfy the requirements of the definition outlined above. The question as to what constitutes similar profiles is not always easy to answer, and the broad criterion that is used at present is whether a morphological or analytical difference will have considerable impact on the use of the soil. The close co-variance of soil and parent material over much of Malaya tends to simplify the recognition of series.

The series is given a geographic name indicating a locality where it is well developed or where it was first recognised. The geographic name should be a well established one and should be as simple as possible. Malay names are used almost exclusively and where possible a single name rather than a double or triple name should be preferred. Each series should also have a defined type locality where the characteristics of the series can be inspected.

(b) *The Soil Phase*

The soil phase is commonly used as a sub-division of the series, but strictly speaking it is a sub-division of any category without itself being a category of the system of classification. It is based on any characteristic or combination of characteristics potentially significant to land use; for example, depth of the soil, presence of laterite, severe erosion, drainage, or salinity. At the series level, phases are used to show differences of lesser rank than the pedological characteristics that differentiate the soil series. They are important for some kinds of land use and may indicate transient or artificially induced changes not accompanied by significant changes in the morphology of the soil. For example, drained phases are recognised where the drainage of the series has been improved artificially. The phase names are placed after the series as follows:—

Segamat Series, lateritic phase.

(c) *The Soil Variant*

The soil variant should be clearly distinguished from the soil phase. It is a unit of convenience designed to avoid unnecessary multiplication of series names. It is closely related to the soil from which it derives its name but differs in characteristics at the same level of separation. It permits the soil surveyor to avoid establishing separate series for soils of minor extent. Thus, a soil may be defined as a variant in one survey and later raised to the rank of a separate series when found to be more extensive. By using the term variant, the soil surveyor tells his readers that he recognises in the profile enough criteria to justify a new series but for one reason or another it cannot be conveniently established. In Malaya variants have been commonly used to distinguish between profiles which have similar properties apart from colour; for instance, Serdang Series, red variant. If further mapping reveals such variants to be of sufficient extent, they will be elevated to series rank.

(d) *The Soil Association*

The soil association is a compound mapping unit consisting of a group of soils which are geographically and topographically associated in a defined proportional pattern. The term has been confined to reconnaissance maps, where there is insufficient field data available to permit of any further subdivision on the final maps. The association is essentially similar to a soil complex but the pattern is sufficiently coarse to be resolved on ordinary detailed maps, whereas the pattern within a complex cannot be resolved easily on detailed maps. The association is the commonest mapping unit in the schematic-reconnaissance survey. Although by definition associations may show combinations of various groups of soils, in Malaya they consist almost exclusively of series, and the association is named after the most important series occurring within it, or by combining the names of component series.

(e) *The Soil Complex*

The soil complex is also a compound mapping unit containing an intimate mixture of two or more soil series that cannot be differentiated on ordinary detailed soil maps. As with associations, soil complexes do not form a category in the soil classification and it is thus not correct to give them a separate taxonomic name. They are allotted composite names derived from the names of their principal constituent units.

As is the case with an association, the soil complex can only be described in terms of its constituent units and this should always be done carefully. In addition, a description of the pattern including the percentage occupied by each unit should be given.

(f) *Miscellaneous Land Units*

In a rapid schematic-reconnaissance soil survey it is not always necessary to do more than delimit the boundaries of certain landscape types which are easily recognised and which are mostly of fairly low agricultural potential. These units will be categorised more precisely as the level of soil survey becomes more intense, but it has been found very convenient to make use of a number of these groupings, the names of which are almost always self-explanatory. They serve the somewhat specialised requirements of the schematic-reconnaissance survey by eliminating those landscape units which are easily recognised and yet which are commonly most inaccessible. However, many of these mapping units will probably not find much further use on completion of the schematic-reconnaissance survey. The following descriptions of the common miscellaneous land units are included here for the guidance of soil surveyors:

Steepland

This is defined as the land occurring above the steepland boundary (see definition on page 16), which has average slopes generally exceeding 25°, and often exceeding 35°, and which is topographically unsuitable for extensive agricultural development. Such land is more suited to permanent forest, either productive or protective depending on the commercial value of the indigenous tree species.

During reconnaissance soil surveys, detailed soil examination of steepland is considered unnecessary in view of the fact that the agricultural development opportunities in such areas are obviously limited by the steepness of the slope, and because no extensive agricultural development has taken place in those areas in the past.

Much expense and time is saved by demarcating the steepland boundary at an early stage in a survey and excluding the steep terrain from the area covered by the rentis net. The unsurveyed area identified in this manner is marked as steepland on reconnaissance soil maps.

Disturbed Land

Malaya has been a major source of tin and gold since the dawn of history, and as these metals were mostly mined by open-cast methods from shallow alluvium, extensive areas of land, conservatively estimated at 2 per cent of the country, have been disturbed by this activity.

Although the mining technique varies from place to place the end result is usually the same, leaving the landscape littered with abandoned mining pools and low mounds, ridges, and flats composed of pale coloured quartz sand, sticky grey structureless clay, and all possible mixtures between these two textural grades. The raw soils which gradually develop are easily distinguishable from the soils developed in areas where the profile is essentially undisturbed, but no attempt has yet been made to categorize the wide variety of skeletal profiles found on such mined land. As this land offers negligible opportunties for subsquent agricultural development it has been found convenient to classify such areas as disturbed land during reconnaissance soil surveys.

The smaller, but still considerable areas of urban land which have been developed as building sites, together with airfield runways, quarries, refuse tips, and similar situations where destruction of the profile has resulted from human interference, are also conveniently grouped under this heading for most soil survey purposes.

Peat

Organic soils having a loss on ignition exceeding 65 per cent are described as peat. Malayan peat is characterised by a coarse woody or fibrous texture, high moisture content, acid reaction, and limited crop suitability. It is not unusual to find Malayan peat with loss on ignition exceeding 95 per cent and ranging in thickness from 2 feet to 25 feet, (.6 to 7.5 metres).

The area of peat soils in Malaya has been estimated at one and half million acres, and most of this peat occurs in large swamps on the coastal plains along both the west and east coasts. In some cases the peat may extend inland along the valley bottoms. The west coast peat is commonly underlain by clay, believed to be of marine origin, while the east coast peat is normally underlain by coarse sediments similar to the beach sands which form much of the present coast.

Malayan peat soils invariably remain waterlogged up to the surface throughout most of the year, except where artificially drained, and pit digging for profile examination purposes is therefore impracticable in undeveloped peat swamps, while augering is made difficult because of the coarse woody character of the peat which hinders and often prevents penetration. Even simple depth estimations in peats using a crude wooden or steel probe can be inaccurate in the deeper peat swamps, where the probe can be repeatedly checked by only partly decayed stumps or branches buried in the profile.

Textural differences and variations in pH are two important characteristics which undoubtedly vary within the peats, and these or other features may become the basis for a detailed classification of the peat soils, but for reconnaissance soil survey purposes it has been found convenient to classify the peat primarily on the basis of depth to the underlying mineral soil horizon. The three most commonly used subdivisions are shallow peat (0 to 2 feet or 0 to .6 metres), moderately deep peat (2 to 5 feet or about .6 to 1.5 metres), and deep peat (over 5 feet or 1.5 metres).

Muck

Muck soils are defined as organic soils having a loss on ignition of between 35 and 65 per cent. In practice the muck soil horizon is usually less than 2 feet (.6m) thick and the soils have been found to occur extensively only around the margins of the west coast peat swamps where they form a transition between the peat and the surrounding mineral soils.

Soil survey results have indicated that where the surface muck horizon exceeds six inches (about 15cm) in thickness, the underlying mineral soil is unlikely to have developed obvious horizonation, but consists usually of faintly sulphurous blue-grey or greenish-grey clay similar in appearance to the gleyed parent materials from which many of the alluvial soil series have formed. More detailed examination may in time reveal differences which will lead to the recognition of distinct soil series, but for reconnaissance survey purposes subdivision of muck soil into depth phases based on thickness of the muck soil horizon is probably sufficient. This unit is commonly combined with organic clay and mapped as an association of Organic Clay and Muck.

Colluvium

The term colluvium when used in reconnaissance soil surveys is restricted to recently accumulated material which is formed at the foot of slopes, usually at the edge of small alluvial flats, and which has been transported to these positions by local wash or soil creep. It often occurs as a narrow band, only a few feet in width, separating alluvial from sedentary soils, and a thin mantle of this material may occasionally be found overlying alluvial soil profiles, particularly near the foot of recently eroded slopes. The material is usually pale coloured, loose, and sandy in texture, but profile characters are not sufficiently well documented to permit more precise classification.

Colluvium may also occur on rolling and hilly terrain and the sections of soil profiles which overlie stone lines are often assumed to have been emplaced by colluvial action. In such cases soil forming processes have usually been at work for a sufficiently long period to permit the development of distinct profile characters. Such soils are not mapped in this miscellaneous land unit, but are normally correlated with series which are, for convenience, regarded as sedentary soils; although further work may well demonstrate that accretion by colluvial or mass movement processes is an integral part of their formation.

Organic Clay

The term organic clay has been applied to those soils having an organic surface horizon at least 6 inches (about 15 cm) thick and with loss on ignition between 20 and 35 per cent. These soils are similar in appearance to muck soils and the two usually occur in association and are often grouped together for reconnaissance mapping purposes.

Where the organic clay horizon is less than 6 inches (about 15cm.) thick it is usually possible to classify the soils into standard series on the basis of distinct horizonation resulting from pedological processes, and use of this miscellaneous land unit term should be confined to those soils in which the organic clay layer masks these definable characteristics, or where no horizonation is present in the subsoil.

Local Alluvium

This is a convenient term used to describe the recent deposits of alluvium occurring in the valleys of the smaller streams which are such a conspicuous feature of the Malayan landscape. The small, steepsided valleys, commonly termed ravines, and often featuring an actively eroding valley head, are usually flat bottomed and the unconsolidated material forming the floor of the valleys is contained within the meander belt of the stream, which not infrequently will be eroding into the valley side, leading to the formation of valley bluffs.

The texture of the soils is related to that of the sedentary soils occurring on the surrounding sloping land within the catchment boundary of the stream. The watertable is invariably high, but fluctuates rapidly in response to rainfall, and the vegetation may be of a permanent or seasonal swamp type. Textural variations and changes in micro-relief give rise to soil differences but it is seldom necessary to note these differences during a reconnaissance survey particularly as the areas are always small in extent. For the purposes of such surveys the soils in this group can be best grouped together as soils having wide textural variations, and with a topsoil horizon of organic matter accumulation, but with no other diagnostic horizon.

Riverine Alluvium

Along the major rivers, particularly in inland Malaya, it is common to find a relatively narrow strip of mixed alluvium lying between the recent alluvium adjacent to the river, and the dissected terrain some distance from the river's course. This Riverine Alluvium, as it is mapped, probably consists largely of a variety of soils formed on mainly subrecent alluvium, but the group is wide enough to include soils which intergrade to those formed on recent alluvium, and to those on Local Alluvium occurring in the minor valleys of tributary streams.

Inland Swamp

This term has been used to demarcate a mosaic of waterlogged and poorly drained soils which occur in swamps not immediately adjacent to the coast. Peats, mucks, organic clays and recognisable poorly drained inorganic soils are the main compenents of this unit, but their pattern of distribution is too complex to enable them to be separated at schematic-reconnaissance level.

2. CLASSIFICATION UNITS

The soil series is the basal unit of classification as has already been mentioned under the previous section.

(a) *The Soil Family*

The soil family is a grouping together of similar series for purposes of classification at a level between the series and the great soil group. The concept of soil family has not yet been thoroughly worked out and tested in practice in Malaya, but it can be said that the series within any one family will have broad similarities of parent material; there will be no great differences in the kind and arrangement of genetic horizons within the profile; and the mineralogy of the soils will be similar. For instance, the Rengam family, which as constituted at present contains some five series, comprises series which are formed on granitic rocks, in most cases have an eluvial A/illuvial B horizon sequence and are predominantly kaolinitic with fragments of quartz and, in some cases, feldspar.

(b) *The Great Soil Group*

The great soil group is, at present, the ultimate unit of classification in use in Malaya, and comprises families which have broad similarities of parent material, environmental characteristics, and horizonation. The names used are those commonly referred to in literature pertaining to the tropics. At present the higher categories of classification are under comprehensive revision and it is hoped to be able to produce a system which can be correlated easily with those used elsewhere. The Seventh Approximation outlined in 'Soil Classification,' (Soil Survey Staff, 1960) is also being tested under Malayan conditions.

METHOD OF SURVEY

The physical difficulties and logistical problems faced by a soil surveyor working in Malaya, particularly in the more inaccessible undeveloped forest-covered regions of the country, are very different from those encountered by soil surveyors working in many other parts of the world. This is due to the almost continuous cover of high forest which restricts visibility on the ground and obscures the soil pattern from the air, accompanied in many places by difficult terrain in which steep hills alternate with deep and almost impenetrable swamps. In the gently undulating and hilly land, progress on the ground is slow and a straight line traverse for three miles (or nearly 5 kilometres) through uncut forest can be considered a good day's progress if a satisfactory examination is to be made of the soils occurring along the route. In steep mountainous country the distance covered in a straight line can be very much less because of the deeply incised nature of the mountain topography. The slowest rates of all, however, are those recorded in some deep peat swamps where as little as a quarter mile (or .4 km) a day might be attained, with every inch of the way having to be cut to allow for bodily progress.

Under these conditions much of the time of a soil surveyor is taken up with logistical problems such as how many men he should employ, or how much road or riverine transport will be necessary for a large scale jungle exploration and how many days rations and other supplies will be required by his field parties. Working out the detailed answers to these problems and completing the necessary arrangements in an efficient manner are an unavoidable part of the job and are of fundamental importance to the success of any jungle survey programme. Many of these tasks can and should be carried out by reliable subordinates such as Agricultural Assistants or Junior Agricultural Assistants, but the surveyor must retain overall supervision.

The work of the various labourers comprising a normal soil survey group ranges from porterage duties through rentis cutting and pit digging to more responsible jobs such as chaining; soil sampling; and recording elementary details of topography, soil, and vegetation observed along the various exploratory routes. An average labouring force may number up to 30 persons of varying degrees of technical knowledge and these men are usually split into smaller parties of about 5 persons, each led by a literate team leader who is capable of using a prismatic compass and of keeping a running log of his observations. These teams are responsible for separate phases of the field programme such as rentis cutting, soil sampling, raft and base camp construction, and chain and compass surveys of unmapped access routes such as aborigine footpaths, or timber extraction tracks as well as for porterage of supplies to the various working parties.

A normal survey preliminary is to design a rentis network which consists of a complex of inter-connecting rentis lines cut on fixed compass bearings traversing the area under examination, but avoiding the steeper mountain masses and the more impenetrable swamps. The direction of the rentis lines is most important, and these are normally designed to cut across the dominant geological or topographical units which may be known or suspected to exist within the survey region, as in this way they will be likely to cut the greatest number of soil boundaries. If there is no apparent grain to the land, however, it may be found more convenient to offset the rentis line at right angles to any existing access routes, such as forest roads or navigable rivers. In fact, the actual rentis net laid down is commonly a compromise between these two alternatives. On a reconnaissance soil survey, the rentis lines are generally parallel and spaced about two miles (about 3 km) apart. Short cross rentis₂ are cut between the main lines at intervals of between 5 and 10 miles (8 and 16 km) in order to complete the inter-connecting network. The speed of cutting a rentis in low-lying forested country seldom exceeds one mile (1.6 km) per day on average, and a rentis team of 5 men cutting a 12 mile (19 km) rentis line are therefore unlikely to finish the job in much less than 2 weeks. Distance along the rentis is indicated by marker posts set at one chain (about 20 metres) intervals by the cutting party and numbered consecutively with an indelible pencil.

Normally the rentis teams are trained to carry out soil sampling at the same time as they cut and measure the rentis. Samples are taken with a six-inch post-hole auger at quarter mile (.4 km) intervals during a reconnaissance soil survey. The sampling is done at arbitrary depths most commonly 0-6″ (0-15 cm), 6-12″ (15-30 cm), 12-24″ (30-60 cm), and 24-36″ (60-90 cm). The samples, which are collected in polythene bags in order to retain their moist condition, are placed within numbered canvas bags which enables ready identification later, and affords better protection than the polythene under the heavy wear and tear of jungle travel. They are then carried either to the base camp or the office where they are arranged in sequence and examined by the soil surveyor himself before he goes into the field to examine the soils in greater detail along selected $rentis_2$. This preliminary examination gives a very useful broad picture of the area and often enables the main soil boundaries to be located to within a quarter mile (.4 km), or whatever other unit has been chosen as the sampling distance. Occasionally the soils along some of the sampled lines may be so completely uniform and the classification so obvious and familiar that no further field examination by the soil surveyor or his field assistant may be necessary. This presupposes completely reliable rentis teams, which is not always the case. It has been found prudent in the past to keep a close check to ensure that the samples are actually collected from the points specified and that the rentis has in fact been cut to the distance stated. If the pattern of soils appears complicated from the samples and if new and unrecognisable series are emerging, or if the main boundaries must be located to a greater degree of accuracy, the soil surveyor himself must traverse the rentis lines to examine the soils in more detail and to record the boundaries with greater precision.

In examinations of this nature, the soil surveyor is usually accompanied by a lightly laden, fast travelling party of three or four of his fittest and most energetic labourers so that he can make fairly rapid progress and cover perhaps 5 or 6 miles (about 8 or 10 km) of thoroughly examined rentis each day. In such inspection the soil is examined with a $1\frac{1}{2}$ inch (3.8 cm) screw auger usually mounted on a 40-inch (about 100 cm) shaft with a fixed steel handle, although a 6-inch (15.2 cm) posthole auger may be used as well, and borings are made at varying intervals depending on the complexity of the soil pattern; while soil pits down to 6 feet (nearly 2 metres) in depth may be dug when a very detailed examination is necessary.

Full notes are made of the soil, topography, vegetation, and other relevant features during a field examination of this nature and portable pocket tape-recorders are a valuable asset for this purpose. The hot, wet conditions in the jungle render writing a task which is resorted to only when unavoidable, but speaking into a microphone clipped to the shirt or held in the hand involves no discomfort whatever. The quantity and quality of recording on reconnaissance soil surveys has increased considerably since these machines have come into use. A constant check must be kept on the recorder to ensure that it is operating.

During the surveyor's examination of the rentis the opportunity is taken to check the depth and positioning of the borings made by the sampling teams to verify that they have completed their work in a satisfactory manner. When travelling along rentis lines, the soil surveyor avoids retracing his steps down an already examined rentis because this is both monotonous and time-wasting, and the cross $rentis_2$ cut between the main lines of the net are utilised to avoid this. They also enable a useful cross-check to be made on the direction and distance traversed by each individual rentis, thus allowing for a more accurate plotting of detail on the base map.

The information collected is recorded sometimes in the field, but more often in the office or base camp immediately after each period of examination, on two inches to one mile (1:31,680) or 1 to 25,000 topographic maps whichever are obtainable. Before marking in the field data, every precaution should be taken to see that the actual ground position of the rentis has been accurately fixed upon the map itself, for there is always a possibility of a faulty compass or a careless compass operator or even a deliberate attempt at under-chaining on the part of the labourers, which could result in considerable inaccuracies in the positioning of soil boundaries on the final map. Details recorded along the rentis lines are transferred to traverse sheets as in the sample shown in Fig 2 and these are filed to form a permanent record of detail observed, not all of which will appear on the final map.

FIGURE 2.

SAMPLE TRAVERSE SHEET

MAP SHEET 2 K/6 & 10	W. P. Panton	19
STATE Kelantan		DATE 5.8.57
GRID POSITION	TRAVERSE DETAILS From camp on S. Pahi along rentis Bg. 150/63 (1250 m) chains to S. Pas, then up short rentis leading south. Back to Post 51 on first rentis and out to Pahi Station via various jungle tracks on banks of S. Pahi.	
2 K/6. / 348816	Down rentis Bg 150° for 63 chains (about 1250 metres) from south bank of S. Pahi. Post O. River bank 15′ (about 4.5 m.) high, small narrow strip of recent alluvial fine sand. Post 0-6. Gently undulating 3-4° land under good jungle with brownish yellow sandy clay loam Rengam Series.	
2 K/10 / 349814	Post 6-6½. Rengam sandy clay loam on 12° to south slope. Post 6½-7. Alluvial swamp. Flows to west. Post 7-14½. Very nice Rengam brownish yellow sandy clay loam undulating land with slopes up to 20° at Post 13 and 14. Post 14½-15. Alluvial swamp. Flows to east. Post 15-19. Undulating land 10-20° slopes to north-west. Very nice brownish yellow to reddish yellow sandy clay loam Rengam with good jungle.	

