RECONNAISSANCE SOIL SURVEY

OF

SELANGOR

by

I. F. T. WONG
(Division of Agriculture)

MINISTRY OF AGRICULTURE AND LANDS
MALAYSIA.

OCTOBER, 1970

BULLETIN 122

Published by and obtainable from:

THE PUBLICATIONS BRANCH,
MINISTRY OF AGRICULTURE AND LANDS,
KUALA LUMPUR, MALAYSIA.

Price: M $ 4.00

RECONNAISSANCE SOIL SURVEY

OF

SELANGOR

by

I. F. T. WONG
(Soil Scientist)

MINISTRY OF AGRICULTURE & LANDS
KUALA LUMPUR, MALAYSIA.

BULLETIN 122

Published by and obtainable from:

THE PUBLICATIONS BRANCH,
MINISTRY OF AGRICULTURE AND LANDS,
KUALA LUMPUR, MALAYSIA.

Price: M $ 4.00

RECONNAISSANCE SOIL SURVEY

OF

SELANGOR

by

I. F. T. WONG
(Soil Scientist)

MINISTRY OF AGRICULTURE & LANDS
KUALA LUMPUR, MALAYSIA.

CONTENTS

PART II

APPENDIX I.

APPENDIX II.

(FIGURES & MAPS)

TABLES

PREFACE

This is a revised version of the reconnaissance soil survey report of Selangor which was produced in 1966 as the Malayan Soil Survey Report No. 6/1966 by the Soil Science Division of the Department of Agriculture, Kuala Lumpur. The revision is mainly in the soil suitability classification which now follows the Soil Suitability Classification for Malaysia published in 1970.

In bringing the soil suitability classification in line with the latest Malaysian-wide one the suitability of each soil series to crop growth has had to be reassessed since not only rubber and oil palm are now considered but other dryland crops and padi are also taken into account. The result, however, does not show drastic changes as the previous suitability classification has been found to fit quite closely the broad requirements of most crops except those favoured by wet regimes.

In this revision all the soils in the state have been considered together. Thus, while more detailed maps and reports are available for the northwest and the Kuala Langat regions, in the map accompanying this report the soils in those two regions are also shown at the same broad reconnaissance level as the soils in the other parts of the state. In the report, however, an attempt has been made to include the range of characteristics found in the soils of those two regions with those of the rest of the state.

I. F. T. Wong.

PART I

INTRODUCTION

This report on "The Schematic Reconnaissance Soil Survey of Selangor" is part of the nationwide effort at assessing the potential agricultural land in West Malaysia. For various reasons, but mainly because of the urgent need to have a general assessment of the agricultural potential of large tracts of undeveloped land in West Malaysia for rural development, the soil survey programme for the State of Selangor has been pursued in stages rather than in one concerted effort.

The peat swamp of the Kuala Langat (north) Forest Reserve was surveyed in 1956 (Coulter) and the survey of the Northwest Selangor Swamp Region was completed in 1962 (Acton). The soil maps for these two swamp regions have been incorporated in the final soil map to cover the State of Selangor.

The present report deals mainly with the survey of the soils of the remaining areas including the hill soils which were not covered in the earlier two surveys. Where appropriate, however, data obtained from the two previous surveys have been incorporated. The field work for this project was started in early 1965 and completed by mid 1966.

With the exception of the mountainous region to the east, the Kuala Langat Peat Swamp to the south and the mangrove swamps along the coast and on the off shore islands, most of the survey area has been developed. The remaining undeveloped areas are situated in forest reserves; these are the Bukit Badong, Rantau Panjang and Bangi Forest Reserves.

The network of roads throughout the State of Selangor has made easy access possible, with the result that the soils could be mapped in greater detail than would have been possible otherwise.

Besides fulfilling the need for the regional reconnaissance soil survey, semi-detailed surveys were also carried out on estates which needed soil suitability certificates for oil palm cultivation. Although these semi-detailed surveys have made it necessary to slow down the pace of the reconnaissance survey they have, nevertheless, made it possible to have a more detailed appraisal of the soils in those selected areas than would be required for a schematic reconnaissance survey.

As this is a first broad assessment of the soils of the State, emphasis has been laid on the morphological characteristics of the soils as observed in the field. It is realized, however, that supporting data from laboratory analysis and crop tests are necessary in order to have a more complete appreciation of the genesis and agricultural potential of the various soils found in the region.

It is commonly known that the underlying geology in West Malaysia has a marked influence on soil development and Selangor is no exception. Thus, it has been possible to recognise 4 broad groups of soils, in the survey area, based on geology and these are:—

1) Sedentary soils on igneous parent materials,
2) Sedentary soils on sedimentary and metamorphic parent materials,
3) Marine alluvial soils,
4) Riverine alluvial soils.

Besides the above four groups of soils miscellaneous land units have also been mapped of which peat swamps and mining land form a considerable proportion.

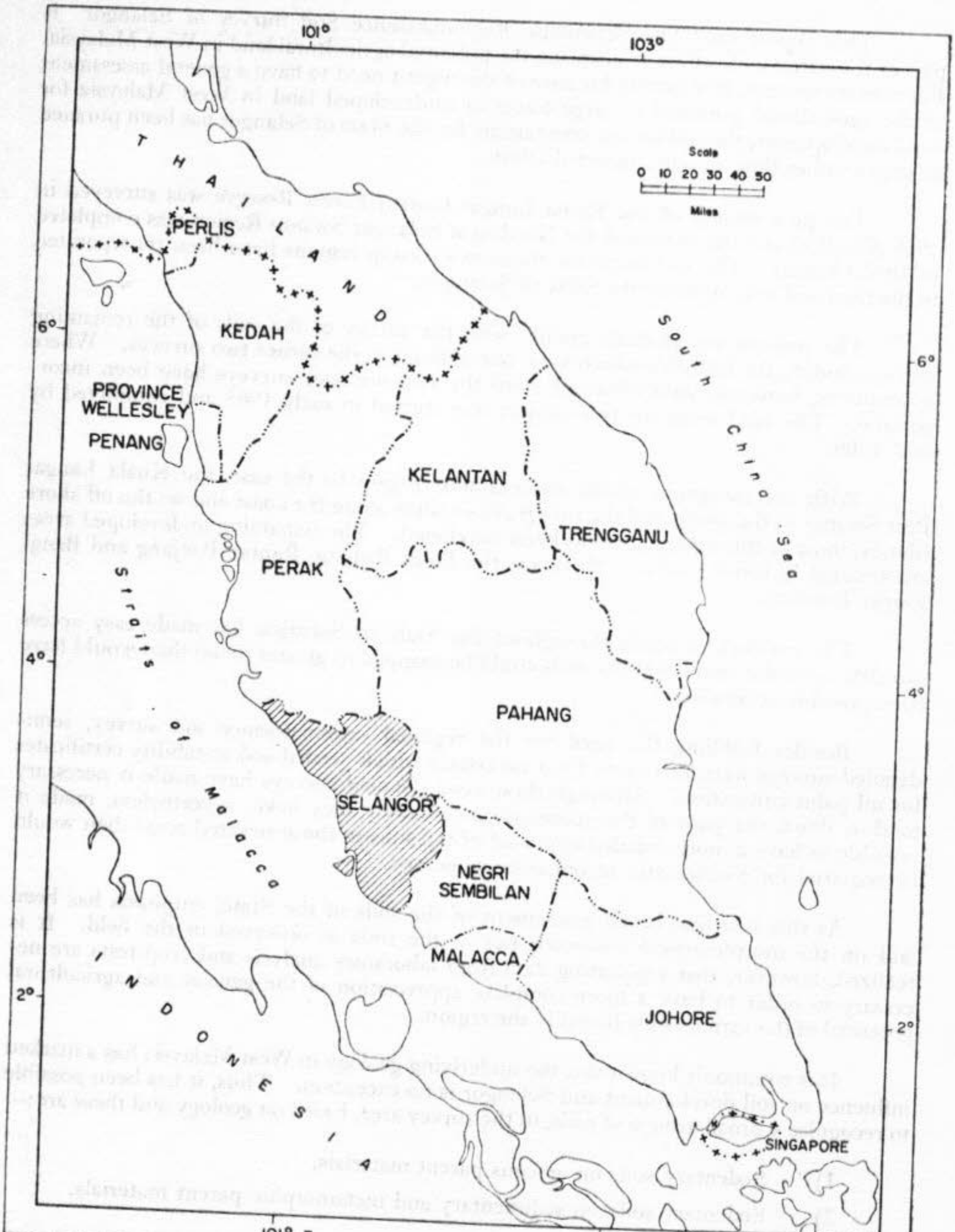


Figure 1. Sketch Map of West Malaysia showing position of Selangor.

LOCATION AND EXTENT

The area surveyed is situated within latitudes 101° 10'E and 102° 00'E and longitudes 2°35'N and 3° 50'N. It is bounded in the north by the Sungai* Bernam, the east by the Main Range, the south by the Sungai Sepang and the west by the Straits of Malacca (Fig. 1.)

The total area of Selangor, as measured from 1 inch to 1 mile topographical maps, is 2,020,880 acres or 3,158 square miles. Out of this total, 509,000 acres were surveyed before 1965 leaving 1,511,880 acres to be surveyed from early 1965 to mid 1966.

PHYSICAL FEATURES AND DRAINAGE

Part of the Main Range of West Malaysia stretches along the eastern border of Selangor. It forms the interstate boundary between Selangor and Pahang. This range of intrusive granite is succeeded to the west by folded sedimentary strata which form the foothills. Owing to the displacement of the sedimentary strata by the granite intrusion the terrain in the foothills regions is more rugged especially where schist and quartzite formations occur. Away from the main range where the sedimentary structures have been less altered by the granite intrusion the country is more undulating.

Associated with the folded sedimentary strata are isolated, steepsided limestone hills which are concentrated mainly in the valleys of the Sungai Kanching and Sungai Batu to the north of Kuala Lumpur. Extending from the foothills to the Straits of Malacca is the coastal plain, the flatness of which is broken intermittently by low isolated hills of folded sedimentary strata and very rarely by granite outcrops (e.g. Kuala Selangor). Also situated within the coastal plain are two large depressional areas; these are the North-west Swamp Region and the Kuala Langat Swamp which is in the south. The coastal plain which comprises approximately one third the total area of Selangor is less than 50 feet above sea level.

Five major rivers drain the state, from the Main Range watershed to the Straits of Malacca in the west. The Bernam and Selangor Rivers drain the north, the Klang River the centre and the Langat and Sepang Rivers the southern portions of the state. These rivers are quite swift at their headwaters where the slope of the land is steep but on reaching the alluvial flats they meander sluggishly and often overflow their banks after heavy rains thus leaving a fine riverine alluvium over their floodplains.

GEOLOGY

A synopsis of the chronological sequence of the geological formations in Selangor is as follows (Roe, 1951 and Geological maps, 1948 & 1964):—

Recent and Pleistocene:	Swamp deposits.
	Alluvium from sub-aerial denudation of mountain ranges.
Tertiary:	Shale and sandstone interstratified with which are two coal seams. Partly overlying these is a quartzite boulder bed.
Post-Triassic:	Granite and its differentiates and also including vein quartz.
	Also small basic intrusions such as the altered dolerite in the Ulu Bernam valley.

Sungai* = River

Triassic: Predominantly arenaceous sedimentary rocks consisting of sandstone and subsidiary bands of shale which are occasionally graphitic. Near the granite contact the sandstone and shale have been metamorphosed to quartzite, quartz schist, shistose grit, hornstone, quartzite-conglomerate, mica schist, graphitic schist, phyllite and indurated shale.

Permo-Carboniferous: Schist, phyllite and indurated shale with minor intercalations of limestone, shale and quartzite.

Middle Silurian: Limestone, shale and schist.

It is interesting to note that there is no apparent relationship between the geological age of sedimentary rocks and the soils derived from them. Textural differences in the parent rocks, on the other hand, have a marked influence on the final weathering product, a sandstone weathers down to produce a sandier soil than a shale. In the igneous rocks the same result has been observed; the granites, rich in quartz, weather down to sandy or gravelly clays with a predominance of angular quartz grains in the coarse fraction.

Granite and its differentiates are confined mainly to the Main Range with a few isolated low hills near the coast e.g. Kuala Selangor Hill and Jugra Hill. Folded sedimentary formations comprise the bulk of the foothills with metamorphosed sediments occurring closer to the granite massif.

The only occurrence of unmetamorphosed sediments is in the coal-bearing Tertiary shales, sandstone and quartzite boulder beds at Batu Arang.

Recent alluvium comprises coastal and inland deposits. The coastal alluvium which is confined to the coastal plain consists mainly of clay and silt, though intermittent sand and shell beds are sometimes incorporated within the finer alluvium. There is a belt of sandy beach deposits stretching from Jeram to Port Dickson in Negri Sembilan (Dennett, 1929).

Inland alluvium is confined mainly to the flood plains of the rivers and streams. These are of varied textures and compositions and are usually intermixed with colluvium near the base of hills and ridges.

Swamp deposits are confined mainly to the Kuala Langat Forest Reserve in the south and the Northwest Region. These deposits consist of peat overlying clay at variable depths which have been observed to be as deep as 13 feet in the Kuala Langat Forest Reserve (Coulter, 1956).

CLIMATE

The climate of the state of Selangor is governed by the moist monsoonal air-streams and the physiographical features of the land mass.

There is no distinct dry season for the climate consists of two wetter periods followed by two less wet ones. The moistureladen southwesterly winds prevail from May to September; an intermonsoonal period then ensues until early November; from November to March the northeast monsoon sets in and is followed by a second intermonsoonal period until early May.

