RECONNAISSANCE SOIL SURVEY OF MALACCA

by

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Malayan Soil Survey Report No 3/1967

WITH THE COMPLIMENTS

OF

THE DIRECTOR OF AGRICULTURE,
WEST MALAYSIA,
KUALA LUMPUR.

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PART I

INTRODUCTION

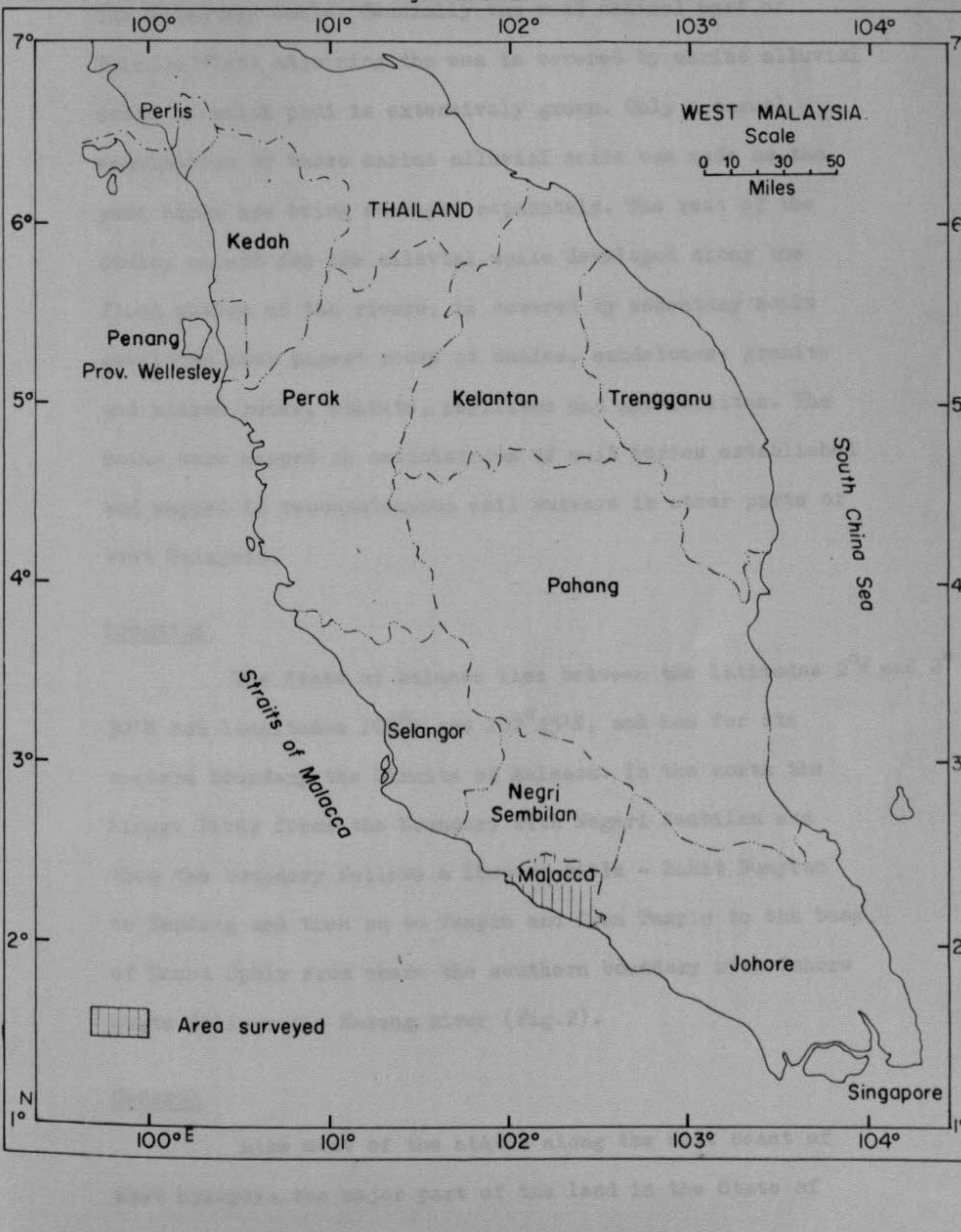
This soil survey report together with the accompanying maps is the result of field work carried out between June 1966 and January, 1967. The report covers the State of Malacca which occupies an area of 409,600 acres or 0.3 per cent of West Malaysia. (Fig.1). The report contains in addition to information on soils in both the developed and undeveloped areas, a map showing the soil suitability classification of these soils. The purpose of this Reconnaissance Soil Survey is to ascertain the suitability for agriculture of undeveloped regions and the possibilities for diversification of crops in the country's rural development programme.

The State of Malacca is covered by parts of Map Sheets 112, 113, 114 and 121 of the New Series topographical maps.

Areas where the average slope of the terrain is more than 20° and which are considered too steep for normal agricultural development occupy 9,000 acres or 2.25 per cent of the State, were not surveyed.

The soils found in the State of Malacca can be broadly classified into two classes - the Alluvial Soils and

Fig. I. LOCALITY MAP



the Sedentary Soils. Generally the west central part of Malacca State adjoining the sea is covered by marine alluvial soils on which padi is extensively grown. Only a casual examination of these marine alluvial soils was made as the padi soils are being surveyed separately. The rest of the State, except for the alluvial soils developed along the flood plains of the rivers, is covered by sedentary soils developed over parent rocks of shales, sandstones, granite and allied rocks, schists, phyllites and amphibolites. The soils were mapped as associations of soil series established and mapped in reconnaissance soil surveys in other parts of West Malaysia.

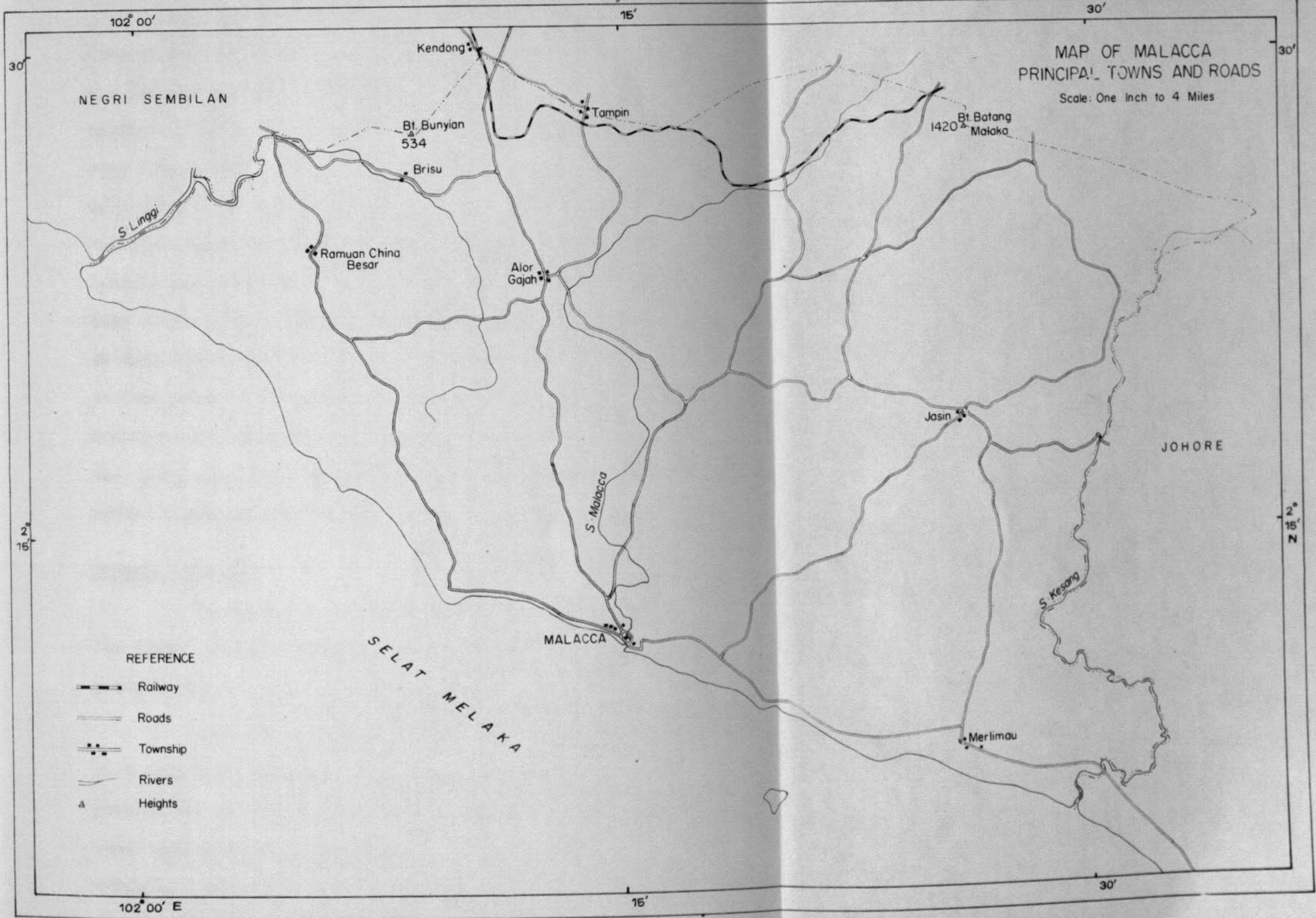
Location

The State of Malacca lies between the latitudes 2^{o}N and 2^{o} 30'N and longitudes 102^{o}E and $102^{o}45'$E, and has for its western boundary the Straits of Malacca. In the north the Linggi River forms the boundary with Negeri Sembilan and then the boundary follows a line of hills - Bukit Bunyian to Kendong and then on to Tampin and from Tampin to the base of Mount Ophir from where the southern boundary with Johore State follows the Kesang River (Fig.2).