	Post 19-21. Hilltop, moderately undulating, old track runs to S.S.W.
	Post 21-28. Slopes to south, between 5 and 20° undulating land with brownish yellow and reddish yellow Rengam sandy clay loam.
	Post 28-33½. Gently undulating, 5-3° slope land. Pale brownish yellow sandy clay loam Rengam, gently undulating phase.
	Post 33½-34. Coarse colluvial light grey sand.
	Post 34-37. Gently undulating Rengam phase.
	Post 37-39. Edge of hillsoil (Rengam) on east, and swamp on west.
	Post 39-40. Alluvial swamp. Small stream flows to southwest.
	Post 40-44. Gently undulating rather pale yellow Rengam sandy clay loam.
	Post 44-45. Alluvium.
	Post 45-57. Gently undulating phase of Rengam sandy clay loam. About 5° slopes.
	Post 57-58. 15° to south slope, good Rengam sandy clay loam.
	Post 58-61. Gently undulating phase Rengam sandy clay loam.
357790	Post 61-63. Recent riverine alluvium under belukar.
approx.	Post 63. S. Pas, flowing W.S.W. by W. Granite rocks "in situ" in river bed forming occasional rapids. Down rentis Bg 18° for 25 chains (495 m) from this position.
	Post O. River bank. S. Pas.
	Post 0-4½. Recent alluvial free draining silty to fine sandy loams on 20′ (6 m) high river bank.
	Post 4½-9. Rentis runs up small alluvial strip with Rengam sandy clay loam on east and west sides.
	Post 9-16¼. Gently to moderately undulating rather pale coloured Rengam sandy clay loam.
	Post 16¼-19. Swamp alluvium.

The field map and notes obtained in this manner form a most valuable record of the survey work which has been obtained at some considerable cost and every precaution should be made to preserve these records for posterity. Vertical plan filing cases and insect proof filing cabinets help to preserve such records and are a legitimate expense under the circumstances.

Aerial photographs are of restricted use in Malaya during field work in most types of forested terrain. In practice, it is found that the one inch to a mile (1: 63,360) aerial reconnaissance topographic maps as well as the more recently produced New Series topographic sheets published by the Survey Department normally reflect the relevant details which appear on the aerial photographs themselves; and this is because the maps have been compiled largely from the available photographic material and any obvious boundaries which can be seen from the air in the relatively uniform forest cover are already transferred on to the one inch (1: 63,360) maps.

There are some recent aerial photographs available and those of good quality are useful in that they show unmapped tracks and trails such as timber extraction tracks, and furthermore, steroscopic inspection of them prior to surveying furnishes background knowledge of the terrain, particularly where good topographic maps are not available. They are not taken into the field on jungle surveys, however, because of the difficulty of locating positions on them accurately and because no convenient method of preventing rapid deterioration of photographs in the moist humid conditions of the Malayan forest has been devised. Occasionally, however, a careful study of the aerial photographs may indicate a change in the vegetational pattern which might be correlated with a soil change on the ground but which may not be shown on the corresponding topographic map, and a preliminary examination of the photographs is therefore advisable before any period of field work is commenced. Sometimes a rudimentary map showing the main ecological types can be prepared at this stage. This may prove useful in the field and may later be incorporated on to the field map at the compilation stage, after a correlation between soil and vegetation has been proved by actual field examination.

There is in fact no reliable alternative to visual examination of the soils on the ground in undulating forested terrain under Malayan conditions, and this explains the time-consuming nature of soil surveys in Malaya. This of course applies only to the undeveloped regions of the country, and in the more developed and open areas where access is much easier soil surveys can be carried out much more rapidly. Greater use can be made of aerial photographs and the methods are generally comparable with those practised in most other parts of the world.

The preparation for the soil survey should include a study of all the available literature pertaining to the natural features of the area to be surveyed and particularly to any geological data. Considerable geological information is available in unpublished form and can be obtained either from Field Offices of the Geological Survey or from the Headquarters in Ipoh. An understanding exists between the Director of Geological Survey and the Director of Agriculture by which a free interchange of relevant unpublished data is ratified subject to the normal acknowledgement requirements.

After consulting relevant information, a reconnaissance is made along the roads and passable tracks and the major soils are noted. Key areas are examined in some detail so that sufficient information may be gained to draw up a preliminary skeleton legend and decide on the kinds of units to be mapped. The legend, although very approximate at this stage, is an essential device for categorising the soil units which are likely to be mapped, and by the time the preliminary inspection is completed and before field mapping begins, the framework of a controlled working legend of soil units as such should be drawn up. Inevitably, this preliminary legend will be incomplete but it is an essential requirement to enable the soils to be mapped in classifiable units as they are encountered, and thus to allow the field work to proceed systematically. It will be added to and revised as the survey progresses.

During the course of the survey, information on the various series being mapped will accumulate and from time to time this should be used to prepare standard series descriptions. These descriptions of a page or two in length should include an introduction, in which the main distinguishing features of the series are summarised; a full detailed profile description; some indication of the range in characteristics; and notes on terrain, drainage, vegetation, uses, distribution, type location, derivation of the series name, pit description numbers, sample numbers, and remarks. In selecting the profile description for inclusion in this standard description, the central concept of the series should be aimed at. These standard series descriptions provide the basis for the descriptive part of the report which will accompany the final soil map.

SOIL MAPS

1. BASE MAPS AVAILABLE IN MALAYA

The soil surveyor working in Malaya is very fortunate in being able to obtain high quality topographic maps for all areas of the country. Topographical surveys have been carried out extensively in Malaya since the end of the 19th century, and many areas have been mapped two or even three times during the intervening period.

As would be expected in an area the size of Malaya, the quality of the maps varies from place to place, mainly because the programme of mapping and of revision mapping usually takes many years to reach finality.

Details concerning the more useful map series, and a few individual maps which are relevant to soil studies, are given below: —

1 inch to 1 mile Topographic Sheets

The standard mapping scale has always been 1 inch to 1 mile (1:63,360) and three series of maps, having very variable standards, comprise the most recent coverage of the Malay Peninsula.

Hind 1035 Series

The earliest of the three series is the Hind 1035 Edition, which is often referred to as the Old Series (standard mapping) edition. These sheets are currently the only available 1 inch maps for a large proportion of western Malaya north of the Johore and Malacca border, particularly in Selangor, Perak, Province Wellesley, Kedah, and Perlis and also parts of Pahang.

The mapping was carried out mainly between 1910 and 1941, and the maps were prepared by rigorous ground survey methods, without the aid of aerial photographs. All these maps show generally accurate contours at 50 foot (15 metres) vertical intervals. The land use detail shown on this series is now out of date, and in areas where development in recent years has been rapid, the maps can be very misleading. However, the physiography in the developed areas is surprisingly accurate, and stream lines in most areas are fairly reliable. The contouring also attains quite a high standard of accuracy, although ridge lines do not show up as prominently as on the latest new series sheets for the same areas, (see below).

Many of the early Hind 1035 sheets have gone through several editions, and rapid revisions to some of the sheets have been made from time to time with the aid of aerial photographs. Much of the revision work has been undertaken by military units since the end of the Second World War, and these revision sheets are known as 2-GSGS edition sheets. They often include the most up-to-date road and track detail, which has been included to meet present day military requirements.

Air Reconnaissance Series

The air reconnaissance series, often referred to as the Old Series (air recce) edition, covers those parts of the country which were not covered by the Hind 1035 mapping programme, and were very quickly prepared during the early days of the Emergency, commencing in 1948. They are compiled from aerial photographs which were flown during the Emergency and are of variable quality as the best type of camera was not used. Very little rigorous ground control was available owing to the limited amount of ground survey which had been carried out in the areas covered by this programme during the pre-war period. This edition covers large parts of Kelantan, Pahang and Trengganu.

Accurate contours are not shown on these maps. The relief is indicated by form lines which do not maintain constant height, and are generally drawn at vertical intervals ranging from 500ft. (approx. 150m.) to 1000 ft. (300m.) or more. A further form line. which corresponds very approximately to the 250 foot (approx. 75m) contour, is also shown, and is very useful for soil survey reconnaissance mapping purposes. Streams are usually plotted with a high standard of accuracy and the relief can be interpreted with fair confidence from a study of the drainage pattern and the form lines. Occasionally mistakes occur, particularly in the less steeply sloping parts of the country, where streams may be shown flowing in the wrong direction, and the greatest confusion is likely to arise when the mistake is only discovered during a field reconnaissance.

The accuracy of the detail shown on the air reconnaissance sheets is always questionable since the photographs used were of variable quality and no ground verification was carried out.

New Series

In 1947 the Topographical Division of the Survey Department commenced a resurvey of the States of Malaya on the 1 inch to a mile (1: 63,360) scale, based on a new projection, known as the Malayan rectified skew orthomorphic, and field work was commenced in the Johore-Malacca region and in the Trengganu and Kelantan coastal areas. To date sheets have been published for the whole of Johore, Malacca and the Langkawi Islands, and parts of Negri Sembilan, Selangor, Penang and Province Wellesley, and much of the northern part of Kelantan and the coastal part of Trengganu, together with a few sheets covering southeast Pahang.

Field work is presently being concentrated in Northern Pahang, Perak and Kedah, so that the air reconnaissance series maps and the old Hind 1035 series maps mav be replaced by the new series sheets in the shortest possible time.

The New Series sheets are extremely accurate, and are based on rigorous ground control and field checks, and are compiled from a mixture of old and recent photographs including same very good quality photographs flown by the Survey Department in recent years. Contours and drainage lines are extremely accurate, and land use detail is up-to-date. Because of the much better quality of these new maps, soil surveyors commencing surveys in areas not covered by published new series sheets should always enquire whether compilation sections of the new series sheets are available, as the compilation is usually a year to two ahead of the publication, and in such instances copies showing contours, if the compilation has reached this stage, and on a scale of 2½ inches to 1 mile (1: 25,344), can be obtained from the Topographical Division of the Survey Department.

New Series — 1:25,000 Maps

The compilation of the New Series sheets is carried out on a scale of 2½ inches to a mile (1: 25,344) and published sheets are available on a scale of 1: 25,000 for the developed areas covered to date by this re-survey. These maps make very suitable base sheets for soil surveys and uncoloured copies, which are more convenient than the coloured edition, are usually obtainable. Unfortunately, copies of the forest covered areas are not published in this series, owing to the limited demand, but it is always possible to obtain copies of the less well finished compilation section on the similar scale of 2½ inches to a mile (1: 25,344) for such areas. These can be obtained from the Topographical Division.

Photostat Enlargements

Because the Hind 1035 and Air Reconnaissance series maps are only published on the 1-inch scale, it is often necessary to enlarge these maps for soil survey purposes. A photostat reproduction and enlargement service is available at almost all State Survey Offices, and also at the Survey Department Headquarters in Gurney Road, Kuala Lumpur.

Enlargement from 1 inch maps up to a scale of 2 inches to a mile (1: 31,680) is usually found acceptable for soil survey purposes, and this degree of enlargement enables a standard sized 1 inch Hind or Air Reconnaissance sheet to be conveniently enlarged on to 4 photostat sheets. This is possible because a quarter of a 1 inch sheet, when enlarged to this scale, just fits within the shorter side of a standard 18 × 24 inch (45×60 cm) photostat plate; while enlargements onto a larger scale, such as 2½ inches to a mile (1: 25,344), will require 9 photostat copies instead of 4, thus increasing reproduction costs by a wide margin. A further disadvantage of enlarging 1 inch maps to a greater scale than 2 inches to a mile (1: 31,680) is that the enlargements will be variable in shape and for that reason inconvenient for field work.

4 inch to 1 mile (1:15,840) Forest Reserve Map Series

The Survey Department carried out a number of surveys on this scale over certain forest reserves at the request of the Forest Department during the inter-war period. Copies of some of these maps are still available and enquiry should be made at the appropriate State Survey Office.

Cadastral Sheets

Land registration in Malaya is based on the Torrens system, which depends on very accurate ground survey of the boundary of each title area. The very accurate cadastral survey sheets prepared for this purpose cover all the developed parts of the country. The scale is normally 8 chains to 1 inch (1: 6,336) and copies of these sheets can be obtained with little difficulty from State or District Survey Offices.

State Maps

This collection of maps, often termed the Land Utilization series, is printed on different scales for the States of Malaya, as follows:—

State	*Scale*
Kedah and Perlis	2 miles to 1 inch (1: 126,720)
Penang and Province Wellesley	1 mile to 1 inch (1: 63,360)
Perak	2 miles to 1 inch (1: 126,720)
Selangor	2 miles to 1 inch (1: 126,720)
Negri Sembilan	2 miles to 1 inch (1: 126,720)
Malacca	1 mile to 1 inch (1: 63,360)
Johore	3 miles to 1 inch (1: 190,080)
Pahang	4 miles to 1 inch (1: 253,440)
Trengganu	3 miles to 1 inch (1: 190,080)
Kelantan	3 miles to 1 inch (1: 190,080)

The detail shown on these State land utilization sheets is compiled largely from the cadastral survey sheets and title information, and the land use groupings therefore reflect the purpose for which the land was alienated, as shown on the alienation titles, rather than the actual land use situation. For this reason the term land utilization can be misleading, while considerable changes in the land use pattern have in any case occurred since the maps were prepared. These maps can be obtained in both coloured and uncoloured editions.

4 miles to 1 inch (1:253,440) Topographical Sheets

These sheets, printed in a military edition, each cover the same area as 16 Old Series 1 inch sheets. 21 separate sheets are available covering the whole of Malaya. They are sometimes referred to as the Quarter Inch Series.

1:500,000 Map of Malaya

In recent years a useful wall map of Malaya on a scale of 1:500,000 (7.89 miles to 1 inch) has been published. This map can be obtained in both coloured and uncoloured editions, and the scale is very satisfactory for publication of schematic-reconnaissance soil maps. Soil maps for Trengganu and Kelantan were printed on base plates taken from this map.

12 miles to 1 inch (1:760,320) Map of Malaya

This smaller map, which shows very similar detail to the new 1:500,000 map, also makes a suitable wall map. It is obtainable in several editions of which the most recent was published in 1959. Copies are obtainable in colour and plain.

18 miles to 1 inch (1:1,140,480) Topo Sheets Index Diagram

An index diagram showing the areas covered by the Old Series Hind and Air Reconnaissance sheets and the New Series sheets is available from the Survey Department, and is indispensable for map reference purposes.

1948 Geological Map of Malaya

This map, which has been out of print for several years, is the most useful geological map showing the main geological formations on a sufficiently large scale (12 miles to 1 inch or 1:760,320) for field study purposes. The compilation is based almost entirely on prewar geological records.

1 inch to 1 mile (1:63,360) Geological Maps

These maps, which are obtainable from the Geological Survey in Ipoh, are superimposed on the Hind 1035 series sheets, and the following 4 maps were published prior to the Second World War: —

$$2\frac{N}{1};\ 2\frac{N}{13};\ 2\frac{N}{14};\ 3\frac{B}{4}$$

The following 13 sheets have been published since the end of the Second World War, but based largely on pre-war geological surveys: —

$$2\frac{N}{5};2\frac{N}{9};2\frac{N}{8};3\frac{B}{12};2\frac{P}{13};2\frac{P}{14};3\frac{D}{1};3\frac{D}{2};3\frac{B}{8};2\frac{N}{12};3\frac{B}{7};3\frac{B}{10};3\frac{B}{11}$$

Approximately 40 unpublished geological maps are also understood to be available for reference in the archives of the Geological Survey in Ipoh, and publication of these maps, with accompanying memoirs, can be expected during the next few years. These unpublished maps are almost entirely based on post World War II geological surveys.

Forest Resources Map of Malaya

This map is really a very simple small scale land use map compiled from alienation records and incorporating boundary details of the game and forest reserves. It was published in 1951 on a scale of 12 miles to 1 inch. (1: 760,320)

1962 Vegetation Map of Malaya

This map was published in Volume 18 of the Journal of Tropical Geography in August 1964, and is on a scale of 24 miles to 1 inch. (1: 1,520,640).

1962 Soil Map of Malaya

This map was also published in Volume 18 of the Journal of Tropical Geography and is on the same scale as the vegetation map. Extra copies are obtainable from the Soil Science Division, Research Branch, Division of Agriculture.

Rainfall Map of Malaya

This map which is based on an analysis of rainfall records in the 1930—1939 period was prepared by the Meteorological Service, and was published in 1947. Dyeline copies of this map are available from the Soil Science Division.

Except where indicated in the text, copies of the above maps, if in print, are obtainable from the Map Sales Office, Survey Department, Mountbatten Road, Kuala Lumpur; or from the Survey Department Headquarters in Gurney Road. A list of available maps can be obtained on enquiry at the Map Sales Office.

2. METHODS OF COMPILATION

In Malaya a mapping scale of between 2 and 2½ inches to a mile has been found satisfactory for schematic-reconnaissance and detailed-reconnaissance soil survey purposes, and copies of the uncoloured edition of the published 1: 25,000 New Series sheets therefore make excellent field sheets. Unfortunately these maps have only been published for a limited area, but in those areas for which New Series 1 inch maps have been published without an accompanying 1: 25,000 edition, copies of the 2½ inch compilation sheets which were used in the preparation of the 1 inch maps can be obtained from the Chief Surveyor, Topographical Division. Similar, but only partly completed, compilation sections can also sometimes be obtained from the same source for those areas in which new series mapping is being undertaken, although such pre-publication sheets are of little use to the soil surveyor unless the compilation shows contour detail.

Planetable sheets were originally prepared at a scale of 2 inches to 1 mile (1: 31,680) for the Hind edition of Old Series maps, and then reduced to 1 inch (1: 63,360) for publication, and copies of these old planetables can occasionally be obtained, although most of the records are believed to have been destroyed during the war. In the case, therefore, of most Hind edition, and all of the Air Reconnaissance edition Old Series sheets, no larger scale maps are obtainable than those on the 1 inch publication scale, and in order to obtain a suitable field sheet for reconnaissance soil survey purposes enlargements must be prepared from the published sheets. Such enlargements can most conveniently be made to a scale of 2 inches to 1 mile (1: 31,680) by photostat machine as explained in the section on base maps.

It is normal soil survey practice to obtain 2 copies, or positive prints in the case of photostat enlargements, of each field sheet. One of these copies becomes the field map and is used during the course of the survey to plot observed soil boundaries, soil sample and examination points, traverse routes, including rentis positions, and other relevant field data; while the other copy, which is called the data sheet, is retained in the office and used to compile a permanent record of the soil survey results in a manner suitable for ready reference.

The data sheet is not simply a fair copy of the field map, as the information drafted on to this sheet is designed to show only the factual data obtained during the field examination, and to exclude the boundary detail which is obtained by extrapolation from this data during the compilation of the final soil map.

This manner of recording the field data is considered desirable because of the advantage of having a visual presentation on a large scale of the soil survey results, free from the high degree of error which is inevitable when soil boundaries are extrapolated under normal Malayan reconnaissance soil survey conditions. This applies particularly to areas of undisturbed or regenerating forest, but is also applicable to most areas covered by mature tree crops, and is a consequence of the physical limitations to lateral ground observations and therefore to field sketching of soil boundaries. It is this difficulty, together with the access problems normal to most forest areas, which has brought about the evolution of the rentis examination method on which most Malayan soil surveys depend.

The information shown on the data sheet comprises all the traverse routes, including accurate plots of the rentis net, in red waterproof ink; while soil examination points, brief notes on the soil types, series names, and positions of soil boundaries observed or inferred along the line of traverse, are all plotted in blue ink.

The next stage in compilation is carried out on a transparent Ethulon or tracing paper overlay placed over the completed data sheet, and on this the soil boundaries are extrapolated. This transparent overlay is called the compilation sheet. The detail shown on the data sheet is the main source of reference for drawing in the soil boundaries, but field note books, standard traverse notes and description sheets, aerial photographs, and the field map on which tentative soil boundaries may have been drawn during the course of field work, will all be consulted during this exercise. The two sheets (data sheet and compilation sheet) are then mounted on filing strips and stored together in a vertical plan filing cabinet from which they can be readily extracted for reference.

The separation of the factual soil information on the data sheet from the inferred boundary detail on the compilation sheet is particularly useful for making appreciations of the development potentialities of particular areas of land from the soil survey records, which is perhaps the most important interpretation made from soil surveys in undeveloped forest areas. In making such appreciations, it is advantageous to know which areas were actually examined, and this is best determined from a study of the rentis data plotted onto the data sheet, free of extrapolated boundary detail, which is inevitably of a lower standard of accuracy.

