DETAILED RECONNAISSANCE SOIL SURVEY OF THE BUKIT IBAM AREA, SOUTHEAST PAHANG

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The area in the neighbourhood of Bukit Ibam may be defined as that area bounded by the Sungei Jeram on the west, the Sungei Rompin on the south, the Sungei Aur on the east and with the watershed of the Sungei Tepesok forming the northern boundary. (see accompanying soils map) These limits encompass approximately 32,000 acres of land which lies to the west of central south-east Pahang (see Fig. 1), and which are contained within new series map sheets 98 and 99.

1. Introduction

The detailed reconnaissance soil survey of the Bukit Ibam area was carried out as part of a schematic reconnaissance soil survey of South East Pahang which is still in progress. The survey of the Bukit Ibam area was undertaken in such detail for the following reasons:-

(i) Approximately 90% of the rentis lines examined were previously cut by the Rompin Mining Company and soil inspection pits had been dug along these lines at quarter mile intervals.

(ii) The author felt that it would be more advantageous to map and report on this area as soon as possible, rather than to incorporate this information in a final report on the South East Pahang region in 1967, when the writer's present assignment terminates.

(iii) Should the area prove favourable for the development of oil palm, the State Government would most probably be interested in locating smallholder schemes adjacent to this area as soon as possible.

(iv) It would prove of considerable assistance in understanding the soil pattern as it was appearing on a schematic reconnaissance scale.

A total of 39 soil profiles from soil pits were recorded, and all other soil pits were either visited, or samples from these pits were examined after collection by the Geological Department, Rompin Mining Company.

One new soil series is described in the text and model profile data are presented in Appendix 3.

2. Physiography

There are two major highland blocks of steeply and very steeply sloping country on the western and eastern edges of the northern half of the area (see Fig. 2). These are the Bukit Pemandang - Bukit Tapakok; and the Bukit Sembilan - Bukit Salong blocks; respectively to the east and west of the valley of the S. Tepesok.

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Between these blocks the land is moderately flat, where it forms the valley of the Sungei Tepesok. To the south, these highland areas give way to rather broken country of a rolling to steep nature, with relatively flat alluvial terraces adjacent to the Sungei Aur and Sungei Jeram on the eastern and western borders and along the smaller Sungei Tepesok which drains the centre of the region.

The following terms, relating to the terrain, are used throughout the text:-

level	-	with average slopes less than 2°
undulating	-	average slopes between 2° & 5°
rolling	-	average slopes between 5° & 12°
hilly	-	average slopes between 12° & 20°
steep	-	terrain with average slopes greater than 20°.

3. Geology

The oldest rocks in the area belong to a sub-formation called the Ibam Series. Lithologically, the Series contains quartzites, sandstones and tuffaceous sandstones interbedded with narrow lenses and bands of quartz porphyry. These beds are probably of the same age as the later phases of the Pahang Volcanic Series (4) which occurs over widespread areas of Pahang and adjoining states. This association indicates a probably lower Triassic age for the beds of the Ibam Series.

These beds are conformably overlain by strata composed of dark coloured shales with some minor quartzite bands, which are in turn overlain by beds of the Arenaceous Series (4). In the region under discussion the Arenaceous Series can be split into a rather distinctive bed of red tuffaceous sandstones and conglomerates interbedded with strata of quartzose sandstones and minor shales.

The progressive shallowing of the seaway over this area towards the end of the Triassic, was contemporaneous with a period of uplift, when these beds were folded into a series of steeply dipping anticlines and synclines.

Probably in mid-Jurassic times, a transgression took place to the south, west and north of the area which covered the south-western corner with sediments. Two groups of rocks are represented; the "Quartzites", consisting of quartzite and minor sandstones, which are thought to underlie the other group which comprise of the Jeram Valley Shales series.

A shallowing of this seaway in Upper Jurassic times followed by a probable withdrawal altogether in the early Cretaceous and this was probably due to a period of uplift accompanied by faulting with a north - south orientation.

A shallow transgression to the south of the area during the

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later Cretaceous gave rise to a series of quartzitic and conglomeratic beds, but these Lesong Forest Beds do not outcrop in the area surveyed.

A further period of faulting in the late Cretaceous or early Tertiary was responsible for shaping the present relief, and at the same time the intrusion of the igneous bodies in the area probably took place.

The period of erosion has continued through the Tertiary to the present day with the resulting accumulation of alluvial deposits adjacent to the larger rivers as a consequence of sea level fluctuations during the Pleistocene.

See Figure 3 for an outline of the distribution of rock types in the area.