TABLE 1

Mean Monthly & Annual Rainfall

Locality	J	F	M	A	M	J	J	A	S	O	N	D	Annual	Years Recorded
K. Kubu	6.84	5.35	8.99	11.75	10.69	7.25	6.17	8.14	9.30	15.31	12.80	9.00	111.59	60
K. Lumpur	6.30	6.24	9.26	10.85	8.01	5.41	3.93	5.82	7.43	10.46	10.88	8.68	93.27	43
K.Selangor	7.30	4.29	5.21	6.53	5.13	3.70	3.51	4.44	5.83	9.05	9.39	8.68	73.06	68

(Drainage and Irrigation Department, 1961)

The Main Range on the eastern border of the state causes both the southwesterly and northeasterly winds to rise on reaching them resulting in heavy precipitation in the foothills region and a gradual decrease in precipitation towards the coast.

Maximum daily temperatures, in the lowlands region are often above 90 °F while minimum temperatures are close to 65 °F giving a mean annual temperature of about 80 °F. The foothills region is cooler, with the mean annual temperature approaching 65 °F. Daily humidity is high being usually above 80%.

In table 1, the average monthly and annual rainfall data for Kuala Kubu, Kuala Lumpur (Weld Hill) and Kuala Selangor are given. From this table it is possible to see the difference in rainfall in the main range, the foothills region and the coastal plain.

AGRICULTURE

It is estimated from available topographical maps that rubber grows on about 26% of the agricultural land (530,000 acres). This crop is grown on a wide variety of soils. It thrives well on well drained soils but responds poorly under water-logged conditions. In more undulating to flat country a move has been made to replant rubber land with oil palm. This is especially true of estates situated along the coastal plain where water-logged conditions are more prevalent; oil palm estates have been established on this plain between Banting and Sepang for more than 15 years. Coconuts have also been cultivated on a large scale, mainly along the coast. It is common to find coconuts intercropped with bananas, tapioca and coffee which, together with coconuts, is one of the main crops grown along the coastal plain; its cultivation is concentrated mainly on the coastal alluvium extending from Klang to Banting.

Tea-growing is of limited extent, being confined mainly to the hills in the Kuala Langat (north) swamp. Pineapples have been cultivated quite successfully on the peat of the Kuala Langat Swamp Region. At present most of the land that is not alienated for agriculture or mining is under forest reserve, the largest area being in the Kuala Langat Swamp Forest; smaller areas are the Ayer Hitam and Bangi Forest Reserves situated to the south of Kajang and the Bukit Badong and Rantau Panjang Forest Reserves to the east of Batang Berjuntai.

SOIL FORMING FACTORS

Soil is the collection of natural bodies on the earth's surface, containing living matter, and supporting or capable of supporting plants, (Soil Survey Staff, 1960). It is the product of the influence of climate and living matter on parent rock materials as conditioned by relief over periods of time.

Climate is one of the strongest soil forming factors in Selangor. The effect of the high temperature and humidity throughout the year has resulted in intense weathering of rocks and this strong rock-alteration process is reflected in the wide extent of soils and the scarcity of unweathered rock outcrops. It is only on hill tops and along stream beds that rock exposures are commonly encountered and even then the rocks may be partially weathered.

As a result of intense rainfall and high temperature leading to rapid weathering of minerals, most West Malaysian sedentary soils, irrespective of parent materials, are highly leached, low in nutrient status and mainly kaolinitic (Ng, 1965).

Parent rock material also has a strong influence on the final make-up of the soil. Granites, which consist principally of quartz, micas and feldspars are commonly porphyritic. They weather to produce a sandy or coarse sandy clay with a brownish yellow colour which becomes yellowish red with depth. The colour is due to the release and subsequent oxidation of iron from the decomposition of the micas. The clay which is principally kaolinite is the end product of the break-down of the feldspars. Quartz remains as comparatively unaltered angular grains. Granite weathering is usually deep and it is not unusual to find 50 feet or more of weathered material overlying unweathered rock.

Quartzites and other metamorphic rocks and sedimentary rocks rich in quartz weather down to produce a sandy soil. The colour of the soil depends on the composition of the original rock; reddish colours are seen in soils derived from parent rocks with a higher admixture of clays and other minerals rich in iron while yellow colours are common in soils developed on more quartzitic parent rocks.

Where argillaceous rocks predominate the soils produced are more clayey. Colours of the soils again reflect the composition of the parent rocks - the darker the bedrock the browner or redder the soil produced.

Often the arenaceous and argillaceous strata occur interbedded and the soils produced are either intermediate in characteristics or they change from one series to another within very short distances.

Soil formation is also influenced by the slope of the land. Under the moist climatic conditions prevalent in West Malaysia the process of peneplanation by the agency of water on steep slopes is quickened. Consequently, soils on hill tops are more juvenile and shallower than those on the lower slopes. In the Main Range region slopes increase to 20° and more from about the 250 feet contour, while steep slopes often occur in the quartzite and schist ridges in the foothills region from as low as the 150 feet contour. Granite hills in the lowlands tend to have more rounded crests so that the terrain is more undulating and less broken than the sedimentary country. Slope and terrain classes have been set up by the Malayan Soil Survey Staff in order to aid in the reconnaissance soil survey programme. This classification is set out below in table 2 with mapping symbols used in the field:—

TABLE 2

Slope and Terrain Classes

Angle of Slope	Terrain Classes	
	Single Slopes	Complex Slopes
0° — 2°	Level or nearly Level, A,	Level or nearly level, C,
2° — 6°	Gently sloping, A2	Undulating, C2
6° — 12°	Strongly sloping, A3	Rolling, C3
12° — 20°	Moderately steeply sloping, A4	Hilly, C4
20° — 25°	Steeply sloping, A5	Steep, C5
25° +	Very steeply sloping, A6	Very steep, C6

Time is also an essential factor in soil formation. Soils with profiles as deep as 50 feet or more must have taken a long time to develop. The accumulation of a band of subaerial 'laterite' concretions is another indication of the maturity of a soil for a considerable period would have to elapse before the iron from percolating solutions have time to accumulate in that horizon.

Another indicator of the maturity of a soil which can best be brought to light by a mechanical analysis is the accumulation of clay in a subsoil horizon as a result of downward leaching of the colloidal clay particles over long periods of time.

The influence of living matter on soil formation is a subject that could be studied more thoroughly when time permits and only some general observations can be made in a report of this nature. A thick vegetative cover reduces the erosion hazards of the soil. Plants with abundant roots improve the structure and aeration of the soil, for soils under such a condition tend to develop crumb structures. Termites and earthworms, by their burrowing activities help in providing aeration channels in the soil besides improving the tilth of the soil.

There is, at present, no striking evidence to indicate the influence of the natural vegetation on the formation of distinct soil types. On the other hand, broad correlation can be made between broad groups of soils with the vegetation; the coastal swamps support mangrove forests of **Avicennia, Sonneratia, Rhizophora** and **Bruguiera;** the peat swamps support their own special type of vegetation consisting of a three-layered tree structure with stemless palms a common feature of the plant community (Wyatt-Smith, 1964).

Away from the swamps the vegetation changes to a lowland dipterocarp forest up to about 2,000 feet above sea level; among the important timber producing trees in this region are Chengal **(Balanocarpus heimii),** Kapur **(Dryobalanops aromatica),** Kempas **(Koompassia malaccensis),** Kedondong **(Canarium and Santira spp.),** Nemesu **(Shorea pauciflora),** Red Meranti **(Shorea acuminata** and other species) and Keruing **(Dipterocarpus baudii** and other species) (Wyatt-Smith, 1964). Hill dipterocarp forest predominates at elevations between 2,000 and 4,000 feet above sea level and above 4,000 feet the vegetation changes to a montane forest.

METHODS OF SURVEY

The advancement of agricultural and mining development in Selangor has resulted in the construction of a good network of roads and motorable tracks. Such is the intensity of motorable roads and tracks that the whole soil survey programme was accomplished mainly by means of landrover traverses.

Soil examinations were made at ¼ mile intervals except where noticeable changes in the soil occurred, when examination points were closer. Where uniform soils were encountered examination points were further apart.

The soils were examined in road cuttings, in pits dug specifically for soil examination, or by means of augers; a 1 inch diameter screw auger was used for examining sedentary soils and a 6 inch diameter posthole auger for alluvial soils.

Base maps used were the 1 inch to 1 mile topographical maps supplied by the Survey Department. Geological maps of Selangor were also used in locating the probable positions of soil boundaries especially of the sedentary soils since the underlying geology has a distinct influence on the overlying sedentary soil.

The mapping unit used was the soil series which is defined as a group of soils possessing similar profile differentiating characteristics, except for the texture of the surface soil and developed from a particular parent material (U.S.D.A. Soil Survey Manual, 1951). Another unit used was the soil variant which is a unit of convenience set up in order to include soils of limited extent which differ from a known soil series in one differentiating profile characteristic e.g. colour.

Experience has shown that it is not always possible to map separate series on a reconnaissance level. Thus a larger unit has been used which is the soil association. A soil association consists of a group of two or more series of soils geographically associated in a defined proportional pattern. The order of naming the soil associations begins with the more predominant soil series and ends with the least extensive series. Soil series which occupy less than 10% of the area in an association are not indicated in the association name.

SOIL SUITABILITY CLASSIFICATION

The soils of Selangor have been grouped under five suitability classes. The classification adopted is the "Soil Suitability Classification for Malaysia" (Wong, 1970) which is indicated in abbreviated form in Appendix II. The criteria used in classifying the soils of Selangor follow closely the parameters set out in the Malaysian-wide classification.

The suitability classification is applied at soil series level. In a reconnaissance survey, however, not all the soils can be mapped at series level. This is also true for the soils of Selangor, which have been mapped as associations of series. In the soil suitability map accompanying this report the map units are made up of soil associations which have been grouped together according to similarity of soil suitability class. Each association has been considered as a unit and its suitability classification has been based on the number and seriousness of crop growth limitations occurring in it.

In table 3 the suitability classification of soil series and mixed groups is indicated. In this table it will be noticed that many soil series have more than one suitability class either because they occur over a wide range of terrain classes, have variable drainage regimes or variation in effective rooting depth.

TABLE 3

Soil Suitability Classification

Class I	Class II	Class III	Class IV	Class V
Rengam (up to 6° slopes) Serdang (up to 6° slopes) Munchong (up to 12° slopes) Prang (up to 12° slopes) Selangor (well drained) Kangkong (well drained) Briah (well drained)	Rengam (6 - 12° slopes) Serdang (6 - 12° slopes) Munchong (12 - 20° slopes) Prang (12 - 20° slopes) Tavy Selangor (imperfectly drained) Kangkong (imperfectly drained) Briah (imperfectly drained) Akob (imperfectly drained) Merbau Patah (imperfectly drained) Colluvium Jambu	Rengam (12° + slopes) Serdang (12° + slopes) Prang (lateritic) Kedah Seremban Malacca (deep phase) Durian Bungor Batu Anam Selangor (poorly drained) Kangkong (poorly drained) Briah (poorly drained) Local Alluvium Inland Swamp Association Colluvium	Kedah Kranji Telok Mangrove Swamp Association	Kedah Malacca Steepland Disturbed Land

PART II

DESCRIPTION OF SOIL SERIES

Soils Derived From Igneous Rocks

Of all the soils derived from igneous rocks the soils of the Rengam Series developed on granite are the most extensive and prominent. Minor occurrences of dolerite-derived soils identified as the Segamat Series have been observed but these can only be indicated on maps of larger scale.

Rengam Series

Soils of the Rengam Series are developed over a wide range of terrain from undulating and rolling to hilly (4° - 20°) but because of their close proximity to the Main Range most of them occur on rolling terrain. They are normally developed on medium to coarse grained granite from which they derive their characteristic 'gritty feel' which is due to the presence of angular quartz grains. The topsoil of dark greyish brown (10YR 4/2) colour, under jungle or tree crops is usually 1 to 2 inches thick while under grass it can be as thick as 6 inches; this topsoil has a sandy to coarse sandy clay loam texture, friable consistence and weakly developed fine subangular or moderately developed medium granular and crumb structure. The subsoil which is normally more than 6 feet thick can be as deep as 50 feet or more. It has a higher clay content than the topsoil, with a sandy or coarse sandy clay texture, brownish yellow (10YR 6/6) colour grading to a yellowish red (7.5 YR 6/8) colour with depth; consistence in the subsoil is friable to firm and the structure is moderately developed medium subangular blocky. A good indication of the higher clay content in the subsoil is the presence of thin coatings of clay (clayskins) along root channels and structural faces of the soil. In deep cuttings the soil close to bedrock is streaked with yellowish red and red colours due to the oxidized iron which has been released through the weathering of the micas and hornblendes in the granite.

Lateritic phases are rare though stone lines formed by the fragmentation of vein quartz have been observed in the profiles.

Suitability Classification

Soils of the Rengam Series, because they are deep and friable, are easily permeable to water and offer very little hindrance to root ramification. These soils are normally sited on sloping land and are not subject to waterlogging. Consequently, on slopes up to 6° they are of Class I suitability as they are suitable for the cultivation of a very wide range of crops including rubber, oil palm, bananas, coffee, cocoa and fruit trees.

In Selangor they usually occur on slopes between 6° and 12° in which case they are more susceptible to erosion and are thus placed in class II. Occasionally they occur on slopes steeper than 12° when the increased erosion hazard causes them to be placed in class III; under such conditions they would be suitable mainly for the cultivation of rubber.

Use and Management

At present rubber is the main crop grown on these soils. Fruit trees, vegetables, and tapioca are cultivated to a much lesser extent. Oil palm has recently been planted on the undulating land of one estate.

Erosion by slumping and gullying is a common feature of these soils especially on steeper slopes, because of their friability. For this reason it is most important that vegetative covers are established on fresh cuttings. Sheet erosion is also significant on newly cleared areas where the organic topsoil can be washed away by a few rain storms.