Appreciation of the cropping potential, management needs, and general development requirements of an area which is shown from the data sheet to have been examined in detail and actually traversed during the survey can always be made with greater confidence than is the case in the intervening areas between traverse lines, for which the soil boundaries are extrapolated and plotted separately on the compilation sheet. Comparisons between the factual data and the compilation are readily made by positioning the transparent compilation sheet over the data sheet.

Another advantage in having the results preserved on two separate sheets is that as further information is obtained about the soils of the area, either from detailed soil surveys, or from *ad hoc* soil and land inspections, the detail can be superimposed onto the data sheets without affecting the validity of the existing data; while revisions of the extrapolated boundary detail consequent on the new data can be incorporated onto a new compilation sheet which then replaces the original overlay. When this is done it is best to destroy the old compilation, to avoid any possibility of inadvertent reference.

Some discretion should be used in permitting access to soil survey field records preserved in this manner, and cautionary advice should be given to persons who are allowed to refer to these records and who are unlikely to appreciate the reliability of soil survey data shown on such a large scale. These records can be invaluable to soil surveyors, and others, with the necessary experience to make sound judgements from the technical data, but they can be dangerously misleading if they fall into the wrong hands.

For convenience it is useful to have the soil boundaries on the compilation sheets reduced to a 1 inch to 1 mile (1: 63,360) scale and superimposed on a copy of the appropriate standard 1 inch map series, and these reductions are also very useful for quick reference, for which purpose they are conveniently stored in the vertical plan filing cabinet with the 2 inch records.

A further reduction down to a scale of between 2 miles to 1 inch (1: 126,720) and 1: 500,000 (7.89 miles to 1 inch) will normally be necessary for publication, and this is best done onto a base map, specially prepared for the purpose during the early stages of the survey. The final publication scale will depend not only on the quality of the surveyor's field work and his professional judgement, but also on the time devoted to the survey, the degree of physical development and of existing access within the area, financial considerations, the quality of the base maps, and a host of other variables. Reduction is most conveniently and accurately carried out by means of a vertical reflecting projector.

3. AERIAL PHOTOGRAPHS

The generally high quality and extensive coverage afforded by the topographic map series for the Malay States, and the restricted availability and only average quality of much of the aerial photography, have been instrumental in reducing the dependence on aerial photographs of soil surveyors working in Malaya to a lower degree than is common in many surrounding territories.

Limitations on the use of aerial photographs are particularly apparent in forest covered regions, where the relatively uniform and dense vegetational cover obscures most of the ground detail which is necessary for accurate soil mapping, and it is in these areas, which cover about 70 per cent of the country, that soil surveys have to date been most extensively carried out.

A comparison between an aerial photograph and an accurately contoured topographic map for almost any forest-covered area enables the relative advantages and disadvantages of the two base media to be readily appreciated. The advantages of the aerial photographs are confined largely to the small amount of extra detail concerning vegetational differences between broad forest types. They are outweighed by the advantages of having a clear definition of the physiography in the form of drainage lines and contours accurately shown on a rigidly surveyed base, as is the case on the topographic maps. For these reasons it has become general practice to rely mainly on the topographic base maps for reconnaissance soil surveys, and to plot soil survey data and extrapolate soil boundaries directly onto these maps, rather than onto photographs.

The use of photographs in such surveys is therefore restricted to a preliminary inspection prior to commencing field work, and to office checking of details which may be obscure on the available maps but which can be clarified under stereoscopic examination.

Field experience soon gives the surveyor a measure of the reliance which can be placed on the different media, and as a broad generalization it can be said that high quality photographs are more useful in the more detailed types of reconnaissance surveys, and are of most value in those areas which are only mapped on the air reconnaissance edition. The quality of this edition varies enormously from sheet to sheet and the photographs are in practice most frequently consulted in the areas where ground control data at the time of compilation was of a very low order, resulting in inaccurate plotting of low ridges and drainage patterns in the lower-lying areas.

A comprehensive collection of aerial photographs is held in the photo library of the Topographical Division, Survey Department Headquarters, Gurney Road, Kuala Lumpur; and this collection consists mainly of aerial photographs taken since 1947 by the R.A.F., mainly using Eagle cameras, and reproduced on a wide variety of scales, including 1:25,000, 1:30,000; 1:40,000; 1:60,000 and 1:90,000. The whole country is covered by this collection, and some areas have been photographed 6 to 7 times, giving a wide choice of scale and quality.

In more recent years the Survey Department has obtained photographs of areas being re-surveyed by the Topographical Division, using an R.C. 8. camera mounted in a Dove aircraft. The earliest of these photographs, which are all on a scale of 1:25,000, were taken in 1959, and up to the present time almost 25 per cent of the country has been covered in this manner. Most of this coverage is of Selangor, Perak, and Negri Sembilan, together with small parts of Pahang. Copies can be borrowed, or purchased, from the Chief Surveyor, (Topographical Division) who will also prepare photo-mosaics at a small extra charge.

Photographic reconnaissance specifically for soil survey purposes may be arranged through the Survey Department, who will supply the camera and operator, and arrange for the aircraft hire, as well as carry out the film processing.

Government aircraft can also be hired for reconnaissance and transportation flights necessary for soil survey purposes at special rates applicable only to government departments. De Haviland Doves and Herons, Scottish Aviation Single and Twin Pioneers, and Sud-Aviation Alouette helicopters are amongst the aircraft available, and application should be made to the Ministry of Defence, Gurney Road, Kuala Lumpur. A special application form giving full flight details must be submitted with each application, and the choice of aircraft must be made with due consideration for the aims of the reconnaissance. Very broad reconnaissances over wide areas, and communication flights between the main airfields are best carried out in the Doves or Herons; more detailed reconnaissances over a wide area, and communication flights between the smaller airstrips are most satisfactorily made in single or twin Pioneers; while detailed observations and short-range tranportation and supply missions into the jungle can be conveniently carried out in the helicopters.

Helicopters can be brought into landing zones specially constructed by soil survey staff, if made in accordance with Ministry of Defence requirements, under special arrangements. A useful network of Helicopter Landing Sites also exists throughout central Malaya.

4. MAP PRODUCTION

When preparing maps for publication it is useful to have some knowledge of the stages involved in printing, so that the difficulties faced by the printer can be better appreciated and allowed for in the final draft.

In the case of lithographic colour printing, which is the usual process followed in soil map publication, the lithographer first prepares a negative contact on Estar Base film from the transparent draft submitted by the publisher, and from this he prepares sufficient non-photo or ferro-prussiate blues on Cut-N-Strip film or Astrofoil to match the number of separate basic colours required in printing. After cutting out, or masking out, the unnecessary detail by hand for each colour, the prepared Cut-N-Strip or Astrofoil, as the case may be, is placed on a photosensitised or aluminium coated zinc plate and the necessary printing screens are placed between the two materials, after which the pack is exposed to give the finished zinc printing plate. The printing then commences, with the plate containing the background detail, usually in grey, being run off first, followed by a black print of the soil boundary detail, title and frame, and then the various colour plates until the printing operation is completed. Trimming and folding of the sheets is then carried out in accordance with the publishers or editors instructions.

The soil scientist is usually directly responsible for bringing the map to the final draft stage, and this draft is most conveniently prepared on a thick, distortion-resistant transparent film, such as Permatrace or Durafilm. Unfortunately these polyester-type materials are often difficult to write on with mapping pens and waterproof drawing inks, and this is usually caused by a greasy surface film which is inherent to this type of material. A light rubbing with dry cotton wool dipped in french chalk will often improve the quality of the surface. Mixing the waterproof ink with equal quantities of oxgall can also help the ink to adhere to the material. Very smooth and greasy patches which do not respond to this processing may be treated with methylated spirit, but this should be used cautiously as the spirit will also remove pre-existing linework, including the images on photo-sensitive copying materials.

Draft maps should wherever possible be prepared on the same scale as the final publication, provided a competent draftsman is available to carry out the work. If the draft is handed to the cartographer with instructions to reduce for publication, the draft should be prepared on white drawing paper and not on transparent base material, as an extra photographic stage will be necessary to bring about the reduction. Lettering is most conveniently done using clarifoil impressions, and stencilling or freehand lettering should be avoided. Similarly, the cheapest types of tracing cloth and ordinary tracing paper should be avoided owing to the inferior quality of such material and particularly to a tendency to shrink or expand under conditions of variable humidity.

For soil maps a very satisfactory final print can be obtained by using a standard published map as a base plate, which will show all the background detail necessary for position finding. 1 inch standard topographic map sheets should be ideal in this respect for detailed soil maps, while smaller scale state maps are useful for reconnaissance sheets, and these can be run off in light grey (not black) ink, after which a black ink outline of the soil boundaries, legend, title and frame can be superimposed upon the grey background. Such a combination of grey and black ink gives a very pleasing finish to the map and the necessary emphasis to the soil detail. When both a black and a grey plate are to be used, the draft prepared on permatrace by the soil scientist should include only the detail which is necessary for printing the black plate, and an already published sheet, which represents the grey plate, should be fixed beneath the transparent film to ensure that the draftsman obtains a correct matching of the two plates.

When a pre-existing base map on the correct scale is not available, a photo-reduction, or enlargement, of the published topographic sheet may be made to give the correct size grey plate, and this can then be placed beneath the transparent film to guide the draftsman. The background detail for the 1962 Soil Map of Malaya, for example, was obtained in this way, by reducing the latest 12 miles to 1 inch (1: 760,320) physical map of Malaya down to half scale. In other cases, where sensible reduction may not be possible because the detail will come out too fine and indistinct, as happens when 1 inch to 1 mile (1: 63,360) New Series topographic sheets are reduced to a half inch to 1 mile (1: 126,720) scale, the entire map must be completely re-drafted by selecting the necessary background detail and reducing manually from larger scale originals. Such a map can usually be satisfactorily reproduced in black and colour only, without the extra grey plate, as the background detail will be then limited to what is necessary for interpretation of the soil data, and will not be sufficiently great to obscure the actual soil boundaries.

When the final draft showing the black plate detail has been prepared the colour selection must be made, and for this the Survey Department Standard Colour Chart should be consulted. This code is built up from six basic colours known as first and second yellow, red, and blue respectively, and indicated by the numbers 3, 6, 9, 12, 15, and 18 on the chart. All other colours, numbering 757, can be prepared by appropriate combination of up to four of these basic colours, together with several types of screening in black, grey and purple, which are made up of a selection of rulings, dots, and crosses.

As a separate plate is needed for each basic colour required in the printing process, and each plate is expensive, the choice of colours in the final maps is partly governed by considerations of economy, and about ten suitably contrasting colours, which are reasonably consistent with the standard soil colour code* can usually be obtained using three or four

* No detailed colour code has yet been compiled, but the colours used on soil maps published to date follow the broad groupings shown on the 1962 Soil Map of Malaya (Panton, 1964).

basic colour plates, so that, with the rather cheaper black and grey plates included, a total of five or six plates is necessary for printing a normal soil map. A very complex soil map, using perhaps 30 or 40 separate colours from the chart, would almost certainly need the maximum of eight plates.

In order to assist the printer in preparing the plates, it is advisable to prepare a hand coloured guide, matching the water colours as closely as possible to the colour selection made from the chart, and using a dyeline copy of the black plate draft. The Survey Department colour chart index number should also be written over each colour compartment on the guide, and, in addition, extra copies of the map should be prepared for each of the basic colours as a double check for the printer. These colour key sheets should then be very carefully checked and re-checked to ensure that no single colour compartment, including the legend, has been omitted from any sheet. It is usually possible to obtain plastic colour proofs, made from the negatives, for carrying out a final check of the accuracy of the colour detail before printing commences. Mistakes which are not discovered at this stage can easily pass unnoticed until after the final map has been printed, by which time it is too late to obtain a correction without the expenditure of much time and money.

The final drafting stage consists of drawing in the map frame, and very special care should be taken to ensure that this is correctly orientated to the latitude and longitude lines of the base map, and that the size of the frame, together with the margin and binding edge, is related to the size of the publication in which the map is to appear. It is advisable to prepare a dummy copy, at the correct size, and check the position of the folds in relation to the map detail when the format for the colour, legend, title, etc. is being decided if an aesthetically satisfying production is desired.

For the best professional results high grade printing inks and best quality paper should be specified. It is also worth bearing in mind that the most satisfying results are likely to be obtained if the drafting and printing stages are not hurried. Slight errors made through hasty preparation may stand out sharply in the final print, and act as a permanent embarrassment to the author and a minor irritant to the user.

SOIL REPORTS

Every completed soil survey must be finalised by the preparation of the soil map and a report, and in some instances it may be desirable to have one or more progress reports prepared during the course of the survey. In Malaya, soil maps and reports are either printed or duplicated depending on the size of the area surveyed and to some extent on the interest which is likely to be shown in the results of the survey. There are three main vehicles of publication: -

(a) Bulletins of the Department of Agriculture which are used for reports covering areas at least as large as individual States. These are accompanied by printed maps and are normally fairly comprehensive.

(b) Papers in the Malayan (now Malaysian) Agricultural Journal and in other locally published journals such as the Journal of Tropical Geography. These reports normally embrace smaller areas than those published as bulletins but are usually of considerable pedologic and land use interest.

(c) Malayan Soil Survey Reports. These reports are cyclostyled and bound with a printed cover. They may be supplemented with a printed map, or with a coloured sunprint. This type of report has been introduced to meet the requirements of the schematic-reconnaissance survey, and in general cover the area surveyed by one man in a period of about two years. They have the advantage of making technical soil survey data available promptly and yet in a reasonably elegant form.

Until the results of the soil survey are published, the information is relatively inaccessible and for the most part cannot be used without interpretation personally by the soil surveyor. Consequently the preparation for publication should be finished without delay and before the dispersal of essential members of the survey team. The soil report is aimed primarily at agricultural officers, scheme and estate managers and advisors, and others who require soil information. However, it should contain enough technical data to satisfy the interest of other soil scientists.

The following is an idealised framework for the preparation of a soil report. This need not be followed slavishly but should act as a guide when preparing material for publication: -

1. INTRODUCTION

   Purpose of the survey; location and size of the area surveyed; general description of the area; methods of survey.

2. THE ENVIRONMENT

   Physiography and terrain; geology; vegetation; climate.

3. THE SOILS

   Dominant soil-forming factors; mapping and classification units; legend; description of individual soils including main environmental characteristics, main profile characteristics, variations, present land use, potential crop suitability, analyses.

4. SOIL CLASSIFICATION

   The arrangement of series into families and great soil groups.

5. SOIL SUITABILITY

   Soils classed according to suitability for agriculture.

6. MAIN CONCLUSIONS

7. REFERENCES
Literature cited in text.

8. ACKNOWLEDGEMENTS

9. APPENDIX
Detailed profile descriptions for the main series.

10. SOIL MAP

11. MAP SHOWING SOIL SUITABILITY

Tables, figures, and photographs may be used wherever possible to summarise or emphasise certain features. Every report should include, near the beginning, a sketch map showing the situation of the area surveyed in relation to the country as a whole or the State as a whole.

Chapter 4

SOIL IDENTIFICATION AND CLASSIFICATION

THE identification of soils in the field is of vital importance to soil surveyors and of very real interest to many other people. Since about 1950 many workers in various parts of Malaya and in different organizations have established approximately 200 separate soil series. Not all these units satisfy the requirements of the series definition. Some are duplications and many are not described well enough for them to be of much practical value. The responsibility for rectifying this situation lies directly with the Soil Survey Section of the Soil Science Division, Division of Agriculture, as the major body actively pursuing soil survey in Malaya. This can only be done in close co-operation with other organizations which use soil data and which in some instances carry out soil surveys. A free interchange of information and an acceptance of the prerogative of the Division of Agriculture to ratify the setting up of new series are essential to establish a generally acceptable soil classification.

To date all series of which there is any record have been culled to less than 100 common series which form the basis of a soil register to be built up and maintained in the Soil Science Division in Kuala Lumpur. These series are in general either firmly established by common usage or of wide extent, and available descriptions are currently being revised with a view to compiling comprehensive and diagnostic data for each. Existing information is summarised in the following key to provide a ready reference to the main differences between series:

KEY TO THE NAMES OF THE COMMON SOIL SERIES

I. SEDENTARY SOILS

A. On granite

1. Subsoil colour predominantly brown (strong brown to pale brown, 7.5YR5/6, 10YR8/3)
   (i) on steep slopes with gravelly textures and shallow profiles .... BUKIT TEMIANG
   (ii) at high altitudes (4000 ft or about 1200m) with podzol characteristics .... GUNONG PADANG
2. Subsoil colour predominantly yellow (brownish yellow, reddish yellow, pale yellow 10YR6/8, 7.5YR6/8, 2.5Y8/4)
   (i) with coarse sandy clay to clay loam textures and brownish yellow colour, becoming red with depth .... RENGAM
   (ii) pale colour and coarse texture throughout .... TAMPIN
   (iii) reddish yellow subsoil colour and gravelly texture, on hilly terrain .... BUKIT LUNCHU
3. Subsoil colour predominantly red (red to yellowish red, 2.5YR5/8, 5YR4/6)
   (i) red colour within 30 inches of the surface.......................... RENGAM, red variant

(ii) prominent feldspar phenocrysts in subsoil .... KALA

B. On quartz porphyry, rhyolite and dacite

1. Subsoil colour predominantly yellow (2.5Y6/6-7/6)

   (i) colour yellow to olive yellow with silty clay textures and firm consistence .... KULAI

   (ii) mottled pale yellow to yellowish brown subsoil, silty clay texture with waxy feel .... CHENAIN

2. Subsoil colour predominantly brown (10YR4/4, 7.5YR5/6)

   (i) dark yellowish brown to strong brown sandy clay loam on very compact, strongly mottled horizon .... HARAD

3. Subsoil colour predominantly red (yellowish red 5YR 4/8-5/8)

   (i) friable clay loam on dacite YONG PENG

C. On granodiorite and quartz diorite

1. Subsoil colour predominantly red (yellowish red 5YR 4/8-5/8)

   (i) on steep slopes with relatively shallow profiles .... BUKIT AJIL

   (ii) friable clay to clay loam textures on undulating to hilly terrain .... KAMPONG KOLAM

2. Subsoil colour predominantly brown (7.5YR5/6-8)

   (i) fine sandy clay loam textures common .... JERANGAU

(ii) close packed laterite within 24in (60cm.) .... MASAI

D. On andesite and diorite

1. Subsoil colour predominantly red (2.5YR4/6, 5YR4/8-5/8)
   (i) friable, strongly structured clay on andesite.................. SEGAMAT
   (ii) friable clay to silty clay with laterite normally within 24 in. (60 cm.) on dioritic gabbro... SENAI
2. Subsoil colour predominantly brown (10YR5/6-7.5YR5/6)
   (i) friable, strongly structured clay normally on hilly terrain KATONG

E. On basalt

1. On rapidly drained sites
   (i) colour predominantly brown (10YR4/4-5YR4/4) strongly structured clay..................... KUANTAN
2. On slowly drained sites
   (i) clay to gravelly clay with unusual greenish grey colour.... PELAWAN

F. On schist and hornfels

1. On schist
   (i) yellowish brown to brownish yellow (10YR5/6-6/8) fine sandy loam to fine sandy clay loam .... BATANG MERBAU
   (ii) strong brown to reddish yellow (7.5YR5/8-6/8) sandy clay to clay with laterite...... SEREMBAN

2. On hornfels
   (i) friable, strongly structured red to yellowish red (2.5YR5/8-5YR5/8 clay to clay loam... PATANG

G. On argillaceous sediments (shale, phyllite, argillite and mudstone)

1. With dominantly lateritic profiles (laterite is a major profile feature normally occurring within 24 in. or 60 cm.)
   (i) laterite which may be massive or nodular, within 24 in. (60 cm.) and thicker than 36 in. (90 cm.) .... MALACCA
   (ii) laterite within 12 in. (30 cm.), mapped mainly in Kelantan... TANDAK
   (iii) characterised by pea-sized black concretions, mapped mainly in Kedah................ CHUNGLOON
   (iv) laterite within 24 in. (60 cm.) mapped mainly in Kedah...... GAJAH MATI
   (v) Subsoil yellowish brown (10-YR5/8) silt loam with laterite concretions within about 8 in. (20 cm.) .... PADANG BESAR

2. With yellowish and brownish colours dominant
   (i) brownish yellow (10YR6/6) very firm compact silty clay which may have laterite fragments at depth over variegated clay .... DURIAN
   (ii) yellowish brown (10YR5/6) friable fine sandy clay with strong structures................ BUNGOR

(iii) yellowish brown (10YR5/4) loam on reddish yellow (7.5-YR6/6) clay loam, mapped mainly in Kedah.................. NAMI

(iv) yellowish brown (10YR5/8) to brownish yellow (10YR-6/8) firm sandy clay loam with laterite concretions below about 24 in. (60 cm.) mapped mainly on hilly terrain in Johore..................... BUKIT RESAM

(v) strong brown (7.5YR5/6) to reddish yellow (7.5YR6/8) friable to firm silty clay loam; laterite fragments may occur... MUNCHONG

(vi) strong brown (7.5YR5/6) firm loam to clay loam with laterised parent material fragments BATU LAPAN

3. With reddish colours dominant

(i) yellowish red (5YR5/8) to yellowish brown (10YR5/8) friable sandy clay loam over nodular laterite normally deeper than 24 in. (60 cm.) and thinner than 36 in. (90 cm.) .... TAVY

(ii) yellowish red (5YR5/8) silty clay loam.......................... MUNCHONG, red variant

(iii) yellowish red (5YR5/6) mottled, friable clay.................. JEMPOL

4. With pale colours dominant

(i) Pale yellow (2.5Y7/4) to light grey (2.5Y7/2) mottled very firm silty clay; laterite fragments normally present......... BATU ANAM

(ii) Light grey (10YR7/1-5/1) fine sandy clay loam to clay; mottled .... APEK

5. With greyish or brownish profiles on carbonaceous shale

(i) Greyish brown (2.5Y5/2) firm silty clay loam to clay......... KEMUNING

(ii) Yellowish brown (10YR5/6) friable clay loam................. POHOI

H. On arenaceous sediments (quartzites, quartzose sandstones, conglomerates)

1. Subsoil colour predominantly brown

(i) yellowish brown (10YR5/8) to brownish yellow (10YR6/6) friable fine sandy loam......... KUALA BRANG

(ii) Strong brown (7.5YR5/6) to yellowish red (5YR5/8) sandy loam to sandy clay loam ..... SERDANG

(iii) Brown (7.5YR5/4) fine sandy loam .... KUALA NERANG

(iv) Strong brown (7.5YR5/6) to yellowish red (7.5YR6/6) sandy loam, shallow profiles normally on steep slopes.......... KEDAH

(v) Clay loam with nodular laterite at about 24 in. (60 cm.)... MONG GAJAH

(vi) Yellowish brown (10YR5/6) loam with nodular laterite at about 12 in. (30 cm.)........... POKOK SENA

2. Subsoil predominantly pale coloured

(i) Light yellowish brown to pale yellow (2.5Y6/4-7/4) loamy sand ....