4. Vegetation

The greater part of the Bt. Ibam area is under undisturbed primary forest. The peripheries, adjacent to the S. Aur and the S. Jeram, and along the S. Tepesok, are either subject to aborigine shifting cultivation practices or are supporting secondary forests of varying age. An area of disturbed land due to mining and the accompanying township, is located towards the northern part of the area.

In the undisturbed areas, the dominant vegetation is the Red Meranti - Keruing Forest, which occurs over large areas of lowland in East Pahang, and in many other parts of Malaya. The highland areas are under Seraya Ridge Forest, Riverine Dipterocarp and Seraya Forest, and a mixture of Red Meranti - Keruing Forest and Seraya Hill Forest. (See Fig. 4 for the distribution of Forest types).

Most of the agriculturally suitable soils are found under the Red Meranti - Keruing Forest. This type of forest, together with the Seraya Ridge Forest, and mixtures of these two types of forest, form the economic timber stands of the area.

5. Climate

Climate records for this part of Pahang are relatively few, and those available, are usually of such short duration that they can only convey an approximate picture of the nature of the climate.

Rainfall probably ranges between 90 and 110 inches annually with a 4 month maximum during November through February when approximately half the annual precipitation occurs. Minimum precipitation is in the months of June and July when the monthly totals will rarely exceed 6 inches. Maximum monthly precipitation can be expected in December, when the whole of the east coast of Malaya is subject to the North - East Monsoon, and this will probably be of the order of

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15 to 30 inches. (3).

Average shade temperatures are in the low-eighties during the day, falling to the mid-seventies at night. (2). The humidity varies between 65% during the drier months, to near 100% during the time of the North - East Monsoon.

6. Soil Classification

The soils of the Bukit Ibam area have been classified in accordance with the system at present used throughout Malaya. The basic unit of the classification is the soil series, which by definition is: ' a grouping of soils with similar profiles, similar temperature and moisture regimes, and the same or very similar parent material '. (6). One new soil series has been located and mapped and a model profile for this series is presented as Appendix 3. In one instance a 'variant' of a particular series has been mapped.

One 'Soil Complex' has been mapped, but for convenience this has been included in the section with the miscellaneous Land Units', in the Legend on the Soil Map. A 'complex' may be defined as 'a compound mapping unit containing an intimate mixture of two or more soil series that cannot be differentiated on ordinary detailed soil maps. (6). The soil complex mapped is the Telemong - Akob Association. The term 'Association' has been retained to conform with it's usage in reports covering other areas of Pahang. (10).

The '<u>Miscellaneous Land Units</u>' are mapping units utilised when difficulties are encountered in separating distinct (or similar) soils which are developed over the same parent material (such as is the case with the soils which have been grouped into the Local Alluvium Association and the Inland Swamp Association) or soils which are influenced by one over-riding factor. This is the case with Steepland Association, where all areas with slopes too steep for agricultural usage (under a sensible land use plan) are grouped; and with the areas designated as Disturbed Land, where man's activities have seriously interferred with the soils.

The remaining soils, which are mapped at a series or variant level, are divided into:-

<u>Sedentary Soils</u> - these are soils which are developed on rocks which reside in their normal place of outcrop, in contrast to -

<u>Alluvial Soils</u> - which are developed on eroded materials which have been transported by flowing waters and deposited to form either terraces or flood plains.

The fertility level in the Sedentary Soils is generally a reflection of the nature of the parent rock. Consequently the soils

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developed over igneous rock types are considered to have a higher agronomic potential than those over sedimentary rocks.

The sandy textures of the soils on alluvial terraces is no impediment to the continued removal of the soluble elements by percolating waters; thus, it is most probable that the soils on Older and Sub-Recent Alluviums which are no longer accumulating, will be considerably reduced in soluble plant nutrients; whereas the soils on Recent Alluvium, which have a continual addition of fresh materials, will probably have a slightly higher agronomic potential. It should be noted however, that in some of the smaller valleys, soils on older alluvium may derive some extra nutrients by washings of soil from adjacent sedentary soils.

7. Legend

The mapping legend is as follows:-

A. Sedentary Soils

a) Soils Developed Over Igneous Rocks

1. On diorites and granodiorites.
   Jerangau Series

b) Soils Developed Over Sedimentary Rocks

1. Over quartzites, shales and quartz porphyry.
   Malacca Series
   Batu Anam Series
   Durian Series

2. Over quartzites and sandstones.
   Kuala Brang Series
   Kedah Series

3. On tuffaceous sandstones, conglomerates and minor shales.
   Jempol Series

4. On red and gray shales and minor sandstones.
   Munchong Series
   Jeram Series

B. Soils on Alluvium (Alluvial Soils)

a) Soils on Older Alluvium
   Rasau Series

b) Soils on Sub-Recent Alluvium

1. Well drained
   Holyrood Series

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2. Imperfectly drained
Holyrood Series (Grey Variant)