General

Like most of the states along the west coast of West Malaysia the major part of the land in the State of

Figure 2


MAP OF MALACCA
PRINCIPAL TOWNS AND ROADS
Scale: One Inch to 4 Miles
102° 00′
15′
30′
2° 15′ N
102° 00′ E
NEGRI SEMBILAN
JOHORE
SELAT MELAKA
Kendong
Tampin
Bt. Bunyian
534
1420 Bt. Batang Malaka
Brisu
S. Linggi
Ramuan China Besar
Alor Gajah
S. Malacca
Jasin
S. Kesang
MALACCA
Merlimau
REFERENCE
Railway
Roads
Township
Rivers
Heights

Malacca has been developed. The areas which remain undeveloped are the forest reserves scattered around the State - the largest of which is only about 6,000 acres. Thus, there is very little land available for large scale agricultural development. As a result of this well developed nature of the State there is a good network of first class all weather roads joining the major towns in the State and at the same time dividing the State into small rectangles. In addition to this network of first class roads there is also an excellent network of lateritic roads especially in the rubber estates enabling the wide use of a landrover for the survey. Even the few forest reserve in the State have either timber tracks or other tracks going through them.

Present Land Use

Tin mining is only carried out in two places in the State - around Kesang and Chin Chin. However in both these places the mines are very small gravel pump mines.

Agriculture which forms the most important source of income and livelihood of the rural population is at present mainly dependent on two major crops - rubber and padi. Rubber which is easily the most important crop occupies virtually all the land alienated for agriculture covered by sedentary soils in the State. Oil Palm is just being planted for the first time in the State on the Diamond

Jubilee Estate near Jasin.

Padi, the next largest crop grown in the State occupies virtually all the land alineated for agriculture covered by alluvial soils, especially along the coast and the flood plains of the rivers. The highly acid nature of the coastal alluvial soils results in poor yields compared to other parts of the country and as a result this land is slowly being converted to land for housing by dumping lateritic earth over these areas. This paractice if not curtailed will in the near future cause a decrease in the acreage of land on which padi is grown.

Rubber and padi together take up virtually 95% of the land under agriculture in the State. The timber industry as expected is only a small industry in the State.

Method of Survey

Before the survey proper was carried out all the available relevant data was obtained and studied. Fortunately, the Director of Geological Survey allowed the use of Rishworth's Draft Geological Map of Malacca and in addition to this, Dr. B.N. Koopmans of the Department of Geology, University of Malaya kindly allowed the use of the Geomorphological Map of the State made from aerial photographs. Using these two maps as a guide a quick preliminary survey was done cutting across as many geological and geomorphological boundaries as possible to obtain a rough indication of the different types of soils present in the state. In this respect due acknowledgement must be given to Inche Law Wei Min, Soil Correlator and Inche B. Gopinathan, Soil Scientist, Negeri Sembilan for their valuable guidance and help.

Having obtained a rough idea of the soils present in the State the survey proper was initiated. The base maps used in the field for the survey were topographical maps of the New Series at a scale of 1:25,000 or 2½ inches to one mile. The excellent network of roads in the State made the field work relatively easy. Road traverse was the only means of survey carried out. While out in the field on a traverse, the contour height which marks the steepland boundary - usually the 250' contour for the State - was delineated on the field sheets. The extent of the flood plains along the rivers and other significant topographic features were also recorded directly on the field sheets.

Road-cuttings were abundant along most of the roads present in the State and these were widely used for soil examination purposes. Along the estate roads drain cuttings were common and these were also used. The soil was identified from these cuttings and other such exposures and recorded by directly plotting on the field sheets. Where cuttings were not available auger borings were made to examine the soil.

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Borings were made with a two-inch screw auger at depths of 0-6", 6-12", 12-18", 18-24", 24-30" and 30-36". Any soil boundary observed in the field was directly plotted on the field sheets. As most of the forest reserves had tracks through them no rentis work was done. During the field work an assessment of the suitability of the soils for the various crops was also noted.

When the field data had been plotted, the mapping units were decided upon and the boundaries of the mapping units then delineated on a transparent overlay. In the areas between two locations where no examination was made either a geological or a physiographic boundary was used to extrapolate the soil boundary. Wherever possible the soil boundaries were again checked after the map was reduced to one inch to a mile, and finally reduced to 2 miles to an inch for printing. It must be clearly pointed out here the limitations of such extrapolations and of the resulting map. The map only gives a broad outline of the soil pattern and should not be used as a guide to lay down any experiments or small schemes without further detailed examination.

PART II

THE ENVIRONMENT

The soil is that part of the earth's surface containing living matter and that which is capable of supporting plants (Soil Survey Staff, 1960). It is a natural body which is constantly subject to change by a combination of a number of factors - soil forming factors - of which five play a predominant part. These are namely, topography and terrain on which the soil is sited, the parent material from which the soil is derived (i.e. the geology), the climate, the length of time of its development and the vegetation. Depending on the part of the world in which one is, one or more of these factors may be the dominant factor which controls the soils formation. In this part of the world the geology and climate seem to be the most dominant factors.

Topography and Terrain

Topography and terrain influence to some extent soil formation and development. The slope and terrain class of an area very often reflects strongly the nature of the parent material and in some cases a difference in the soil. Thus for example, the more rugged terrain with round hills is very often associated with igneous intrusions - especially acid igneous rocks while the gently undulating and rolling terrain often suggests a soil derived from sedimentary rocks. Flat or nearly level terrain is often a result of peneplanation or some alluvial deposit. In an area of sedimentary rocks the areas having rolling to hilly terrain with prominent ridges usually have sandstones as the parent rock.

Under moist and humid tropical conditions, both erosion and weathering are quite intense. Generally, there is a balance between erosion and rock weathering but on steep slopes on hilly or mountainous terrain surface run-off and surface erosion very often surpasses the formation of soil and hence rocks are more often than not exposed on the surface with hardly any soil cover. As a consequence one would expect to reach the parent material, if not the parent rock at much shallower depths in areas of strong relief than in areas of gentler terrain. Thus for example, in areas where granites predominate one would expect to reach the weathered rock material at about three or four feet depth when the terrain is hilly but would have to go a depth of about twenty feet on a undulating terrain.

The slope of the land was measured with an Abbney Level. The slope and terrain classes used in West Malaysia is reproduced in Table I.

Table I

Slope and Terrain Class

Slope in Degrees	TERRAIN CLASSES	
	Single Slope	Complex Slopes
$0-2^\circ$	Level or nearly level, A_1	Level or nearly level C_1
$2^\circ-6^\circ$	Gently sloping A_2	Undulating C_2
$6^\circ-12^\circ$	Strongly sloping A_3	Rolling C_3
$12^\circ-20^\circ$	Moderately steeply sloping A_4	Hilly C_4
$20^\circ-25^\circ$	Steeply sloping A_5	Steep C_5
$25^\circ+$	Very steeply sloping A_6	Very steep C_6

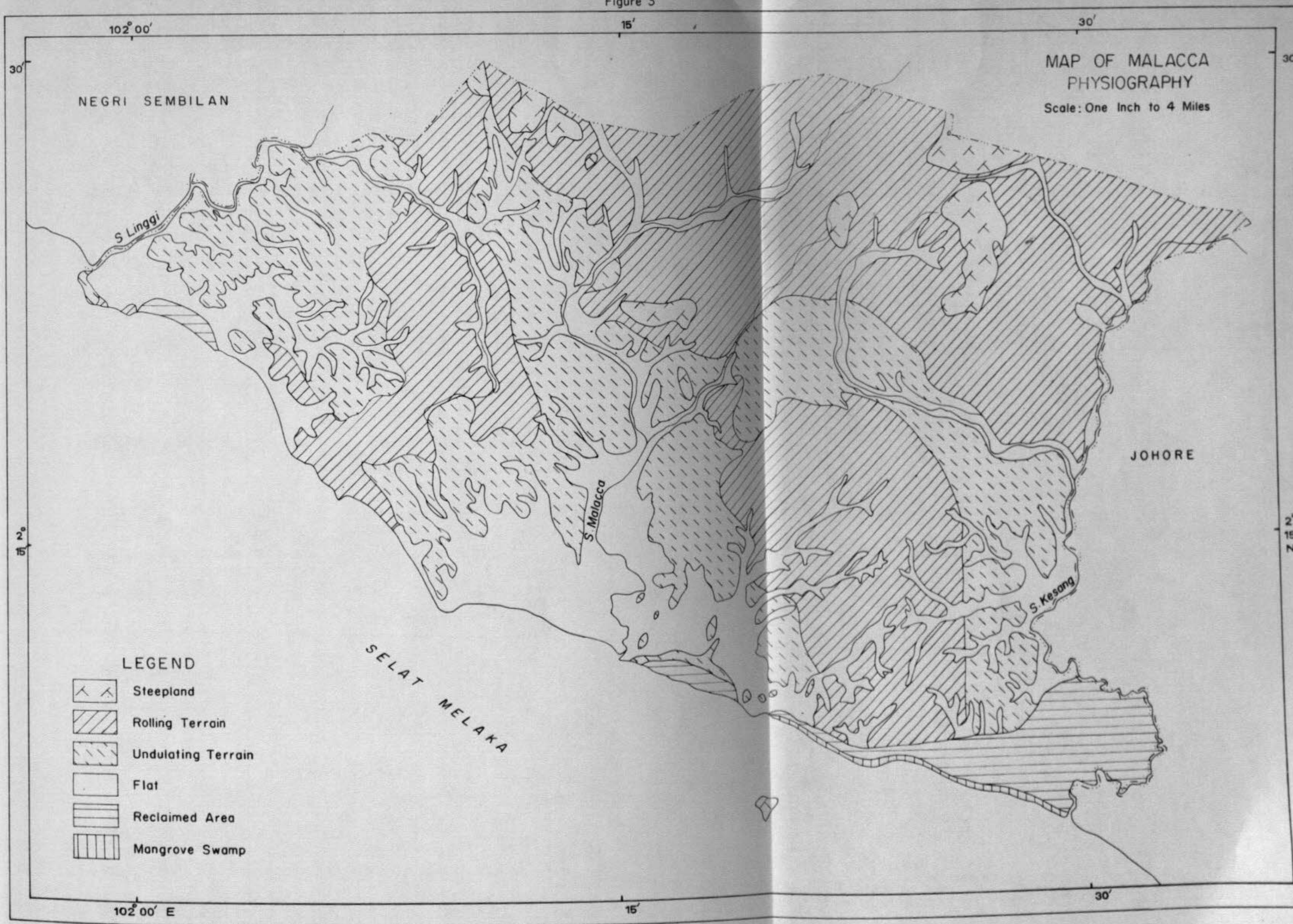
(Leamy and Panton, 1966)

A physiographic map of Malacca State (modified from B.N. Koopmans) is shown in Fig.3. The area indicated as "Reclaimed land" on the map was reclaimed from the sea by the building of bunds and subsequent drainage. The other terms used are those given in Table 1.