3. Subsoil colour predominantly red ... MARANG

(i) Yellowish red (5YR5/8) to red (2.5YR5/6) sandy clay loam .... SERDANG, red variant

J. On limestone and calcareous shales

1. With laterite

(i) Moderately structured red (2.5YR4/6) clay loam subsoil with few small laterite concretions at depth; on limestone .... KAKI BUKIT

(ii) Moderately structured red (2.5YR4/6) clay loam subsoil with dense nodular laterite concretions within 24 in. (60 cm.), on limestone.............. KODIANG

2. Without laterite

(i) Deep, uniform strongly structured dark red (2.5YR3/6) clay loam on limestone....... LANGKAWI

(ii) Strongly structured, very friable reddish yellow (7.5YR-6/8) clay on calcareous shale.. WENG

II. ALLUVIAL SOILS

A. On River Alluvium

1. On floodplains and recent terraces

(a) Very well drained

(i) Yellowish brown (10YR5/4) to strong brown (7.5YR5/8) sandy textured and friable... TELEMONG

(ii) Yellowish brown (10YR5/8) to strong brown (7.5YR5/8) silty textured.......................... TELAGA

(iii) Light grey (10YR7/1) silt textured from rewashed rhyolitic ash .... HALU

(b) Moderately well drained

(i) Yellowish brown (10YR5/4) mottled fine sandy loam to clay loam.......................... AKOB

(c) Imperfectly drained

(i) Black (5YR2/1) sandy loam to clay loam over light grey (10YR7/1) mottled sandy clay loam, occurring in association with fresh water swamps......... JARAU

2. On river basin deposits in the Kelantan "deficiency area"

(a) Moderately well drained...... KAMPONG CHERANG HANGUS, PADANG GONG CHENAK, LATI

(b) Imperfectly drained............... BUKIT TUKU KAMPONG LUBOK KIAT KAMPONG PUSU

3. On river basin deposits

(a) Imperfectly drained

(i) Mottled olive grey clay loam over light grey or white waterlogged subsoil .... MERBAU PATAH

(b) Very poorly drained

(i) Mottled olive grey sticky loam over white, structureless, waterlogged subsoil.................. TIAN BAHRU

4. On plain tracts

(a) Imperfectly drained

(i) Brown (10YR5/3) silty clay over mottled light grey (2.5-Y7/2) to grey (10YR6/1) clay grading into bluish grey (5BG-6/1) silty clay.................... BRIAH

5. On valley tracts

(a) Imperfectly drained

(i) Yellowish brown sand or clayey sand over grey mottled sand or clayey sand; formed on colluvium........................ KAMPONG KUBOR

B. On Marine Alluvium

1. Excessively drained

(i) Very loose, structureless dark grey (10YR4/1) sand over light grey (10YR7/1) sand formed on ancient beach remnants along the West Coast... JAMBU

2. Very well drained

(i) Loose, structureless sand with podzol profile characteristics formed on old beaches along the East Coast.................. RUDUA

3. Poorly drained

(a) On coastal swamps

(i) Dark brown silty clay over dark grey or black muck, formed under mangrove vegetation .... KRANJI

(ii) Dark grey to black over light grey or white mottled clayey sand to sandy clay, formed on lagoonal swamps between sand ridges........................ RUSILA

(b) On the coastal plain

(i) Dark greyish brown (10YR-4/2) silty clay loam over mottled light brownish grey (10-YR6/2) and greenish grey (5GY5/1) silty clay............ SELANGOR

(ii) Deep black topsoil on light grey to light olive grey clay with mottles at depth.......... KANGKONG

4. Very poorly drained

(i) Dark reddish brown (5YR2/2) clay loam over mottled light yellowish brown (10YR6/4) silty clay and greenish grey (5G6/1) silty clay............... TELOK

(ii) Very dark greyish brown organic clay on dark brown muck over bluish grey structureless clay, formed in brackish water.......................... LINAU

(iii) Firm, structureless light grey loamy sand to sandy clay loam developed on old marine beach sands in fresh water swamps .... PENOR

C. On Subrecent Alluvium

1. Very well drained

(i) Friable light yellowish brown (10YR6/4) to brownish yellow (10YR6/6) sandy loam... HOLYROOD

(ii) Dark brown (10YR4/3) to yellowish brown (10YR5/4) and yellow (10YR8/6) loose, structureless sand with iron oxide accumulation in the subsoil .... SUNGEI BULOH

2. Well drained

(1) Greyish brown (10YR5/2) strongly structured silt loam to silty clay on pale yellow (2.5Y7/4) clay or clay loam... SITIAWAN

3. Poorly drained

(i) Light grey (10YR7/1) sandy loam to sandy clay loam subsoil .... HOLYROOD grey variant

(ii) Mottled light grey (10YR7/1) to white (10YR8/1) clay to sandy clay .... MANIK

(iii) Grey silty clay over light grey to white silty clay to clay, few mottles .... SOGOMANA

D. On Older Alluvium

(i) Friable moderately structured brownish yellow (10YR6/8) sandy clay loam, compact subsoil .... HARIMAU

(ii) Friable, weakly structured brownish yellow (10YR6/8) to reddish yellow (7.5YR7/6) sandy clay loam to gravelly clay loam, very compact subsoil .... ULU TIRAM

(iii) Firm, weakly structured reddish yellow (7.5YR6/6) to yellowish red (5YR5/8) sandy loam to sandy clay loam, very compact subsoil............ TAMPOI

(iv) Firm, strongly structured brownish yellow (10YR6/8) silty clay loam..................... TAI TAK

(v) Firm to very firm brownish yellow (10YR6/6) clay loam to sandy clay loam............ RASAU

(vi) Grey (10YR5/1) clayey sand to loamy sand on light grey (10YR6/1) and pale yellow (2.5Y7/4) sandy clay, with few mottles .... SEGARI

LEGEND FOR THE SCHEMATIC-RECONNAISSANCE SURVEY

Most of the series and variants which have been encountered so far during the course of the schematic-reconnaissance survey have been grouped into classification units up to family level in the following legend. This will be extended and modified as the survey progresses and can only be finalised at its conclusion. The family groupings have already been revised considerably since they first appeared in the draft copy of this Manual, issued in mid-1965.

I. SEDENTARY SOILS

A. On acid and intermediate igneous rocks

	Map Symbols*
RENGAM FAMILY	
Rengam Series	RGM
Bukit Lunchu Series	BLU
Bukit Temiang Series	BTG
Gunong Padang Series	GPG
Kala Series	KLA
KULAI FAMILY	
Kulai Series	KLI
Chenain Series	CHN
Harad Series	HRD
Tampin Series	TPN
KAMPONG KOLAM FAMILY	
Kampong Kolam Series	KKM
Jerangau Series	JRA
Rengam Series, red variant	RGM/1
Yong Peng Series	YPG
Katong Series	KTG
Bukit Ajil Series	BAL

B. On intermediate and basic igneous rocks

SEGAMAT FAMILY	
Segamat Series	SGT
Senai Series	SNI
KUANTAN FAMILY	
Kuantan Series	KUN
Pelawan Series	PLN

C. On schist, hornfels and calcareous rocks

*These are standardised three letter abbreviations, using prominent letters from the series name, which have been established for use on maps and in field notes. Variants are indicated by numerals and phases may be indicated by lower case letters, following a stroke placed after the series symbol.

PATANG FAMILY

Patang Series	PTG
Seremban Series	SBN
Weng Series	WNG

LANGKAWI FAMILY

Langkawi Series	LKI
Kaki Bukit Series	KBT
Kodiang Series	KDG

D. On argillaceous and arenaceous sediments.

MALACCA FAMILY

Malacca Series	MCA
Tandak Series	TDK
Gajah Mati Series	GMI
Chungloon Series	CGL
Padang Besar Series	PBR

TAVY FAMILY

Tavy Series	TVY
Bukit Resam Series	BRM

DURIAN FAMILY

Durian Series	DRN
Bungor Series	BGR
Kuala Brang Series	KLG
Batang Merbau Series	BMU

JEMPOL FAMILY

Jempol Series	JML
Munchong Series, red variant	MUN/1
Serdang Series, red variant	SDG/1

MUNCHONG FAMILY

Munchong Series	MUN
Batu Lapan Series	BLN

POHOI FAMILY

Pohoi Series	PHI
Kemuning Series	KMG

BATU ANAM FAMILY

Batu Anam Series	BTM
Apek Series	APK
Marang Series	MRG

POKOK SENA FAMILY

Pokok Sena Series	PKA
Mong Gajah Series	MGH

SERDANG FAMILY

Serdang Series	SDG
Kuala Nerang Series	KNG
Nami Series	NMI
Kedah Series	KDH

II. ALLUVIAL SOILS

A. On Recent Alluvium

TELEMONG FAMILY

Telemong Series	TMG
Telaga Series	TLA
Halu Series	HLU

BRIAH FAMILY

Briah Series	BRH
Jarau Series	JRU
Merbau Patah Series	MPH
Tian Bahru Series	TBU
Akob Series	AKB

SELANGOR FAMILY

Selangor Series	SLR
Kangkong Series	KGG
Telok Series	TLK

Drive, is of course open to considerable criticism with regard to the nomenclature, but has undoubtedly fulfilled its main purpose, which was to supply a relatively simple picture of the broad soil distribution pattern over the whole country.

The classification used on this Map is summarised in the following Table: -

TABLE IV

1962 SOIL CLASSIFICATION

Soil Group	Brief Description	Example
Lithosols/Shallow latosols	Steep land soils with parent material on or close to the surface.	Bukit Temiang Series.
Red and yellow latosols. Red and yellow Podzolic soils.	Undulating land soils with deep profiles.	Rengam Series. Serdang Series.
Reddish brown latosols.	Undulating land soils with deep profiles developed from basic igneous parent materials.	Kuantan Series. Segamat Series. Kampong Kolam Series.
Laterite soils.	Undulating land soils with strongly developed laterite horizons developed from iron-rich argillaceous parent materials.	Malacca Series. Gajah Mati Series.
Low humic gleys	Alluvial soils of the main plains and the river valleys.	Selangor Series. Akob Series.
Podzols	Soils with iron or humic "B" horizons, developed from highly siliceous parent materials over relatively flat topography.	Rudua Series. Sungei Buloh Series. Gunong Padang Series.
Organic soils	Peats and mucks.	
Azonal soils	Recent marine sediments.	Kranji Series.

The following further explanations are relevant to this Table: —

(1) The Lithosol/Shallow Latosol group includes shallow Red Yellow Podzolic soils and Podsols, particularly at higher altitudes.

The soils within the Red and Yellow Latosol/Red Yellow Podzolic group were not separately shown on the Map owing to the difficulty experienced in mapping firm boundary lines between these two groups on reconnaissance surveys. It is considered that under Malayan conditions, the absence or presence of a textural B horizon would be a useful diagnostic feature for separating soils into one or other of these groups, and furthermore it seems that the more heavily textured soils tend towards the Latosolic type; while the lighter textured soils are closer to the Podzolics. Latosolic features may become more dominant towards the south of Malaya, largely as a result of the change in the climate as the Equator is approached. Certain reservations were felt with regard to the widespread recognition of the Podzolic group in view of the strong prevalence of rather sandy surface soil horizons in Malayan hill soils which is attributed to strong surface wash and mass movement under the normal conditions of erosion.

(3) The well structured and strongly coloured soils derived from intermediate and basic igneous rocks have been classed as Reddish Brown Latosols since Owen first considered this question. More recently, suggestions have been made that some of these soils may be Reddish Brown Lateritic Soils as in the case of the Kampong Kolam Series, and Grumusols as in the case of the Kuantan Series (Moormann et al. 1964).

(4) The use of a separate group of Lateritic soils at the great soil group level, while not new, is not a common grouping which is generally accepted in soil li-

terature. Nevertheless, strong arguments in favour of such a grouping can be adduced from a study of Malayan soils.

The appearance of more precise definitions of the commonly used classification units (Dudal and Moormann, 1964; World Soil Resource Report 12, 1964) and the inauguration of soil correlation with other countries in the region (Moormann et al. 1964) have encouraged further modification to these earlier classifications at the great soil group level. The advent of the Seventh Approximation (Soil Survey Staff 1960) and Amendments (Dr. Guy D. Smith, personal communication) has enabled this attempt to be extended to higher classification categories.

At present the technical soil classification is evolving slowly along two parallel avenues, employing conventional names up to great soil group level and introducing the Seventh Approximation terminology beyond that, and although no finality can be expected at least until 1967, the following Table shows the tentative taxonomic trends: —

TABLE V
COMPARATIVE CLASSIFICATION

Series (examples only)	Great soil groups (after Panton, 1962)	Great soil groups (World Soil Resource Report, 1964)	7th Approximation and Amendments	
			Sub-order	Order
Selangor	Low humic gley	Alluvial soils	Aquent	Entisol
Bukit Temiang	Lithosols/ shallow Latosols.	Regosols	Udent	Entisol
Rengam	Red and Yellow Latosols/ Red and Yellow Podzolic	Red Yellow Podzolic soils.	Udult	Ultisol

Series (examples only)	Great soil groups (after Panton, 1962)	Great soil groups (World Soil Resource Report, 1964)	7th Approximation and Amendments	
			Sub-order	Order
Kampong Kolam	Reddish Brown Latosols.	Reddish Brown Lateritic Soils (low base status).	Argox	Oxisol*
Segamat	Reddish Brown Latosols.	Red Yellow Ferralsols.	Acrox	Oxisol*
Malacca	Laterite soils	Ferruginous (Tropical) Soils.	Haplox	Oxisol*
Rudua	Podzols	Podzols.	Humod	Spodosol
Harimau	Not distinguished.	Pale Yellow Ferralsols.	Haplox	Oxisol*
Peat	Organic soils.	Organic soils.	—	Histosol

* The classification of soils into, and within, the Oxisol Order follows the modifications suggested by Haantjens (1965).

ANGLE OF SLOPE AND PER CENT GRADES

Degree	Per cent
2	3.5
4	7
6	10.5
8	14.1
10	17.6
12	21
15	26.8
20	36.4
25	46.6
30	57.7
40	84.0

EQUIVALENT MAP SCALES

British Units	Fractional Scale (R.F.)
32 miles to 1 inch	1: 2,027,520
24 miles to 1 inch	1: 1,520,640
16 miles to 1 inch	1: 1,013,760
12 miles to 1 inch	1: 760,320
8 miles to 1 inch	1: 506,880
4 miles to 1 inch	1: 253,440
2 miles to 1 inch	1: 126,720
1 mile to 1 inch	1: 63,360
40 chains to 1 inch	1: 31,680
32 chains to 1 inch ($2\frac{1}{2}$ in./1 mile)	1: 25,344
20 chains to 1 inch	1: 15,840
10 chains to 1 inch	1: 7,920
8 chains to 1 inch	1: 6,336
5 chains to 1 inch	1: 3,960

Fractional Scale (R.F.)	British Units
1: 2,000,000	31.57 miles to 1 inch
1: 1,000,000	15.78 miles to 1 inch
1: 500,000	7.89 miles to 1 inch
1: 250,000	3.95 miles to 1 inch
1: 100,000	1.58 miles to 1 inch
1: 25,000	0.395 miles to 1 inch or 31.56 chains to 1 inch

SOIL DESCRIPTION SHEET AND ABBREVIATIONS

The following soil description sheet and standardised abbreviations for the main morphological features have been found reasonably satisfactory under Malayan conditions. The disadvantage of an arbitrary system such as this is that observations tend to be confined to the listed headings and personal initiative is minimised. On the other hand, all soil profile data is recorded in a consistent and standardised manner, which is a very great advantage in correlation work, and probably warrants retention of this system at least until the conclusion of the schematic-reconnaissance survey.

The soil description sheet is printed with the abbreviations on the back and is carried in the field on a metal clipboard along with the traverse sheets.

FIGURE 3

SOIL DESCRIPTION SHEET

Field No.	Rainfall:	Location	Vegetation
Lab. No.	Grid Ref.		

Landform	Elevation	Slope and Terrain Class	Drainage/Water Table	Erosion	Parent Material

Horizons		Sample Depth & Number	Colour	Texture	Consis-tence	Structure	Channels, Roots, Casts Etc.,	Clayskins (C) & Pores (P)	Identifiable Minerals	Mottles	Stones & Concre-tions	Boun-dary
Symbol	Thick-ness											

Special Features/Notes:

Tentative/Established Series	
Phase	Group
Surveyor:	Date:

SUGGESTION ABBREVIATIONS

1. Texture:

gravel	g	stony loam	stl
very coarse sand	vcos	silt	si
coarse sand	cos	silt loam	sil
sand	s	clay loam	cl
fine sand	fs	silty clay loam	sicl
very fine sand	vfs	sandy clay loam	scl
loamy coarse sand	lcos	fine sandy clay loam	fscl
loamy sand	ls	coarse sandy clay loam	coscl
loamy fine sand	lfs	stony clay loam	stcl
sandy loam	sl	silty clay	sic
fine sandy loam	fsl	clay	c
very fine sandy loam	vfsl	muck	m
gravelly sandy loam	gsl	peat	p
loam	l	mucky peat	myp
gravelly loam	gl	peaty muck	pym

2. Consistence:

Wet Soil —		*Moist Soil —*	
non-sticky	wso	loose	ml
slightly sticky	wss	very friable	mvfr
sticky	ws	friable	mfr
very sticky	wvs	firm	mfi
non-plastic	wpo	very firm	mvfi
slightly plastic	wps	extremely firm	mefi
plastic	wp		
very plastic	wvp	*Cementation —*	
		weakly cemented	cw
		strongly cemented	cs
		indurated	ci

3. Structure:

Size —		*Shape —*	
very fine	vf	platy	pl
fine	f	prismatic	pr
medium	m	columnar	cpr
coarse	c	blocky	bk
very coarse	vc	angular blocky	abk
		subangular block	sbk
Grade —		granular	gr
structureless	0	crumb	cr
weak	1	single grain	sg
moderate	2	massive	m
strong	3		

Example: moderately to strongly developed medium and fine subangular blocky = mf2-3sbk.