c) Soils on Recent Alluvium

1. Well drained
Telemong Series

2. Imperfectly drained
Akob Series

C. Soil Complexes

a) Undifferentiated Soils On Recent Alluvium
Telemong - Akob Association

D. Miscellaneous Land Units

a) Undifferentiated shallow Immature Soils on Recent Alluvium
Local Alluvial Association

b) Undifferentiated Poorly Drained Organic Soils
Inland Swamp Association

c) Undifferentiated Soils on Slopes in Excess of 20°
Steepland Association

d) Soils which Have Been Disturbed by Man's Activities
Disturbed Land.

3. Discussion of the Various Soil Units

A. Sedentary Soils

a) Jerangau Series

The soils of this series occur over rolling to steep terrain and are developed over rocks of granodioritic and dioritic composition. On the diorite outcrops the soils range in colour towards the Kampong Kolam Series but not sufficiently so to be assigned to that series. This variation indicates that the parent materials are probably more acidic than normal diorites and so could best be called quartz diorites. This series is restricted to areas where these intrusions outcrop on the surface, predominantly in two small areas in the upper part of the valley of the S. Tepesok.

In the Bt. Ibam area the Jerangau Series soils can be recognised by their strong brown to yellowish red coloured subsoil which has a fine sandy clay loam to clay loam texture, friable consistence and moderate to strongly developed fine and very fine sub-angular blocky structure. This horizon is normally overlain by a thin, brown

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or yellowish brown, fine sandy clay loam horizon with moderate to strongly developed fine sub-angular blocky and fine crumb structure and having friable consistence. Stones of quartz diorite are often seen in the subsoil, and some fine nodular fragments of laterite may be present.

These soils have a high agronomic potential, by Malayan standards, and they are being cultivated to oil palm in many parts of the country.

b) Malacca Series

This is one of the most widespread soils in Malaya and is usually found developed over shales. However, due to the wide range of parent rock types on which the soil is formed in the Bt. Ibam area, it is considered that the rocks over which this soil is found have very little pedological influence on these soils at present. The laterised horizon, occurring at about 24" and the underlying mottled clay horizon, and probably the present parent material of the Malacca Series. This soil overlies shales, quartzites and quartz porphyry rocks and is found over a wide range of terrain (from undulating to steep). Generally, however, it is found in rolling topography, and as cappings on broad, flat ridges.

The series is characterised by a dense compact laterite layer, composed of nodular concretions and massive laterite, usually occurring between 12 and 24 inches depth in the profile and greater than 3 foot thickness. (See Plate 4) The topsoil is usually a brown or yellowish brown loam to clay loam, of very friable consistence and with moderately developed very fine sub-angular blocky and fine crumb structure. This horizon gives way to a strong brown or yellowish red clay loam of friable consistence and moderately developed fine sub-angular blocky structure above the laterite layer. At depth, the soil is a slightly compact reddish brown or yellowish red clay which invariably has pronounced light coloured mottles present.

The Malacca Series is usually considered to be of limited agricultural potential and is normally not recommended for oil palm. However, in areas of favourable topography, and where the laterite layer is at a greater depth than 24", this soil could possibly be developed for oil palm. Prior experimental work would give a much better indication of the suitability of these deeper Malacca Soils for oil palm, and it is recommended that trial plots be established.

c) Batu Anam Series

Developed predominantly on shales with some minor quartzite and quartz porphyry bands, this Series is found in association with soils of the Malacca Series, normally occupying the strongly sloping and moderately steep sides of narrow valleys.

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These soils have a friable greyish brown to pale brown silt loam topsoil with moderately developed very fine sub-angular blocky structure. This horizon gives way to a light yellowish brown to pale yellow clay loam with friable consistence and workable structure, giving way at about 18" to a stoney horizon with some nodular laterite and fragments of the parent rocks.

In other parts of Malaya this soil exhibits firm to very firm consistence in the slightly compact subsoil. Although almost all of the Batu Anam soil observed had a more friable subsoil, this could possibly be an exceptional case and Batu Anam Series soils with a moderately compact subsoil could be encountered on more detailed investigation.

Due to the generally accepted low agronomic potential, the stony and possibly compact nature of the subsoil, and its occurrence in regions of steeper slopes, the Batu Anam Series is considered to be unsuitable for oil palm. However, where these soils are encountered in areas of more gentle relief, trial plots could be established to assess its potential.

d) Durian Series

This soil is developed over a variety of rock types, ranging from shales, through sandstones and quartzites to quartz porphyry. The Durian Series is probably similar to the Malacca Series (and possibly the Batu Anam Series) in that the nature of the rock type on which the soil occurs is not significantly influencing the development of the present soil; but rather, the compact red and white mottled clay horizon often observed towards the base of the profile is probably the parent material of this series. These soils are found over rolling to hilly terrain and commonly occur adjacent to the Malacca and Batu Anam Series.