Climate

Lying in the tropics, West Malaysia experiences a warm humid climate. The Northeast Monsoon blows from October to March while the Southwest Monsoon blows from May to September. Both these monsoons do not seem to have very much

Figure 3


MAP OF MALACCA
PHYSIOGRAPHY
Scale: One Inch to 4 Miles
NEGRI SEMBILAN
JOHORE
SELAT MELAKA
S. Linggi
S. Malacca
S. Kesang
LEGEND
Steepland
Rolling Terrain
Undulating Terrain
Flat
Reclaimed Area
Mangrove Swamp
102° 00′
15′
30′
2° 15′ N
102° 00′ E

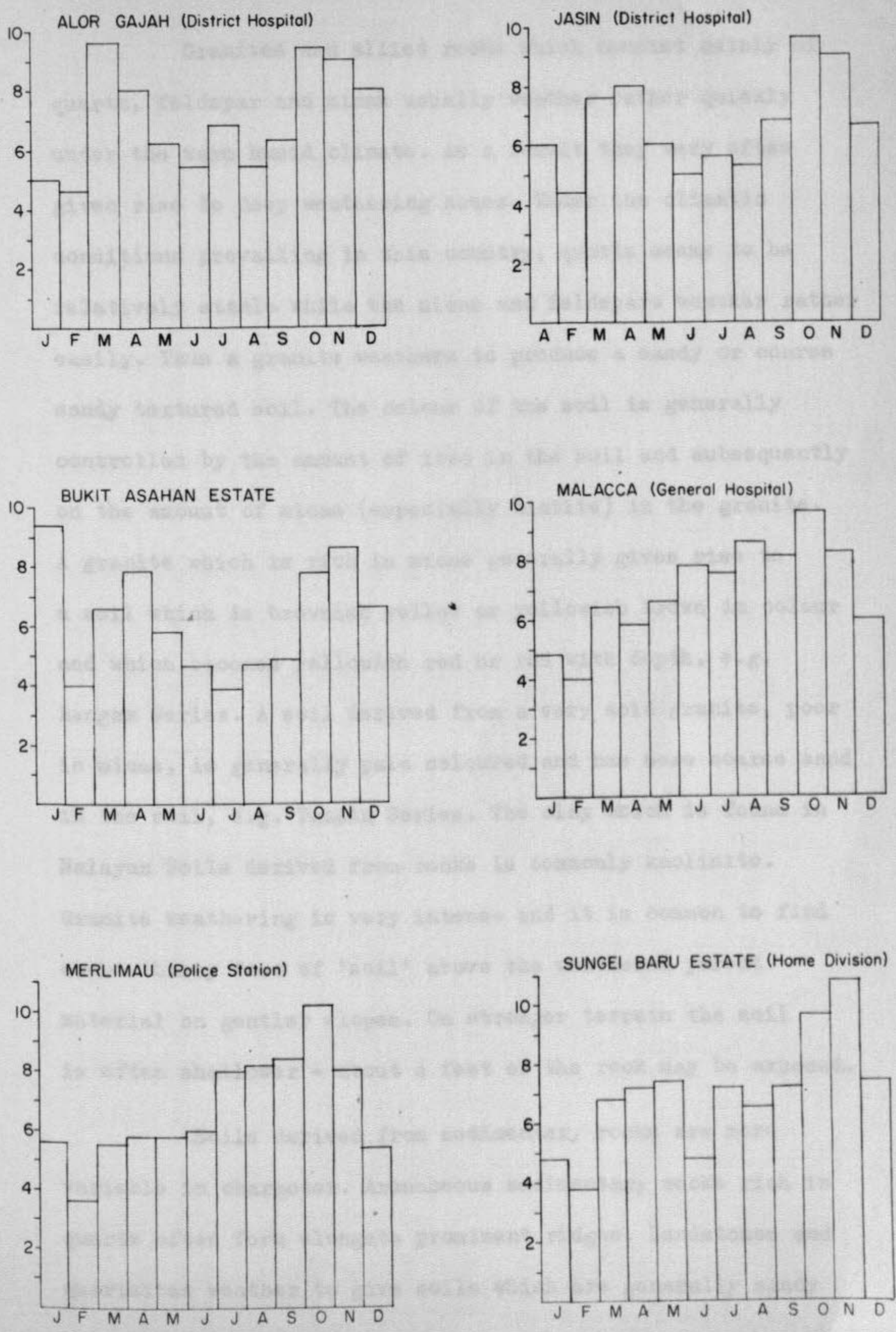
effect on Malacca as the Main Range lies in the northeast and the Indonesian island of Sumatra lies to the southwest of the State. From the table showing the mean monthly rainfall (Drainage & Irrigation Department) at six selected sites in the State (Fig.4) it can be clearly seen that the rainfall is fairly low but uniform with a slight increase towards the end of the year. Malacca State generally receives between 80-100 inches of rainfall in a year.

Parent Material

In West Malaysia it has been found that the parent material from which a soil develops plays a very important part - not only in profile development but also in the chemistry and nutrient status of the soil. The term 'parent material' as used in this report refers to the weathered rock material from which the soil develops as different from parent rock or the unweathered portion of the earth's crust.

The Draft Geological Map of Parts of Malacca and Negeri Sembilan (Rishworth, 1964) shows that virtually the whole of the eastern half of the State to be granite while the rest of the State to be of sedimentary rocks. No distinction is made between solid rocks and alluvial deposits. During the survey of a brief look at the geology was made to confirm this.

FIG. 4. MEAN MONTHLY RAINFALL OF SIX SELECTED SITES IN MALACCA STATE



Granites and allied rocks which consist mainly of quartz, feldspar and micas usually weather rather quickly under the warm humid climate. As a result they very often given rise to deep weathering zones. Under the climatic conditions prevailing in this country, quartz seems to be relatively stable while the micas and feldspars weather rather easily. Thus a granite weathers to produce a sandy or coarse sandy textured soil. The colour of the soil is generally controlled by the amount of iron in the soil and subsequently on the amount of micas (especially biotite) in the granite. A granite which is rich in micas generally gives rise to a soil which is brownish yellow or yellowish brown in colour and which becomes yellowish red or red with depth, e.g. Rengam Series. A soil derived from a very acid granite, poor in micas, is generally pale coloured and has more coarse sand in the soil, e.g. Tampin Series. The clay which is found in Malayan Soils derived from rocks is commonly kaolinite. Granite weathering is very intense and it is common to find about thirty feet of 'soil' above the weathered parent material on gentler slopes. On stronger terrain the soil is often shallower - about 4 feet or the rock may be exposed.

Soils derived from sedimentary rocks are more variable in character. Arenaceous sedimentary rocks rich in quartz often form elongate prominent ridges. Sandstones and quartzites weather to give soils which are generally sandy textured and friable. Argillaceous rocks on the other hand generally weather to produce soils which are clayey and firm. The colour of these soils is very variable depending on the original composition of the rock. More often than not, the argillaceous and arenaceous rocks are found interbedded with one another. This results in intermediate textures in the soil. In areas where sedimentary rocks predominate there is a greater variation in the soil pattern than in areas where granites are dominant.

Soils derived from strongly metamorphosed rocks are controlled by the type of metamorphic rocks and the chemical composition of the rock. Generally the soils tend to be uniform and friable throughout the profile.

<u>Time</u>

The geological age of the rocks is not important to soil development but what is more important is the geomorphological age. The geomorphological age gives us the length of time for which the rock has been exposed and the time for which the rock has been subject to soil forming processes. The formation of laterite, the degree of profile development are controlled by this factor.

The Draft Geological Map of Parts of Malacca and Negeri Sembilan (Rishworth, 1964) does not assign any age to the rocks found in the State. The Geological Map of

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Malaya (1964) gives a Permian age to the sedimentary rocks in the State while the granite is considered to be Jurassic. However, recent age determinations on the granites suggests that the coarse-grained prophyritic granite around Tampin is Jurassic while the pink granites found in Batang Malaka, Bukit Senggeh and Bukit Sedanan are of a much younger Early Tertiary (Eocene 72 million years old) (Unpublished data from the Geological Survey).

The fact that in the State of Malacca, massive laterite forms almost flat cappings on low hills seems to suggest that at one time the laterites may have formed a peneplain which was subsequently dissected. However no concrete evidence to support this has been found.

Vegetation

No data is available to relate soil types with vegetation but some such indications have been noted (Wyatt-Smith, 1964). Broad correlations however can be made between the different soils and the vegetation. The coastal swamps which are subject to tidal influences support the Mangrove Swamp Forests. These forest are also found along the estuaries of the major rivers which are tidal. The common species found in these areas are Rhizophora spp., Aviceniia, Bruguiera and Sonneratia.