4. Pores:

Few	(1 - 3/sq. inch or about 6.5 sq. cm.)	1P
Many	(4 - 14/sq. inch)	2P
Abundant (more than 14/sq. inch)		3P

5. Clayskins:

Patchy clayskins on few peds and in some pores	1C
Discontinuous clayskins on some peds and in many pores	2C
Almost continuous clayskins on most peds and in most pores	3C

6. Mottles:

Abundance —		*Contrast —*	
few	f	faint	f
many	m	distinct	d
abundant	a	prominent	p
profuse	p		

Size —	
fine	1
medium	2
coarse	3

Example: few medium prominent strong brown mottles = f2p7.5YR5/6.

7. Horizon boundaries:

Sharp	sh
Distinct	ds
Indistinct	id
Diffuse	df

APPENDIX 3

THE COLLECTION AND PREPARATION OF SOIL MONOLITHS

A Soil Monolith is a vertical section of the upper part of a soil profile, which is preserved in a suitable protective case for display, instruction, and correlation purposes. The standard monoliths in the Soil Science Division collection are 48 inches in length, 7 inches wide and 2 inches deep (about $122 \times 18 \times 5$ cm.).

In taking a monolith a pit is first dug to a depth of about 5 feet (about 1.5 m.) and one vertical face is then carefully smoothed to a depth of at least 4 feet (about 1.2 m.) and a width of at least 1 foot (about .3 m.), and into this is pressed a steel frame, measuring $48'' \times 9'' \times 3''$ (about $122 \times 23 \times 7.5$ cm.) until the outside edge of the frame lies flush with the smoothed profile surface. A steel backing plate is then fixed onto the edge of the frame, to give extra rigidity to the frame and the enclosed soil column, after which the frame and contents are carefully separated from the surrounding soil and transported, with the minimum of vibration, to the laboratory. Detailed notes on the profile characters as seen in the pit should be made at the time the monolith is extracted, with particular care being made in noting the natural soil colour and structure, which in the case of the monolith may show a gradual change after several years of even the most careful preservation. A series of soil samples should also be taken for chemical analysis together with an extra large sample of the top 12 inches (30 cm.), which will be placed in a suitable container beside the monolith for determination of soil textural class by feel. If possible a sample of the parent rock or parent material should also be taken.

After leaving the soil to dry out for a few hours, or perhaps a few days in the case of a very moist heavy textured alluvial soil, the exposed surface of the monolith is very carefully smoothed and a wooden mounting board, covered with a thick layer of cellulose acetate in acetone cement, is placed over the exposed surface, and the board, frame and contents inverted. When the cement has set, the steel frame is carefully lifted off the monolith and the edges of the column trimmed down until the column is a uniform width of about 7 inches (about 18 cm.). Wooden side and base pieces 2 inches (5 cm.) deep are then fixed firmly into position around the edge of the column, and the exposed surface of the monolith is structured down to show up as well as possible the natural structural elements of the profile.

The monolith is next carefully sprayed with a 2.5% phenol solution in water until the moisture content approximates to average field conditions, the phenol being added to the water simply to sterilize the soil in order to prevent the growth of fungus and multiplication of soil fauna which might otherwise take place. A glass plate, the underside of which has been treated with a 1 : 2 glycerine/water mixture to reduce condensation, is then securely fixed over the prepared monolith face, and the entire monolith frame enclosed in a complete polythene envelope which is sealed to the glass with a suitable glue such as white Bostick.

Monoliths prepared in this way have been preserved intact and without undergoing any noticeable alteration for many years.

APPENDIX 4

THE CONSTRUCTION OF RELIEF MODELS

INTRODUCTION

A relief model is a graphic way of showing the physiographic features of a region in three dimensions. It is particularly effective in translating factual resource data into terms readily comprehended by people who have not been trained in map interpretation. Such a model also assists technical personnel in their analysis of a region and, if the model is constructed with care and precision, it can emphasise facets of the geological structure which had not been obvious before.

MATERIALS

The materials required are very simple — a topographic base map which is the source of information; plywood or cardboard to form the core of the model; plasticine to round off the angular plywood edges; plaster of paris to make a mould of the model so that it can be reproduced in durable material; and paint (poster type is most effective) to illustrate the required pattern (soils, land use, forestry, geology etc.) on the model.

SCALE

The scale selected depends on the purpose of the model and on the size of the region involved. Vertical exaggeration of the scale is almost always necessary. On a model based on a 1 inch to 1 mile (1: 63,360) map, if the horizontal and vertical scales are the same, a 5,000 ft. (about 1,525m) mountain will be a little less than 1 inch (2.5 cm.) high on the model. If the model is observed by a person standing at a table, with his eyes about 30 inches (about 75 cm.) above the model, the effect is the same as if the terrain is viewed from an aircraft flying at nearly 160,000 ft. (nearly 49,000 m.). At this height the topography will not show up very well. In practice, 30,000 ft. (about 9,000 m.) is a satisfactory altitude from which to observe mountainous terrain and a similar effect, from 30 inches (about 75 cm.) above the model, will be obtained if the vertical scale is exaggerated 5 times i.e. 5,000 ft. (about 1,525 m.) mountains are shown as nearly 5 inches (12.5 cm.) high instead of nearly 1 inch (2.5 cm.) high. A 1: 5 horizontal to vertical ratio model has therefore been found satisfactory in depicting the Malayan landscape when the horizontal scale is 1 inch to 1 mile (1: 63,360).

It should be remembered that a model exaggerated in this way will be distorted in comparison with the view from an aircraft at 30,000 ft. (about 9,000 m.) and in particular slopes on the model will appear steeper than they actually are. However, the distortion is most obvious at an angle close to the horizontal, and least obvious from a near vertical, or normal, viewpoint.

On smaller scale maps an even greater exaggeration is necessary if the proper effect is to be obtained, and a 1: 9.6 ratio of horizontal to vertical has been found satisfactory for 1: 500,000 horizontal scale models. On such a model, Gunong Tahan, a 7000 ft. (approx. 2100 m.) peak and the highest mountain in Malaya, is shown to be about 1¾ inches (4.5 cm.) high, similar to the impression which would be gained from an aircraft flying at approximately 125,000 ft. (38,000 m.) Without this exaggeration, i.e. with horizontal and vertical scales the same and Gunong Tahan shown about 1/6th of an inch (.4 cm) high, the effect would be similar to that obtained from an artificial satellite at a height of about 230 miles (368 km.) above the earth — obviously unsatisfactory for demonstration purposes.

PROCEDURE

The construction procedure is as follows:

1) Having decided on the vertical scale to be used, plywood or cardboard of a uniform thickness is chosen. The material chosen should have a thickness that represents the difference in height between two consecutive contour lines, or a convenient multiple of this. For example, if the contour lines on the map are at 50 ft. (about 15 m.) intervals, the material should have a thickness that represents 50 ft. (15 m.) on the model to be constructed, or, say, 250 or 500 ft. (75 or 150 m.) i.e. in the case of a 1 inch to 1 mile model with a vertical exaggeration ratio of 1: 5, the material should be 1/20, or $\frac{1}{4}$ or $\frac{1}{2}$ an inch thick (.125 or .6 or 1.25 cm.), as the case may be.

2) The outlines of two consecutive contour lines (e.g. 50 ft. or 15 m. and 100 ft. or 30 m.) are traced onto a piece of the chosen material.

3) The plywood or cardboard is then cut along the outer contour line which, in this case, is the 50 ft. (15 m.) contour.

4) The outlines of the 100 ft. (30 m.) and 150 ft. (45 m.) contour lines are next traced onto another piece of material of the same thickness.

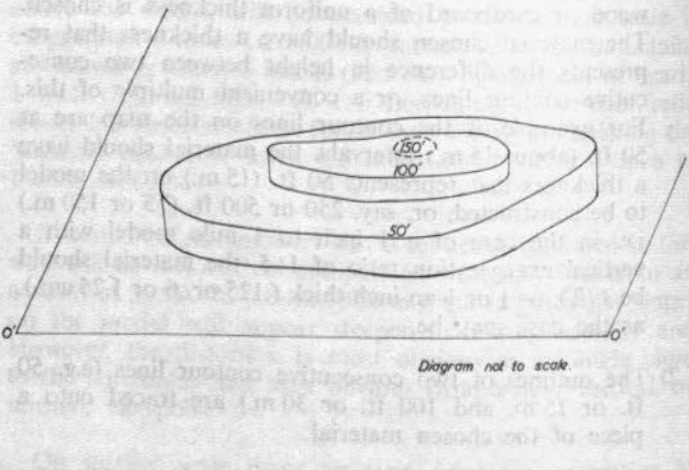
5) This second piece of plywood or cardboard is also cut along the outer tracing i.e. the 100 ft. (30 m.) contour.

6) After cutting, this second piece is fitted on its own outline previously drawn on the top of the first piece (see Fig. 4a).

FIGURE 4

RELIEF MODEL

a



b

7) When the pieces have been glued together they will ascend in very sharp steps of, say, 50 ft. (15 m.) intervals. These sharp steps can be evened out with plasticine filling, and if done with care this produces a realistic replica of the topography. The final product in cross section should appear as in Fig. 4b.

8) The whole model is then enclosed in a frame so that the highest point on the model is well below the top of the frame and a plaster of paris mould is made. Builders grade plaster, costing about $15 (Malayan) per hundredweight bag, and known locally as white powder, is quite satisfactory for modelling purposes, and much cheaper than pharmaceutical brands. Before pouring the plaster of paris, the model is covered with a light grease such as vaseline to prevent the plasticine from sticking to the inside of the mould. A mixture of 15 lbs. (7 kilos) of plaster and 7 pints (4 litres) of water will harden in 5 to 15 minutes. Foam rubber or plaster of paris replicas can then be run off from the mould and painted to show the desired information.

APPENDIX 5

FIELD EQUIPMENT

The basic items of equipment used by soil surveyors in the field become adapted to the particular survey conditions, and experience of soil surveying under Malayan conditions has led to the selection of certain items of equipment which have proved their superiority for the job in hand. The particular qualities required are sturdiness and simplicity, while under certain circumstances light weight and small size are also very desirable secondary characteristics. Unfortunately, all these features are seldom found in one item, and the quest for new models capable of withstanding the inevitable wear and tear of jungle conditions is never-ending.

The standard tools for soil examination include 1½ or 2 inch (3.8 or 5 cm.) diameter screw augers, for which purpose wood testing augers fitted with 40 inch (approx. 100 cm.) steel shafts, with welded steel handles, have proved extremely satisfactory. 6 inch (15.2 cm.) diameter posthole augers, supplied with 40 inch (approx. 100 cm.) shafts, are also used for routine examinations and sampling, and both these types of auger are obtainable locally. For peat soil examination, a Hiller type auger with extension rods sufficient to allow examination to depths of 20 feet (6 m.), is useful, although simple notched probes cut from strong saplings of sufficient length and diameter may be more effective for making rapid examination of many of the coarse woody peats found in most Malayan peat swamps.

Portable power augers, capable of boring 18 inch (about 45 cm.) or 24 inch (about 60 cm.) diameter holes to depths of about 30 inches (about 75 cm.) are useful in some detailed surveys in the more accessible areas which are covered by light undergrowth, although the models currently available are too bulky and heavy for manhandling under forest or dense secondary vegetation.

Tractor-mounted augers, driven from the power-takeoff, have proved extremely effective for soil examination in padi areas, and other areas of flat or almost flat land over which a tractor can be freely manoeuvred. 24 inch (about 60 cm.) diameter holes can be bored to 36 inches (about 90 cm.) in a matter of seconds, which permits soil examination to be made "in situ" in permeable soils having a high watertable, and which would otherwise flood as quickly as a soil examination pit could be dug by hand.

Detailed examination and sampling pits are dug with a changkul (large hoe), and a chop betul (a small spade). These pits are normally dug to a depth of 5 feet (nearly 1.5 meters), although deeper pits, to depths of 20 even 25 feet (6 to 7.5 m.), may be necessary in some instances. Rope, and a bucket or pongkis (a flat plaited basket) are necessary for removing earth from the deeper pits. Square edged spades, hand trowels, pick axes, and strong pocket knives are all useful tools for soil examination purposes.

For rentis cutting, campsite construction work, and for emergency road clearing, heavy cutting knives (military-style parangs or kukris), and axes are indispensable.

Camping equipment should be light in weight, simple, and of robust construction. Tents must be waterproof, but sidewalls are usually unnecessary and millerain (cotton-nylon mixture) tents with detachable walls, and fly sheets, are ideal in this respect. Guy ropes and pegs are unnecessary, as rotan lines and wooden stakes can always be cut in the forest for immediate use. Tarpaulin, of medium thickness, is also useful for making a simple tent, but while cheaper than millerain, it is less satisfactory owing to its greater weight and its tendency to rot and lose its waterproofing very quickly if not well cared for.

Thick polythene sheeting is satisfactory for making bivouac encampments. A comfortable camp-bed can be made by stretching a tarpaulin sheet tightly across a frame made from cut branches, while a thin sleeping bag and a small airpillow are welcome additions.

Burners, paraffin lamps, light folding furniture and many other items considered standard camping equipment in other parts of the world, prove more of a nuisance than an asset during soil surveys under Malayan conditions, where all equipment and supplies often have to be carried for long distances. A small pocket torch and a reliable lighter are essential, while cooking utensils are usually restricted to a cheap saucepan and frying pan, and eating utensils to a metal plate and mug, knife, fork, spoon and can opener. Food is most conveniently taken in cans, and there is very little opportunity for living off the land during a soil survey field reconnaissance. Military or police rations can be purchased from local sources and used to diversify the camp menu. Rice, salt, sugar, and canned foods, spare changes of clothing, medicines, etc. should be packed in leakproof light metal ambongs (backpacks) which can be made to the required dimensions by any local tinsmith.

The best clothing is usually the lightest, as this will dry quicker, besides being cooler. Short-sleeved shirts, long trousers of khaki drill or similar material, light canvas, rubber soled ankle boots with tongues sewn up to the top edge of the boot, and woollen puttees, to prevent leech bites, are very satisfactory for the rougher sort of field work, which may include frequent swamp and stream traversing, while for day trips in developed country short trousers are often preferred.

Small 4 wheel drive vehicles are most convenient for transporting men and materials on rough roads, including forest tracks, while light vans with ample seating accommodation are more comfortable and economical in the better roaded areas. Bicycles can speed up progress along tracks in many areas inaccessible to other vehicles, and can usually be borrowed or hired locally. For river transport, wooden boats with outboard motors, in a wide range of sizes, are extremely useful, but in many of the shallower rivers powered craft are useless. Dug-out perahus (canoes) can usually be hired locally in such an event, or bamboo rafts can be constructed specially for the journey. Aircraft are particularly useful for reconnaissance purposes, and details of the range of available types is given on page 96. Helicopters may save time and money if used for staff and labour force transportation or supply missions in remote forest areas.

Portable two-way radio sets are often useful when close communication is desirable between groups of soil surveyors, and have proved their worth during detailed reconnaissance padi soil surveys, particularly for calling up the soil correlator in cases of doubtful series identification. Pocket tape recorders of simple but robust design have appeared on the market in recent years while hard-backed field notebooks or cyclostyled forms held in a metal clipboard can supplement the tape recorders on all types of survey.

Munsell colour charts, military-style liquid prismatic compasses and altimeters, and colourimetric field pH test kits are standard items of equipment for all Malayan soil surveyors, and these are contained in capacious locally-made field bags of water-proof canvas. Vehicle-mounted compasses are also standard equipment for road traversing purposes.

AIDS TO THE IDENTIFICATION OF COMMON MALAYAN ROCKS

The following notes are designed to help soil surveyors recognise different types of parent rocks. Simple descriptive terms have been used in consideration of the fact that many soil surveyors have not had comprehensive geological training. These notes do not give precise definitions of rock types, for which the soil surveyor should refer to a textbook of petrology.

1. IGNEOUS ROCKS

A useful primary distinction of igneous rocks can be made according to their origin whether erupted (volcanic)), injected (hypabyssal), or emplaced (plutonic); and their composition, whether acidic (high in felsic* and low in ferromagnesian minerals), intermediate (approximately equal amounts of

TABLE VI. IGNEOUS ROCKS

	ACID		INTER-MEDIATE	BASIC	ULTRA-BASIC
VOLCANIC	Rhyolite	Dacite, Quartz-andesite	Andesite, Trachyte	Basalt	Serpentine
HYPABYSSAL	Granite-porphyry, Quartz-porphyry, Micro-granite		Andesite, Micro-diorite	Dolerite	
PLUTONIC	Granite	Grano-diorite, Quartz diorite	Diorite, Syenite	Gabbro, Norite	Peridotite

*Felsic = minerals rich in silica, for example quartz and feldspar.

felsic and ferromagnesian minerals), basic (low in felsic and high in ferromagnesian minerals) or ultra-basic (predominantly ferromagnesian minerals). The broad relationship between the main igneous rocks occurring in Malaya is outlined in the above chart (Table VI). It must be emphasized that this is an extremely simplified version which is hardly acceptable to modern petrologists, but it does provide a rough outline which can be readily comprehended.

GRANITE: Granite is a predominantly light coloured greyish, whitish or pinkish coarse grained igneous rock of relatively light weight, containing essentially quartz, visible without the aid of the microscope, much feldspar, and mica or other coloured minerals. Grey porphyritic granite with large crystals of orthoclase is the commonest type of granite exposed in Malaya, and may be regarded as the typical rock of the granite suite. There are, however, many variations from this type of rock due to differences in texture and mineral composition. There is never any non-crystalline base or ground mass between the minerals as granite is typically holocrystalline (comprised entirely of crystals).

GRANITE PORPHYRY: This is a fine grained granitic rock with a holocrystalline groundmass, composed mainly of alkaline feldspar and quartz, through which are dispersed large crystals of orthoclase and plagioclase with smaller crystals of quartz, biotite, and sometimes hornblende or pyroxene. The essential difference from granite is its fine grained texture and the presence of large feldspar phenocrysts.

QUARTZ PORPHYRY: This is a fine grained greyish, pinkish or brownish rock with scattered phenocrysts of quartz throughout the groundmass. The groundmass of most Malayan quartz porphyries is crystalline but it is not possible to pick out individual crystals even under the microscope. In some cases, feldspar has crystallized out as well as the quartz giving a quartz-feldspar-porphyry.

RHYOLITE: This is a pale coloured relatively light weight rock in which flow structures can be seen. Small phenocrysts of quartz are commonly scattered throughout a non-crystalline groundmass.

GRANODIORITE: In a true granite orthoclase is more common than plagioclase. In granodiorite, the reverse is true. The same is true of diorite but, unlike a granodiorite, there is no free quartz in a normal diorite. Thus, granodiorite is intermediate in composition between granite and diorite. In hand specimen it is very similar to granite although it tends to be slightly darker coloured. Many Malayan granites are somewhat transitional to granodiorite in composition.

QUARTZ DIORITE: This is essentially a diorite in which free quartz is present. It is holocrystalline, and outwardly resembles grey granite, but may usually be distinguished from it by the striated faces of its feldspars, and the somewhat higher proportion of dark minerals.

DACITE: Dacite and quartz andesite are the volcanic equivalents of granodiorite and quartz diorite. Dacite is darker coloured and slightly but noticeably heavier than rhyolite and contains quartz phenocrysts in a fine grained, largely non-crystalline groundmass.

DIORITE: This is a dark grey coloured, moderately heavy holocrystalline rock which does not contain any free quartz, but contains a fairly high percentage of dark coloured minerals, usually hornblende and black mica.

ANDESITE: This is the volcanic equivalent of diorite and is a dark grey or black rock which is quite heavy in hand specimen and has a compact groundmass through which striated feldspar prisms may generally be observed. The texture of the rock ranges from finely crystalline to essentially glassy with small phenocrysts of dark coloured minerals throughout. The andesites usually contain acid plagioclase and one or more of the minerals, biotite, amphibole and pyroxene. Malayan andesites commonly have a distinct greenish colouration.

GABBRO: This is a coarsely crystalline black or greenish black heavy rock. It consists essentially of calcic plagioclase, pyroxene and often has olivine as an accessory. There is usually no quartz.

NORITE: This rock is similar to gabbro but has orthorhombic pyroxene, usually hypersthene, instead of clinopyroxene (augite). In hand specimen, it is very similar to gabbro.

BASALT: This is a dark coloured, heavy volcanic rock which is very fine grained and in which it is often impossible to recognise individual crystals with the unaided eye. In some cases basalts contain uncrystallized material which occurs as a brown or green glass. They consist essentially of basic plagioclase, feldspars, and pyroxenes with olivine as an accessory. Many basalts are black, extremely compact, apparently homogeneous rocks which break with a splintery or conchoidal fracture.