In the Bukit Ibam area these soils have a light yellowish brown or pale brown silty clay loam topsoil, of very friable consistence and moderately developed granular and crumb structure over a rather compact brownish yellowish to pale yellow clay loam or silty clay loam with moderately developed sub-angular blocky structure. At the base of this compact horizon a thin line of quartz pebbles is often encountered above a layer of pebbles of nodular laterite, usually not more than 8" thick. This soil rests on a very compact red and white coarsely mottled clay commonly containing fine angular fragments of quartz.

Where the Durian Series occurs over rolling terrain, it could be used for oil palm. However, it should be noted that these soils are generally considered to have a low agronomic potential. Although the laterite is not sufficient to interfere with rooting, the rather compact subsoil over the laterite may be a definite impediment.

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e) Kuala Brang Series

These soils appear to be restricted to areas of quartzites and sandstones, sometimes interbedded with minor shales. They are generally found over undulating to rolling country, but sometimes occur on slopes of 20° and over. However, on the steeper slopes, normally in excess of 18°, they give way to shallow soils of Kedah Series.

Soils of this series are characterised by their brownish yellow colour and sandy textures. The topsoil is usually a brown to yellowish brown fine sandy loam of friable consistence and having moderately developed fine sub-angular blocky and granular structures. This horizon overlies a friable, brownish yellow or yellowish brown, fine sandy clay loam with weakly developed fine and medium sub-angular blocky structure; often with a few fine laterite pebbles, weathered quartz and shale fragments below three feet.

This is probably the most suitable sedentary soil in the area for oil palm on the basis of its friable consistence and fine structures, which allow easy root ramification, and its occurrence in areas of more gentle relief. It should be noted however, that whilst it is currently assigned to Class II of the Malayan Soil Suitability Classification (6) ('soils with few minor limitations to agricultural development', and regarded as being suitable for a wide range of crops including oil palm), Panton (9) remarks 'this soil is only moderately fertile and permanent crops such as oil palm, cacao and manila hemp are unlikely to grow well without large dressings of fertiliser'.

f) Kedah Series

The Kedah Series appears to be restricted to sandstone and quartzite parent materials, and, in the Bt. Ibam area, normally occurs on slopes steeper than 16°. It is usually found on the steeper slopes adjacent to the Kuala Brang Series.

This Series has a weakly structured, very friable, brown to yellowish brown sandy loam topsoil, over a yellowish brown or brownish yellow sandy clay loam subsoil of firm consistence and a weakly developed structure. Coarse quartz fragments occur throughout the subsoil, and this Series is usually very stony, with sandstone and quartz stones below 18 inches. There may be some weak development of laterite in this stony horizon.

Because of the steepness of the topography on which this soil occurs, and its stoniness, it is considered unsuitable for oil palm.

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g) Jempol Series

This soil is developed on conglomerates, tuffaceous sandstones and minor bands of interbeded red shales, and is confined to a hilly ridge which parallels the S. Aur near the eastern edge of the area surveyed.

The topsoil is a reddish brown, friable, sandy loam with moderately developed, fine sub-angular blocky and fine crumb structure. This is underlain by a yellowish red, coarse sandy clay loam of friable consistence and moderately developed medium and fine sub-angular blocky structure. Pebbles of nodular laterite and quartzite normally occur in the base of this horizon at about 20 inches. This gives way to a very stony layer of laterite and fragments of parent material in a red coloured clay matrix. (See Plate 3).

Steepness of slope and the stoniness of this soil make it unsuitable for oil palm.

h) Munchong Series

This soil is of very restricted occurrence in the Bt. Ibam area, being confined to a small valley between the Sg. Jeram and the S. Tepesok. The Series is developed on shales with minor bands of sandstone and the topography is gently rolling.

The topsoil is a friable, yellowish brown or light yellowish brown silty clay loam with moderately to strongly developed fine sub-angular blocky and fine crumb structure. This horizon gives way below 4 inches to a strong brown silty clay loam tending to clay loam with depth. The consistence is friable and it has a moderately to weakly developed fine and medium sized sub-angular blocky structure. A few mottles and some fine particles of laterite may occur below about 36 inches.