Further inland where the marine alluvial clays have drained, the forests felled and the land cultivated the original swamp forests have regenerated to 'Gelam Forests'. Melaleuca leucadendron often associated with Ploiarium alternifoliam, both occur as scattered trees on the seasonally wet swamps. These 'gelam' forests are very often indicative of the very acid nature of the soils on which they are found.

Except for a few forest reserves almost the whole of Malacca State is under cultivation. In the Merlimau Forest Reserve wind damage to the lowland forest in 1917 resulted in the evolution of Shorea - dominated forest. The other forest reserves in the State are mainly covered by the Red Meranti-Keruing Forests which are characterized by a high percentage of the Red Meranti group of Shorea and Dipterocarpus. These are the main commercially important forests of Malaya (Wyatt-Smith, 1964).

PART III

DESCRIPTIONS OF SOILS

The soils were identified as SOIL SERIES in the field following the definition of Leamy and Panton, 1966. At this level of reconnaissance survey, the soil series were grouped into SOIL ASSOCIATIONS. Soil associations, wherever possible were limited to two members but in areas where the soil pattern was very complicated more soil series were grouped together.

Although the soils were mapped on an association basis they will here be described at the SERIES level. Soils derived from similar parent materials will be described together as a group. Following the description a short note on the present land use and its suitability will also be made.

A. Soils Derived from Acid Igneous Rocks

In the State of Malacca, granites of two ages have been found. Radioactive dating of these granites has shown that the Main Range granite found near Tampin is of Jurassic age (230 million years). This granite is a two mica granite and biotite is a prominent mica. They are generally porphyritic. Around Bukit Senggeh and Batang Malaka non-porphyritic pink granites of Early Tertiary age (72 million years) occur. (Unpublished data from Geological Survey). These granites are rich in potash feldspar and poor in micas - especially biotite. The soil developed on the porphyritic granite is usually the Rengam Series with very coarse sandy loam textures while on the pink granites the Tampin Series with coarse sandy clay textures predominate. Soils on the porphyritic granite are also generally of stronger colour.

<u>Rengam Series</u>

This soil which is derived from granites covers nearly the whole of the central part of the State. They are characterized mainly by their coarse sandy, or sandy clay loam textures. They are moderately well structured, free draining and friable soils with profiles which normally exceed 10 feet in depth. The colour in the subsoil is generally yellowish brown but it gets redder with depth.

These soils are developed generally on undulating to rolling terrain (4-12^{o}) and occassionally on hilly terrain (12-20^{o} slopes). The topsoil is generally a dark greyish brown (10YR4/2) sandy clay loam or sandy loam, only a few inches thick, and has a weakly developed subangular or crumb structure. The subsoil which can be quite deep depending on the terrain, is a friable brownish yellow to yellowish brown (10YR6/6-10YR5/6) coarse sandy clay or sandy clay loam. The structure in the subsoil is generally a fairly well developed medium to fine subangular blocky. At depth the colour is stronger depending on the terrain. The colours range from strong brown to reddish brown (7.5YR5/6-5YR5/4). The texture also becomes heavier and the consistence firmer. The parent material is usually encountered at depths of 10-15 feet. The parent material often has red streaks in a white matrix. The red streaks probably being formed around the weathered biotite where the iron accumulates. Kaolin from the weathered feldspars forms the matrix. Occasionally these reddish streaks tend to form modules but these easily break when pressed between the fingers. In some parts of Malacca especially where the granite passes into sedimentary rocks the soil usually has about six inches of reddish brown friable soil with some loosely packed lateritic nodules overlying what would normally be a Rengam soil. This could probably be a soil derived from overlying schist but seems more likely to be colluvial material. The texture of the Rengam soils around Tampin seems to be much coarser - usually gritty. Rock outcrops are also very common especially along the road between Tampin and Gemas. The soil beside these outcrops is however fairly deep.

Soils of the Rengam Series which occupy an area of approximately 135,000 acres is one of the best soils found in the State. At present most of this area is under rubber. The Ayer Panas, Bukit Senggeh and Bukit Sedanan Forest Reserves are also on these soils. Similar soils in other parts of the country have given good yields for oil palm and thus in keeping with a good land utilisation policy every attempt should be made to convert these areas into oil palm growing areas. The first attempt to grow oil palm is being made by the Diamond Jubilee Estate near Jasin. The deep friable nature of these soils make them well suited for a wide range of crops. Terrain would be the major limitation for any particular crop. These soils suffer greatly from erosion and this can become a major problem. Terracing and a good cover can overcome this hazard.

Occasionally these soils derived from acid igneous rocks are much finer textured and slightly stronger in colour. These soils which are called the Jerangau Series only occur in small areas and did not warrant the setting up of a separate mapping unit. In the Ayer Panas Forest Reserve the soils of the Rengam Series have mica flakes throughout the profile. They were originally mapped as the Batang Merbau Series derived from schist parent material but when profiles reaching the highly micaceous granite (griesen?) were encountered they were then changed to the Rengam Series.

Tampin Series

This series which is of very limited extent occurs in association with the Rengam Series in the Bukit Senggeh Forest Reserve. As mentioned earlier the granites in this area are acidic granites which are much richer in alkali feldspar and poor in micas. The soil developed on this granite is paler in colour than the Rengam Series. Very often the soil is an integrade between the Rengam and Tampin Series.

The Tampin Series occurs on terrain which is undulating to rolling. The topsoil is a friable dark greyish brown (10YR4/2) coarse sandy clay with a poorly developed crumb structure. This is underlain by a coarse sandy clay which is pale brown to pale yellow (10YR6/3 -10YR6/4) with friable consistence. The structure is a weakly developed, medium subangular blocky and clayskins are moderately well developed. The B horizon is generally slightly stronger in colour, has more clay and has firmer consistence. Lower in the profile reddish yellow mottles start to appear, the intensity and colour of which become stronger with depth. The parent material of weathered granite often has large white patches indicating the weathered feldspars. In the Bukit Senggeh Forest Reserve in which they occur the terrain is usually very gently undulating and in the 'lows' the water-table usually lies at a depth of about three feet. Only a small portion of these soils has been cultivated - mainly under rubber. This soil appears to be poorer than the Rengam Series. The heavier textures, firmer subsoils and the higher watertable makes this soil a Class Two soil. No yield data on these soils is yet available but with a good standard of management this soil should be able to support a good stand of a variety of crops - including oil palm.

B. Soils Derived from Sedimentary and Metamorphic Rocks

A wide variety of sedimentary and metamorphic rocks are present in Malacca State. These rocks are common around Alor Gajah. Sandstones and shales are commonly found interbedded with one another and it is difficult to pin point one area where one rock type predominates. The shales found in the State are variable in colour ranging from black, purple and red to grey. Generally the shales tend to be slightly metamorphosed usually to phyllites. This is probably due more to regional metamorphism during folding commonly found in the shales rather than to thermal metamorphism during the intrusion of the granite. Thus it is common to find sericite or even mica schist at the base of the profile. The only metamorphic rock of any reasonable grade mapped in the State is the amphibolite schist found around Bukit Lintang and in the Ayer Kroh Forest Reserve. Laterite seems to be found on almost any sedimentary parent material ranging from the different types of shales, sandstones, schists to even the amphibolite schist.

The terrain on which these soils occur generally controls strongly the thickness of the profile. However in Malacca the terrain is generally undulating to rolling. Where arenaceous rocks predominate as around Tanjong Rimau and around Brisu the terrain is characterized by preminent ridges of sandstones or quartzite giving rise to elongated areas of steepland. Soils derived from sedimentary and metamorphic parent materials are more variable than soils derived from granitic parent materials. In Malacca State six different soil series were mapped on the sedimentary and metamorphic parent materials. They have been mapped mainly as combinations of two such series into associations. A few other soils were also identified during the survey but these occurred in so limited extent that they did not warrant a separate mapping unit.

Serdang Series

In areas where arenaceous or rudaceous rocks predominate the commonest soil mapped is the Serdang Series. These soils are characterized by their sandy clay loam textures and their yellowish brown colour. They have weakly to moderately developed structures and are friable compared to other soils derived from sedimentary rocks. These soils because of their sandy textures are prone to erosion.

These soils occur on terrain ranging from undulating to hilly (4-20°) and as the terrain becomes steeper the soils become shallower. The topsoil is a friable dark greyish

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brown (10YR4/2) to dark yellowish brown (10YR4/4) sandy to coarse sandy clay loam with a friable consistence. The structure is generally a weakly to moderately developed crumb or subangular blocky. The subsoil which is normally four to five feet deep is a brownish yellow (10YR6/6) to a yellowish brown (10YR5/6) sandy to coarse sandy clay loam to sandy loam with a friable consistence and moderately developed medium subangular blocky structures. Weakly to moderately developed clayskins often coat the structural faces. The colour normally becomes slightly stronger with depth and this grades into the weathered parent material of sandstone or quartzite which is often mottled. The mottling often increases if the parent material consists of sandstone interbedded with shale.

The Kedah Series which is found on the steeper slopes has also been identified. This soil is much shallower and more sandy than the normal Serdang Series. The Bungor Series which is generally similar to the Serdang Series except for yellower colours, slightly finer textures and for the occurrence of pale mottles in the subsoil has also been identified.

Soils of the Serdang Series have been mapped around Tanjong Rimau and around Brisu and Kemendore. At present most of these areas are under small holdings of rubber. On account of their friability and moderately developed structures, the soils of the Serdang Series have good aeration and can support a wide variety of crops. These soils have been classified into soil suitability Class 1 and 2 depending on the soils with which they are associated. Terrain is the only factor to be considered when soils of the Serdang Series are developed. On steep slopes either terracing and/or a good cover crop should be a prerequisite for these soils.