SERPENTINE: This rock consists almost exclusively of the dark coloured basic mineral, serpentine. It was probably originally an eruptive ultrabasic rock which has subsequently been altered and is now composed of the serpentine group of minerals. It is a compact faintly glimmering or dull rock, easily cut or scratched, having a prevailing dirty green colour, sometimes variously streaked or flecked with brown, yellow or red. It frequently contains other minerals besides serpentine and one of the commonest is chrysotile or fibrous serpentine which, as veinings of a silky lustre, often ramifies through the rock in all directions.

2. METAMORPHIC ROCKS

These are rocks which have been changed in mineral composition, structure or both under the influence of heat and/or pressure. The following different type of metamorphism can be distinguished:—

(a) Thermal metamorphism, which is the result of heat and gives rise mainly to mineralogical changes.

(b) Dynamic metamorphism. This is the result of stress which gives rise mainly to structual re-arrangements, the rock developing new structures while old ones are lost; and

(c) Regional metamorphism. It is difficult to heat a rock without pressure affecting it. Thus metamorphic rocks such as schist, phyllite, etc., formed under the joint influence of high temperature and powerful shearing are said to have been regionally metamorphosed. The following brief notes describe the commoner metamorphic rocks to be found in the Malayan landscape:—

QUARTZITE: This is a quartz rock resulting from the metamorphism of sandstone. It is a bedded, granular to compact mass of quartz, generally white, sometimes yellow or red with a characteristic lustrous fracture, sometimes possessing a sugary appearance particularly when weathered, occasionally pebbly and even accompanied by conglomerates. The finely granular structure of quartzite is distinctly visible to the naked eye and more or less distinct evidence of crushing and deformation of the grains may be observed. The particles are commonly cemented together with siliceous material. It often contains muscovite and potash feldspar as well as quartz, due to impurities in the original sandstone. Quartzite is produced by the thermal metamorphism of sandstone and thus does not have any marked metamorphic structures.

SLATE: This rock is produced in the first stage of dynamic or regional metamorphism of shale. It is a fairly hard dark rock with a marked cleavage developed in it. There may be some new mineral formation but there is no segregation of minerals into bands.

HORNFELS: This rock represents another stage in the thermal metamorphism of shale and is characterised by the appearance of new minerals such as biotite, and sometimes cordierite. Biotite hornfelses are very common in Malaya in thermally metamorphosed shales close to granite contacts. They are typically compact, close grained rocks, often characteristically spotted.

GNEISS: Intense thermal or regional metamorphism of shale results in the disappearance of biotite and the formation of such high grade metamorphic minerals as sillimanite, garnet, spinel and corundum. In such a high grade rock the recrystallization is so complete that the rock develops a grain size coarser than that of a typical hornfels. Gneiss may in fact resemble granite and differ only in the foliated arrangement of the minerals.

PHYLLITE: This rock is the second stage in the regional metamorphism of shale after slate. It is characterised by the separation out along the cleavage planes of flakes of white mica or sometimes green chlorite. Phyllites are intermediate between normal slates and true mica schists and many show original bedding often well marked by colour bands and by the alternation of sandy layers.

SCHIST: This marks the highest grade of regional metamorphism of sedimentary rocks. Schists have been completely recrystallised. The component minerals are segregated into bands, and typical laminated schistose structures are developed. Contortions are quite common in schists.

MARBLE: When a limestone is heated during thermal metamorphism the calcium carbonate forms crystals of calcite which grow larger and larger as the temperature increases. Marble is a hard, pale coloured rock and the coarseness of its grain is an indication of the degree of thermal metamorphism.

3. SEDIMENTARY ROCKS

These are rocks that consist of materials which have previously existed on or beneath the surface of the earth in another form, and the accumulation and consolidation of which gives rise to new compounds. The commonest sedimentary rocks in Malaya are shales, sandstones and conglomerates, while breccias, agglomerates and tuffs also occur.

SHALE: This is a general term to describe clay that has assumed a thinly stratified or fissile structure. Included are laminated and somewhat hardened argillaceous rocks which are capable of being split along the lines of deposit into thin leaves.

SANDSTONE: This is a rock composed of consolidated sand. The integral grains of sandstone are chiefly quartz and the colour usually arises not so much from the quartz which is commonly white or grey, as from the film which often coats the grains and holds them together as cement. The cementing material may be ferruginous, argillaceous, calcareous, or siliceous.

CONGLOMERATE: This is a rock formed of consolidated gravel or shingle. The component pebbles are rounded and water-worn and may consist of any kind of rock, though usually of some hard and durable type, such as quartz or quartzite.

Breccia: This rock is similar to a conglomerate but is composed of angular instead of rounded fragments and has less stratification than a conglomerate. Volcanic breccia consists of material discharged from volcanoes and consolidated into masses of angular material.

Agglomerate: This rock is normally volcanic in origin and consists of an assemblage of blocks of all sizes up to several yards in diameter. The materials are commonly volcanic rocks but include also fragments of the surrounding rocks. An agglomerate is devoid of stratification but sometimes includes portions which have a more or less distinct arrangement into beds of coarser and finer detritus.

Tuff: This is another rock of essentially volcanic origin which includes all the finer grades of volcanic detritus ranging from coarse, gravelly deposits to exceedingly compact fine grained rocks formed from volcanic dust. The tuffs have consolidated sometimes under water, sometimes on dry land. As a rule, they are distinctly stratified. Near the original vents of eruption, they commonly present rapid alternations of finer and coarser detritus indicative of successive phases of volcanic activity. They necessarily grade into the sedimentary formations with which they were contemporaneous.

EXTRACTS FROM FINANCIAL GENERAL ORDERS RELATING TO TRAVELLING, SUBSISTENCE AND TRANSPORT ALLOWANCES

The following is an extract of those Financial General Orders which relate to travelling, subsistence and transport allowances for journeys on Government duty, together with a copy of Treasury Circular Letter No. 7 of 1960, which is complementary to the F.G.O's.

It should be noted that where a claim is made for reimbursement of expenses for board and lodging actually incurred at a hotel, only such expenses as room rent, charges for morning tea, breakfast, lunch, afternoon tea and dinner are recoverable; provided that no officer whose salary is less than $1,360.00 per mensem will be permitted to claim more than $23.50 in respect of any period of 24 hours' board and lodging. Telephone charges necessarily and unavoidably incurred at a hotel on Government business are also recoverable, provided the officer claiming so certifies on the "chits" or on the covering receipt.

All other charges, including charges for laundry, soft drinks and fruits (which are considered as refreshments), are not admissable as a charge on Government funds.

Each hotel receipt produced in support of a claim, therefore, should have endorsed on it by the officer making the claim, a summary showing total gross charges, deductions in respect of items not recoverable from Government, and balance which will represent the sum recoverable. The endorsement may be made on any available space on the receipt.

As stated in Treasury Circular Letter No. 4/1965, as from 1st May, 1965 the "choice of accomodation should be left to the officer concerned and in such circumstances the officer is permitted to recover:

a) a Subsistence Allowance (i.e. $12.50 a night).

b) Actual lodging charges supported by receipts up to a maximum of $17.50 cents a night in the case of an officer whose salary is less than $1360/- per month in addition to the subsistence allowance as above."

EXTRACT OF FINANCIAL GENERAL ORDERS ON TRAVELLING, SUBSISTENCE AND TRANSPORT ALLOWANCES

TRANSPORT EXPENSES

235. An officer claiming reimbursement of transport expenses under the provisions of this Chapter, should normally travel by the quickest route, provided that:

(a) he may not travel by air without special permission or as may be generally approved from time to time by the Deputy Chief Secretary in the case of officers boine on the Federal Estimates, or by the Menteri Besar or Resident Commissioner in the case of the officers borne on the State or Settlement Estimates;

(b) he is ordinarily required to travel by the Malayan Railway rather than by steamer; and

(c) he is only entitled to travel by such means of conveyance as the head of department may certify to be expedient or necessary. Officers in Division III and IV will not be permitted to use a specially hired or chartered car unless no alternative means of transport are available.

CLASS OF ACCOMMODATION

236. Officers are entitled to be provided with the following accommodation for journeys by rail or steamer:

Officers in Division I and II .... First Class
Officers in Division III .... Second Class, provided that women officers whose salary is not less than $200 a month will be given first class accomodation.
Officers in Division IV .... Third Class.

245. An officer on tour is entitled, subject to the provisions of General Orders 235, 236, 252 — 258, to recover his actual transport expenses necessarily and unavoidably incurred.

246. (a) Subject to

(i) the provisions of sections (d) and (e);

(ii) the certificate of the head of department that it was necessary, and

(iii) the absence of any departmental scale of subsistence allowance approved by the Minister of Finance in the case of officers holding posts borne on the Federal Estimates or the State Secretary or Settlement Secretary in the case of officers borne on the State or Settlement Estimates,

an officer or employee who, in the execution of his duty, sleeps the night away from his headquarters station is entitled to subsistence allowance at such rates as may be generally approved from time to time by the High Commissioner, provided that only half of the prescribed allowance may be drawn by an officer when travelling by vessels including aircraft where the passenger fare defrayed by the Government includes messing. The full allowance may, however, be drawn by officers who provide their own food when travelling by sea. The rates at present approved are detailed in Appendix F.

(b) An additional $3 a night is payable to an officer using his own motor car for a journey on tour, if accompanied by a driver who is employed and paid by him provided that no such addition may be drawn if the officer is not entitled to draw a driver's allowance in accordance with General Order 259.

(c) The question as to what constitutes an officer's or employee's headquarters station shall, in case of doubt, be determined by the Minister of Finance in the case of officers or employees paid from provision in the Federal Estimates and by the State Secretary or Settlement Secretary in the case of officers or employees paid from provision in the State or Settlement Estimates.

(d) Where a Head of Department considers it necessary for an officer to stay in a resthouse or other Government quarters away from his headquarters station subsistence allowance may be drawn for a period not exceeding three months. A Head of Department may not authorise payment of subsistence allowance in excess of a period of three months to secure the performance of any duty without the prior sanction of the Minister of Finance in the case of officers holding posts borne on the Federal Estimates or of the State Secretary or Settlement Secretary in the case of officers holding posts borne on the State or Settlement Estimates.

Provided that in the case of

(i) officers who normally work in the field and sleep the night away from their headquarters, and

(ii) officers who are required to attend short courses of instruction at training centres,

the Minister of Finance in the case of officers holding posts borne on the Federal Estimates or the State Secretary or Settlement Secretary in the case of officers borne on the State or Settlement Estimates, may authorise a commuted allowance, at a rate not exceeding that payable under section (a) above, irrespective of the length of the period of their stay away from their headquarters.

(e) Subsistence allowance may be drawn by an officer on tour during a period of absence from duty through illness not exceeding seven days but may not be drawn in cases where an officer on tour is admited to hospital except with the special sanction of the Minister of Finance in the case of officers holding posts borne on the Federal Estimates or of the State Secretary or Settlement Secretary in the case of officers holding posts borne on the State or Settlement Estimates.

HOTEL EXPENSES

247. (a) An officer of Division I, II or III of the public service on tour is entitled to accommodation in a rest-house and may, if such accommodation is not in fact available, recover instead of subsistence allowance under the previous General Order the actual cost incurred in board and lodging subject to the certificate of the Head of the Department approving the charge.

(b) Where it is necessary for an officer to remain away from his headquarters station in circumstances in which accommodation in a rest-house or other Government quarters is not available he may recover the full cost of board and lodging for a period not exceeding three months. A Head of Department may not authorise payments under this General Order in excess of a period of three months to secure the performance of any duty without the prior sanction of the Minister of Finance in the case of officers holding posts borne on the Federal Estimates or of the State Secretary or Settlement Secretary in the case of officers holding posts borne on the State or Settlement Estimates.

LODGING EXPENSES

248. (a) An officer of Division I, II or III of the public service on tour is entitled to recover in addition to subsistence allowance the actual fees paid for lodging (but not board) incurred at a rest-house and garage fees.

(b) An officer or employee not entitled to use a rest-house or a leased rest-house may be paid lodging allowance at such rates as may be approved from time to time by the High Commissioner in addition to the subsistence allowance paid to him. The rates at present approved are detailed in Appendix F.

DAY ALLOWANCES

249. (a) An officer or employee whose duties require him to remain continuously away from his headquarters station for a period of more than eight but less than twenty-four hours is entitled to a day allowance which will ordinarily be at half the rates approved for subsistence allowance. In special cases with the approval of the Minister of Finance in the case of officers or employees paid from provision in the Federal Estimates or of the State Secretary or Settlement Secretary in the case of officers or employees paid from provision in the State or Settlement Estimates, the full rate for a subsistence allowance may be paid.

(b) An officer on tour required to remain continuously away from his headquarters for a period exceeding thirty-two hours is eligible in addition to subsistence allowance to one day allowance in respect of any balance period of eight hours or more for which no subsistence allowance can be claimed, a subsistence allowance being reckoned as covering subsistence for a period of twenty-four hours.

FIELD ALLOWANCE

250. An officer or employee who, when spending the night away from his headquarters in circumstances which entitle him to subsistence allowance under General Order 246, is compelled to live under canvas or other temporary structure or in a houseboat or unfurnished halting bungalow is eligible to receive in addition to subsistence allowance a field allowance in respect of each unbroken period of 24 hours not exceeding —

Divisions I and II ...... $2.00 a day

Divisions III and IV ...... $1.50 a day

Such extra allowance will not be drawn by Military Officers and other ranks when in camp for instruction or training purposes, or in the course of their normal military duties.

ALLOWANCE FOR DAILY PAID EMPLOYEES

251. For the purpose of relating the wage of employees on daily rates to the salaries of officers on monthly rates, in order to determine eligibility for allowances under General Orders 246 and 250, the wages of employees shall be multiplied by 26.

MILEAGE FOR DUTY

252. Where it is necessary for the efficient performance of the duties attached to his post that an officer should

travel by his own motor-car or motor-cycle, he may be paid mileage for journeys travelled on Government duty at such rates as may be generally approved from time to time by the High Commissioner. The rates at present in force are given in Appendix "C".

RATES OF MILEAGE

253. The rate of mileage payable will be determined in accordance with the type of vehicle used, except that:

(a) No officer on a basic monthly salary of less than $863 may draw mileage at the rates prescribed for a Class "A" car;

(b) No officer on a basic monthly salary of less than $710 may draw mileage at the rates prescribed for a Class "A" or Class "B" car;

(c) No officer on a basic monthly salary of less than $514 may draw mileage at the rates prescribed for a car, unless —

(i) it is shown to the satisfaction of the Financial Secretary in the case of an officer holding a post borne on the Federal Estimates, or of the Mentri Besar or Resident Commissioner in the case of an officer holding a post borne on the State or Settlement Estimates, that the nature of his duties necessitates the use of a car rather than of a motor-cycle; or

(ii) the officer has been certified by a Medical Board of not less than two Government Medical Officers, appointed for that purpose by the Director of Medical Services, or by the Senior Administrative Medical Officer of the State or Settlement as the case may be, to be unfit to ride a motor-cycle.

CLASSES OF VEHICLES

254. (a) A Class "A" car is a car of cylinder capacity of not less than 1,400 c.c.

(b) A Class "B" car is a car of cylinder capacity of less than 1,400 c.c. but not less than 1,000 c.c.

(c) A Class "C" car is a car of cylinder capacity of less than 1,000 c.c.

(d) A motor-cycle means a motor-cycle of cylinder capacity of not less than 225 c.c. Mileage at special rates may be approved by the High Commissioner for motor-cycles, motor-scooters or similar vehicles of cylinder capacity of less than 225 c.c. The rates at present in force are given in Appendix "C".

MILEAGE VOUCHERS

255. (a) Mileage will be claimed monthly on a voucher to which must be attached a detailed statement of all journeys performed on Government duty, signed by the officer making the claim, who will be required to certify and will be held responsible that the claim is made strictly in accordance with all the relevant terms of General Orders 252 to 259.

ONLY ONE MILEAGE CLAIM TO BE MADE IN ANY ONE MONTH

(b) In no circumstances may an officer submit more than one mileage claim in respect of any one calendar month. An officer whose travelling is to be debited to more than one vote will submit his claim for payment from one vote only, and distribution to other votes will be made subsequently by normal accounting methods. Such distribution shall be made in proportion to the mileage travelled.

CONDITIONS OF PAYMENT

256. Mileage is payable only if —

(a) the journeys in question are on Government duty;

(b) they are made in a vehicle kept and maintained by the officer making the claim, and of the class appropriate to the rate of mileage claimed. It is not permissible for two or more officers to claim mileage in respect of the same vehicle in any one calendar month (unless the vehicle has been transferred during the month from one officer to another);

(c) the distances and other particulars are correctly quoted in the statement attached to the relevant voucher.

MILEAGE INTENDED TO COVER WHOLE COST OF TRANSPORT

257. Mileage in accordance with General Order 252 is intended to cover the whole cost of transport on duty of an officer, his servants and baggage by road, and no other charges for such transport will be passed for payment without the certificate of the head of department that it was not practicable or would have caused undue delay or unnecessary expense to the Government to have used the officer's own vehicle.

JOURNEYS BETWEEN PLACES SERVED BY RAILWAY

258. Officers travelling on duty who use their own cars

solely as a means of transport and not inspection between places served by the railway are as a general rule not entitled to draw mileage in respect of such journeys unless the cost to the Government is thereby reduced, but may recover the amount which a railway ticket of the class by which they are entitled to travel would have cost, provided that it is clearly stated in the voucher that the officer travelled by his own car and that the railway fare claimed is not an amount actually disbursed but the equivalent of the fare to which such officer is entitled under General Order 236. Exceptions to this rule are allowed when the officer in charge of the vote certifies on the voucher that in the circumstances it was reasonable that the officer should have used his own car and not have travelled by railway.

DRIVERS

259. (a) An officer to whom mileage is paid in accordance with the foregoing General Orders at the rates for a Class "A" car may, if he employs a full-time licensed driver, be paid in addition a driver's allowance at the rate of 12 cents per mile of duty travelling, subject to a maximum of $60 in any one calendar month.

(b) An officer to whom mileage is paid in accordance with the foregoing General Orders at the rates for a Class "B" car may, if he employs a full-time licensed driver, be paid in addition a driver's allowance at the rate of 12 cents per mile of duty travelling, subject to a maximum of $60 in any one calendar month, provided that the head of the department in the case of an officer borne on the Federal Estimates, or the Mentri Besar or Resident Commissioner in the case of an officer borne on the State or Settlement Estimates, is satisfied that the employment of driver is necessary for the efficient performance of the officer's duties.

TABLE VII

MILEAGE RATES

Duty Travelling in each calendar month	Class 'A' cents per mile	Class 'B' cents per mile	Class 'C' cents per mile	Motor-cycles cents per mile	Light motor cycles and motor-scooters cents per mile
For the 1st 100 miles	38	36	34	16	8
" " 2nd 100 miles	33	29	25	12	6
" " 3rd 100 miles	31	26	21	10	5
" " 4th 100 miles	28	24	19	9	4.5
" " 5th 100 miles	28	23	18	9	4.5
" " 6th 100 miles	27	22	17	8	4
" " 7th 100 miles	26	21	17	8	4
" " 8th 100 miles	26	21	17	8	4
" " 9th 100 miles	25	21	17	8	4
" " 10th 100 miles	25	20	16	8	4
" " 11th 100 miles	25	20	16	8	4
For any travelling beyond the 1st 1,100 miles	25	20	16	8	4
Additional rate for duty travelling in Pahang	6	5.5	—	—	—
Additional rate for duty travelling in Kelantan and Trengganu	6	5	4	2	1

Extract from:

APPENDIX F.

GENERAL ORDERS 246 (a) and 248 (b)

RATES OF SUBSISTENCE AND LODGING ALLOWANCES

(modified in accordance with Treasury Circular Letter No. 4/1965, with effect from 1st May 1965).

(a) Officers of Divisions I, II and III.
Three per cent. of monthly basic salary plus cost of living allowance subject to a minimum of $4 and a maximum of $12.50 a night. Rates of subsistence allowance shall be rounded off to the nearest 5 cents.

(b) Officers of Division IV and daily-rated employees.
Three per cent. of monthly basic salary plus cost of living allowance subject to a minimum of $3 and a maximum of $12.50 a night. Rates of subsistence allowance shall be rounded off to the nearest 5 cents.

2. Rates of Lodging Allowance $3 a night.

COPY

TRY(FS) 2444/Vol. 1/151.

THE TREASURY,
KUALA LUMPUR.
11th May, 1960.

ALL SECRETARIES/PERMANENT SECRETARIES TO MINISTRIES/MINISTERS, HEADS OF FEDERAL DEPARTMENTS.