In other parts of Malaya this soil has been found to be suitable for oil palm.

i) Jeram Series (New Series)

The Jeram Series occurs quite extensively in the western part of the area surveyed, and it is considered that the parent materials of this soil are the rocks of the Jeram Valley Shales sub-formation. The terrain over which this soil is found is predominantly rolling to hilly, with rare steep slopes. The soil is generally found under primary forest, but in the Buloh Nipis region some areas have been cleared for hill padi.

This soil has a thin reddish brown or yellowish red, friable, silty clay loam or clay loam topsoil with moderate fine sub-angular blocky and granular structure. This horizon is underlain by a firm

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yellowish red or red, clay which has moderate to weakly developed, coarse and medium, sub-angular blocky structure. This horizon in turn, gives way between 12" and 24", to a stony horizon of many, small, sub-angular pieces of red shale, often having a thin lateritic crust, in firm, red clay matrix.

The shallow depth of soil developed over parent rock and the generally hilly nature of the terrain in the type area relegate the Jeram Series to Soil Suitability Class 3 (6). Consequently it is fairly safe to consider this soil as having only marginal suitability for the cultivation of oil palm.

The term Jeram Series now includes all soils which were originally designated as Munchong Series (Red Variant). Appendix 3 presents a model profile and analytical data for this Series.

B. Soils on Alluvium (Alluvial Soils)

j) Rasau Series

These soils are developed on older alluvium which forms the highest level of terraces in the area. They occur over very gently undulating to level topography. They are found on terraces of the S. Tepesok, at about 20 - 30 feet above river level in the upper reaches, and in the lower reaches they form part of the old flood plain, occurring at about 15 to 25 feet above river level, but immediately adjacent to the river.

The Rasau Series, as it occurs in the area mapped, has a brown silt loam or loam topsoil with a friable consistence and moderately developed fine sub-angular blocky and fine granular structures. This overlies a yellowish brown or brownish yellow friable to firm clay loam with moderately developed sub-angular blocky structure. Towards the base of the subsoil, normally below 2 feet, the colours may tend towards a strong brown or reddish yellow, whilst the clay content increases to give a silty clay or clay texture. Consistence is friable to firm and the structure is sub-angular blocky and moderately to weakly developed. This latter horizon commonly has fine red and yellow mottles.

Physically and topographically this soil is suited to oil palm cultivation, but it is probably very low in plant nutrients, and no planting should be started without first carrying out investigations at trial plot level. Localised accretion of hill-wash debris from adjacent high land may give rise to a more fertile phase of the Rasau Series in some area.

k) Holyrood Series

The Holyrood series is developed on sub-recent alluvium, (i.e. alluvium which is intermediate in age between the recent alluvium

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and older alluvium). It is found on gently dissected terraces with level to very gently undulating topography. These terraces are usually at about 20 - 30 feet above present river level.

The topsoil is usually a dark brown sandy loam which has friable consistence and moderately to weakly developed fine subangular blocky and fine granular structures. This overlies a yellowish brown to brownish yellow fine sandy loam subsoil with friable to very friable consistence and weakly developed subangular blocky structure. The clay content gradually increases with depth, and throughout the subsoil the textures may range from a fine sandy loam to a fine sandy clay. It is not uncommon to encounter a few pale mottles in either horizon.

Although the terrain over which this Series occurs and the textures of the soil are favourable for oil palm development. It is strongly impoverished in plant nutrients. Attempts to develop the Holyrood Series in oil palm in Perak have not met with a great deal of sucess. Its use for oil palm should only be considered after comprehensive manural experiments have been conducted.

l) <u>Holyrood Series</u> (Grey Variant)

This variant of the Holyrood Series appears to be confined to smaller valleys and is normally located on terraces at about 10 to 20 feet above river level. The parent material is probably a slightly finer grade of sub-recent alluvium than that giving rise to the normal series.

The topsoil is usually a dark brown fine sandy loam or loamy sand with very friable consistence and weakly developed crumb structure. This overlies a very pale brown to light grey fine sandy loam of very friable consistence and weakly developed subangular blocky structure. The clay content usually increases downwards in this horizon, and towards the base of the profile, some white and brown mottles may be encountered.

This variant is probably more impoverished in nutrients than the normal Series and for this reason is best considered as unsuitably for oil palm. However, heavy manuring on trial plots will give a much better indication of its potentialities.

m) <u>Telemong Series</u>

This soil developed over recent alluvium, which is distinguished from sub-recent and older alluviums by being defined as 'those alluviums which are still being formed'. The Series is found on level terraces forming parts of the present flood plains of the S. Aur and S. Rompin and the upper parts of the S. Tepesok.