Munchong Series

The Munchong Series is developed on parent materials which are predominantly argillaceous. The shales or schists are often ferruginous and sometimes interbedded with sandstones or quartzites. This series is generally characterized by the heavy textures and strong brown colours in the subsoil. The colour and texture may vary depending on the parent material. The brownish colours are probably due to the iron present in these soils. These soils are fairly deep friable soils with good structural development.

Soils of the Munchong Series are developed on undulating to rolling terrain. They are commonly associated with soils of the Serdang and Malacca Series. The topsoil is normally a two to three inches of friable yellowish brown (10YR5/4) to dark yellowish brown (10YR4/4) fine sandy clay to sandy clay loam. The topsoil normally has a fine moderately well developed subangular block structure. The subsoil which is fairly uniform and about four feet thick is a friable yellowish brown (10YR5/8) to strong brown (7.5YR5/8) clay or fine sandy clay, exhibiting a fine to medium moderate to well developed subangular blocky structure. The clayskins are also moderately developed. The colour tends to become yellowish red at depth and some faint fine mottles are not uncommon. Occasionally the subsoil has much stronger colours. Occasionally also a narrow band of nodular laterite may be present in the profile. Soils of the Munchong Series which are common in the Ayer Pa'abas area tend to be slightly more sandy and much stronger coloured.

Where soils of the Munchong Series are associated with those of the Malacca Series they are almost always found in the lower slopes of isolated hills which are topped by the lateritic soils. It is thus difficult to assess the suitability of the soil association of these two soils. On this scale of mapping it was not possible to separate these soils. The Munchong Series is a good quality soil while the Malacca Series which is lateritic may be Class 3 or 5 depending on the type and compactness of the laterite. At present most of the areas covered by these soils are planted with rubber. Unless the extent of the lateritic soils is known these areas may not be suitable for diversification. Small localised areas covered by soils of the Munchong Series could be used for market gardening or other crops like tapioca or maize.

Durian Series

Soils of the Durian Series are generally developed in areas of argillaceous parent materials which are low in iron content. Shales, phyllites and siltstones commonly form the parent materials for this series. This soil is characterized by the clay textures and yellowish colours in their subsoil. The structure in the subsoil is a well developed coarse subangular blocky and clayskins are well developed. Occasionally a band of modular laterite or vein quartz may occur between the B and C horizons. In Malacca State the Durian Series is associated with the Malacca and Tavy Series.

The topsoil is a friable to firm, yellow (10YR7/6) to brownish yellow (10YR6/6) clay or silty clay possessing moderately developed subangular blocky structures. The subsoil is a firm to very firm, yellow to brownish yellow (2.5Y 7/6-10YR6/6) clay to silty clay exhibiting well developed, coarse subangular blocky structures with strongly developed clayskins. In some cases a band of about 10 inches thick of nodular or fragmental laterite, or laterised shale may occur at a depth of about two feet. Sometimes

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instead of laterite a thin band (2-4 inches) of fragmental vein quartz is found. Beneath this lateritic or quartz band is a firm highly mottled, yellowish red to reddish yellow (5YR5/8-7/8) clay grading down to fragments of weathered shale.

Soils of the Durian Series typically occur on rolling terrain and is commonly found associated with the Malacca Series. They are common in the area west of Nyalas and north of Bukit Asahan. On account of the firm subsoil and the occasional occurrence of laterite in the profile the soils of the Durian Series are more restricted in their use. The high clay content of these soils makes them 'cake up' in the dry weather and become 'sticky' in wet weather. At present most of these soils are planted with rubber which gives fairly reasonable yields. It is advisable that these areas continue to grow rubber.

Malacca Series

Of the soils derived from sedimentary rocks the soils of the Malacca Series are most widespread in Malacca State. These soils are common in the Alor Gajah District and have been mapped in association with almost all other soils derived from sedimentary rocks identified in the State. The Malacca Series is characterized by the presence of either massive or fragmental or nodular laterite in the profile.

In most cases it is found that these soils form almost flat topped cappings on small isolated hills separated by flood plains of the present day rivers. Munchong and Durian Series which are commonly associated with the Malacca Series occur on the lower slopes. This seems to suggest that these laterite cappings were probably part of an old lateritic peneplain (fossil laterite) which has now been dissected leaving cappings of these laterites at the tops of isolated hills. This however does not suggest in any way that all the laterite found in the State is fossil since evidence of present day laterite is also found as partially hardened nodules found in mottled horizons of many soils including those derived from igneous rocks. Recent ground-water laterites (Panton, 1956) have also been found to occur at the base of hills along the boundary between upland and alluvial soils.

The topsoil of the Malacca Series can vary in thickness. In the massive phase there is usually no topsoil. In the fragmental and nodular phases the topsoil can vary between 0-6 inches but sometimes approaches 1 foot. This topsoil is usually a friable strong brown (7.5YR5/6) to a yellowish brown (10YR6/6) sandy clay loam to clay loam depending on the parent material. The structure is moderately well developed subangular blocky. Beneath this topsoil of varying thickness is a thick band of loosely to compactly packed nodular and fragmental laterite and sometimes even massive laterite. The nodules or fragments of laterite are embedded in a matrix of strong brown (7.5YR5/6) to yellowish red (5YR5/8) clay or clay loam. This horizon which may occur at the surface or at any depth not deeper than one foot may be two to four feet thick. Beneath the lateritic band is a firm, highly variegated clay in which reddish mottles of non-hardened plinthite are found. Where good deep cuttings are seen this grades into weathered shale.

These lateritic soils are at present mainly planted with rubber. The presence of the lateritic band forms an impediment to easy root penetration. A number of quarries are found in areas where these soils predominate. These lateritic nodules make good road metal. It is advisable that rubber continue to be grown on these soils.

Tavy Series

Soils of the Tavy Series are seldom of widespread occurrence. They are commonly found associated with soils of the Malacca or Durian Series. They occur on the lower slopes of small hills with Malacca on the top of the hills and Durian on the lowest slopes. These soils commonly occur in areas of rolling topography and are developed on argillo-arenaceous parent materials. These soils are charact-

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erized by the presence of a band of lateritic nodules of not more than two feet thick occurring at a depth of not less than two feet.

The topsoil of the Tavy Series is usually about 2-3 inches of a yellowish brown (10YR5/4) to reddish yellow (7.5YR7/6) sandy clay loam with a weakly developed crumb to subangular blocky structure and friable consistence. The subsoil is generally an 18 inches thick well developed illuvial horizon of a fairly firm silty clay loam exhibiting a moderately well developed subangular blocky structures and fairly well developed clayskins. This subsoil normally has a reddish yellow (5YR6/8) to brownish yellow (10YR6/6) colour. Underlying this horizon is a band of closely packed nodular lateritic concretions embedded in a matrix of yellowish red (5YR5/8) clay. This lateritic band is commonly 18 inches thick and below it lies a firm heavily reddish mottled clay the colour of which becomes stronger at depth.

Since there is normally almost two feet of soil in Tavy Series this soil is much better than the Malacca Series. However, because of its limited occurrence and common association with the Malacca and Durian Series it is again advisable to continue growing rubber on these soils.

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Prang Series

Soils of the Prang Series have only been identified in the Ayer Kroh Forest Reserve and around Bukit Lintang. They have been mapped in association with the Malacca Series. These soils are developed on amphibolite schist parent materials and are characterized by their uniform profiles, yellowish red colours and fine well developed structures.

This soil has hardly any topsoil present except for a thick mat of roots and dead leaves. Below this the soils is a uniform yellowish red (5YR5/8) friable clay exhibiting well developed fine subangular blocky structures. The subsoil is uniform and deep - usually about 4 feet with some black fine soft nodules of manganese. The colour may become stronger with depth.

On account of the friable consistence and well developed structures these soils appear to be physically well suited for a wide variety of crops. At present these soils support a variety of crops including tapioca, maize, rubber and other vegetables. Moreover the close association of these soils with those of the Malacca Series makes this soil more restricted in its use.

C. Alluvial Soils

The coastal plain and the flood plains of the rivers are covered by soils developed on alluvial parent

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materials. Primarily because of the flat terrain and availability of water these areas are mainly planted with wet padi. Only a cursory examination was made of these alluvial soils, partly because during the field season most of these areas were already planted with padi and partly because the padi soils in the country are being mapped as a separate exercise. The largest group of these alluvial soils is the Linau-Telok Association. These soils are for the major part acid sulphate or 'gelam' soils. In some areas where the soils are quite strongly acidic these areas have been abandoned. Another feature which is common is to fill up the padi land with laterite and to use the land for putting up buildings. If this practice is not stopped the average of padi land in the State will slowly be reduced.

Linau Series

The flat coastal plain in Malacca was probably covered by the sea in quite recent geologic times. The occurrence of some beach ridges more than a mile away from the coast seems to support this. The sea was probably cut off leaving behind a lagoon or a brackish water swamp from which the present plain was formed by subsequent drainage. The drainage of this area seems to have caused the development of acidic conditions in the soil. Two acidic soils have been identified on this plain but it must be pointed out that it

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is possible that the soil pattern is much more complicated.

Of the two acidic soils mapped the Linau Series is by far more common. Soils of the Linau Series are characterized by this highly sulphurous subsoils and their generally poor drainage. The distinct sulphurous odour in the fresh subsoil which often turns black on exposure is evidence of the high sulphur content of these soils. On longer exposures as in the irrigation canals the soil often takes a yellow coating of probably some sulphur compound. The soil is also characterized by a fairly high proportion of partially decomposed organic matter. All these seem to indicate that these soils were developed on materials deposited under reducing or brackish water conditions. In areas which have been cleared and abandoned these soils are covered by Gelam Forests (Melaleuca leucadendron). Where attempts have been made to drain these areas the trees become sparce and more widely spaced.