Treasury Circular Letter No. 7 of 1960

HOTEL ACCOMMODATION WHILE ON DUTY, ON TRANSFER, OR ON DEPARTURE OR RETURN FROM LEAVE

Where it is necessary for an officer travelling *on duty* to stay in a hotel he may recover instead of subsistence allowance the actual cost incurred in board and lodging, subject to the certificate of the Head of the Department that the charge is fair and reasonable in the particular circumstances; provided that in no case will an officer whose salary is less than $1,360/- p.m. be permitted to recover more than the sum of $23.50 in respect of any period of 24 hours' board and lodging. In the case of officers and their families occupying hotel accommodation when proceeding *on transfer or on departure or return from leave* similar principles will apply, with the addition that in no case may an officer whose salary is less than $1,360/- be permitted to recover more than $37/- for 24 hours' board and lodging in respect of two persons occupying a double room. For hotels in Singapore the existing instructions will remain in force.

(LIM KIM CHENG)
b.p. Setia Usaha Perbendaharan

EMPLOYMENT OF JUNIOR SUBORDINATE STAFF & LABOURERS

According to existing regulations the following grades of junior subordinate staff and labourers should be recruited through the local Government Employment Exchange/Labour Office. They must be medically examined and certified as fit for service by a Government Medical Officer before they can be employed. Their employment will be on monthly salaries and cost of living allowances (C.O.L.A.) They are eligible to draw housing allowance if they are not acommodated in government quarters. They are eligible for 14 days vacation leave and 4 days unrecorded leave a year and leave on medical grounds:—

(1) Office boys
(2) Launch drivers
(3) Lorry, car and van drivers
(4) Outboard motor drivers
(5) Watchmen
(6) Mandores
(7) Head labourers
(8) Labourers

Their monthly salaries, allowances, etc. are shown in the attached table. These salaries are paid from the Soil Survey Vote (S. 12, Subhead 21) in the case of those persons who are employed by soil survey staff, including Colombo Plan personnel, and engaged in work directly related to soil survey field operations. It is advisable to employ all staff who are continuously employed (i.e. for longer than 1 month) and who are in most cases likely to be employed for at least one entire field season, in accordance with the existing regulations and at the correct rate of salary and allowance.

Unfortunately no guarantee of continuous employment, in the above sense, can be given in the case of certain categories of labour normally engaged by soil survey units, for the reason that labour requirements fluctuate according to the weather conditions, terrain, access, and the general survey programme; and in such cases it is permissible to engage personnel on a casual basis for a specified period of time (usually less than one month) and at a negotiated wage rate which is an effective compromise between the rate considered appropriate by the soil surveyor and the employee. Labourers; head labourers; and mandores (usually referred to as field labourers; team, or crew, leaders; and head labourers in the survey units), are the categories usually employed in this way, but not infrequently watchmen and outboard motor drivers are taken on for short periods under similar arrangements.

Employment of field staff on a casual basis has considerable advantages for the soil surveyor, as he can in this way reduce the paper work and wage paying procedure, increase the flexibility of his work force, and effect considerable economies in the use of his available funds. For example, a soil survey casual labourer employed for a 20-day jungle trip in any one month would be paid a total of $100 if employed at $5 per day; which compares well with a regulation labourer who would earn $88.70 for his combined monthly salary, basic salary, COLA, and basic rate housing allowance, together with $60 subsistence allowance and $30 field camping allowance for 20 days in the jungle, which would bring his total pay to $178.76 (without including overtime for week days, weekly holidays, and public holidays which may be spent in the jungle).

It is important to remember that under no circumstances should a casual employee earn more than the equivalent regulation rate, as this would lead to audit and treasury inquiries. While such a possibility is remote, it should always be borne in mind.

The procedure to be followed in employing casual labour is entirely the responsibility of the soil surveyor once he has obtained an assurance that the necessary funds are available from the appropriate vote, which is controlled by the Assistant Director (Research).

After agreement has been reached regarding the daily rate of casual labour and the length of employment, an advance, amounting to a proportion of the total sum to be earned, can be paid to the employee from the cash-in-hand, held in the form of an advance to the soil surveyor for such contingencies. The balance is paid after the work period is concluded, either from the soil surveyors own cash-in-hand, or after receipt of the cheque for the total amount, which is forwarded from the Ministry after the necessary checkrolls have been submitted. Recoupment of the advance money should be made at this stage. All checkrolls must be signed by the labourers when final payments to them have been made from petty cash advances. In such cases the Paying Officer and witness must sign the certificate at the bottom right hand corner of the checkroll after payment to the labourers, and before the checkroll is forwarded to head office.

In the preparation of checkrolls, which should be on Form Gen. 70, the Vote Head should be inserted after the heading "Head of Service". After "Pay List and Acquittance..." the nature and place of work must be stated and the period given also. Care should be taken to enter the names of the labourers correctly.

There are no normal hours of work for casual labourers, neither are they entitled to overtime or housing allowance.

The rate of pay is based on the classification of the labourer. For instance, a head labourer is normally paid $7 per diem, a team leader $6 and a labourer $5. But these rates will normally vary from place to place, and individual soil surveyors should do their best to negotiate fair rates of pay. Higher rates may be necessary in order to obtain willing assistance in some parts of the country, while lower rates are often possible in many central and east coast areas. There will be no Employees Provident Fund deductions for casual labourers.

A Certificate should then be inserted on the checkroll as follows: - "Compared with checkrolls and found correct" in order to comply with Ministry requirement. Similarly the certificate at the left foot of the checkroll should also be signed by the soil surveyor or his assistant.

Four copies of the checkroll should be sent to the A.D.R's office where a covering voucher will be prepared and signed by the A.D.R., who is the officer responsible for expenditure, and then forwarded to the Ministry for checking. After the voucher and checkrolls have been checked, the documents and cheque are sent direct to the paying officer from the Ministry. It should be noted that under normal circumstances the cheque does not come to the A.D.R's office, which has no control over the movements of the voucher, checkroll or cheque once the voucher has been prepared and passed to the treasury section of the Ministry. Vouchers are normally forwarded to the treasury section within four to seven days of receipt, depending on the amount of work in hand. Delays are most likely to occur at the end of the month when salary sheets and subsistence vouchers are being dealt with.

On occasions the soil surveyor may be able to recruit aborigine labourers living in the ulu on a casual basis. Separate arrangement for pay and ration allowance should be discussed with the appropriate Protector or Assistant Protector for the State concerned before direct negotiations are undertaken with the aborigines themselves.

TABLE VIII

SALARIES AND ALLOWANCES PAYABLE TO JUNIOR SUBORDINATE STAFF AND LABOURERS

Junior staff/ employee	Salaries & Allowances p. month				Overtime per hour			Allowances for duty away from HQ. Stn.				Remarks
	Basic salary	COLA	House allce. (Basic rate)	Total	Week day at 1¼ time	Weekly holiday at 1½ time	Public holiday at double time	Day allce. per day	Subsis. allce. per night	Field camp allce. 24-hr.	Lodging per night	
Div. IV. staff on establishment under Personal Emoluments in the Annual Estimates:—												
(1) Office Boys (salary scale: $71 × 1.50—74)	$71.00	$ 7.07	$5.00	$83.07	–	–	–	$1.50	$3.00	$1.50	$3.00	Candidates for appointment as Office Boys must have attained 14th but not 16th birthday. Service to be terminated on 21st birthday.
(2) Launch drivers (salary scale: $96 × 3—120)	96.00	10.07	8.00	114.07	61c.	73c.	98c.	1.60	3.20	1.50	3.00	
Industrial&Manual Group employees on Open Votes under Other Charges, Annually Recurrent in the Annual Estimates:—												
(1) Lorry, car&van drivers	102.06	10.26	8.00	120.32	65c.	78c.	$1.04	1.70	3.35	1.50	3.00	With incremental scales ($102.05—105.84—110.16).
(2) Outboard motor drivers	86.94	7.56	5.00	99.50	55c.	66c.	88c.	1.50	3.00	1.50	3.00	Employment restricted to D.I.D.
(3) Watchman	85.32	7.56	5.00	97.88	54c.	64c.	86c.	1.50	3.00	1.50	3.00	
(4) Mandores	90.18	7.56	5.00	102.74	56c.	67c.	90c.	1.50	3.00	1.50	3.00	
(5) Head labourers	85.32	7.56	5.00	97.88	54c.	64c.	86c.	1.50	3.00	1.50	3.00	
(6) Labourers	76.14	7.56	5.00	88.70	46c.	55c.	74c.	1.50	3.00	1.50	3.00	With Incremental scales ($76.14—84.24).

FIRST AID AND HEALTH GUIDE

The following notes are by no means exhaustive and are included merely as a guide to immediate action in the case of injury. Any serious or potentially serious injury should be regarded with immediate concern, and expert medical assistance should be sought as quickly as possible. A small first aid manual, such as that published by the St. John Ambulance Association, should be included in any first aid kit which may be assembled for prolonged survey operations in remote areas.

BITES

The soil surveyor is vulnerable to bites from a variety of animals, of which leeches and insects can be the most annoying. Direct encounters with the larger animals, including elephant, seladang, tiger, bear, wild boar, and crocodile, are fortunately rare but in cases of mauling, which may cause severe lacerations and even loss of limbs, first aid consists of control of bleeding and dressing the wound, and treatment for shock. For the correct method of emergency treatment for wounds and shock see below.

(1) LEECH BITES. Leeches are probably the most troublesome form of animal life met by the soil surveyor working in lowland forest.

The leeches can be most efficiently extracted by applying the lighted end of a cigarette or by burning with a lighted match, when they will quickly withdraw. Salt sprinkled on the leech has the same effect. Brushing the leech off or pulling it out incurs danger of leaving some part of the animal in the wound and this may give rise to infection, although experience indicates that the risk is slight. Application of strong carbolic soap to a leech is often effective in causing it to release its hold, and the soap can conveniently be carried in an old lipstick container for this purpose. Silk or nylon stockings may make an effective barrier against the large buffalo leech which is common in padi fields.

(2) SCORPION OR CENTIPEDE BITES. Fortunately these are not commonly met with under Malayan field conditions, but the possibility should not be entirely ignored. In the case of a serious bite a constrictive bandage should be applied on the heart side of the bite, followed by treatment similar to that given for snake bites (see below).

(3) WASPS, BEES, AND HORNETS. Attacks by stinging insects are of fairly frequent occurrence, but fortunately the most commonly met wasp (Penyengat) has a comparatively light sting, and several such stings can usually be sustained without incapacitating the average healthy surveyor.

The more painful stings can be treated by the application of methylated spirit, alcohol, weak ammonia, or a solution of bicarbonate of soda, but as these are seldom immediately available, with the possible exception of the second, a proprietary multi-purpose soothing ointment, such as the readily available tiger balm, often proves to be a pain-relieving substitute.

(4) SNAKES. Fortunately, snakes encountered during soil surveys in Malaya are seldom aggressive, and bites are rare in forest country, although the incidence is higher in some areas of agricultural land, particularly oil palm estates. In case of snake bite first aid should be directed towards preventing the venom injected from reaching the general circulation.

This is done by applying a restrictive bandage on the heart side of the bite above the knee or elbow of the bitten limb. Rubber bands, a shoe string, a handkerchief, or anything practicable can be used as a bandage, and if the bite is on the finger or toe, apply a second bandage around the digit. These should be kept in place for half an hour and then removed for half a minute, and this procedure continued for three hours. If after this time the patient is apparently well, they can be removed.

After fixing the bandages, the wound should be bathed in a dark red solution of potassium permanganate in order to remove excess venom from the skin.

When this is done, the soft tissues around the bite can be cut along the length of the limb with a sharp clean knife or razor blade to encourage bleeding and to wash out the venom. Only in extreme emergency should the wound be sucked, and if possible the sucking should be done through a thin piece of rubber or polythene. Medical aid should of course be sought immediately. The patient should lie still and be given warm tea or coffee, or water, and if breathing fails artificial respiration should be applied.

BROKEN LIMBS

Steep cliffs, rapids and waterfalls, slippery roads and tracks should obviously be traversed with caution, but accidents will happen.

Unless there is immediate danger from some other cause, for example rock falls, the casualty should not be moved until the injured part of the body has been immobilised. This means supporting the fractured part in such a way that movement is impossible, in order to prevent further injury caused by the broken ends of the bones damaging other tissues.

Bandages and splints are necessary to immobilise the limbs, and can be made from articles of clothing, branches, metal clipboards etc. in an emergency. The body can be used as a splint in case of an arm injury. The splint should immobilise the joint above and below the fracture, and bandages should not be applied over the fracture, but alongside. The casualty should be made comfortable and then transferred as quickly as possible to the nearest source of medical attention. A stretcher can be made easily from camp bed canvas or tent cloth, and saplings, if the casualty cannot walk or travel in a sitting position.

BURNS

There are three general kinds of burn, namely thermal, sunburn and chemical, all of which can be classified according to depth or degree. In first degree burns the skin is reddened; in second degree burns blisters develop; while in third degree burns there is deeper destruction affecting the underlying growth cells that continually form new skin.

(1) Thermal Burns. Burnt hands and scalded feet frequently result from camp accidents. Use sterile dressings, or if not available, treat clean clothes to render them as sterile as possible, and apply the dressings in several layers. Then add additional covering to exclude air as much as possible, using clean tightly woven material if available.

Blisters should not be deliberately broken although they may break when the dressing is applied.

If the burn is serious make the patient lie flat, and if it involves more than 10 per cent of the body align the body so that the feet are about 10 inches (25 cm.) higher than the head. If the hand is burned, elevate above the level of the body and keep it elevated.

For a burn of the eye gently remove any foreign matter, provided the pain can be tolerated. Cover with a dry sterile gauze pad or a dry clean soft bandage and immediately arrange for medical attention. Do not drop oil or ointment in the eye unless necessary to relieve the pain pending medical care.

(2) Sunburn. Persons with light skin complexion should always limit the time of initial exposure.

For mild sunburn, cold cream or such oil or greases as cooking oil may relieve pain. Butter or margarine should not be applied. A dressing should be used if blistering appears, and the injured area should not be exposed again to the sun until healing is complete.

(3) CHEMICAL BURNS. These are unlikely to be encountered during soil surveys with the possible exception of acids from broken batteries or testing bottles. When such acids come in contact with the skin injury commences instantly, and first aid should be given immediately. This consists of washing away the chemical with large quantities of water and then treating as for a thermal burn. The burn should be shielded from direct sunlight until healing has occurred.

CUTS

Wash away dirt outside the wound with clean water, or with alcohol if available, but do not try to wash out the dirt in the wound. Then apply antiseptic (2% solution of iodine for example). The iodine should be applied in one stroke and allowed to dry before bandaging. Then apply sterile gauze and fix with adhesive tape to press cut edges together. Never apply iodine near eyes or body cavities and never apply adhesive tape directly over iodine.

FEVERS, ETC.

The soil surveyor or his staff are likely to succumb sooner or later to a variety of fevers, some of which cause only temporary discomfort and others of which may be extremely serious. Flu can spread like wildfire through a jungle party in a matter of days, and cause a temporary stoppage of field activity, but have no other serious consequences, while on other occasions one man be so obviously ill that special effort has to be made to transfer the patient to hospital with the utmost speed. An ample supply of aspirins is useful for treatment in the case of feverish illness.

FUNGUS INFECTION

This normally occurs on the feet, particularly between the toes, but may appear in the hair, on the skin, and under the nails. The commonest type of fungus infection met with in Malayan forests is known as Singapore foot.

Complete prevention is almost impossible for any length of time under normal soil surveying conditions in forest terrain, but open footwear should be worn during off-duty hours, and the feet kept as dry as possible when camping.

When infection occurs, the infected parts should be treated with a proprietary brand of fungicidal powder or ointment, which is best done in the evening.

HEAT EXHAUSTION AND STROKE

Heat exhaustion is caused by excessive loss of water and salt from the body. The symptoms are dizziness and faintness and perhaps a pale moist cool skin.

The patient should rest in a cool shaded place and drink cool salt water. It is worth taking a salt tablet at regular intervals of a few days when undertaking energetic field work within the forest, or when working in hot areas with little shade.

Heat stroke is a serious condition, but fortunately not common under Malayan soil survey conditions. Symptoms include high body temperature and unconsciousness, and the patient should be kept as cool as possible, by bathing in cold water and fanning, while medical aid should be sought immediately.

HYGIENE

At least one bath a day is necessary on purely social considerations under reconnaissance soil surveying conditions in Malaya, but inadvertent soakings taken during stream crossings and in swamp traverses, as well as in thunderstorms, usually increase this figure to a much higher level. Clothes should also be washed each day, even if there are no opportunities for drying them, and the habit of donning wet clothes each morning is easily acquired, and can be refreshing under some circumstances.

Water is always abundant in Malaya although the purity is variable. The normal practice is to treat all water by boiling when in camp and to carry sufficient boiled water for refreshment purposes during the day, or alternatively to "brew up" during halts, but no harm usually results from rinsing the mouth with fresh clear untreated stream water in remote areas.

MALARIA

Soil surveyors engaged in regular field work should take regular prophylactic doses of a proprietary anti-malarial tablet such as Chloroquin or Nivaquin. In case of an attack of malaria, treatment consists of the same tablets, at the recommended dose. Medical aid should be sought at the earliest opportunity.

RINGWORM

10 per cent Salicylic acid solution applied to the affected skin has been found to be a suitable treatment for this complaint, which is quite common among labourers.

SHOCK

Shock is a condition of severe depression of vital bodily functions which usually accompanies severe injury, and is a common cause of death after serious accidents. The main cause of shock is loss of blood from the circulatory system, but it should be remembered that this loss may be internal, due to haemorrhage, as well as external.

Symptoms include an attack of faintness or a state of collapse, which may be accompanied by giddiness and faintness; coldness; nausea; pallor; cold clammy skin; vomiting; a slow pulse and unconsciousness.

Emergency treatment consists of reassuring the casualty in order to calm his nerves; lay him down with head slightly lower than feet, loosen his clothing about neck, chest and waist and wrap him in a blanket, millerain tent cloth or other dry warm material; sips of any liquid other than alcohol may be given if the casualty complains of thirst. If unconscious, the casualty should be laid on his stomach or on his side, to avoid interference with breathing due to possible vomiting.

SKIN IRRITATIONS

Contact with certain types of plant life, of which the rengas tree is the most notorious in Malaya, or with some marine animals, including iellyfish, can cause pronounced skin irritations which can be extremely painful. Antihistamine is the standard treatment, or calomine lotion. When these are not available, the best advice is to avoid scratching the affected areas, and to grin and bear it. Medical advice should of course be sought in the case of very serious irritations.

TETANUS

The danger of tetanus (lock-jaw) should be considered in all wounds. Punctured wounds, especially those contaminated with soil or manure, probably have the highest incidence of tetanus, but many cases of tetanus result from wounds so insignificant that the patient does not recall them until specifically questioned. The particular need is for medical attention, and possible immunisation against tetanus. The danger of tetanus illustrates one of the reasons why even the most insignificant wound should be cleansed without delay.

TICKS, SAND FLIES, MITES, ETC.

These insects are a common nuisance, particularly in many lallang-covered cultivation patches and in areas of young secondary forest, as well as on beaches and disused mining areas. Dusting of the affected area with D.D.T. powder is usually sufficient to remove the insect from the body or clothes, while prevention of attack can be effected by liberal use of dimethyl-phthalate or similar liquid or ointment repellant. Unfortunately, under Malayan field conditions these repellants are washed away, by rain, river, or perspiration and the effectiveness is therefore short-lived.

WOUNDS

Incised wounds, caused by misdirected parang blows are a common form of injury, normally self-inflicted, during rentis cutting and free traversing in forest, and during camp and raft construction work, while lacerated or contused wounds may result from a chance encounter with one of the larger animals or by bruising against rocks in rapids, stream crossings, etc.

In treating wounds cleanliness is particularly important, but unfortunately not easily attained in the field. The hands should be cleaned thoroughly with soap and water, and the wound should be bathed only with water treated with an antiseptic, such as potassium permanganate in sufficient quantity to make the water dark red. Water needs to be boiled for 20 minutes to make it completely sterile.

The casualty should sit or lie down and the bleeding part elevated, to reduce the loss of blood. After exposing the wound, foreign bodies visible and easily picked out should be removed, using a clean dressing, but avoiding the disturbance of any blood clots which may already have formed. Pressure to control the flow of blood should be applied, either directly with the hand to that part of the wound from which the blood is flowing, or by squeezing the whole wound area tightly, or by applying a constrictive bandage or tourniquet (see below) and then cover with a dressing and bandage. The injured part should then be immobilised in a similar way to that recommended for broken limbs.