The soil has a light yellowish brown to greyish brown sand or loamy sand topsoil with loose or very friable consistence and weakly

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developed very fine sub-angular blocky and granular structures. This is underlain by a loamy sand to sandy loam subsoil of colour range varying from yellowish brown to pale yellow. The subsoil has very friable to friable consistence and weakly to moderately developed fine sub-angular blocky structure. A structureless, dark yellowish brown to olive brown loamy sand or sand may often be encountered below 3 feet.

These soils are regarded as being suitable for oil palm on the basis of their topography and probable moderate nutrient status. Flood susceptibility and very sandy textures however, are definite limitations which should be noted.

n) Akob Series

This soil is developed on recent alluvium on the flood plains of the larger rivers. Generally, the areas of Akob Series soils are of slightly lower elevation than the adjacent areas of Telemong soils. They are swampy, and almost definitely subject to seasonal fluctuations of water table within the soil profile.

They have a yellowish brown or light yellowish brown silty clay loam to clay loam topsoil offriable to firm consistence and with weak fine sub-angular blocky structure. They commonly have iron staining along root channels and may have common, fine, light grey mottles in the topsoil. The sub-soil is a pale yellow to light grey clay loam to silty clay, with many, medium sized, red and grey mottles. Consistence is firm and the fine and medium sub-angular blocky structure is only weakly developed.

Before development in oil palm, these soils will need to be drained. After drainage the soils should be well suited to the palm, but susceptibility to periodic flooding is greater in this soil than in the Telemong Series and will be a limiting factor in management.

C. Soil Complexes

o) Telemong - Akob Association

This mapping unit is employed when it is impossible to differentiate the Telemong and Akob Series at the scale of mapping. Within the areas so designated both series will be encountered. These undifferentiated soils will most probably be suitable for oil palm, but limitations, as mentioned for the individual series, will apply.

D. Miscellaneous Land Units

p) Local Alluvium Association

A mapping unit employed to include all soils developed on recent alluviums in minor valleys tributary to the major streams and rivers of the area. In some places these soils approximate to the

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Telemong Series, whilst in other areas they are very stony, poorly drained grey clay soils. Normally, because of their erratic distribution and variability, they are not considered as suitable for oil palm. However, a further investigation of these soils in areas where the topography and other soils are favourable to the development of oil palm, could show that they also are favourable to the cultivation of that crop provided drainage can be effected.

q) Inland Swamp Association

The soils mapped as the Inland Swamp Association in the Bt. Ibam area have not been studied in detail. They are confined to a small area adjacent to the S. Aur, and are developed over alluvial sands and silts from the S. Aur. It is anticipated that both organic and inorganic soils will be encountered in this area. (8) & (10).

The organic soils will be either 'organic clays' or 'mucks' containing 20 - 35% and 35 - 65% organic matter respectively. The latter soils usually have weaker structures and a much greater depth of organic horizon developed over the underlying greyish brown clay soil than the organic clays.

The inorganic soils will probably have a dark greyish brown sandy loam topsoil and a rather characteristic light gray or white sandy horizon between 6 and 24 inches. There will probably be considerable amounts of humus incorporated in the topsoil and possibly in a layer under the pale sandy horizon.

This Association is characterised by poor drainage and the water table normally occurs within 6 inches of the surface for most of the year and often covers the surface of the soil.

The poor drainage is obviously a serious limitation. Once these soils have been drained however, the more clayey members of the Association (i.e. the organic clays and mucks) should produce soils suitable for oil palm. Some of these soils however, may be in a strongly reduced or highly acidic state, and it may be necessary after drainage to allow some time for the oxidising effects, of air and percolating rain water, to ameliorate these conditions before planting. The more sandy soils would probably require considerable care after draining before they can attain anywhere near the degree of suitability reached by the clay soils. (8).

r) Steepland Association

All areas which have slopes in excess of 20° have been included in this Association. The boundary has been marked off by reference to the contour lines shown on the new series maps which cover the area at a scale of one inch to one mile. This 'steepland boundary' has been found to closely conform with the 250 foot contour, giving a pattern which follows the steepland/non-steepland relation-

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ship as seen in other areas of lowland Malaya.

Although the soils making up this Association are developed from a variety of parent materials they have been grouped together on the basis of their susceptibility to severe erosion on clearing. These factors, coupled with their topography make the soils of this Association unsuitable for oil palm.

s) Disturbed Land

This group includes soils which have no present agricultural potential because of their current use as mine sites, tailing areas and townships. They are unsuitable for oil palm.

9. Conclusion

Whilst many of the soils found in the area mapped are regarded as suitable for the cultivation of oil palm, almost all of them have some minor limitations which must be overcome during the initial stages of development. However, these initial problems should prove to be easily surmountable.

Those soils which are designated as marginally suitable have a major limitation which will probably require careful attention before they can be developed. Such areas should be considered as Phase 3 of a planting program, to be effected, only after extensive experimentation with trial plots.