Soils Derived From Sedimentary And Metamorphic Rocks

With the exception of the Miocene beds in Batu Arang all the older sedimentary formations in Selangor have been folded by the intrusion of the Main Range granite. Metamorphism has occurred in the older sediments, being most pronounced along the periphery of granite areas. Although the Miocene sediments have not been folded the soils developed from them bear similar morphological characteristics to those developed on older formations. The texture and iron content of the parent rock appear to have the most influence on the type of soil produced; a coarse-grained siliceous rock low in iron initially weathers to produce a yellow to brownish yellow soil while an argillaceous rock, rich in iron, on weathering, will alter to a strong brown clay loam soil. Except for three soil series, the Prang, Seremban and Batang Merbau Series which are derived from schists, all the other soils have been formed from a mixture of metamorphosed and non-metamorphosed sediments. The overriding profile development factors are the texture and iron content in the parent rock material. Slope of the land has an indirect influence on profile development, juvenile soils being formed on steeper slopes as a result of erosion. Thus it has been possible to map 8 different soil series in the regions where the underlying strata consisted of quartzites, sandstones, shales, phyllites and low grade schists. These are the Serdang, Munchong, Kedah, Batu Anam, Durian, Malacca, Tavy and Bungor Series.

Serdang Series

One of the most extensive soils in Selangor is the Serdang Series. It is developed on quartzites, sandstones and sandy shales; often the underlying rock has intercalations of silty and micaceous shales and phyllites. The soils of this series occur on undulating and rolling to hilly land (4° - 20°) but mainly on rolling terrain (6° - 12°); as the terrain becomes steeper the Serdang Series soils grade into the shallower soils of the Kedah Series. The topsoil is 1 - 2 inches thick under jungle conditions; it is dark greyish brown (10YR 4/4) to dark brown (10YR 4/3) in colour, sandy loam to sandy clay loam in texture with friable consistence and moderately developed medium crumb and weakly developed fine subangular blocky structure. The subsoil, which is more than five feet thick, is yellowish brown (10YR 5/6) to brownish yellow (10YR 6/8) in colour at times grading to strong brown (7.5YR 5/8) with depth; texture in the subsoil is sandy clay loam to sandy clay with a consistence that changes from friable to firm with depth and a moderately developed medium subangular blocky structure. Clayskins are common in the subsoil coating the root channels and structure faces. Lateritic phases occur and occasionally it has been observed that a Serdang Series soil grades into a Malacca Series with massive laterite boulders close to the surface e.g. at the quarry at the 14¾ mile Sungai Buloh Road.

Suitability Classification

Soils of the Serdang Series have been placed in class I and II because of the thickness of the profile and the friability of its constituents which enhances drainage, aeration and root penetrability. These soils are suitable for a wide range of crops including rubber, oil palm, bananas, manila hemp, maize, tapioca, ground nuts, tobacco, soya beans, garden vegetables, tea and fruit trees. The short term crops, however, are more suitable on slopes below 6°. Where the soils of the Serdang Series have been placed in class III it is because they occur on slopes of 12° or more. In this case the soils are suitable mainly for rubber cultivation.

Use and Management

Rubber and oil palm grow well on this soil though oil palm does better on the gentler slopes. Tea, tobacco, manila hemp, maize, fruit trees, tapioca and some dryland annual crops have been cultivated on this soil. Some of the crops have, however, only been cultivated on an experimental basis to-date.

Because of its friability and good permeability soils of the Serdang Series are easily erodable when exposed and it has been noticed that under scrub vegetation or tree crops without a good cover crop the topsoil can be washed away leaving a truncated soil with very little organic matter in it.

Kedah Series

A distinctive feature of the soils of the Kedah Series is that they are shallow soils developed on hilly to steep (12° - 25°) terrain. They usually occur in association with the Serdang Series which occur downslope, both soils being derived from similar parent materials, namely, quartzites, sandstones and sandy shales with minor intercalations of silty and micaceous shales and phyllites. The topsoil of 1 - 2 inches thickness is normally dark yellowish brown (10YR 3/5) to greyish brown (10YR 5/2) in colour with a fine sandy loam to sandy loam texture, friable consistence and weakly to moderately developed medium subangular blocky structure. The subsoil which is rarely thicker than 20 inches is yellowish brown (10YR 5/5) grading to strong brown (7.5YR 5/8) or reddish yellow (7.5YR 6/6) with depth. The parent material is usually encountered at about 20 to 24 inches depth.

Suitability Classification

The steepness of the terrain and the shallowness of the soils of the Kedah Series are serious limiting factors which narrow the suitability range of these soils to a few crops only.

This is commonly a class V soil as it is usually situated on slopes of 20° or more. On less steep slopes it would be a class IV soil when its thickness is less than 20 inches. Only occasionally is its thickness more than 20 inches in which case it would be a class III soil, slope being the only serious limitation.

Use and Management

Rubber is the only crop that has been grown on this soil to-date. Judging from the number of bare patches on rubber estates where erosion by slumping has taken place the limitation of these soils for crop cultivation and the need for cover cropping and other conservation measures, should cultivation be contemplated, are sufficiently evident.

Munchong Series

Closely associated with the Serdang Series are soils of the Munchong Series.

These soils are derived from ferruginous silty and clayey shales, phyllites and low grade schists with occasional bands of quartzite and vein quartz. Because of variability in the mineralogical composition of the parent materials of this series the variation in the potassium content within the series is as great as that between different soil series. Higher potassium values have, however, been obtained in soils derived from phyllites and low grade mica schists which are highly probable sources of a greater quantity of potassium fixing micaceous minerals.

The topsoil of 1 to 3 inches is a dark brown (10YR 4/3) clay loam with a friable consistency and a moderately developed medium crumb and weakly developed fine subangular blocky structure. The subsoil of more than 3 feet thickness is a reddish brown (5YR 4/4) clay loam becoming a clay at depth; the consistence is friable while the structure is moderately developed medium subangular blocky. Discontinuous clay-skins are also present in the subsoil, coating root channels and some ped faces. But the most diagnostic feature of the subsoil is the presence of laterite concretions and boulders which make this zone very compact.

Suitability Classification

Shallow phases of the Malacca Series in which the lateritized zone is very close to the surface are placed in class V because the effective rooting depth is very shallow. The deeper phases are placed in class III because the deeper rooting zone and high clay content of the soil enhances its suitability for crop cultivation.

Use and Management

The laterite concretions and boulders are in demand as road metal but where the deep phase occurs rubber has been grown on it. When exposed the toposil tends to erode away leaving a hard crust of cemented laterite pebbles and boulders on the surface. Cover cropping will, however, prevent excessive erosion.

Tavy Series

In the survey area soils of the Tavy Series have been found in a small area near the headwaters of the Sungai Lui in Ulu Langat District. They occur in association with soils of the Bungor Series in rolling terrain.

The topsoil of 1 to 3 inches is a yellowish brown (10YR 5/4) clay loam with firm consistence and moderately developed medium crumb and weakly developed fine subangular blocky structure. The subsoil is characterized by the presence of a band of laterized shale pebbles mixed with quartz from 18 to 36 inches depth; the change in soil colour from yellowish brown to strong brown (7.5YR 5/7) is also another diagnostic property. The texture in the subsoil is silty clay loam to silty clay with a friable to firm consistence and moderate to weak medium subangular blocky structure.

Suitability Classification

The presence of laterized shale pebbles forming a zone of impedence to root ramification usually beyond 18 inches depth places these soils in class II.

Use and Management

The main crop grown on these soils is rubber with bananas and fruit trees in lesser extent. Cover cropping is necessary on these soils for they tend to have surface erosion which will raise the level of the lateritic zone closer to the surface.

Bungor Series

Soils of the Bungor Series occur in hilly to steep terrain. They are of very limited extent in Selangor being confined mainly to the schist country in the catchment of Sungai Lui in Ulu Langat District. These soils are developed from low grade schists or indurated shales. They are found in association with soils of the Tavy Series.

The topsoil of about 3 inches is a dark yellowish brown (10YR 4/4) fine sandy clay with few quartz gravels; it has a friable consistence and moderately developed medium crumb and fine subangular blocky structure. The subsoil to about 30 inches depth is a light olive brown (2.5Y 5/4) fine sandy clay with a friable to firm consistence and fine to medium moderately to strongly developed structure. A distinctive feature of the subsoil is the presence of almost continuous pale brown (10YR 6/3) clayskins coating root channels and structure faces. At about 30 inches depth weathering schist or durated shale is encountered.

Suitability Classification

As the soils of the Bungor Series are found on hilly to steep terrain they are placed in class III.

Use and Management

Rubber is the main crop grown on these soils. Fruit trees are also cultivated on them but to a lesser extent. The main limitation to agricultural exploitation of these soils is topographical so that the main conservation practice needed is cover cropping and contour terracing which, however, cannot be too deep for otherwise bedrock will be encountered.

Of the three schist-derived soils identified, the Prang and Seremban Series are the most extensive while the Batang Merbau Series which occurs in association with the Seremban Series in a very limited area can only be indicated on maps of larger scale than the one accompanying this report. Nevertheless, this is a friable soil, predominantly yellow in colour, with numerous mica flakes impregnated in the subsoil.

Prang Series

Soils of the Prang Series are developed on schists. They occur in undulating to hilly (2° - 20°) terrain.

Below a very thin leaf mat the topsoil varies from 1 to 12 inches in thickness; it has a dark brown (7.5YR 4/2) to dark red (2.5YR 3/6) colour, clay loam to clay texture, friable consistence and weakly to moderately developed fine subangular blocky structure. The subsoil ranges in colour from yellowish red (5YR 4/6) to dark red (2.5YR 3/6) with a clay texture, friable consistence and weakly developed fine or moderately developed medium subangular blocky structure. Besides the deep phase of five to six feet depth, there is a shallow phase in which laterized schist appears at or close to the surface.

Suitability Classification

The suitability classification of the soils of this series is based on slope or lateritic concretion limitations. On slopes up to 12° these soils would be placed in class I while in the 12° - 20° slope range they would be placed in class II. The shallow lateritic phase would be a class III soil.

Use and Management

Rubber has been the main crop grown on these soils. At the time of the survey it was observed that oil palm was also being planted on these soils. Bananas and fruit trees are also expected to grow well on the Prang Series soils. Except for a thin leaf mat the topsoil is quite devoid of organic matter; this condition is the result of sheet erosion which is most serious in areas where cover cropping is lacking. As slumping on exposed cuttings is also of common occurrence, cover cropping is necessary for the proper maintainance of these soils.

Seremban Series

In regions where metamorphosed sediments have been formed it has been observed that the Seremban Series soils are most likely to occur, for these soils are developed on quartz-mica schists which are frequently intermixed with phyllites and vein quartz. These soils occur in undulating to hilly (4° - 20°) terrain. They have also been observed to occur in steeper terrain as the contact between the underlying schist and intrusive granite is approached. A characteristic feature of the Seremban Series soils is the presence of quartz gravels and angular pebbles in the subsoil together with platy laterized schists or phyllite pebbles. The topsoil of 2 - 4 inches is a dark greyish brown (10YR 4/2) or yellowish brown (10YR 5/4) fine sandy clay to fine sandy clay loam with a friable to firm consistence and a moderately developed fine subangular or moderately developed medium crumb structure. The subsoil which goes down to a depth of about 40 inches has a reddish yellow. (7.5YR 7/8 to 5YR 5/8) colour; it has a fine sandy clay texture with variable amounts of quartz gravels, a friable to firm consistence and moderately developed medium subangular blocky structure. A loose layer of predominantly platy laterized schist or phyllite pebbles occurring between 12 and 24 inches from the surface is another diagnostic feature of this series.

Suitability Classification

Because of the presence of a moderately high content of loose laterized pebbles within the profile the Seremban Series soils have been placed in class III.

Use and Management

At the time of the survey these soils were cultivated with rubber, oil palm and fruit trees.

Erosion by slumping is the most common form of soil destruction. This form of erosion occurs mostly in areas where exposed cuttings have not been planted with grass or cover crops.

Soils Derived From Marine Alluvium

The marine alluvium which forms the western coastal plain of Selangor covers approximately one-third the total area of the state. Under natural undrained conditions this alluvium is greenish grey or bluish grey in colour: when drained, however, the surface soil changes to a grey colour with distinct mottles of yellow and red, indicative of the oxidation of sulphur and iron compounds occurring within the soil. According to Dennett (1932) "A sample of blue clay kept in the laboratory more or less under field conditions has passed from the blue through the grey to the yellow-red state in a period of some nine months." A strong smell of hydrogen sulphide is noticeable in the permently waterlogged subsoil, as much as 0.35 per cent having been recorded (Dennett, 1932). The common marine clays are the least leached among West Malaysian soils. In fact they are the most fertile soils of the country. They consist of more than 50% montmorillonite clay (Ng, 1965) and are known to contain a high proportion of phosphorous in the organic topsoil. Potassium and magnesium reserves are also high.

The continuity of the marine clay is broken by sandy beaches stretching from Jeram to Morib. These sandy beaches are thought to have been formed by the deposition of sediments, brought in by south-easterly currents, from the quartzite islands off shore and Jurgra Hill which is granitic. Beds of sand and shells have been found as far as two miles inland but these are not extensive. The clay, on the other hand, is not only extensive, but very thick; a bore-hole made at Lapan Utan Estate, Kuala Selangor, went down 220 feet without reaching bedrock (Scrivenor and Jones, 1919). Similarly a bore-hole was made at Erik Estate, on the Bernam River to a depth of 352 feet with a similar result (Willbourn, 1922).

Five soil series and one variant have been identified on the coastal deposits. These are the Selangor, Kangkong, Telok, Kranji and Jambu Series. The variant mapped is the Selangor Variant which is of limited extent.

Another mapping unit used in the survey is the Mangrove Swamp Association which is the juvenile stage of the Selangor Variant; this soil in its natural condition is subject to tidal inundation; it supports a mangrove swamp forest. When improved, as on parts of Carey Island, Dusun Durian and Bukit Panjong Estates, it may support coconuts, oil palm and rubber depending on the proportion of sand and shells to clay. Where the sand and shells are predominant poor growth of crops has been observed.

Selangor Series

The most extensive soils on the coastal plain are the Selangor Series. North of Jeram village the marine alluvium is predominantly clay but in the south there is an uneven admixture of fine quartzose sand and shell beds. The zone of mixed clay, fine sand and shells is however, very narrow, separating the beach sand from the clay. The soils developed from the clay, sand and shell mixture are juvenile and, as they are quite restricted in extent, have been mapped as variants of the Selangor Series.