Constrictive bandages are rubber bandages with tape attachments for fastening, but a narrow folded tringular bandage, or even elastic belt may be used in an emergency. The aim is to reduce the flow of blood through the veins and arteries. The bandage should be only tight enough to control the flow of blood to the bleeding part, and it must be cautiously loosened after fifteen minutes and only re-tightened if bleeding has not ceased. The most effective use of constrictive bandages requires further instruction, and a good first aid manual should be consulted for fuller details.

FIRST AID KIT

It is advisable to take along a small first aid kit during camping trips, and this should include the following:—

Aspirins
Antiseptic fluid
10% salicylic acid solution
Potassium permanagate crystals or 2% solution
Insect repellant
Anti-malarial tablets
Salt tablets
Soothing ointment
Fungicidal powder or cream
1″ and 3″ bandages
Lint or gauze in ½ oz. packet
Cotton wool in ½ oz. packet

Adhesive tape, or dressings of various size
Triangular bandage
Prepared sterile dressings
Scissors
Safety pins
Torch with spare batteries.

These should be packed tightly into a leakproof and reasonably airtight metal container. The word UBAT (medicine) should be written clearly on the outside.

A SHORT HISTORY OF SOIL SURVEY IN MALAYA

Studies on the classification of Malayan soils can be traced to the early years of this century. The published works of Akhurst and Haines, Barrowcliff, Belgrave, Dennet, Grantham, Greenstreet, Hamilton, Savage and Wilshaw show how much attention this subject received between the First and Second World Wars. In all these studies the importance of parent material was recognized and repeatedly stressed, and frequent reference was made to existing geological maps. However, apart from a map of the Rubber Research Institute's Experiment Station at Sungei Buloh, prepared by Akhurst and Haines, no true soil maps were published, and the only systematic surveys known to have been made of extensive areas were those commissioned by certain large planting companies for their own properties. The unpublished works of Tommerup and Cole who worked respectively for Dunlop Malayan Estates, Ltd. and Guthrie and Co. (M) Ltd., were excellent pioneer efforts in this sphere. Interest was revived in the post World War II period and a notable advance was made in 1951, when Owen published a provisional classification of Malayan soils, in which he proposed names for a number of soils then known to exist in the peninsula. This classification was unfortunately not accompanied by a soil map, but it marked the beginning of the classification system which is now being followed.

Later, in the ninteen-fifties, Coulter and others carried out a number of soil surveys of some of the major swamp areas along the west coast of Malaya, including the Kuala Langat (North) Forest Reserve and the trans-Perak Swamp. These surveys were designed primarily to determine the suitability of the soil for padi before planning drainage and irrigation facilities. They sampled soils at regular intervals along specially cut rentis or traverse lines; these samples were mechanically analysed, and soil maps showing the principal textural groups were produced.

During the same period a number of detailed maps of both sedentary and alluvial soils were prepared for a few areas of developed land in several regions of the country, using profile characteristics observed in the field as the basis of the classification. In the midfifties, reconnaissance soil surveys of some extensive padi areas were undertaken, and a schematic-reconnaissance soil survey programme for the whole country was also started. This ambitious programme was intended to elucidate the broad soil pattern for the entire country, and give a realistic appreciation of the soil suitability, and therefore of the agricultural development potential in both the undeveloped and developed areas. It was considered that reconnaissance soil surveys of this nature, if systematically carried out, would give a far greater return than if effort was concentrated on detailed soil surveys of restricted areas carried out largely for ad hoc purposes, although these could never be completely eliminated. For reasons of convenience, it was decided that the schematic-reconnaissance mapping programme should be carried out on a State basis, commencing with the northeast States, where the need for soil surveys was considered to be greatest, and soil maps on a scale of 1: 500,000 with accompanying reports have been published for the States of Trengganu, Kelantan, and Kedah. More recently, maps on larger scales, accompanied by reports, have been produced for large parts of Johore, Pahang, and Selangor.

Field work has since been concentrated in Pahang and Johore, and the remaining soil maps and reports for these States are gradually becoming available. In addition, a large number of ad hoc surveys have been carried out in various parts of the country, and the information provided by such work, as well as from other sources of a less direct nature, was used to compile a small scale map of Malayan soils which was completed in 1962.

Systematic detailed surveys were also carried out over a number of large alluvial areas particularly in Kedah and Kelantan. Unfortunately the results of these surveys have not been published, but the records are preserved in the Soil Science Division and will doubtless prove of great value during any future re-survey.

In addition to the official soil survey programme, which is undertaken by the Soil Science Division staff of the Division of Agriculture, certain private organisations have undertaken soil surveys, mainly of oil palm estates, to help with agronomic studies, while soil scientists on the staff of the R.R.I. have also carried out a number of detailed surveys of rubber estates in recent years, and liaison has been maintained with these organisations which have mostly adopted the soil classification of the Division of Agriculture.

References cited in this Appendix are set out in chronological order in Appendix 11.

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Appendix 12.

SOIL SUITABILITY CLASSIFICATION IN MALAYA

One of the most important objects of soil survey is to interpret the data so as to predict the behaviour of the soil when it is used by man. Many methods of doing this are available, and the one chosen here is based on features of the soil or its environment which limit the suitability of the soil for agriculture. The term "suitability" is used in preference to the alternative terms "productivity", or "fertility" because it is felt that these alternatives infer more experimental and analytical information about the soils than in fact exists at present. This classification is erected solely on the observations made by soil surveyors combined in some cases with information concerning the performance of the main crops on different soils. Experimental confirmation in the near future would be most desirable.

The scheme is necessarily broad in approach because it is based on data obtained from the schematic-reconnaissance survey of Malaya. It is therefore aimed primarily at assessing suitabilities for the main economic crops of the country, i.e. rubber and oil palm, and does not contain enough detail to predict satisfactorily for crops with special requirements such as padi. In the case of such crops, far more detailed soil information than is at present available is required before any realistic appraisal can be made, and, even then this should be supported by a comprehensive system of field trials.

In erecting this classification certain assumptions have been made, and the most important of these is that the plant nutrient deficiencies which characterise Malayan soils, almost without exception, will be corrected by fertilizer application under agriculture. Fertilizer requirements are not mentioned here because the necessary information is not available for the wide range of soils considered, but it can be bluntly stated that all soils will require fertilizer application, and until this universal limitation is corrected, the scheme as outlined here will have only restricted application. Some soils, however, have acute plant nutrient deficiencies in which minor as well as major nutrients are involved, and as this condition is regarded as far more difficult to diagnose and correct than the normal situation, it is included in the classification as a limitation.

The limitations to the suitability of the soils for agricultural development are divided into three groups as follows: -

VERY SERIOUS LIMITATIONS

These are impediments to development which are extremely difficult to correct; which severely reduce the productivity* of the soils; or which could result in very serious damage to the land under development. They are: —

1. Slopes steeper than 20°.
2. Massive, thick laterite at or very close to the surface.
3. Extreme rockiness — i.e. boulders and rocks almost entirely covering the surface.
4. Land disturbed by mining.
5. Toxicity caused by abnormally high amounts of certain elements.

The classification of slopes steeper than 20° as a very serious limitation may be controversial in view of the satisfactory techniques which have been evolved in parts of the tropics for cultivating slopes as steep and steeper than this. However, steep terrain is retained under this heading because

* The term "soil productivity" is used here as defined by Kellogg (1961 p. 15) i.e. "Soil productivity is that quality of a soil that summarises its potential for producing specified plants or sequences of plants under defined sets of management practices."

it is considered desirable at present to direct attention to the very large areas of undeveloped land with slopes less than 20°, and also because it does not seem as if the agricultural population of Malaya is yet high enough to warrant exploiting such difficult terrain. In the future, when most land has been developed and when the population has increased considerably, development of steep land may be justified, but at present this is not so. Conversely, the case for retaining many, if not all, of these areas under permanent forest, either productive or protective, is likely to be increasingly emphasised in the future as the conservation role of forest in the steep lands becomes more readily appreciated, and as the need for water catchment, game and recreational reserves is felt.

SERIOUS LIMITATIONS

These are impediments to development which are quite difficult to correct; or which considerably reduce the productivity of the soil; or which require the adoption of special techniques to be overcome. They are: —

1. Acute nutrient deficiencies — including trace element as well as major element deficiencies.
2. Very poor and poor drainage.
3. Moderately steep slopes (12° - 20°).
4. Massive, thick laterite within 2 feet (about 60 cm.) of the surface.
5. 2 feet (about 60 cm.) or more of acid peat.
6. Strong compaction.
7. Sand texture throughout.
8. Acid sulphate conditions.
9. Saline conditions.

MINOR LIMITATIONS

These are impediments to development which are relatively easy to correct; or which only slightly reduce the productivity of the soil; or which to a minor extent restrict the range of crops which should be grown. They are:—

1. Susceptibility to flooding.
2. Weak structures within the top 4 feet.
3. Imperfect or moderate drainage.
4. Acid peat less than 2 feet (about 60 cm.).
5. Weak or moderate compaction.
6. Alkaline pH.

On the basis outlined above the following five classes have been established:—

CLASS 1: SOILS WITH NO LIMITATIONS TO AGRICULTURAL DEVELOPMENT

These are deep, well drained, friable, well structured soils on slopes less than 12°. They are suitable for rubber and oil palm as well as a wide range of other crops.

CLASS 2: SOILS WITH FEW MINOR LIMITATIONS TO AGRICULTURAL DEVELOPMENT

These soils occur on slopes less than 12° and have no serious disability. The range of crops for which they are suitable is restricted in some cases by the type of limitation, e.g. susceptibility to flooding or up to 2 feet (60 cm.) of peat, but apart from this most other soils in this class are suitable for a wide range of crops including rubber and oil palm.

CLASS 3: SOILS WITH AT LEAST ONE SERIOUS LIMITATION TO AGRICULTURAL DEVELOPMENT

These soils occur on a wide range of slopes up to 20° and most of them cannot be developed satisfactorily without amelioration of the limiting factors. Their suitability tends to be restricted to certain crops under specified management practices. Some will support rubber and oil palm under a high standard of management.

Class 4: Soils with more than one serious limitation to agricultural development

These soils occur on slopes up to 20° and will require a high standard of development and management to produce reasonable yields. Some will support rubber but most will be restricted to specialised crops, such as pineapples on peat. However, without question these soils would be best left in forest at present.

Class 5: Soils with at least one very serious limitation to agricultural development

The obstacles to the development of these soils are so great that they should remain in forest or be allowed to regenerate to forest.

OIL PALM SOILS

Recently, there have been an increasing number of requests to the Soil Science Division to advise on the suitability of soils for oil palm cultivation in connection with the current programme of crop diversification. Several officers are called upon to perform this work and it is important that they adhere to the same standards. In practice the soils are classed as suitable, marginal or unsuitable for oil palm cultivation and the assessment is based on the following conditions of the soil and its environment:

1. *Terrain*

   (a) Most slopes between 0° - 12° .... suitable
   (b) Most slopes between 12° - 20° .... marginal
   (c) Most slopes greater than 20° .... unsuitable.

2. *Physical Impediments*

   (a) When an impenetrable and/or compact layer is absent or more than 4 feet (about 120 cm.) below the surface .... suitable

(b) When an impenetrable and/or compact layer lies between 2 and 4 feet (60 - 120 cm.) below the surface .... marginal

(c) When an impenetrable and/or compact layer lies within 2 feet (60 cm.) of the surface...unsuitable

3. *Drainage*

(a) When the gley horizon is 3 ft. (90 cm.) or more from the surface .... suitable

(b) When the gley horizon is 1 - 3 ft. (30 - 90 cm.) from the surface .... marginal

(c) When the gley horizon is 1 ft. (30 cm.) or less from the surface .... unsuitable.

4. *Texture*

A sand texture throughout the profile is *unsuitable* as the drainage would be excessive under such a condition.

5. *Toxicity*

Soils having extreme acidity, salinity and high toxicity are *unsuitable* for oil palm cultivation.

6. *Thickness of peat*

(a) 0 - 2 feet (0 - 60 cm.) thick .... suitable

(b) 2 - 4 feet (60 - 120 cm.) thick .... marginal

(c) 4+feet (120 cm. +) thick .... unsuitable

7. *Rainfall*

A distinct dry period of 2 months or more, annually recurrent, is *unsuitable for oil palm cultivation.* This condition is so far known to exist in the extreme north of Malaya.

APPENDIX 13.

LAND CAPABILITY CLASSIFICATION IN MALAYA

A physical land classification which is based on the results of soil and other natural resource surveys can be most successfully applied to the planning of land use in undeveloped areas. In such regions, use plans for large tracts of land can be executed with minimum complication caused by the socio-economic factors which must inevitably be considered in more developed areas, where the use pattern has been firmly established.

Much of the land in Malaya falls into this undeveloped category, as less than 30 per cent of the total area has been alienated and therefore committed for a definite and often irrevocable use. The remaining 70 per cent of the land area fortunately contains considerable reserves of unexploited minerals, uncultivated soil, uncut forest, and unutilized water, and as surveys of these and other resources are in an advanced stage, an opportunity is now presented for utilizing the results of these surveys for the practical purpose of development planning.

It is apparent that Malaysia can learn from the experiences of other countries, many of which are more economically advanced than herself, in planning for use of the unused areas before the land in question is irretrievably committed to a particular use which may later be found to be inappropriate. In order to do this it is extremely important that the results of surveys and other investigations are co-ordinated for land planning purposes. This in turn implies a spirit of co-operation not only between the agencies conducting such surveys, but also with those carrying out the physical planning and actual development.

Such conditions exist in the States of Malaya, where an impetus has been given to this work by the pressing need to settle large numbers of landless persons, particularly from the crowded west coast States, by opening up large areas of unexploited land, particularly in the east coast States and in the interior, which are the places with the greatest potentials for agricultural, forest, and water use development.

Land Capability Classification has been seized upon as being the appropriate technique for translating the technical data amassed by the survey agencies into meaningful terms for the developers and the community at large. The essence of this classification is its simplicity, the intention being to present the data in such a way that it is understandable to those who are not necessarily well informed about the actual resources. The maps which embody this classification are intended to be used as guides to planning by the development authorities, who should thus be able to prepare their development plans with greater assurance, and to direct their efforts into those areas where the most beneficial results can be expected.

The classification is a very simple one, and it divides the land into the following five broad groups: —

CLASS I — Land possessing a high potential for mineral development and therefore best suited for mining.

CLASS II — Land possessing a high potential for agricultural development with a wide range of crops and therefore best suited to agricultural diversification.

CLASS III — Land possessing a moderate potential for agricultural development with a restricted range of crops and therefore best suited to agricultural development with crops having a wide range of soil tolerance.

CLASS IV Land possessing a potential for productive forest development and therefore best suited to commercial timber exploitation.

CLASS V Land possessing little or no mineral, agricultural, or productive forest development potential but suitable for development as protective reserves for conservation, water catchment, game, aborigine, recreation, or similar purpose, or possibly suitable in the future for productive forest plantations with introduced species.

The story of how Land Capability Classification has come to occupy its present place in the field of economic planning is an interesting one which goes back several years. In 1954 a World Bank mission visited Malaya, and in a comprehensive report recommended the creation of a Land Use Survey team to direct attention towards diversification crop potentials, particularly in the undeveloped areas, and to co-ordinate the survey aspects over the entire resource-use field with emphasis given to opportunities for agricultural development. (International Bank for Reconstruction and Development, 1955). Later, in 1962, a team of experts provided by the Ford Foundation visited Malaya in order to undertake a study of agricultural diversification of the Malayan economy and to report and make recommendations thereon. The report particularly emphasized the need for more soil surveys but advocated that greater attention should be given to surveys of resources generally. Emphasis was also given in this report to the need for utilizing the indigenous forests to better effect, and to ensuring that the permanent forest estate was sited in those areas where it would least interfere with the pressing need to develop more land for agriculture (Paarlberg et al. 1963).

In many respects these recommendations were reflecting local sentiment in the technical departments of Government.

A degree of co-operation amongst the various resource survey agencies had existed for many years and in some cases this extended to joint field programmes, and a healthy exchange of field data and experience.

During the period of the Malayan First Five Year Plan (1956-60) data collected by the resource survey teams was applied to development problems by means of a certification system, which was introduced to assist in ensuring that land chosen for large agricultural development schemes was suited to the purpose of the scheme, and particularly to the crop which would be the mainstay of the scheme. The certificates, which were insisted upon by the development agencies, principally the Federal Land Development Authority, included a clearance certificate prepared by the Geological Survey to the effect that the area was free of workable mineral deposits, and a similar clearance from the Forest Department indicating that the area had been properly exploited of commercial tree species prior to felling and clearing. A soil suitability certificate was also insisted upon, and this was supplied by the Division of Agriculture which carried out a soil examination of each site before issuing the certificate. In some cases the soil suitability certificates were withheld for several years until the crop in question had been proved suitable by observation of a test plot under the prevailing soil and other environmental conditions, or until the soil had been ameliorated by drainage or other improvement measures.

Within a few years some sixty major schemes, each covering 4,000 acres, (about 1600 hectares), and several hundred smaller schemes, mostly between 50 and 300 acres (20 and 120 hectares) in extent, have been successfully established in various parts of the Malay peninsula. Soil survey data was invaluable in determining the correct siting of these schemes, and the desirability of accurate country-wide soil maps and reports was appreciated over a wide field of development interests.

The advent of the Malayan Second Five Year Plan in 1961 saw the introduction of the Red Book, a compendium which includes information on the present land use pattern, and proposals for development during the period of the plan, which was prepared for each of the seventy administrative districts and which proved to be a useful device for stimulating development at all levels of the administration. This very practical approach to development is outside the scope of the present manual, but deserves mention as it is a most striking innovation which has contributed greatly to the immensely successful current Malaysian Rural Development drive. It has brought the lower echelons of local expertise into the planning process, and has considerable popular appeal, while it has also helped to create a realization of the importance of careful selection and sound planning throughout the country.

Experience in dealing with the problems of development led to a general recognition throughout all sectors of Government concerned with land administration and resource development, that the present land use pattern, which had largely resulted from a laissez-faire approach to land alienation and a somewhat arbitrary system of allocating land for reserve purposes in the past, was incompatible with the best economic uses over many areas. For example, agricultural development was being forced on to erosion-prone hillsides in some areas where the demand for agricultural land was particularly great, while in neighbouring districts lowland areas of good topography which contained rich soil might be gazetted as forest reserve and remain unutilized.

Sensible re-allocations which reflected the capability of the land as deduced from existing survey data, usually based on reconnaissance soil surveys, were proposed from time to time, but only on a small scale, and they were ad hoc in the sense that no systematic appreciation was yet being carried out on a national basis. These ad hoc plans however worked very successfully and have culminated in recent years in a proposal to carry out a detailed natural resources appraisal and prepare a development master plan for a particularly large area, covering 600,000 acres, (240,000 hectares) which has been found from reconnaissance soil surveys to be well suited for a large development scheme incorporating both agriculture and forest exploitation.

The experience gained from these exercises in development planning for better natural resource utilization has emphasized the importance of co-ordinating the data from resource surveys and using it for classifying the broad land use capabilities, and a logical follow-up was to draw up a generally acceptable land capability classification system using fixed criteria to mark the limit of suitability for the different resources, and to apply this classification over the States of Malaya as a whole.

The classifications used in the resource suitability maps which are contributed by the three main resource survey organizations, and which are used in the compilation of the land capability classification and maps, have been accepted only after considerable debate and revision between representatives from the resource contributory groups and the main development agencies of Government. The objective has been to establish economically valid criteria which give land capability boundaries indicating a realistic use purpose to which the land might be put, within a sound conservation context.

The soil suitability classification, outlined in Appendix 12, details the criteria used for the soil survey data. The boundaries between the five suitability classes constitute the details for the soil suitability map, which represents the soil resource contribution for purposes of land capability classification. Classes 1 and 2 of the soil suitability map comprise Class II of the land capability classification, while Class 3 of the soil suitability map comprises Class III of the land capability classification.

Because mining in Malaya mainly takes the form of soil-mining in open-cast alluvial workings, 4-class mineral potentiality maps, contributed by the mineral resource survey organizations, are also used for land capability classification purposes, and the mineral potentiality boundaries are based on criteria which give an economically acceptable boundary for Class I of the land capability classification. A similar 4-class forest productivity map, contributed by the forest resource survey organization, is based on criteria which gives an economically acceptable boundary for Class IV of the land capability classification.

Land capability maps, accompanied by reports summarising the resource potentialities of the areas, and contrasting the present development pattern with the resource development opportunities, are prepared on a district basis from the contributed resource survey data.

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