Appendix 1, attached, summarises the potentialities in accordance with the Soil Suitability Classification for Malaya (6) and the limitations of each soil unit mapped, and Appendix 2 outlines the environmental range of oil palm.

Climatologically there are no restrictions to the development of the area in oil palm.

The hypothesis that the soils of the Malacca, Batu Anam and Durian Series are developing from either the lateritic horizon, or from the underlying, weakly cemented, strongly mottled, clay horizon, rather than the underlying rocks should provoke an interesting academic discussion. It has been noted by the writer, that some latosolic soils recorded by other workers in Indonesia (7) and Africa, have developed over a mottled clay horizon similar to that encountered in this area.

10. Acknowledgements

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Geological information, and the topographic base map from which the Soils Map was drawn, were provided by Inche B.D. Mellor, Chief Geologist, Rompin Mining Company. The Vegetation Map (Fig. 4) has been adapted from Lee Peng Chong (5).

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APPENDIX 1 POTENTIALITIES AND LIMITATIONS OF EACH SOIL MAPPING UNIT

MAPPING UNIT	PARENT MATERIAL (ROCK)	TERRAIN	SOIL SUITABILITY ASSESSMENT*	SUITABILITY FOR OIL PALM	ACREAGE	LIMITATIONS
Jerangau Series	Grano-diorite and quartz diorite	Rolling to steep	CLASS I – slopes over 12° – CLASS III	Suitable	845	1. Terrain 2. Shallow soils in places
Malacca Series	Shales, Quartzite and quartz porphyry.	Rolling to steep & on broad ridge tops.	CLASS III – Shallower than 2'– CLASS V	Marginal Suitability	3,448	1. Terrain 2. Shallow soils
Batu Anam Series	Shales, Quartzite and quartz porphyry	Rolling to steep – in the heads of narrow valleys.	CLASS III (on rolling terrain) & CLASS IV	Marginal to Unsuitable	1,056	1. Terrain 2. Shallow soils 3. Compact subsoil
Durian Series	Shales, sandstones, quartzites, and quartz porphyry.	Rolling and hilly	CLASS III	Suitable	8,000	1. Terrain 2. Shallow soils 3. Compact subsoil
Kuala Brang Series	Sandstone & quartzite	Undulating to rolling (rare hilly)	CLASS II	Suitable	5,338	1. Occasionally terrain
Kedah Series	Sandstone and quartzite	Hilly to steep	CLASS V	Unsuitable	333	1. Terrain 2. Shallow soils
Jempol S rbes	Tuffaceous sandstone and conglomerates	Hilly to steep	CLASS IV	Unsuitable	832	1. Terrain 2. Shallow soils
Munchong Series	Shales and minor sandstones	Rolling	CLASS I	Suitable	122	None
Munchong Series (Red Variant)	Red Shales (occasionally arenaceous)	Rolling and hilly	CLASS III	Marginal Suitability	1,882	1. Terrain 2. Shallow soils 3. May be Fe. toxic
Rasau Series	Older alluvium	Gently undulating	CLASS III	Marginal ? Suitability	794	1. Very low nutrient status
Holyrood Series	Sub-recent alluvium	Level to very gently undulating	CLASS III	Marginal suitability to unsuitable	358	1. Very low nutrient status 2. Sandy texture
Holyrood Series (Grey variant)		Level to very gently undulating	CLASS IV	Unsuitable	678	1. Extremely low nutrient status

APPENDIX 1

POTENTIALITIES AND LIMITATIONS OF EACH SOIL MAPPING UNIT

MAPPING UNIT	PARENT MATERIAL (ROCK)	TERRAIN	SOIL SUITABILITY ASSESSMENT*	SUITABILITY FOR OIL PALM	ACREAGE	LIMITATIONS
Telemong Series	Recent Alluvium	Level	CLASS II	Suitable	941	1. Flood susceptible 2. Sandy textures
Akob Series		Level to depressional	CLASS II	Suitable	160	1. Flood susceptible 2. Sandy textures
Telemong - Akob Association		Level to depressional	CLASS II	Suitable	474	1. Flood susceptible 2. Some sandy texture Some poor drainage
Inland Swamp Association	Organic accumulation over recent alluvium	Level to depressional	Varies CLASS III & CLASS IV	Marginally suitable (suitable after drainage)	653	1. Very poor drainage
Local Alluvium Association	Very young alluviums	Level	Varies generally CLASS III	Marginally suitable to unsuitable	2,822	1. Poor drainage 2. Stony and sand texture 3. Flood liable
Steepland Association	Mixed	Steep and very steep	CLASS V	Unsuitable	9,798	1. Terrain 2. Stony soils
Disturbed Land	Parentage	Level to steep	CLASS V	Unsuitable	640	1. Already in use 2. Shallow or compact soil 3. Many have mineral toxicities.
				Total Average	39,174	