The Selangor series soils occur in level to slightly depressional areas. The topsoil of 6 to 10 inches thickness is dark brown (7.5YR 4/2) to black (10YR 2/1) clay, silty clay or organic clay that is slightly sticky or friable with a weakly developed fine subangular blocky structure. During dry weather pronounced cracking occurs in this horizon. The deep subsoil consists of mottled clay or silty clay to a depth of three or four feet where the permanently moist bluish grey (N 5/) marine clay occurs. The mottled subsoil is friable to slightly sticky at the top becoming sticky with depth; structure changes from weakly or moderately developed medium subangular blocky at the top to weakly developed coarse columnar below. Topsoil which has slumped down cracks often coat ped faces. The permanently moist C horizon is plastic and structureless; it may emanate a sulphurous odour due to the presence of sulphuretted hydrogen.

Suitability Classification

Rubber has been grown successfully on the Selangor Series clays without fertilizer applications because the marine clay parent material is rich in plant nutrients. Continuous cropping, however, will deplete the nutrient reserves so that eventually fertilizers will need to be added if cropping on a sustained yield basis is planned. The Selangor Series is a class I soil which is ideally suited for the cultivation of oil plam besides coconuts, bananas, pineapples, coffee, fruit trees and short term crops. Where it is imperfectly drained it would be a class II soil. Under irrigated conditions it would be in class III in the general classification but would be highly suitable for padi cultivation.

Use and Management

Rubber, oil palm, coconuts and coffee are at present grown on the Selangor Series soils. Bananas and fruit trees are also grown on a small scale. Padi, on the other hand, is extensively cultivated on these soils under irrigated conditions.

As the soils of the Selangor Series are situated on the coastal plain the main management problem is provision of proper drainage; good structure and aeration of the profile is conserved when water-logging by saline, brackish or fresh water is prevented.

Kangkong Series

Being confined solely to the northwestern region of the state the soils of this series have been mapped during the reconnaissance soil survey of that region (Acton, 1966). For the sake of completeness the description of these soils, given by Acton, is also included here.

Soils of the Kangkong Series are developed from recently deposited marine alluvial clays and are found mainly in the peninsular region near the mouth of the Sungai Bernam. The landform consists of a level plain the surface of which is only a few feet above sea level at high tide. The water table has been significantly lowered by means of drains prior to agricultural development. These soils have not been identified in undeveloped regions of the survey area.

These soils are distinguished from other marine clay soils by the coarse prismatic to blocky structure of the subsoil horizons which possess firm and rubbery consistency, and often light greenish grey colours. Iron oxide deposits along root channels are very rare.

The surface horizon consists of dark grey to black friable clay ranging from 0 – 4 inches in depth, and has a moderate to strongly developed medium crumb structure. Where the organic topsoil is shallow or absent the surface horizon is hard, has a strongly developed coarse subangular blocky structure and often pronounced cracking during dry weather. The second horizon extends to 12 or 18 inches in depth and is grey, light grey, or greenish grey in colour with a prismatic to blocky structure. A partial coating of topsoil, which has slumped down the cracks, often covers the prism faces. The consistency is always firm and the soil tends to dig out in slabs. Mottles of strong brown to yellowish brown colour commonly occur as well as concretionary yellowish brown, olive brown or olive yellow gritty deposits. Such deposits are most common below 24 inches embedded in a matrix of grey to greenish grey clay. Bluish grey deposits may occur along root channels. The structure of this horizon is not strongly developed, and the consistency occasionally is somewhat looser. This horizon generally is saturated with water.

Suitability Classification

This is usually a class II soil as it is imperfectly drained. When well drained it is a class I soil. It is suitable for the cultivation of rubber, coconuts and oil palm besides annual crops and, when irrigated, for padi also. Under irrigated conditions, however, these would be class III soils as they would be poorly drained.

Use and Management

These soils have been utilized for coconut cultivation and to a much lesser extent for padi.

As the internal drainage of these soils is slow, a system of closely spaced drains has been found necessary to lower the water table to permit the growth of coconuts. A coastal bund has been observed to prevent ingress of saline water which when allowed to flood the soils has been found to retard the growth of coconuts.

Telok Series

These soils have been found in association with the Selangor Series mainly in the southeastern corner of Carey Island and the Tanjong Karang - Sabak Bernam padi-growing region. These clay soils are believed to be of brackish water origin. The topsoil of 2 - 5 inches is a dark grey (10YR 4/2) organic clay with a friable consistence and moderately developed fine subangular blocky structure. Occasionally iron deposits of a strong brown (7.5YR 5/8) colour may coat part of the structural faces. The subsoil consists of a mottled layer overlying bluish grey marine clay at 28 to 30 inches depth. The mottled layer is a clay ranging from greyish brown (10YR 5/2) at the top to light brownish grey at the base; consistence is slightly sticky and structure changes from strongly developed fine subangular blocky at the top to moderately developed coarse subangular blocky below. Mottle colours are yellowish brown (10YR 5/8) and strong brown (7.5YR 5/8). Partly decomposed organic matter also occurs in this layer. The bluish grey marine clay below the mottled layer is permanently moist, structureless, plastic and sulphurous.

Suitability Classification

The Telok Series soils are placed in suitability class IV because they occur in poorly drained depressional areas in their natural condition; they have shallow topsoils with highly sulphurous subsoils; these limitations narrow the crop suitability range of these soils considerably.

Use and Management

Soils of the Telok Series in the area mapped are under swamp forest, rubber, coconuts and oil palm. Those soils under swamp forest, when well drained would be suitable for the cultivation of oil palm and coconuts; deep rooting crops like rubber would not be as suitable on such soils owing to the shallow water-table and the sulphurous subsoil. Drainage should be effected gradually as rapid lowering of the water-table could intensify acidity by oxidation of sulphide compounds to sulphuric acid.

Kranji Series

The Kranji Series soils are juvenile as they are developed on marine clays under swamp conditions. They are found in the mangrove swamp areas over recent marine and estuarine clays on the mainland coast and on the islands off the coast.

Profile differentiation is seldom developed on these alluvial soils as they are under tidal influence in their natural state. A typical profile consists of a bluish grey (N 5/) sticky and structureless clay with a strong sulphurous odour from the surface down.

Two sets of soil samples were collected from the Kapar Forest Reserve. One set of samples was obtained about 10 yards from the beach while the other was collected about a mile inland close to a bunded area. Table 4 shows the results of pH, conductivity, sulphate and chloride analysis of the two sets of samples. These results indicate a high salinity in the soil and a tendency for the soil to increase in acidity as a result of the oxidation of sulphur compounds to sulphate following drainage and aeration.

Suitability Classification

These are class IV soils because of their very poor drainage and saline condition.

Use and Management

In their natural condition Kranji Series soils support a mangrove forest; but when bunded and allowed to be leached of the excess soluble salts these soils improve in structural development.

Ameliorated Kranji Series soils support a good stand of coconuts and they have every chance of being suitable for oil palm cultivation in their improved state.

Jambu Series

The stretch of beach from Morib to Port Dickson in Negeri Sembilan is sandy. The fine sand is mixed with the silts and clays of the mangrove swamps of the coast. But where these sands have not been mixed with the silts and clays they have been mapped as the Jambu Series.

TABLE 4

Analysis of Kranji Series Soils

Sampling Site	Depth (ins.)	pH		Conductivity Mhos x 10^{-6}	Sulphate m.e./100g.	Chloride m.e./100g.	Sulphate %	Chloride %
		Fresh	Air dry					
Inland	0 – 6	6.5	5.9	11,100	9.87	55.01	0.484	1.953
	6 – 12	6.8	6.0	10,000	6.18	49.98	0.303	1.455
	12 – 18	6.7	5.8	11,100	9.54	52.00	0.468	1.846
	18 – 24	7.2	6.1	11,100	9.26	50.98	0.454	1.810
	24 – 30	7.1	5.8	12,500	11.17	48.99	0.548	1.739
	30 – 36	7.5	5.9	12,500	9.34	52.98	0.458	1.881
Beach	0 – 6	6.6	6.1	9,100	5.20	76.00	0.255	2.698
	6 – 12	6.2	5.9	6,400	3.89	30.28	0.191	1.075
	12 – 18	5.9	5.7	6,400	4.95	35.77	0.243	1.270
	18 – 24	5.9	5.7	9,100	5.16	60.98	0.253	2.165
	24 – 30	5.6	5.5	10,000	7.69	68.98	0.377	2.449
	30 – 36	6.0	5.1	12,500	4.54	60.98	0.223	2.165

The topsoil of 1 to 4 inches is usually white (10YR 8/1), with a medium sand texture, loose consistency and no structure.

The subsoil to a depth of more than 36 inches is a light brownish grey (2.5Y 6/2) medium sand with uneven patches coloured olive grey (5Y 4/2) to dark olive grey (5Y 3/2); the subsoil is also loose and structureless.

Suitability Classification

Acute nutrient deficiency and excessive drainage are the two main limitations to crop growth in the Jambu Series soils. These limitations cause these soils to be placed in class II.

Use and Management

Coconut is the main crop grown on the Jambu sands and the poor yields observed on the coconut plots on these sands are clear indications of the acute nutrient deficiencies inherent in them. Cashew is being cultivated on beach sands along the West Malaysian east coast and it is very likely that this crop will also grow on the Jambu sands. Oil palm cultivation is being attempted on these soils and only time will show whether an economic return can be obtained from them.

Mangrove Swamp Association

These soils occur in close association with the Kranji and Jambu Series soils. They consist of an intermixture of patches of sand and clay which are unevenly mixed so that their profiles consist of an uneven interstratification of sand and clay. They occur in the swamps along the coast and are concentrated mainly along the Jeram - Morib - Sepang beach and on some of the mangrove swamp islands near the coast. There is no profile differentiation in these soils as they are constantly being renewed by new sediments brought in by tidal saline water. Associated with their waterlogged environment is a strong sulphurous odour in the subsoil.

Suitability Classification

These are class IV soils as they are poorly drained and are inundated by saline water constantly.

Use and Management

In their natural condition these soils support a mangrove forest. When bunded they support coconuts which, however, do not grow as well as on the neighbouring improved Kranji Series soils.

Soils Derived From Riverine Alluvium

Where streams and rivers are still actively depositing alluvium, soils are very immature; there is hardly any horizon differentiation in such soils. In the alluvial flats which are subject to less frequent flooding horizonation has occurred to some extent in the alluvium. It has been possible to distinguish three soil series under such conditions; these are the Merbau Patah, Akob and Briah Series, the Merbau Patah and Akob soils occurring near the upper reaches of the Sungai Bernam while the Briah Series are developed from riverine alluvium overlying marine alluvium on the coastal plain.

Briah Series

Silty and clayey alluvium deposited by the larger rivers as they meander over the coastal plain in their lower courses have distinct profile characteristics over the underlying marine alluvium under freshwater or brackish water conditions. The topography on which they develop is flat or depressional. These soils have been mapped as the Briah Series. They often occur in close association with soils of the Selangor Series with intergrades between these two series being quite common.

The topsoil of 3 to 6 inches of the Briah Series is a dark brown (7.5YR 4/2) silty clay which is slightly sticky when wet; the structure is weakly developed fine subangular blocky. The subsoil is more than 3 feet thick with a colour which grades from light grey (5Y 7/2) at the top to grey (5Y 5/1) at 3 to 4 feet depth below which a permanently moist bluish grey or greenish grey marine clay occurs; the texture of the subsoil is silty clay while the consistence increases in thickness with depth; structure increases in size and changes in shape with depth from a weakly developed fine subangular blocky at the top through strongly developed coarse prismatic and moderately developed coarse subangular blocky to a structureless plastic clay at depth. Mottles of yellowish brown (10YR 5/8), reddish yellow (7.5YR 7/6) and strong brown (7.5YR 5/6) commonly occur in the subsoil. Another characteristic feature of this series is the sulphurous odour emanated from the soil below the permanent water table, indicative of anaerobic conditions.

Suitability Classification

When well drained these soils are suitable for a wide range of crops. They are then considered to be class I soils. Often they are imperfectly drained when they would be class II soils. But in their natural undrained condition the strongly gleyed subsoil occurs close to the surface. Under such a condition which is a serious limitation, these soils are considered to be of class III suitability.

Use and Management

Where drainage improvements have been effected these soils support good stands of rubber and fruit trees. They are eminently suitable for oil palm cultivation as this crop thrives better under a moist environment which is a characteristic of these soils. Padi cultivation would also be possible in these soils with proper water control.

Merbau Patah Series

Soils of the Merbau Patah Series have been found in the upper reaches of the Sungai Bernam.

The topsoil to 4 inches depth consists of a dark yellowish brown (10YR 4/4) silty clay loam with a slightly sticky consistency and moderately developed medium crumb and fine subangular blocky structure. The subsoil changes in colour from light yellowish brown (2.5Y 6/4) to grey (5Y 5/1) at 30 to 36 inches depth; texture throughout is silty clay with a sticky consistency and weakly developed fine subangular blocky structure. A characteristic feature of the subsoil is the presence of strong brown (7.5YR 6/6) mottles.

Suitability Classification

These are imperfectly drained soils. As such, they are considered to be class II soils.

Use and Management

Although rubber and oil palm are grown on these soils after drainage, rubber does not grow as well on them because of their moist condition. Padi cultivation, on the other hand, would be suitable.

Akob Series

Akob Series soils occur in association with those of the Merbau Patah Series. These are sandier soils than the Merbau Patah Series.

The topsoil to a depth of about 4 inches is a dark brown (10YR 4/3) to dark yellowish brown (10YR 4/4) loam to silty clay loam, friable and with a moderately developed medium crumb and fine subangular blocky structure. The subsoil to a depth of about 12 inches is also loam to silty clay loam with a light yellowish brown (10YR 6/4) colour, with a slightly sticky consistency, moderately developed fine subangular blocky structure and a few strong brown (7.5YR 5/6) and yellowish brown (10YR 5/4) mottles. Below this second horizon the soil changes to a light grey (5Y 6/1) or light olive grey (5Y 6/2) fine sandy clay loam with abundant strong brown (7.5 YR 5/6) and yellowish brown (10YR 5/4) mottles to 36 inches. Numerous mica flakes impregnate the subsoil.