The topsoil of the Linau Series is commonly 6 inches thick,very dark brown (10YR2/2) silty clay or clay. This horizon usually has a fibrous root mat especially if under virgin conditions. In the subsoil the colour changes to a dark greyish brown (10YR3/2) while the texture remains a silty clay or clay which is friable and loose if dry and sticky when wet. This horizon which usually goes down to a depth of about two feet may have about 15% decaying organic matter (mainly decaying roots). This horizon when freshly exposed gives a strong sulphurous odour and turns grey or black. Beneath this subsoil is very often a grey (5YR6/1) to dark bluish grey (5B4/1) marine clay also giving off a distinct sulphurous odour.

Obviously these acid sulphate soils on account of their poor natural drainage, high concentrations of sulphur compounds and low pH pose a formidable problem to their development. The problem is generally how to raise and maintain the pH of the soil at a level suitable for agriculture. Liming is one method of lowering the acidity but this is an expensive method. This problem probably arose by the good drainage canals which were built to drain the padi fields. It is common to find that in areas where the drainage has been rapid - as around the larger drains and at the junctions of two drains even the shrubs fail to grow. Most of these areas are at present under padi and some market gardening. Considering the extent of these acid sulphate soils all over the country some research has been carried out in order to characterize these soils. The next step would be to try to improve them economically or to carry out field trials and to produce a variety of padi or other crops capable of giving economic yields on these soils.

Telok Series

The Telok Series is an acid sulphate soil which has been mapped in association with the Linau Series. However this soil is only of limited extent. Like the Linau Series the Telok Series has also been developed from brackish water deposits. Compared to the Linau Series this soil does not give off such a strong sulphurous odour. A characteristic feature of this soil is the presence of prominent reddish mottles and decaying organic matter in the subsoil.

The topsoil of the Telok Series tends to be organic - usually an organic clay or muck to a depth of about three inches and has a dark grey (10YR4/1) to very dark grey (10YR3/1) colour. This surface horizon has a moderately developed medium crumb structure with yellowish red mottles both on ped faces and especially along root channels. The subsoil horizon which varies from eight to twenty inches in thickness is a greyish brown (10YR5/2) to dark greyish brown (10YR4/2) clay exhibiting weakly developed coarse blocky structures. Reddish or yellowish red mottles are abundant in this horizon. Organic matter may also be present in this horizon. The parent material consists of a greenish grey gleyed horizon which may be sulphurous.

Like the soils of the Linau Series their poor drainage and high acidity of these soils make them a problem soil. The padi which is currently being grown does not give very high yields.

Briah Series

This soil which is developed on the flood plains of the present day streams has only been mapped along the banks of the Kesang River along the State boundary with Johore. This soil is generally poorly drained and is susceptible to flooding. Some organic clays and some shallow peat found in the area have not been separated but are included in this mapping unit. These soils continue across the Kesang River into Johore. In the State of Malacca these soils occupy approximately 20,000 acres.

The topsoil is generally a pale brown (10YR6/3) or brown (10YR5/3) silty clay. The structure and consistency depend on the drainage and if it has been drained the topsoil is about three inches deep with a medium crumb structure and friable consistence. The subsoil is generally a light grey (10YR6/1) or light brownish grey (10YR6/2) silty clay or clay with pronounced yellowish mottles which increase both in size and abundance with depth. Commonly the subsoil becomes variegated with strong brown or reddish yellow iron stains especially along root channels. In the drained soil a weakly developed coarse blocky strunture is exhibited. Beneath this mottled zone is a light grey (10YR7/1) clay

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with hardly any mottles. A bluish grey sticky clay is sometimes found at a depth of about three feet. This clay may give off a faint sulphurous odour.

Except for small areas of this soil under padi most of this area is still under swamp conditions. If good drainage can be effected then this area could be developed into a good dryland crop area. If irrigation could be provided in addition to drainage the areas on both banks of the Kesang River can be developed into good padi land.

Kranji Series

Stretching as a narrow band along virtually the whole of the west coast of West Malaysia are immature or juvenile soils developed over recent marine alluvium. In their natural state they are subject to flooding by tidal waters and normally support mangrove swamp vegetation. These Kranji soils are juvenile soils with hardly any profile development. The profile consists of uniform greenish grey or bluish grey clay which is sulphurous at depth.

The surface horizon consists of a grey to dark grey clay or organic clay which may vary from 1-4 inches in depth. The structure of this topsoil depends on the organic content but is poorly development and sticky. The subsoil is a greenish grey clay containing abundant decaying roots up to a depth of about 30 inches. Below this lies a greenish grey clay which is sulphurous. These soils because of the flooding by sea water are rich in dissolved salts. Some attempts have been made to drain these areas but before this can be done good bunds have to be built and maintained to prevent inundation by sea water. The area must be drained effectively for a sufficient length of time to leach out the dissolved salts before any cultivation can take place.

Rudua Series

Along the Merlimau-Kampong Pasir Road a number of beach ridges occur about three or four miles away from the present coast and probably mark the position of the coast in the recent past. These stranded beach ridges with the accompanying swampy swales or depressions are similar to those found along the East Coast of West Malaysia and give rise to two different soils - the Rudua Series developed on the ridges and the Rusila Series developed in the depressions.

In Malacca these soils have only a very limited occurrence. These soils are characterized by their sandy textures and almost white colours. A feature which is found in these soils in Malacca is the presence of mica flakes throughout the whole profile. The Rudua Series occurs on a ridge which is approximately five feet above the level of the surrounding flat land. They have a deep humic top of about six inches of sand the colour of which depends on the amount of vegetation present. A light grey (2.5Y 7/2) sand which is structureless occurs to a depth of about 30 inches. A poorly developed humic horizon of about 2-3 inches occurs coinciding with the watertable between 30 and 36 inches. Below the watertable is a grey or light grey (10YR6/1) sandy clay loam or sandy clay which contains no mica. This latter horizon appears to be buried horizon of a former soil. Vegetation is rather scarce on these soils and the surface horizon tends to be a thin layer of bleached quartz sands. These are weakly developed podsols when compared to the Rudua Series found on the East Coast. At present most of this area is used for kampong cultivation with coconut being planted in some areas. The trees however are very variable in character but generally are poor.

Rusila Series

Closely related to the Rudua Series is the Rusila Series which is developed in the depressions between the beach ridges. These soils are normally waterlogged. The topsoil consists of about44 inches of muck of decaying matter overlying a dark greyish brown (2.5Y 4/2) sandy loam. The soil is wet and sticky and the horizon is usually about 6 inches thick. The subsoil is a grey to light grey (2.5YN7-N6) loamy sand which is wet and sticky with some medium to fine distinct brown mottles appearing at depth. Some small areas occupied by these soils have been drained and planted with coconuts but like those grown on the Rudua Series these also are poor.

D. Miscellaneous Land Units

Local Alluvium

This mapping unit includes all those materials which have been moved by water and deposited on the basins of the small rivers. The flood plains of these rivers consists of variable textured soils. Included in this unit are some minor colluvial deposits found at the base of some steep slopes. These alluvial deposits seldom have any profile development. The texture of these soils depends on the parent materials from which the sediments are derived, the speed of the stream and the terrain. These alluvial deposits are only of variable fertility and are mainly used for padi but some market vegetables and some rubber is also planted on these deposits. This unit has sometimes been exagerated on the map during the reduction. In many areas this unit has been inferred from topographic sheets with some field checking.

Steepland

An area which, because of the overall nature of its terrain is unsuitable for agriculture is termed as steepland. Steepland in West Malaysia has been recognized as areas which have an average slope of greater than 20°. In Malacca the steepland boundary generally occurs at a height of 250 feet above sea level. The steepland boundary was delineated from topographical maps and checked whenever possible in the field.

The soils developed on areas of steepland are shallow and possess juvenile profile characteristics. However where the parent material is granitic the profile may be still quite deep. The steepland areas suffer from severe erosion when cleared for development. Virtually all the steepland found in the State of Malacca is under forest and every effort must be made to keep these areas as such.

Disturbed Land

This mapping unit refers to areas which due to man's activities have been changed. Thus urban and mining lands fall into this category. Thus these areas are mainly limited to the areas around the larger towns. Around Chin Chin and Kesang tin mining has left these areas covered with tin tailings which are no longer suitable for agriculture.

PART IV

SOIL CLASSIFICATION AND SOIL SUITABILITY

Soil Classification

The basic unit of soil mapping and soil classification is the Soil Series. A soil series consists of soils having similar profile characteristics and which derived from similar parent materials (Leamy & Panton, 1966). This similarity of profiles is dependant on the soil forming factors. Any major difference in one or more of these factors very often results in dissimilarities in the profile and the soil should be classified as a different soil series.

Various attempts have been made to classify Malayan Soils (Owen, 1951; Panton, 1964; Leamy, 1966(a) & (b); Joseph, 1966) above the series level. The soils mapped in the State are being fitted into the classification by Leamy (1966 b) although there is evidence to suggest a need for revision at this stage (Table 2).