* See Appendix 13. Soil Survey Manual for Malayan Conditions (Ref. 3) pp. 193-6

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APPENDIX 2

THE ENVIRONMENTAL RANGE OF OIL PALM*

1. Topography

a) slopes of 0-12°	suitable
b) slopes of 12-20°	marginal
c) slopes greater than 20°	unsuitable

2. Physical impediments

a) a stony or compact layer absent or deeper than 4'	suitable
b) a stony or compact layer between 2' & 4'	marginal
c) a stony or compact layer less than 2' from the surface	unsuitable
d) excessively sandy or stony soils	unsitable
e) peat or organic accumulation less than 2' thick	suitable
f) peat or organic accumulation between 2' & 4' thick	marginal
g) peat or organic accumulation greater than 4' in thickness	unsuitable
h) poorly drained soils	marginal - unsuitable

3. Chemical impediments

Soils having extreme acidity or toxic levels of minerals are unsuitable for oil palm.

4. Rainfall

A distinct dry period of 2 months or more, annually recurrent, is unsuitable for oil palm cultivation.

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* Leamy & Panton. 1966 (6) pp. 194-195.

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APPENDIX 3

MODAL PROFILE DESCRIPTION

Soil Series: JERAM SERIES Profile No. S.E.P. 041

Symbol: JEM

Location: East from the S. Jeram near Kg. Buloh Nipis at Peg 80 on Line 8 (W). Sheet 98 Grid Reference.

Parent Material: Red Shales

Topography: Strongly dissected ridge country. 11°

Terrain Class: Rolling - hilly

Vegetation: Primary forest of poor producer forest quality - mapped as Red Meranti - Keruing Forest.

Drainage: Well drained

Profile:

Aeh 0-2½" Reddish brown (5YR 5/4); very fine sandy clay loam
to clay loam; very friable to friable; moderate,
fine sub-angular blocky and fine granular; many
roots; few small and large channels; few pores;
boundary diffuse -

AB 2½-12" Yellowish red (5YR 4/8); clay loam; friable; weak
to moderate; medium and fine sub-angular blocky
and weak fine granular; common roots; few fine and
large channels; few pores; patchy to discontinuous
clayskins mostly on pores and channels; boundary
diffuse -

Bt 12-19" Yellowish red (5YR 4/6); clayloam to clay; friable;
moderate, medium and fine sub-angular blocky break-
ing to very fine sub-angular blocky; rare roots;
few large channels; common pores; discontinuous
clayskins; few, rounded gravel of laterised shales;
boundary distinct;

BC 19-36"+ Red (2.5R 4/6); stony clay; friable; weak to moderate,
coarse and medium sub-angular blocky breaking to
moderate, fine and very fine sub-angular blocky no
roots or channels; common pores; discontinuous to

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almost continuous clayskins in pores and on ped faces; stony with rounded and sub-angular gravel and small stones of red shales and laterised shales.

Tentative Suitability Classification: Class S.

Higher Classification: Red Brown Oxisol.

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SERIES Jeram Series SYMBOL Jem.

Horizons	Aeh	AB	BT	BC				
Depth	0-2½"	2½-12"	12-19"	19-36"				
Clay %	28	33	37	47				
Silt%	25	26	20	26				
Fine Sand%	44	40	37	20				
Coarse Sand%	1	Tr	Tr	2				
Gravel	Nil	Nil	2.10	2.41				on original sample.
Stones	Nil	Nil	Nil	0.85				
pH air dry.	4.1	4.6	4.6	4.8				
pH ov. dry								
Moisture %	2.2	1.7	1.8	2.3				air dry - ov. dry.
Loss on ignition %	6.4	6.4	2.8	3.9				
Organic Matter %								
Carbon %	2.02	0.42	0.36	0.21				
Nitrogen%	0.21	0.08	0.05	0.04				
C/N	9.61	5.25	7.20	5.25				
Easily P.ppm.	26	12	11	8				N/10 NaOH
Soluble K.ppm.	59	7	7	7				N/2 CH_3COOH
C.E.C.	14.00	7.43	7.08	10.71				
K^+ (meq/100 gm.)	0.16	0.04	0.04	0.07				
Ca^{++} (meq/100 gm.)	0.10	0.16	0.16	0.16				
Na^+ (meq/100 gm.)	0.06	0.02	0.02	0.04				
Mg^{++} (meq/100 gm.)	0.68	0.10	0.10	0.26				
B.S%	7	4	4	5				

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