Suitability Classification

Similar to the Merbau Patah Series, soils of the Akob Series are imperfectly drained. Thus, they are considered to be class II soils.

Use and Management

Rubber and oil palm are grown on these soils but because of the moist condition inherent in them the rubber trees do not attain high yields. Padi cultivation, however, would be suitable on these soils.

Miscellaneous Land Units

Besides soils with series names there are also tracts of lands in which the soils have not been classified into series but have been mapped in groups such as the Inland Swamp Association, the Local Alluvium - Colluvium Association, Disturbed Land and Steepland. This mapping device has been resorted to in order to group soils of varied characteristics which occur in such a complex pattern that it is not possible to separate them further on a reconnaissance survey of this nature.

Inland Swamp Association

In the large coastal depressions in the southern and north-western sections of the state, poor drainage conditions have resulted in the production and accumulation, through long periods of time, of relatively undecomposed plant remains called peat.

Around the edges of the peat swamps oxidation of the peat has resulted in the formation of muck which consists of between 35 and 65 percent of organic matter determined as the loss in weight after ignition for 1 hour at 750°C. The muck occurs in association with organic clays which contain less than 35 percent organic matter and more than 65 percent mineral material. Besides peat, mucks and organic clays, there are other less extensive inland swamps in which the waterlogged soils consist of mineral matter mainly; the textures of these soils vary widely from sands to clays. All these swamp soils of the inland areas have been mapped as the Inland Swamp Association.

Suitability Classification

The peats, organic clays and mucks and other inland swamp soils in their natural poorly drained condition are placed in class III.

Use and Management

Before the inland swamp soils can be considered for agricultural exploitation they should be drained properly. With the peats care should be taken not to lower the water-table too far down as peats are known to oxidize, on exposure to air, to a fine red or brown powder and this is an irreversible drying process.

Drainage of the mucks and organic clays in some cases should also be done in slow stages as speedy lowering of the water-table results in the oxidation of the sulphides in the soil to sulphates and particularly sulphuric acid which increases the acidity of the soil and makes it toxic to plants. Furthermore, the large amounts of aluminium brought into solution may result in aluminium toxicity (Wilshaw, 1940).

Pineapple is the only crop that has been grown successfully on peat in the area surveyed. Oil palm has also been grown with some success on shallow peat underlain by marine clay while organic clays and mucks have proved quite suitable for this crop. Rubber is the least suitable of the three crops on inland swamp soils mainly because of the high watertable associated with these soils. It is common to observe in such areas stunted rubber trees with their lateral roots exposed above the soil surface. Bark regeneration is also poor on rubber trees growing on the inland swamp soils.

Local Alluvium

The sediments deposited by streams and rivers (near their upper reaches) are so variable in profile characteristics that they have been collectively mapped as Local Alluvium.

These are juvenile soils which are constantly being renewed by the deposition of fresh sediments when the streams and rivers flood their banks; profile differentiation has not yet occurred in such fresh alluvium. Water-logging is common in these soils as they occur in the flats surrounding the rivers and streams. Textures range from clay to sand, depending on the situation of the soil on the flood plain; parent material and size of the streams or rivers also influence the texture of the soil in different localities though generally the coarser fractions are deposited near the source and the finer sediments further downstream.

Suitability Classification

For dryland crops Local Alluvium are class III soils because of the very poor to poor drainage conditions under which they occur. These conditions are, however, suitable for the cultivation of padi.

Use and Management

When properly drained Local Alluvium has been used for the cultivation of rubber, oil palm, bananas and other crops but always in conjunction with the development of more extensive soils which occur around them.

In poorly drained conditions such as at Beranang, Local Alluvium has been developed for padi cultivation.

Colluvium

At the base of hills and ridges it has been observed that the soils are not sedentary but have moved down from above and accumulated at the base of the hills and ridges. Normally such soils are more prominent where a stream flows in the valley between hills. It is suspected that the downward movement of the soil is due to the action of rain-water besides slumping. The soils found in such situations have been mapped as colluvium in association with the alluvium deposited by streams. Colluvium consists of an undifferentiated assortment of weathered rock material. Profile development may consist of an organic-stained topsoil overlying undifferentiated weathered mineral material.

Suitability Classification

As colluvium occurs at footslope positions it may be imperfectly to poorly drained. It would thus be a class II or III soil.

Use and Management

Where drainage conditions have been improved rubber, oil palm and fruit trees have been grown on colluvium but they are very limited in extent and are usually utilized in conjunction with the development of adjoining sedentary soils of wider extent.

Disturbed Land

Land that has been opened for mining or has been used for town sites has been mapped as disturbed land. Such land has very slight or no potential at all for large scale agriculture at the moment. Land that has been mined for tin is usually filled with slime or quartz sand and is in no condition for tree crops although vegetable gardening on a small scale is being practised on small patches of tin tailings. The main mining area is around Kuala Lumpur though a considerable proportion of land has also been disturbed on either side of the Kuala Lumpur - Tanjong Malim trunk road. All disturbed land is of class V suitability.

Steepland

All land with slopes above 20° have been classified as too steep for agricultural development although for heavy textured soils this slope limit could be extended to 35°. The soils on such land are shallow and juvenile. When exposed such land has been observed to erode rapidly. In the foothills region near the Main Range, steepland occurs above the 250 feet contour while at the Main Range slopes become steep between the 500 and the 750 feet contours. Away from the Main Range and foothills region steepland is found on the quartzite and schist hills and ridges at elevations as low as 150 feet above sea level. Because of their susceptibility to erosion when exposed steepland is best left under forest in line with a sound land use policy.

Extent of Series and Associations

Whenever possible the soils in the final map have been indicated as separate series; but in a survey of this nature it has only been possible to map groups of soil series in association. In table 5 the extent of the various soils are indicated either as separate series or as associations of series. For a soil series to be included in an association it has to occupy 10 per cent or more of the area mapped under the association.

TABLE 5

EXTENT OF SOIL SERIES AND ASSOCIATIONS

	Acreage
Rengam Series	89,573
Serdang - Munchong Association	78,875
Serdang - Munchong - Kedah Association	67,213
Serdang - Munchong - Seremban Association	59,885
Serdang - Kedah - Durian Association	23,482
Kedah - Serdang - Munchong Association	12,570
Kedah - Batu Anam - Durian Association	62,221
Munchong - Seremban Association	18,913
Tavy - Bungor Association	1,497
Malacca Series	2,335
Prang Series	3,738
Selangor - Kangkong Association	62,000
Selangor - Briah Association	245,384
Briah Series	27,000
Selangor - Telok Association	39,320
Merbau Patah - Akob Association	4,843
Jambu Series	883
Kranji Series	83,902
Kranji - Mangrove Swamp Association	40,698
Inland Swamp Association	542,200
Local Alluvium - Colluvium Association	48,214
Steepland	410,382
Disturbed Land	95,752
Total:	2,020,880

CONCLUSION

The Schematic Reconnaissance Soil Survey of Selangor indicates that this State is largely developed and, except for the peat swamps, has very limited extent of land suitable for future large scale development.

Of the 449,500 acres of undeveloped land, 210,000 acres occur in peat swamps in northwest Selangor, 127,000 acres in the peat swamps of the Kuala Langat (approximately 120,400 acres) and the Bukit Cherakah (approx. 6,600 acres) Forest Reserves. These are potential pineapple growing areas.

34,700 acres of sedentary soils which are eminently suitable for rubber cultivation and in parts may also be suitable for oil palm cultivation are situated in the Bukit Belata (approx. 14,000 acres), Bukit Badong (approx. 1,700 acres), Rantau Panjang (approx. 17,600 acres) and the Bangi (approx. 1,400 acres) Forest Reserves.

The mangrove swamps on the coastal fringe and the off shore islands are occupied by soils of the Kranji Series and the Mangrove Swamp Association. These swamps, presently under forest reserves, are the main sources of mangrove timber. They cover an area of about 77,800 acres. The soils occurring there, in their present waterlogged and saline conditions, are unsuitable for agriculture. But those soils occurring along the coastal fringe may in time be considered for agricultural exploitation because of their accessibility. Should this situation arise, it should be borne in mind that the amelioration of those soils will involve high drainage costs. But when bunded, and properly leached of excess salts, these soils can be cultivated with oil palm, coconuts, coffee and bananas, their suitability for the cultivation of these crops depending on the proportion of sand and shells to clay.

ACKNOWLEDGEMENTS

The author wishes to acknowledge his grateful thanks to Dr. Ng Siew Kee, Senior Soil Scientist, for his constant encouragement during the survey period and his constructive, critical comments of the draft report; to Mr. Law Wei Min, Soil Correlator for his valuable comments and corrections of the draft script; to Mr. W.P. Panton, Natural Resource Co-Ordinator, for his constructive comments of the draft script; to Mr. Chin Kim Wah, Soil Chemist and his laboratory staff for the mechanical and chemical analysis of soil samples; to the team of draughtsmen for the preparation of the soil and soil suitability maps and all the other staff members of the Soil Science Division who in one way or another helped to make it possible to complete the survey.

REFERENCES

Acton, C.J., (1963): Reconnaissance *Soil* Survey of the Northwest Selangor Swamp Region. (Unpublished Report.)

Burton, C.K., (1964): The Older Alluvium of Johore and Singapore. *J. Trop. Geography*, Vol. **18,** pp 30 - 42.

Coulter, J.K., (1950): Peat Formations in Malaya. *Malay. Agric. J.* Vol. **30,** pp. 63 - 81.

" (1956): The Kuala Langat (North) Forest Reserve. *Malay. Agric. J.* Vol. **39,** pp. 185 - 189.

" (1957): Development of the Peat Soils of Malaya. *Malay. Agric. J.* Vol. **40,** pp. 188 - 199.

Dale, W.L. (1959): Rainfall of Malaya, Part, I. *Jour. Trop. Geography* Vol. **13,** pp. 23 - 37.

" (1963): Surface temperatures in Malaya. *Jour. Trop. Geography* Vol. **17,** pp. 46 - 71.

Dennett, J.H., (1929): Preliminary Results of a Soil Survey in Selangor. *Malay. Agric. J.* Vol. **17,** No. 7.

" (1932): The Western Coastal Alluvial Soils. *Malay. Agric. J.* Vol. **20,** pp. 298 - 303.

Drainage & Irrigation Dept. Fed. of Malaya, (1961): Hydrological Data - Rainfall Records 1879 - 1958.

Gobbett, D.J., (1964): The Lower Paleozoic Rocks of Kuala Lumpur, Malaysia. *Federation Museums Journal*, Vol. **IX,** New Series. pp. 67 - 79.

Leamy, M.L. & Panton, W.P., (1966): Soil Survey Manual for Malayan Conditions. Division of Agriculture, Bull. No. **119.**

Ng Siew Kee, (1965): The Potassium Status of Some Malayan Soils. *Malay. Agric, J.* Vol. **45,** No. 2.

Null, W.S., Acton, C.J., & Wong, I.F.T., (1965): Reconnaissance Soil Survey of Southern Johore. Malayan Soil Survey Report No. 1/1965.

Panton, W.P., (1964): The 1962 Soil Map of Malaya. *J. Trop. Geog.* Vol. **18,** pp. 118 - 124.

Panton, W.P., (1965): Types of Malayan laterite and factors affecting their distribution. 6th International Congress of Soil Science, Paris.

Richardson, J.A., (1947): An Outline of the Geomorphological Evolution of British Malaya.
Geological Magazine Vol. LXXXIV, pp. 129 - 144.

Roe, F.W. (1951): Geology and Mineral Resources of the Fraser's Hill AreaSelangor, Perak, Pahang.
Federation of Malaya, Geol. Survey Memoir No. 5.

" (1953): Geology and Mineral Resources of the Neighbourhood of Kuala Selangor and Rasa, Selangor.
Federation of Malaya, Geol. Survey Memoir No. 7.

Rosenquist, E.A., (1964): Soils and the fertilization of Rubber & Oil Palm.
J. Trop. Geog. Vol. **18,** pp. 148 - 156.

Scrivenor, J.B. & Jones, W.R., (1919): The Geology of South Perak, North Selangor, and the Dindings. Geological Dept Federated Malay States.

Smallwood, H.A., (1965): Reconnaissance - Schematic Soil Survey of the Kluang-Muar-Labis Region of Johore. Malayan Soil Survey Report No. 2/1965.

Soil Survey Staff, (1951): Soil Survey Manual. U.S. Dept. Agriculture Hand-book No. **18.**

Willbourn, E.S., (1922): An account of the geology and mining industries of South Selangor and Negri Sembilan. Geolo- gical Dept. Federated Malay States.

Wilshaw, R.G.H., (1940): Note on the Development of high acidity incerta in coastal clay soils of Malaya. *Malay Agric. J.* Vo.l **28.**

Wong, I.F.T., (1970): A Soil Suitability Classification for Malaysia. Soil Science Division, Department of Agriculture, Kuala Lumpur.

World Soil Resources Report, 12, (1964): Preliminary Definitions. Legend and Correlation Tablefor the Soil Map of the World. FAO/ UNESCO Project.

Wyatt - Smith, J., (1964): A Preliminary vegetation map of Malaya with descriptions of the vegetation types. *J. Trop. Geog.* Vol. **18.**

APPENDIX I

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.

Easily soluble potassium was determined by extraction in N/2 acetic acid (ratio 10:1) followed by estimation in the lange flame photometer.

Organic phosphorus was determined by finding the difference between the phosphorus content of an ignited 0.3N NaOH extract and an un-ignited extract.

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.

Soil samples were also digested in 6N hydrochloric acid for 8 hours after ignition at 450°C for 2 hours. This method was used for the determination of iron, calcium and magnesium besides the more resistant forms of phosphorus and potassium.