Soil Suitability

The soils mapped in the State have been grouped into five soil suitability classes based on their limitations to agricultural development. The classification is based on the proposed Soil Suitability Classification For Tree Crops of Leamy and Panton (1966); Wong (1966) and Ng (1968). Data collected subsequent to these papers has made it possible

TABLE 2

CLASSIFICATOON OF THE SOILS MAPPED IN MALACCA (MODIFIED FROM LEAMY 1966)

ORDER	SUB ORDER	GREAT SOIL GROUP	SUB GROUP	FAMILY	SERIES
OXISOL	ARGOX	RED BROWN OXISOLS NORMARGOX	TYPIC NORMARGOX	KAMPONG KOLAM	PRANG
			ULTIC NORMARGOX	-	-
	ACROX	YELLOW RED OXISOLS NORMACROX	TYPIC NORMACROX	-	-
			PETRIC NORMACROX	-	-
		DARK BROWN OXISOLS HAPLACROX	TYPIC HAPLACROX	-	-
	PETROX	CONCRETIONARY OXISOLS NORMIPETROX	TYPIC NORMIPETROX	MALACCA	MALACCA
			ULTIC NORMIPETROX	TAVY	TAVY
ULTISOL	UDULT	RED YELLOW ULTISOLS TROPUDULT	TYPIC TROPUDULT	RENGAM & MUNCHONG	RENGAM SERDANG & MUNCHONG
			ACRENTIC TROPUDULT	-	-
		YELLOW GREY ULTISOLS PLINTHUDULT	HAPLIC PLINTHUDULT	KULAI	TAMPIN
			TYPIC PLINTHUDULT	DURIAN	DURIAN
			AQUIC PLINTHUDULT	BATU ANAM	BATU ANAM
		LIGHT GREY ULTISOLS TROPAQUULT	TYPIC TROPAQUULT	-	-
			PSAMMENTIC TROPAQUULT	RUSILA	RUSILA
SPODOSOL	HUMOD	PODSOLS, TROPOHUMOD	TYPIC TROPOHUMOD	RUDUA	RUDUA
ENTISOL	UDENT	BROWN ENTISOLS HAPLUDENT	TYPIC HAPLUDENT	-	-
		BROWN GREY ENTISOLS HAPLAQUENT	TYPIC HAPLAQUENT	BRIAH	BRIAH
			HYDRIC HAPLAQUENT	-	-
		DARK GREY ENTISOLS HYDRAQUENT	TYPIC HYDRAQUENT	KRANJI	KRANJI, LINAU & TELOK

to make some modifications on the limitations to agricultural development as suggested by these authors. These are subject to revision when more chemical, crop performance and other data are available. The list of limitations is as follows:-

A. Very Serious Limitation

1. Slopes: Greater than 20°
2. Effective (Tillable) Soil Depth: Less than 6"
3. Rockiness: Extreme - Greater than 75% of surface covered by rocks
4. Toxicity: Abnormally high amounts of certain elements
5. Acid sulphate conditions at less than 1 ft. from surface
6. Disturbed Land

B. Serious Limitations

1. Slope: Slopes less than 20° but greater than 12°
2. Effective Soil Depth: 6 to 12 inches
3. Rockiness: Moderately extreme 50-75% of surface covered by rocks
4. Nutrient Status: Multiple Micro-nutrient Deficiencies
5. Drainage: Very Poor Drainage: almost permanently waterlogged

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6. Acidity: pH in the region of 3

7. Peat: Greater than four feet thick

C. Moderate Limitations

1. Slopes: Slopes less than 12° greater than 6°

2. Effective Soil Depth: 1 ft. to 2 ft. thick

3. Rockiness: Moderate - patchy rock outcrops covering between 25-50% of surface

4. Nutrient Status: Generally low in nutrient levels

5. Drainage: Poor - Flooding and fluctuating watertable within 12 inches from surface

6. Acidity: pH between 3 and 4

7. Peat: Between 2 and 4 feet in depth

8. Water Stress: Susceptible to severe seasonal water stress

D. Minor Limitations

1. Slope: Greater than 2° but less than 6°

2. Effective Soil Depth: Between 2 ft. to 3 ft. thick

3. Drainage: Imperfectly drained - Watertable at 36 inches

4. Peat: 1-2 ft. thick

Using the above limitations the following five soil suitability classes have been established:-

Class 1	Soils with no limitations to agricultural development - suitable for a very wide range of tree crops.
Class II	Soils with few minor limitations to agricultural development - suitable for a wide range of tree crops.
Class III	Soils with at least one serious limitation to agricultural development - suitable for a restricted range of tree crops. Some soils will support oil palm with a high standard of management.
Class IV	Soils with more than one serious limitation to agricultural development - suitable for a restricted range of specialised crops.
Class V	Soils with at least one very serious limitation to agricultural development - not suitable for general agriculture.

It must be noted here that it is very difficult to assign one series to a particular class because of the number of factors involved. Thus the surveyor in the field is the best person to assign the class for a particular soil type at the particular place. A suitability map accompanies this report.

PART V

CONCLUSION

The reconnaissance soil survey of the State of Malacca was carried out as part of a national exercise to determine the broad soil pattern of the country and to locate large areas which are suitable for agricultural diversification. One of the chief aims of this survey is to locate undeveloped land which is suitable for development.

Agricultural diversification which is a 'hot' topic in this country can only be carried out with any success with the aid of reliable soil maps and agronomic data. Yield figures of the various crops on the different soils have to be obtained and from these data a more realistic land use policy can be formulated. Although our knowledge of the agronomic data is scarce the little which we have clearly indicates that in Malacca a better and more realistic use of the land may be achieved. At the present only two crops are grown to any extent in the State. The alluvial soils found along the coast and along the flood-plains of the rivers are mainly planted with padi. This is probably largely due to the flat terrain and the easy availability of water. Virtually the rest of the State where the sedentary soils are present are either planted with rubber or under forest. These sedentary soils can be divided into two groups:-

1. Soils derived from igneous rocks

2. Soils derived from sedimentary rocks.

The soils derived from igneous rocks are soils which are well suited for a wide variety of crops and every effort must be made to plant or replant these areas with crops of more economic value like oil palm. Smaller areas may be planted with sugar cane, maize, tapioca or other crops which will help to diversify the agricultural economy. The soils derived from sedimentary rocks on the other hand are very often lateritic and because of this can only be planted with crops which are more tolerant such as rubber.

From this reconnaissance survey some important facts have emerged. There are four forest reserves which can be developed in the near future. Three of them have soils derived from acid igneous rocks and thus suited for diversification while the fourth - the Merlimau Forest Reserve is a mixture of soils derived from igneous rocks and sedimentary rocks. A breakdown of these forest reserves is given below:-

Bukit Sedanan F.R.	6,000 acres
Bukit Senggeh F.R.	5,000 acres
Ayer Panas F.R.	3,000 acres
Merlimau F.R.	1,500 acres +
	2,000 acres

From the above table one can see that there is still a fair amount of land still left which can be developed. However the question remains as to whether the forest reserves in the State can be cleared. Forest reserves in the State are both small and few in number. However this is beyong the scope of this report.

Another important area suitable for possible development is found along the Kesang River. This area which is partly under swamp forest and the adjoining area in Johore State is subject to flooding, but with good drainage and irrigation facilities could be used for padi cultivation.

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APPENDIX

Profile Description and Laboratory Analysis of Major Soil Series

Full profile description and laboratory analysis of major soil series have been obtained and are given in the following pages.

Mechanical analysis was done by the Bouyoucos Hydrometer method with "Tetron" as a dispersant.

pH was determined with a glass electrode.

The Walkley - Black method was applied to carbon determination while the micro - Kjeldahl method was used in the nitrogen determination the catalyst being a mixture of selenium, copper sulphate and potassium sulphate.

Easily soluble phosphorus was obtained by leaching with a solution of 2N sodium chloride and 0.2N hydrochloric acid and extraction with 0.1N sodium hydroxide.

Cation exchange capacity values were obtained by leaching with 0.1N barium chloride and titrating with N/50 versenate. Percentage base saturation was calculated as a function of the total cations present in the leachate.

ANALYTICAL DATA OF TAMPIN SERIES

Horizon Symbol	Depth in inches	Percentages				pH	Percentages			C/N Ratic	Easily Soluble p.p.m.	C.E.C.					Total	Percentage Saturation
		Clay	Silt	Fine Sand	Coarse Sand	N KCl	Organic Matter	Carbon	Nitrogen		P N/10NaOH	meq./ 100g.	Potassium	Calcium	Sodium	Magnesium	K+Ca+Na +Mg.	
AH	0-2	20	6	20	58	4.2	1.01	0.59	0.07	8	54	4.79	0.27	0.46	0.14	0.56	1.43	36
AB	2-8	24	6	16	57	3.8	0.50	0.29	0.05	6	44	3.59	0.18	0.19	0.13	0.21	0.71	20
Bt	8-20	30	4	13	57	3.8	0.34	0.20	0.04	5	43	3.76	0.27	0.08	0.27	0.24	0.86	23
BC	20+	36	4	13	48	4.2	0.26	0.15	0.03	5	43	4.62	0.30	0.08	0.27	0.24	0.89	19

Tampin Series

Location: Roadcutting 25½ milestone Nyalas-Mantai New Village road.

Topography: Gently Undulating.

Vegetation: Lallang

Parent Material: Acid Granite.

Great Soil Group: Yellow Grey Ultisol.

Soil Profile:

Ah 0-2"; (greyish brown (10YR4/3) coarse sandy clay loam; friable; structure; many pores; many quartz grits; many fine roots; distinct boundary.

AB 2-8" Brown (10YR5/3) coarse sandy clay; friable to firm; medium to fine, weakly to moderately developed subangular blocky structure; patchy clayskins; few pores; many quartz grits; few large roots; indistinct boundary.

Bt 8-20" Yellow (10YR7/6) coarse sandy clay; firm; medium to fine, weakly to moderately developed subangular blocky structure; discontinuous clayskins; many quartz grits; distinct boundary.

BC 20"+ Brownish yellow (10YR6/6) coarse sandy clay; with few indistinct pale yellowish brown mottles firm; coarse moderate subangular blocky breaking to fine subangular blocky structure; discontinuous clayskins; quartz, mica (sericite) and feldspar(?).