Rengam Series

Location: About 5 chains past 11¼ milestone on the Serdang - Balakong Road.

Grid Reference: 94 - 667823

Topography: 11° slope in hilly country.

Landform: Dissected peneplain.

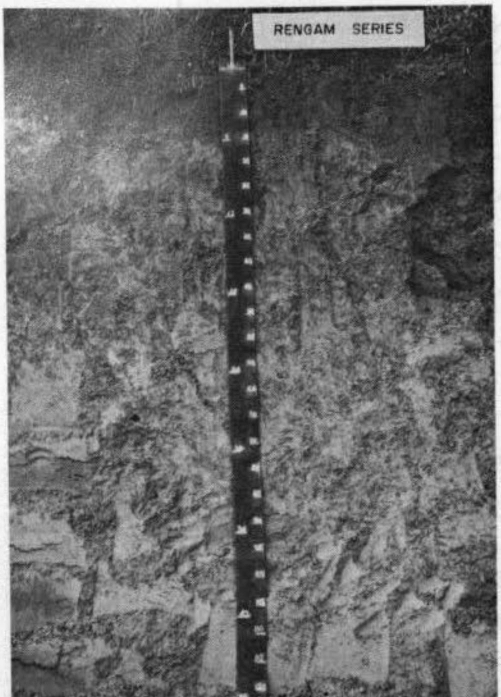
Elevation: 50 feet a.s.l.

Vegetation Belukar

Drainage: Well drained.

Parent Material: Granite.

Soil Profile:



Ah 0 to 6 inches (0-15cm): dark greyish brown (10YR 4/2) sandy clay loam; friable weak fine subangular blocky; abundant roots; boundary distinct.

Ae 6 to 16 inches (15-40cm); brownish yellow (10YR 6/6) sandy clay; friable to firm; moderate medium subangular blocky; few roots; many pores; patchy to discontinuous greyish brown (10YR 5/2) clayskins; boundary diffuse.

Bt 16 to 48+ inches (40-120 +cm); brownish yellow (10YR 6/8) to reddish yellow (7.5YR 6/8) sandy clay; friable to firm; moderate medium subangular blocky; few pores; discontinuous to almost continuous light greyish brown (10YR 6/4) clayskins.

Analysis of Rengam Series

Depth	%				On original sample %			%				Easily soluble p.p.m.				Exchangeable cations m.e./100g.					6N HCl soluble				
ins. (cm)	Clay	Silt	Fine sand	Coarse sand	Gravel	Stones	pH	Loss on ignition	Carbon	Nitrogen	C/N ratio	P N/10 NaOH	P Organic	K N/2 CH3COOH	C.E.C. m.e./100g.	K	Ca	Na	Mg	% Saturation	P (p.p.m.)	Fe_2O_3 (%)	K (m.e./100g.)	Ca (m.e./100g.)	Mg (m.e./100g.)
0-6 (0-15)	36	6	36	24	Nil	Nil	4.6	6	0.87	0.06	14.50	35	22	7	7.41	0.02	0.21	0.06	0.16	6	187	1.71	4.73	3.24	3.54
6-16 (15-40)	45	6	29	24	”	”	4.5	6	0.51	0.02	25.50	32	11	tr.	5.86	0.02	0.16	0.06	0.10	6	142	1.87	5.93	4.86	0.80
16-48+ (40-120+)	47	6	29	23	”	”	4.6	6	0.33	0.02	16.50	31	n.d.	tr.	5.52	0.02	0.16	0.04	0.10	6	—	—	—	—	—

n.d. = not determined.

tr. = trace.

Serdang Series

Location: Serdang Agriculture Experimental Station. Pit situated about 2 chains beyond cocoa plot.

Grid Reference: 94 - 627789

Topography: 20° slope in rolling to hilly terrain.

Landform: Dissected peneplain.

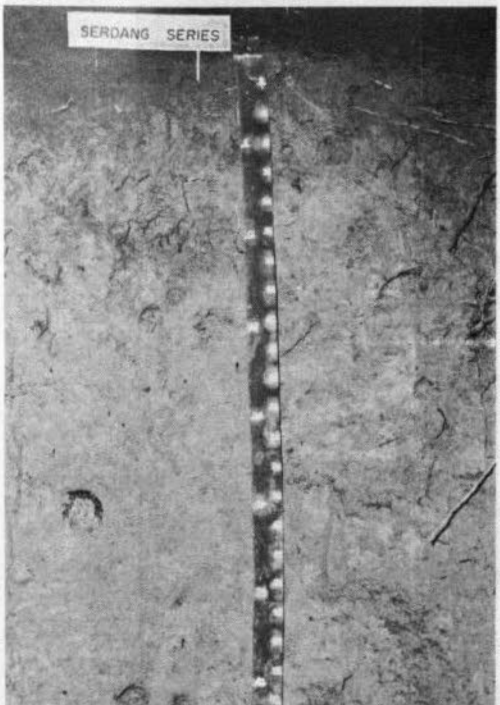
Elevation: 250 feet a.s.l.

Vegetation: Secondary forest.

Drainage: Well drained.

Parent Material: Quartzite.

Soil Profile:



Ah — 0 to 2½ inches (0-6cm); dark yellowish brown; (10 YR 4/4) sandy loam; friable to firm; moderate medium subangular blocky; many roots and ant casts; many pores; boundary distinct.

Btj — 2½ to 24 inches (6-60cm); yellowish brown (10YR 5/8) sandy clay loam; friable; moderate medium subangular blocky; many roots; many pores; patchy clayskins; boundary indistinct.

Bt — 24 to 49 inches (60-123cm); yellowish brown (8.5YR 5/8) sandy clay loam; friable to firm; moderate medium subangular to angular blocky; few earthworm channels, roots and ant nests; many pores; patchy clayskins mainly along root and ant channels.

Analysis of Serdang Series

Depth	%				On original sample %			%				Easily soluble p.p.m.				Exchangeable cations m.e./100g.					6N HCl soluble				
ins (cm)	Clay	Silt	Fine sand	Coarse sand	Gravel	Stones	pH	Loss on ignition	Carbon	Nitrogen	C/N ratio	P N/10 NaOH	P Organic	K N/2 CH3COOH	C.E.C. m.e./100g.	K	Ca	Na	Mg	% Saturation	P (p.p.m.)	Fe_2O_3 (%)	K (m.e./100g.)	Ca (m.e./100g.)	Mg (m.e./100g.)
0-2½ (0-6)	28	4	45	25	Nil	Nil	4.8	5	1.08	0.09	12.0	24	21	30	8.79	0.07	0.16	0.01	0.37	7	122	2.40	2.96	3.57	4.66
2½-24 (6-60)	38	6	36	25	”	”	5.1	5	0.42	0.03	14.0	15	12	26	6.55	0.07	0.05	0.01	0.21	5	131	3.58	3.74	3.57	6.10
24-49 (60-123)	38	9	35	23	”	”	5.1	6	0.27	0.03	9.0	14	—	10	5.34	0.04	0.16	0.01	0.10	6	—	—	—	—	—

Munchong Series

Location: About 10 chains beyond the boundary of the Ulu Caledonian Estate on a track leading to Kali Tin Mine.

Grid Reference: 3 B/11 - 510336

Topography: 7° slope in undulating terrain.

Landform: Dissected peneplain.

Elevation: 100 feet a.s.l.

Vegetation: Belukar.

Drainage: Well drained.

Parent Material: Indurated shale with vein quartz.

Soil Profile:

Ah 0 to 4 inches (0-10cm); very dark grey (10YR 3/1) clay loam; friable; moderate medium crumb and weak fine subangular blocky; numerous roots; boundary distinct.

Btj 4 to 28 inches (10-70cm); yellowish brown (10YR 5/5) fine sandy clay loam; friable; moderate medium subangular blocky; many roots; many pores and discontinuous pale brown (10YR 6/3) clayskins on structure faces; boundary indistinct.

Bt 28 to 45 inches (70-113cm); yellowish brown (10YR 5/5) clay loam; friable to firm; moderate medium subangular blocky; many roots; many pores and discontinuous pale brown (10YR 6/3) clayskins on structure faces; few quartz gravels; boundary indistinct.

BC 45 to 60 inches (113-150cm); reddish yellow (7.5YR 6/6) clay loam; friable to firm; moderate medium subangular blocky; few roots; few pores; almost continuous pale brown (10YR 6/3) clayskins; few quartz gravels; iron coated shale and quartz pebbles embedded in the clay loam matrix.

Analysis of Munchong Series

Depth	%				On original sample %			%				Easily soluble p.p.m.				Exchangeable cations m.e./100g.					6N HCl soluble				
(cm) ins.	Clay	Silt	Fine sand	Coarse sand	Gravel	Stones	pH	Loss on ignition	Carbon	Nitrogen	C/N ratio	N/10 NaOH P	Organic P	N/2 CH3COOH K	C.E.C. m.e./100g.	K	Ca	Na	Mg	% Saturation	P (p.p.m.)	Fe_2O_3 (%)	K (m.e./100g.)	Ca (m.e./100g.)	Mg (m.e./100g.)
0-4 (0-10)	33	24	33	12	Nil	Nil	4.4	7.9	1.99	0.17	11.70	142	88	82	20.04	0.18	0.26	0.02	0.47	5	241	3.03	9.83	3.24	9.48
4-28 (10-70)	33	24	33	11	”	”	4.4	5.0	0.58	0.06	9.67	46	26	65	13.82	0.04	0.05	0.01	0.10	1	131	3.03	10.76	4.54	8.52
28-45 (70-113)	35	26	32	10	”	”	4.4	4.9	0.49	0.05	9.80	6	—	12	11.58	0.02	0.05	0.01	0.21	2	—	—	—	—	—
45-60 (113-150)	33	26	31	11	”	”	4.4	4.5	0.30	0.04	7.50	Nil	—	12	9.85	0.02	0.05	0.01	0.21	3	—	—	—	—	—

Kedah Series

Location: About 5 chains beyond the boundary of Sg. Tamu Estate.

Grid Reference: 3 B/11 - 633356

Topography: 17° slope in hilly to steep terrain.

Landform: Dissected peneplain.

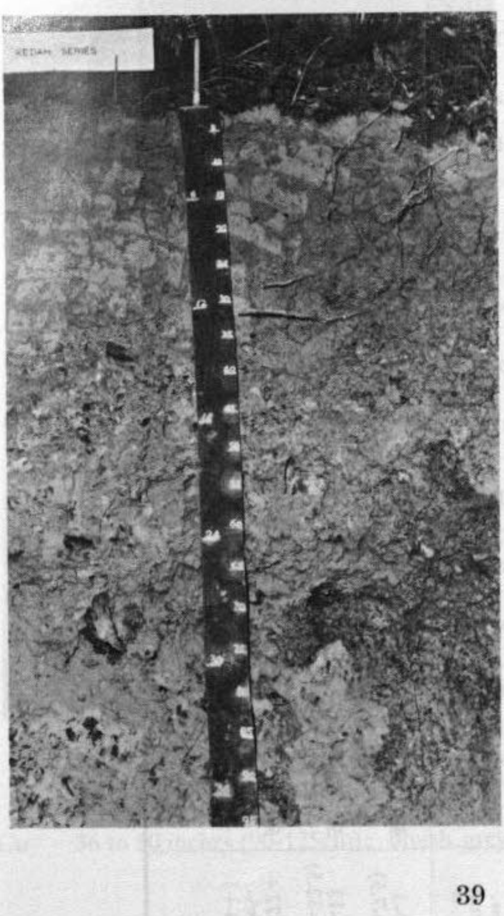
Elevation: Approximately 250 feet a.s.l.

Vegetation: Belukar and smallholder's old rubber.

Drainage: Well drained.

Parent Material: Fine sandy shale intercalated with quartzite.

Soil Profile:



Ah	0 to 3 inches (0-7.5 cm); greyish brown (10YR 5/2) fine sandy clay loam; friable to firm; moderate medium crumb and weak fine subangular blocky; numerous roots; few ant channels; very few pores; boundary distinct.
Btcnj	3 to 13 inches (7.5-32.5cm); light yellowish brown (10 YR 6/5) fine sandy clay to fine sandy clay loam; firm; strong coarse angular blocky; few roots; 2 ant cavities; very few pores; discontinuous light brownish grey (10YR 6/2) clayskins along structure faces; few pisolitic laterite pebbles; boundary distinct.
BC	13 to 72 inches (32.5-184 cm); light yellowish brown (10YR 6/4) gravelly clay; firm; moderate to strong medium to coarse angular blocky; patchy light grey (10YR 7/1.5) clayskins on structure faces; pebbles of quartz and indurated fine sandy shale embedded in the gravelly clay matrix.

Analysis of Kedah Series

Depth	%				On original sample %			%				Easily soluble p.p.m.				Exchangeable cations m.e./100g.					6N HCl soluble				
ins. (cm)	Clay	Silt	Fine sand	Coarse sand	Gravel	Stones	pH	Loss on ignition	Carbon	Nitrogen	C/N ratio	P N/10 NaOH	P Organic	K N/2 CH3COOH	C.E.C. m.e./100g.	K	Ca	Na	Mg	% Saturation	P (p.p.m.)	Fe_2O_3 (%)	K (m.e./100g.)	Ca (m.e./100g.)	Mg (m.e./100g.)
0-3 (0-7.5)	47	14	29	12	1.25	Nil	4.7	9.4	1.75	0.25	7.0	75	53	80	13.65	0.54	0.21	0.08	0.37	9	214	1.69	10.76	2.76	5.79
3-13 (7.5-32.5)	57	14	22	9	0.94	,,	4.5	8.3	0.70	0.14	5.0	27	24	40	9.16	0.07	0.05	0.06	0.31	5	203	2.37	14.40	4.70	5.46
13-72+ (32.5-184+)	55	14	22	11	4.81	0.36	4.6	7.3	0.36	0.09	4.0	Nil	—	35	7.08	0.07	0.05	0.06	0.26	6	187	10.50	5.35	4.34	2.16

Batu Anam Series

Location: West Country Estate, Sungai Chua Division.