55/-

ANALYTICAL DATA OF RENGAM SERIES

Horizon Symbol	Depth in Inches	Percentage				pH N KCl	Percentage			C/N Ratio	Easily Soluble p.p.m. P N/10NaOH	C.E.C. meq./ 100g.	Potassium	Calcium	Sodium	Magnesium	Total K+Ca+Na +Mg.	Percentage Saturation
		Clay	Silt	Fine Sand	Coarse Sand		Organic Matter	Carbon	Nitrogen									
Ah	0-8	39	6	36	23	3.8	2.34	1.36	0.12	11	64	10.09	0.31	0.70	0.08	0.45	1.54	15
Ae	8-14	43	4	33	23	3.7	1.20	0.70	0.07	10	53	7.35	0.10	0.13	0.12	0.16	0.51	7
Bt	14-28+	53	4	27	19	3.7	0.77	0.45	0.05	9	33	8.21	0.09	0.08	0.11	0.16	0.44	5

Rengam Series

Location: Roadcutting at the 24th milestone Malacca-Tampin Road.

Topography: Gently undulating.

Vegetation: Lallang at the edge of estate of mature rubber.

Parent Material: Muscovite-Biotite Granite

Great Soil Group: Red Yellow Ultisol.

Soil Profile:

Ah 0-8"; dark brown (10YR4/3) sandy clay loam to coarse sandy clay loam; friable; fine, weakly developed crumb structure; patchy clayskins; many pores; many quartz grits; many fine roots; boundary diffuse.

Ae 8-14"; yellowish brown (10YR5/6) sandy clay loam; friable; fine weakly to moderately developed subangular blocky structure; patchy to discontinuous clayskins; few pores; few quartz grits; many fine and few large roots; boundary indistinct.

Bt 14-28"+; brownish yellow (10YR6/8) sandy clay loam; friable; medium, moderately developed subangular blocky, structure; discontinuous to continuous clayskins; few pores; few quartz grits; few roots.

ANALYTICAL DATA OF SERDANG SERIES

Horizon Symbol	Depth in Inches	Percentage				pH N KCl	Percantage			C/N Ratio	Easily Soluble p.p.m. P N/10NaOH	C.E.C. meq./100g.	Potassium	Calcium	Sodium	Magnesium	Total K+Ca+Na +Mg.	Percentage Saturation
		Clay	Silt	Fine Sand	Coarse S_and		Organic Matter	Carbon	Nitrogen									
Ah	0-2	28	4	42	30	3.7	1.62	0.94	0.08	12	85	6.16	0.10	0.13	0.08	0.21	0.52	8
Ae	2-10	34	2	38	27	5.6	0.91	0.53	0.06	9	61	5.30	0.09	0.08	0.13	0.21	0.51	10
Bt	10-19	51	4	29	20	3.7	0.60	0.35	0.04	9	40	5.47	0.07	0.13	0.09	0.21	0.50	9
BC	19-34+	53	4	29	17	3.8	0.41	0.24	0.03	8	39	5.30	0.06	0.13	0.09	0.21	0.49	9

Serdang Series

Location: Kemendore Estate, Jasin

Topography: Gently undulating.

Vegetation: Rubber (Mature)

Parent Material: Sandstone/Quartzite.

Great Soil Group: Red Yellow Ultisol.

Soil Profile:

Ah 0-2" dark yellowish brown (10YR4/4) sandy clay loam; friable; fine weakly developed subangular blocky structure; many pores; many fine roots; distinct boundary.

Ae 2-10" brownish yellow (10YR6/6) sandy clay loam; friable; weakly to moderately developed fine subangular blocky structure; patchy clayskins; few pores; few large roots; indistinct boundary.

Bt 10-19" strong brown (7.5YR 5/8) sandy clay; friable; moderately developed medium to fine subangular blocky structure; discontinuous clayskins; few quartz grits; indistinct boundary.

BC 19-34"+ strong brown (7.5YR 5/8) sandy clay; friable; weakly developed medium and fine subangular blocky structure; many quartz grits.

ANALYTICAL DATA OF MUNCHONG SERIES

Horizon Symbol	Depth in Inches	Percentage				pH N KCl	Percantages			C/N Ratio	Easily Soluble p.p.m.	C.E.C. meq./ 100g.	Potassium	Calcium	Sodium	Magnesium	Total K+Ca+Na +Mg.	Percentage Saturation
		Clay	Silt	Fine Sand	Coarse Sand		Organic Matter	Carbon	Nitrogen		P N/10NaOH							
Ah	0-5	30	8	38	29	3.7	2.24	1.30	0.12	11	81	8.89	0.05	0.83	0.07	0.56	1.51	18
Ae	5-11	37	8	34	24	3.5	0.86	0.50	0.05	10	64	7.87	0.07	0.16	0.13	0.19	0.55	7
Bt	11-24	43	10	29	21	3.5	0.46	0.27	0.04	7	56	7.35	0.09	0.08	0.16	0.21	0.54	7
BC	24-36+	43	8	29	23	3.5	0.31	0.18	0.02	9	58	7.18	0.06	0.11	0.11	0.08	0.36	5

Munchong Series

Location: Small-holders rubber - Ayer Pa'abas, Alor Gajah

Topography: Gently undulating.

Vegetation: Lallang.

Parent Material: Shale and sandstone.

Great Soil Group: Red yellow Ultisol.

Soil Profile:

Ah 0-5" yellowish brown (10YR5/6) sandy clay loam; friable; fine, moderately developed subangular blocky structure; many pores; many quartz grits; many fine roots; distinct boundary

Ae 5-11" reddish yellow (7.5YR6/8) sandy clay loam; friable; fine, moderately developed subangular blocky structure; patchy clayskins; few pores; few grits; few roots; indistinct boundary.

Bt 11-24" strong brown (7.5YR5/6) sandy clay loam with few fine faintly distinct pale yellow mottles; friable; coarse weakly developed angular blocky breaking down to medium and fine moderately to well developed subangular blocky structure; discontinuous clayskins; many quartz grits; distinct boundary.

BC 24-36"+ yellowish red (5YR5/8) sandy clay loam with few fine distinct pale yellow mottles; friable; fine weakly developed subangular blocky structure many quartz grits.

58/-

Horizon Symbol	Depth in Inches	Percentages				pH N KCl	Percentages			C/N Ratio	Easily Soluble p.p.m. P N/10NaOH	C.E.C. meq./ 100g.	Potassium	Calcium	Sodium	Magnesium	Total K+Ca+Na +Mg.	Percentage Saturation
		Clay	Silt	Fine Sand	Coarse Sand		Loss on Ignition	Carbon	Nitrogen									
Ap	0-4	62	25	3	Tr	4.5	13.2	3.34	0.28	11.93	155	25.82	0.48	1.74	0.11	1.48	3.81	15
ABg	4-14	68	22	3	Nil	4.5	8.3	0.32	0.09	3.56	53	21.03	0.18	0.95	0.11	1.38	1.24	12
BCg	14-43	62	21	8	Tr.	4.4	7.3	0.23	0.06	3.84	70	20.00	0.22	1.47	0.24	4.79	6.72	34
Cr	43+	65	20	8	Tr.	4.2	7.6	0.23	0.06	3.84	75	22.06	0.30	2.37	0.44	7.55	10.66	48

Briah Series

Location: Parit quarry, Yong Peng

Topography: Flat to depressional.

Vegetation: Coconuts.

Parent Material: Riverine and Marine Alluvium

Great Soil Group: Brown Grey Entisol.

Soil Profile:

Ap 0-4"; brown (10YR5/3) silty clay; firm; subangular blocky structure; many small roots with some medium sized woody lateral roots; many casts; many pores; almost continuous clayskins; boundary distinct.

ABg 4-14"; light grey (10YR6/1) clay; firm; compact structures; few medium to large roots; some decayed root casts; patchy clayskins; reddish yellow (7.5YR6/6) and yellow (10YR7/6) mottles; boundary diffuse.

BCg 14-43"; light grey (10YR6/1) clay; firm; compact; structureless; some root channels with some large ancient decayed roots; reddish yellow (7.5YR6/6) mottles; boundary diffuse.

Cr 43+" greenish grey (5 BG 6/1) silty clay; firm; structureless; some large decayed taproots of forest vegetation and some yellowish red (5YR4/6) staining along root channels; yellowish red (5YR4/6) and light olive brown (2.5YR5/6) mottles.

ANALYTICAL DATA OF LINAU SERIES

Horizon Symbol	Depth in Inches	Percentage				pH N KCl	Percentage			C/N Ratio	Easily Soluble p.p.m. P N/10NaOH	C.E.C. meq./100g.	Potassium	Calcium	Sodium	Magnesium	Total K+Ca+Na +Mg.	Percantage Saturation
		Clay	Silt	Fine Sand	Coarse Sand		Loss on Ignation	Carbon	Nitrogen									
Ah	4-22	56	23	12	1	3.1	14.7	5.01	0.21	23.85	33	30.95	0.11	0.10	0.13	0.36	0.70	2
Cr	22-60+	60	21	11	2	2.6	21.0	6.80	0.17	40.00	45	33.00	0.09	4.58	1.36	17.49	23.52	71

Linau Series

Location: Parit Haji Salleh 11 milestone Ayer Hitam - Batu Pahat Road.

Topography: Depressional

Vegetation: Mature Rubber

Parent Material: Riverine marine alluvium with organic material.

Great Soil Group: Dark Grey Entisols.

Soil Profile:

Od 0-4" brown very fibrous root mat of firm vegetation boundary distinct.

Ah 4-22" very dark greyish brown (10YR3/2) clay; friable; many fibrous roots; some casts; some carbonised roots; many pores; patchy clayskins; boundary diffuse.

Cr 22-60" grey and dark bluish grey (5YR6/1, 5B 4/1) clay; weakly cemented; many roots; stems and leaves with large decayed tap roots; distinct sulphurous smell.

SP/lsl.