Grid Reference: 94 - 664764

Topography: 4° slope in undulating terrain.

Landform: Dissected peneplain.

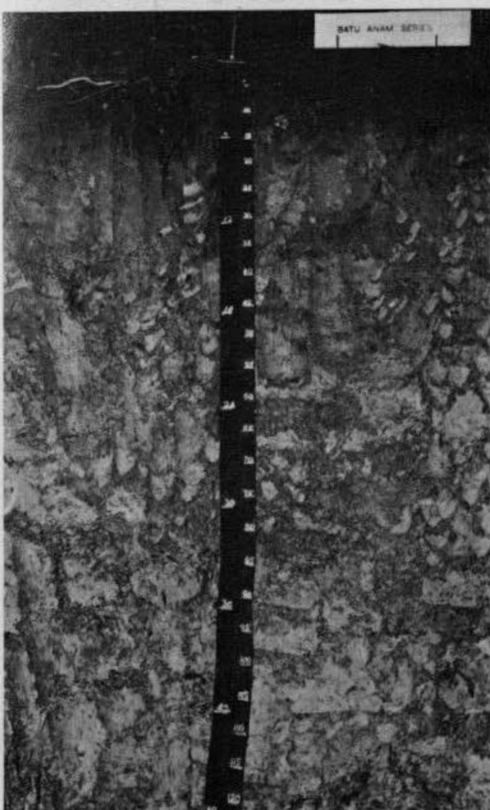
Elevation: 250 feet a.s.l.

Vegetation: Newly tapped rubber.

Drainage: Moderately well drained.

Parent Material: Silty shale.

Soil Profile:



Aeh 0 to 6 inches (0-15cm); brown (10YR 5/3) fine sandy clay; firm; moderate medium subangular blocky; numerous roots, ant casts and channels; very few pores and patchy greyish brown (10YR 5/2) clayskins; boundary distinct.

Bt 6 to 22 inches (15-55cm); brownish yellow (10YR 6.5/6) silty clay with irregular white (10YR 8/0) patches; firm to compact; moderate to strong medium subangular to angular blocky; few roots; few pores; discontinuous light yellowish brown (10YR 6/4) clayskins; few medium distinct yellowish brown (10YR 5/8) mottles; boundary distinct.

BCm 22 to 36 inches (55-90cm); white (10YR 8/0) silty clay; firm to compact; moderate to strong subangular to angular blocky; very few pores; discontinuous brownish yellow (10YR 6.5/6) clayskins; many large indistinct yellowish red (5YR 5/8) mottles; quartz gravels from a disintegrated quartz vein; boundary indistinct.

Cu 36 to 50 inches (90-125cm); bluish grey silty shale with a metallic sheen.

Analysis of Batu Anam Series

Depth	%				On original sample %			%				Easily soluble p.p.m.				Exchangeable cations m.e./100g.					6N HCl soluble				
ins (cm)	Clay	Silt	Fine sand	Coarse sand	Gravel	Stones	pH	Loss on ignition	Carbon	Nitrogen	C/N ratio	P N/10 NaOH	P Organic	K N/2 CH3COOH	C.E.C. m.e./100g.	K	Ca	Na	Mg	% Saturation	P (p.p.m.)	Fe_2O_3 (%)	K (m.e./100g.)	Ca (m.e./100g.)	Mg (m.e./100g.)
0-6 (0-15)	36	15	30	18	1.4	Nil	4.7	6.1	1.11	0.09	12.33	73	30	31	9.14	0.09	0.31	0.10	0.26	8	285	2.63	6.76	5.02	2.41
6-22 (15-55)	53	16	21	9	0.4	0.4	4.5	6.4	0.43	0.05	8.60	62	6	6	8.62	0.04	0.16	0.10	0.10	5	257	1.79	8.58	5.51	3.86
22-36 (55-90)	36	27	23	16	3.2	1.1	4.5	5.4	0.18	0.02	9.00	42	—	6	5.52	0.02	0.16	0.04	0.10	6	—	—	—	—	—
36-50 (90-125)	28	31	25	19	0.7	0.6	4.6	4.8	0.06	0.02	3.00	36	—	tr.	4.31	0.02	0.16	0.04	0.10	7	—	—	—	—	—

tr. = trace.

Malacca Series

Location: Laterite quarry at the entrance to Serdang Agriculture Experimental Station.

Grid Reference: 94 - 659794

Topography: 3° slope in undulating terrain.

Landform: Dissected peneplain.

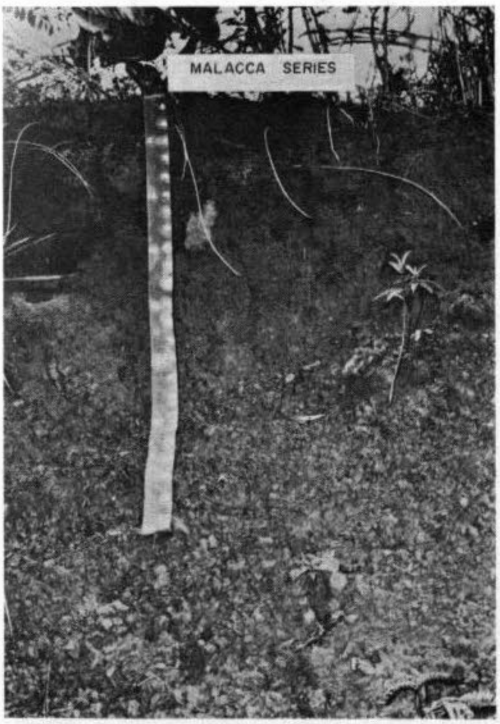
Elevation: 150 feet a.s.l.

Vegetation: Belukar.

Drainage: Well drained.

Parent Material: Shale

Soil Profile:



Ah 0 to 3 inches (0-7.5 cm); dark brown (10YR 4/3) clay loam; friable; moderate medium crumb and weak fine subangular blocky; abundant roots; boundary diffuse.

Bt 3 to 15 inches (7.5-37.5cm); reddish brown (5YR 4/4) clay loam; friable; moderate medium subangular blocky; many roots; many pores; discontinuous dark brown (10YR 4/3) clayskins on structure faces; few quartz gravels; boundary distinct.

Btcn 15 to 36+ inches (37.5-90+cm); reddish brown (5YR 4/4) clay; many fine roots; partially cemented laterized shale pebbles. This layer continues to 6 feet.

Analysis of Malacca Series

Depth	%				On original sample %			%				Easily soluble p.p.m.				Exchangeable cations m.e./100g.					6N HCl soluble				
ins. (cm)	Clay	Silt	Fine sand	Coarse sand	Gravel	Stones	pH	Loss on ignition	Carbon	Nitrogen	C/N ratio	P N/10 NaOH	P Organic	K N/2 CH3COOH	C.E.C. m.e./100g.	K	Ca	Na	Mg	% Saturation	P (p.p.m.)	Fe_2O_3 (%)	K (m.e./100g.)	Ca (m.e./100g.)	Mg (m.e./100g.)
0-3 (0-7.5)	67	8	14	11	1.44	Nil	4.9	17	2.34	0.16	14.63	107	90	46	13.96	0.16	1.10	0.14	0.63	15	235	15.40	2.55	5.19	1.61
3-15 (7.5-37.5)	73	9	11	10	3.43	"	5.0	16	0.78	0.07	11.14	75	38	7	8.62	0.04	0.37	0.14	0.05	7	268	17.15	2.55	3.40	4.34
15-36+ (37.5-90+)	75	11	8	7	37.76	48.52	5.0	16	0.69	0.07	9.85	64	—	7	5.52	0.04	0.16	0.12	0.21	10	—	—	—	—	—

Prang Series

Location: About 5 chains past a sharp bend of the road leading from Prang Besar Estate Office to Bukit Prang Estate.

Grid Reference: 94 - 622702.

Topography: 12° slope in rolling terrain.

Landform: Dissected peneplain.

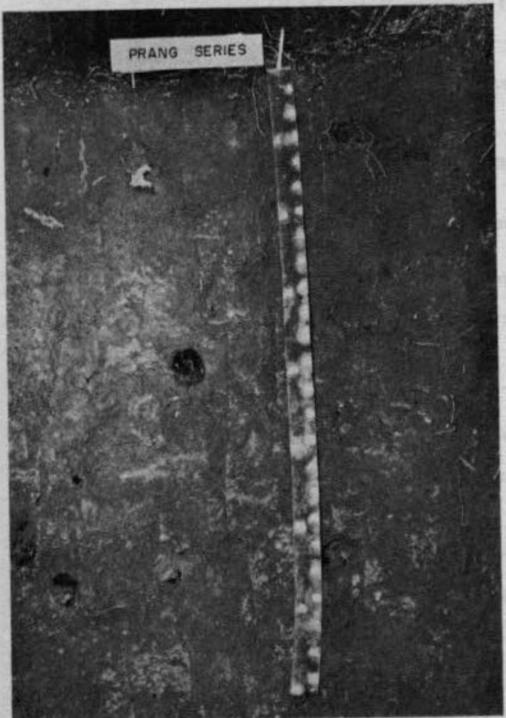
Elevation: about 100 feet a.s.l.

Vegetation: Grass and old rubber.

Drainage: Well drained.

Parent Material: Schist.

Soil Profile:



Od — Very thin litter layer consisting of decomposing rubber leaves and twigs.

AB — 0 to 12 inches (0-30cm); yellowsih red (5YR 4/8) clay; friable; moderate fine subangular blocky; abundant roots; few ant casts; few pores; patchy clayskins with a metallic sheen; boundary indistinct.

Bt — 12 to 48+ inches (30-120 +cm); yellowish red (5YR 4/8) clay; friable to firm; moderate medium subangular blocky; few roots; few pores; discontinuous weak red (2.5YR4/2) clayskins on structure faces.

Analysis of Prang Series

Depth	%				On original sample %			%				Easily soluble p.p.m.				Exchangeable cations m.e./100g.					6N HCl soluble				
ins. (cm)	Clay	Silt	Fine sand	Coarse sand	Gravel	Stones	pH	Loss on ignition	Carbon	Nitrogen	C/N ratio	P N/10 NaOH	P Organic	K N/2 CH3COOH	C.E.C. m.e./100g.	K	Ca	Na	Mg	% Saturation	P (p.p.m.)	Fe_2O_3 (%)	K (m.e./100g.)	Ca (m.e./100g.)	Mg (m.e./100g.)
0-12 (0-30)	77	4	12	4	Nil	Nil	4.4	14.0	1.20	0.10	12.00	84	44	12	10.86	0.02	0.21	0.04	0.10	3	332	15.36	1.09	4.70	1.13
12-48+ (30-120+)	85	3	2	2	,,	,,	4.5	13.0	0.61	0.05	12.20	52	30	6	7.41	0.02	0.16	0.04	0.10	4	214	15.36	1.09	3.89	4.50

Seremban Series

Location: Sg. Tangkas Estate. Approximately ½ mile past a gravel quarry near the entrance of the estate.

Grid Reference: 94 - 751722

Topography: 10° slope in rolling country.

Landform: Dissected peneplain.

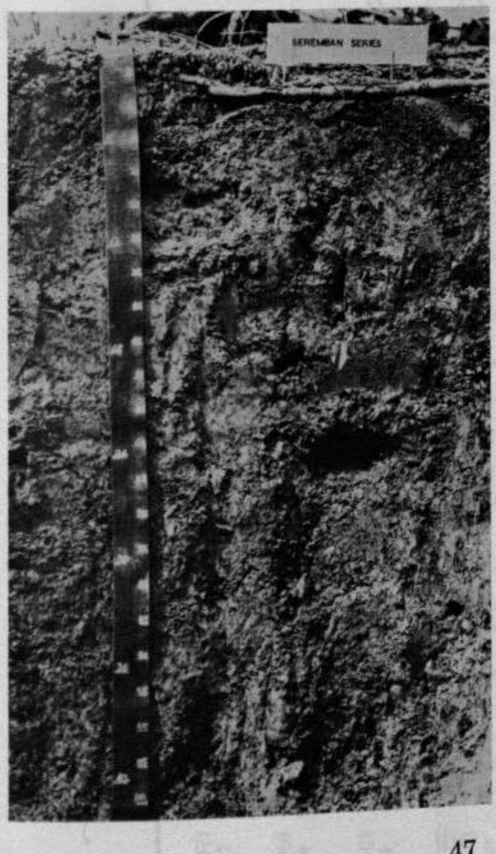
Elevation: 150 feet a.s.l.

Vegetation: Old rubber being felled for replanting.

Drainage: Well drained.

Parent Material: Schist.

Soil Profile:



Ah 0 to 4 inches (0-10cm); yellowish brown (10YR 5/4) fine sandy clay to fine sandy clay loam; friable to firm; moderate to strong medium crumb, numerous roots; boundary distinct.

Bt 4 to 24 inches (10-60cm); reddish yellow (8.5YR 6/6) fine sandy clay; friable; moderate medium subangular blocky; many roots; many pores; discontinuous clayskins very pale brown (10YR 7/3); boundary distinct.

Bticn 24 to 42 inches (60-105cm); reddish yellow (8.5YR 6/6) fine sandy clay; friable to firm; with abundant rounded and platy iron coated schist pebbles.

Analysis of Seremban Series

Depth	%				On original sample %			%				Easily soluble p.p.m.				Exchangeable cations m.e./100g.					6N HCl soluble				
ins (cm)	Clay	Silt	Fine sand	Coarse sand	Gravel	Stones	pH	Loss on ignition	Carbon	Nitrogen	C/N ratio	P N/10 NaOH	P Organic	K N/2 CH3COOH	C.E.C. m.e./100g.	K	Ca	Na	Mg	% Saturation	P (p.p.m.)	Fe_2O_3 (%)	K (m.e./100g.)	Ca (m.e./100g.)	Mg (m.e./100g.)
0-4 (0-10)	45	9	35	15	1	Nil	4.7	8	1.29	0.11	11.72	128	—	24	11.92	0.04	0.16	0.02	0.26	4	167	4.11	1.30	2.59	3.68
4-24 (10-60)	56	6	30	10	2	,,	4.6	8	0.59	0.06	9.83	123	—	7	9.33	0.02	0.05	0.01	0.10	2	165	7.15	1.30	5.83	3.04
24-42 (60-105)	60	14	21	10	21	22	4.7	9	0.44	0.05	8.80	122	—	7	8.98	0.02	0.16	0.01	0.05	3	169	1.29	1.87	4.05	1.44

Selangor Series

Location: Selangor River Estate, about ¼ mile south of the 43rd milestone of the Kampong Kuantan-Batang Berjuntai road.

Grid Reference: 3 B/10 - 167224

Topography: 0° slope in flat terrain.

Landform: coastal plain.

Elevation: Less than 50 feet a.s.l.

Vegetation: Recently cleared of old rubber.

Drainage: Imperfectly drained.

Parent Material: Marine alluvium.

Soil Profile:

Ah 0 to 9 inches (0-22.5 cm); dark grey (10YR 3.5/1) silty clay; friable; moderate medium subangular blocky and weak medium granular; many fine roots; boundary distinct.

Btg 9 to 44 inches (22.5-110cm); light brownish grey (10YR 6/2) silty clay; slightly sticky; moderate medium subangular blocky; few roots; discontinuous clay-skins on structure faces; few quartz gravels; many medium distinct pink (7.5 YR 7/4) mottles; boundary diffuse.

BCg 44+ inches (110+cm); greyish brown (10YR 5/1.5) clay; sticky; weak coarse subangular blocky; few roots; many medium distinct dark grey (10YR 4/1) grey spots.

Analysis of Seremban Series

Depth	%				On original sample %			%				Easily soluble p.p.m.				Exchangeable cations m.e./100g.					6N HCl soluble				
ins (cm)	Clay	Silt	Fine sand	Coarse sand	Gravel	Stones	pH	Loss on ignition	Carbon	Nitrogen	C/N ratio	P N/10 NaOH	P Organic	K N/2 CH3COOH	C.E.C. m.e./100g.	K	Ca	Na	Mg	% Saturation	P (p.p.m.)	Fe_2O_3 (%)	K (m.e./100g.)	Ca (m.e./100g.)	Mg (m.e./100g.)
0-4 (0-10)	45	9	35	15	1	Nil	4.7	8	1.29	0.11	11.72	128	—	24	11.92	0.04	0.16	0.02	0.26	4	167	4.11	1.30	2.59	3.68
4-24 (10-60)	56	6	30	10	2	"	4.6	8	0.59	0.06	9.83	123	—	7	9.33	0.02	0.05	0.01	0.10	2	165	7.15	1.30	5.83	3.04
24-42 (60-105)	60	14	21	10	21	22	4.7	9	0.44	0.05	8.80	122	—	7	8.98	0.02	0.16	0.01	0.05	3	169	1.29	1.87	4.05	1.44

Selangor Series

Location: Selangor River Estate, about ¼ mile south of the 43rd milestone of the Kampong Kuantan-Batang Berjuntai road.

Grid Reference: 3 B/10 - 167224

Topography: 0° slope in flat terrain.

Landform: coastal plain.

Elevation: Less than 50 feet a.s.l.

Vegetation: Recently cleared of old rubber.

Drainage: Imperfectly drained.

Parent Material: Marine alluvium.

Soil Profile:

Ah	0 to 9 inches (0-22.5 cm); dark grey (10YR 3.5/1) silty clay; friable; moderate medium subangular blocky and weak medium granular; many fine roots; boundary distinct.
Btg	9 to 44 inches (22.5-110cm); light brownish grey (10YR 6/2) silty clay; slightly sticky; moderate medium subangular blocky; few roots; discontinuous clay-skins on structure faces; few quartz gravels; many medium distinct pink (7.5 YR 7/4) mottles; boundary diffuse.
BCg	44+ inches (110+cm); greyish brown (10YR 5/1.5) clay; sticky; weak coarse subangular blocky; few roots; many medium distinct dark grey (10YR 4/1) grey spots.

Analysis of Selangor Series

Depth	%				On original sample %			%				Easily soluble p.p.m.				Exchangeable cations m.e./100g.					6N HCl soluble				
ins. (cm)	Clay	Silt	Fine sand	Coarse sand	Gravel	Stones	pH	Loss on ignition	Carbon	Nitrogen	C/N ratio	P N/10 NaOH	P Organic	K N/2 CH3COOH	C.E.C. m.e./100g.	K	Ca	Na	Mg	% Saturation	P (p.p.m.)	Fe_2O_3 (%)	K (m.e./100g.)	Ca (m.e./100g.)	Mg (m.e./100g.)
0-9 (0-22.5)	65	25	4	1	Nil	Nil	3.9	10	1.26	0.17	7.41	76	117	46	24.83	0.24	0.16	0.17	0.42	4	320	1.76	8.32	4.86	10.61
9-44 (22.5-110)	74	19	2	1	"	"	3.7	9	0.75	0.07	10.71	36	8	71	26.03	0.30	0.16	0.14	0.42	7	174	2.63	12.84	6.65	7.31
44+ (110+)	68	18	6	3	"	"	3.4	13	3.30	0.10	33.00	40	—	92	33.44	0.37	0.16	0.14	1.21	6	—	—	—	—	—

Briah Series

Location: North east corner of Selangor River Estate about one chain south of the main road.

Grid Reference: 3 B/10 - 199224

Topography: 0° slope in flat terrain.

Landform: River terrace

Elevation: Less than 50 feet a.s.l.

Vegetation: Mature rubber.

Drainage: Imperfectly drained.

Parent Material: Riverine alluvium over marine alluvium.

Soil Profile:

Ah 0 to 6 inches (0-15cm); dark brown (7.5YR 4/2) silty clay; slightly sticky; weak fine subangular blocky; numerous roots and few earthworm channels; very few pores; boundary diffuse.

Aeg 6 to 18 inches (15-45cm); light grey (5Y 7/2) silty clay; slightly sticky; weak fine subangular blocky; many roots; few pores and patchy to discontinuous clayskins; few medium distinct reddish yellow (7.5YR 7/6) mottles; boundary distinct.

Btg 18 to 30 inches (45-75cm); greyish brown (10YR 4/2) silty clay; sticky; strong coarse prismatic breaking to weak medium angular blocky; few roots and decayed plant remains; many pores; clayskins along root channels; many medium distinct reddish yellow (7.5YR 7/6) mottles; boundary distinct.

Cg 30 to 36+ inches (75-90 +cm); grey (5Y/5/1.5) silty clay; sticky; moderate coarse subangular blocky; few roots and decayed plant remains; few pores; few medium faint strong brown (57YR 5/6) mottles; faint sulphurous odour.

Analysis of Briah Series

Depth	%				On original sample %			%				Easily soluble p.p.m.				Exchangeable cations m.e./100g.					6N HCl soluble				
ins (cm)	Clay	Silt	Fine sand	Coarse sand	Gravel	Stones	pH	Loss on ignition	Carbon	Nitrogen	C/N ratio	P N/10 NaOH	P Organic	K N/2 CH3COOH	C.E.C. m.e./100g.	K	Ca	Na	Mg	% Saturation	P (p.p.m.)	Fe_2O_3 (%)	K (m.e./100g.)	Ca (m.e./100g.)	Mg (m.e./100g.)
0-6 (0-15)	58	32	3	tr.	Nil	Nil	4.0	12	2.82	0.26	10.84	75	154	39	22.76	0.12	0.21	0.12	0.37	4	415	2.19	8.84	4.86	14.71
6-18 (15-45)	65	29	1	"	"	"	3.9	8	0.51	0.06	8.50	22	6	39	20.52	0.12	0.16	0.12	0.37	4	187	2.31	9.36	3.89	13.50
18-30 (45-75)	61	32	2	"	"	"	3.9	9	1.05	0.10	10.50	24	—	32	21.20	0.11	0.16	0.17	1.31	8	—	—	—	—	—
30-36+ (75-90+)	61	30	5	"	"	"	4.3	9	1.05	0.09	11.66	26	—	46	24.48	0.16	0.37	0.17	3.30	16	—	—	—	—	—

tr. = trace.

APPENDIX II

A Soil Suitability Classification for Malaysia

The soil suitability classification presented here is an abbreviated version of the more detailed orginal (Wong, 1970). The criteria used and the method of classification are, however, the same as those indicated in the more detailed classification. This scheme of classification takes into consideration all crops, that is, perennial (tree) crops and padi (wet land) cultivation besides arable farming as forms of land use.

The broad outline of this classification is indicated below together with the parameters, as shown in table 6, by which the soils of the state have been classified.

Class I. **Soils with no limitation or one or more minor limitations to crop growth**

The soils in Class I are suitable for the widest range of crops. They can be profitably cultivated under a moderate level of management. These soils occur on flat to rolling terrain (0° - 12°). They have good water-holding and nutrient-retaining capacities and are well suited to continuous cropping on a sustained yield basis.

The most versatile soils in this class are those found in flat areas where they can be utilized for a very wide range of dryland crops or irrigated for padi cultivation; these are deep, well structured soils with a very high clay content.

Class II. **Soils with one or more moderate limitation to crop growth**

These soils are suitable for a narrower range of crops than Class I soils. A moderate level of management is necessary to obtain economic returns from crops grown on them. Management practices may include erosion control measures, minor drainage and irrigation works, or improvements in the air and water relations.

Class III. **Soils with one serious limitation to crop growth**

As these soils possess one serious limitation besides possibly one or more moderate limitations, they are restricted to a narrow range of crops. Even so, a high standard of management is necessary to develop or conserve them for long term crop cultivation. Necessary management practices may include erosion control measures, an intensive fertilizer programme and/or drainage and irrigation works involving moderate expense.

Class IV. **Soils with more than one serious limitation to crop growth**

In having more than one serious limitation these soils are limited to a very narrow range of crops, often only to specific crops. Even though the choice of crops is very narrow, the level of management for these soils has to be increased if their continuing productivity is to be maintained. Major conservation or amelioration measures are necessary before these soils can be cultivated on a long term basis.

Class V. **Soils with at least one very serious limitation to crop growth.**

The soils included within this class, in their present condition, are the least suitable for crop growth. Where they are not built over for urban development or excavated for mining and quarrying purposes they are best allowed to continue under primary or regenerating forest.

TABLE 6. LIMITATIONS TO CROP GROWTH

SYMBOL	TYPE	VERY SERIOUS	SERIOUS	MODERATE	MINOR
G	GRADIENT	>20° or 25° slopes with light textured soils	12°-20° or 25° slopes with light textured soils	6°-12° slopes with light textured soils	2°-6° slopes with light textured soils
	AND	or	or	or	or
g	TEXTURE	>35° slopes with heavy textured soils	20° or 25°-35° slopes with heavy textured soils	12°-20° or 25° slopes with heavy textured soils	2°-12° slopes with heavy textured soils
d	DRAINAGE	—	Very poorly to poorly drained	Imperfectly drained or Excessively drained	Somewhat excessively drained
c	DEPTH TO STRONGLY COMPACTED LAYER	Less than 10 inches (25 cm)	10 to 20 inches (25-50 cm)	20 to 40 inches (50-100 cm)	40 to 50 inches (100-125 cm)
s	SALINITY	—	Strongly saline	Moderately saline	Weakly saline
a	ACID SULPHATE LAYER	0 to 10 inches from the surface	10 to 20 inches from the surface	20 to 40 inches from the surface	40 to 50 inches from the surface
o	ORGANIC HORIZON	—	(Water logged) any thickness	(Drained) >4 feet thick at the surface	(Drained) 2 to 4 feet thick at the surface
r	ROCKINESS	Extreme (> 75% of soil volume)	Moderately extreme (50-75% of soil volume)	Moderate (25-50% of soil volume)	Slight (10-25% of soil volume)
n	NUTRIENT IMBALANCE	Toxicity caused by extremely high contents of certain elements	—	Acute nutrient deficiencies	Moderate nutrient deficiences
h	HUMAN	Disturbed land	—	—	—

BULLETINS (NEW SERIES)

101.	Pot Experiments on the Insecticidal Control of Padi Stem-Borers. (1956)	$1.50
102.	Field Investigations of padi Stem-Borers, 1955-56 (1957)	$1.50
104.	West Johore Coconut Production Survey. (1958).	$1.25
105.	Reconnaissance Soil Survey of Trengganu. (1958).	$6
106.	Patanga Succincta (L) "The Bombay Locust" in Malaysia. (1959)	$2
107.	Mineral Deficiency Symptoms of Cacao Grown in Sand-Culture. (1959)	$4
108.	Mineral Nutrition of the Rice Plant in Malaya. (1959)	$6
109.	Rice Variety Trials in Malaya. 1954-58. (1959)	$3
110.	Common Diseases and Pests of Crops in Malaya with Suggestions for Their Control (1959)	$1
111.	An Illustrated Guide to Malayan Citrus Species and Varieties. (1962).	$3.50
112.	Some Experiments on Soil Water Plant Relationship in Rice. (1960).	$1
113.	The Malayan Oil Palm and the Analysis of its Products. (1963).	$1
114.	Rice Variety Trials in Malaya, 1958-1961. (1963).	$2.50
115.	Bionomics and Control of Chilotraea Polychrysa (Myer.) in Malaya. (1964)	$3
116.	Chemical Control of Padi Stem-Borers in Malaya, 1959-60. (1965).	$1.50
117.	The Reconnaissance Soil Survey of Kedah. (1965)	$2
118.	The Life-History and Control of the Diamond-Back Moth in Malaya. (1965).	$2
119.	Soil Survey Manual for Malayan Conditions (1966).	$5
120.	Economic Survey of Padi Production in West Malaysia. (1968)	$6
121.	The Bionomics and Control of Nephotettix Impicticeps in West Malaysia. (1969).	$2
123.	A Host list of Plant Parasitic Nematodes in West Malaysia. (1970)	$0.50

Printed by The Economy Printers Sdn. Bhd. 1181-70