

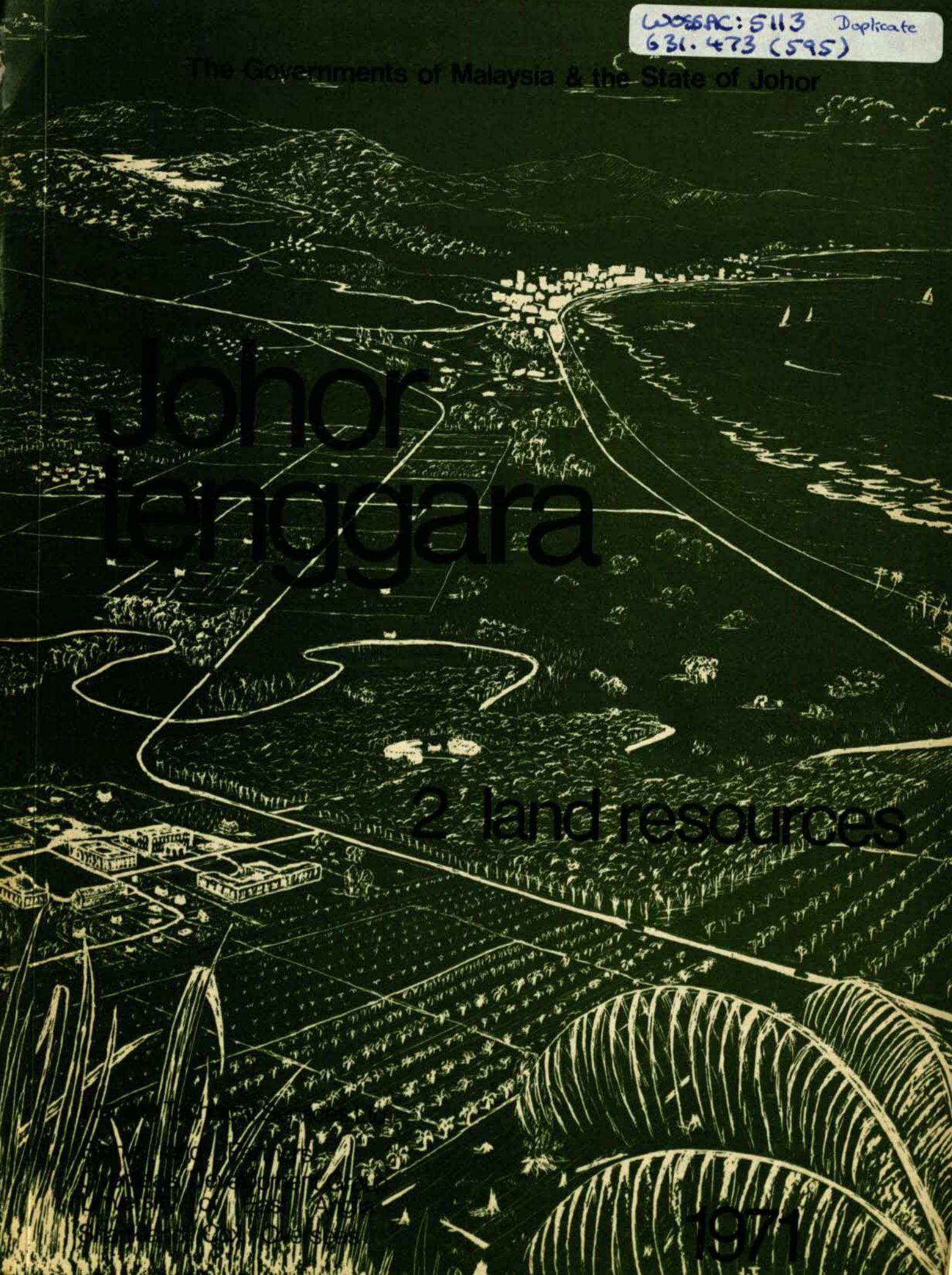
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The Governments of Malaysia & the State of Johor

Johor Banggara

2 land resources

1971



THE GOVERNMENT OF MALAYSIA AND THE STATE OF JOHOR

**JOHOR TENGAH AND TANJONG PENGGERANG
REGIONAL MASTER PLAN**

SUPPORTING VOLUME 2

THE LAND RESOURCES

**Binnie & Partners • Hunting Technical Services Ltd.
Overseas Development Group • Shankland Cox Overseas
University of East Anglia**

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MAP SHEET LAYOUT

AT BACK COVER

CORRIGENDA

- Page 25 Paragraph 7 (last paragraph first column) should read "Trellis pattern of drainage (Figure 5.2c) is quite well developed along the spinal ridge and results from trunk streams following the strike of rock strata with low resistance to weathering".
- Page 26 First paragraph should read "The upper limit to class 4 has been set at 20 degrees which has been raised from 18½ degrees (the present limit of legally permitted cultivation), to 20 degrees to conform more with the natural slope range, which lies more easily at 20 degrees (Leamy and Panton 1966)".
- Page 26 Terrain Class 1, delete comma between mangrove and swamps.
- Page 33 Paragraph 10 line 8 for alluvial read illuvial
- Page 36 2.9 Organic Soils should read 6.2.9 Organic Soils.

CHAPTER 1

1.1 Introduction

1.1.1 Sources of data.

Very little rainfall data existed in the undeveloped region within the Project Area. The developed regions, mainly to the west of the Project boundaries, were well covered by an extensive rainfall network maintained by the Drainage and Irrigation Department (DID). To provide additional information on the rainfall within the Project Area, rain-gauges were installed and operated by the Project at nineteen locations. Complete meteorological data were available from fully equipped meteorological stations at Mersing, Singapore and Kluang. The latter station covered only the period 1929-1941. The location of all stations is shown on Figure 1.1.

1.1.2 Overall climatic type.

Like most of West Malaysia, Johor experiences a typical Rainy Tropical or Tropical Wet climate giving rise to a climax vegetation of Tropical Wet Rain forest. There are no clearly definable seasons, it being warm or hot throughout the year, depending upon one's subjective estimation. Additionally, although the area is subject to a monsoon regime of winds, there is no distinct dry season.

In the Tropical Wet climate zone weather is mainly a diurnal phenomenon. Within a 24 hour period/the variation in many of the elements (e.g. temperature, humidity) which collectively contribute to the general weather pattern, is greater than the variation between mean daily or mean monthly values. In addition to describing and comparing mean values, this report also discusses the diurnal variations of certain elements.

1.2 Rainfall

1.2.1 Types and distribution.

The most frequent type of rain in Johor is a convective type, which is induced during the afternoon period by surface heating accompanied by lack of wind. The heavier and more prolonged falls commonly originate from orographic and boundary rain systems. Orographic rain falls when a moist air mass is intercepted by a coast or mountain barrier, and it is the principal form of rain along the east coast during the NE monsoon. Boundary rain, (which can be likened to the frontal rain of temperate latitudes), results in rainfall at the line of convergence of two moist air masses and is most common during the inter-monsoon transitional periods. It gives rise to some of the more prolonged downpours.

In Johor wet spells generally appear to be associated with the inter-monsoon transitional periods rather than with the actual monsoons themselves. Drier periods are most frequent when the two monsoons are at their height (generally during mid-January to mid-March and during June to July.) Apart from the east coast area, the most reliable rainfall occurs during the transitional periods, (generally mid-March to mid-May, and October to November), and it is mainly of the convective type (afternoon thunderstorms of local distribution). In Johor the SW monsoon is poorly developed, (it in fact appears as a S to SE wind over most of the area), partly due to the shadow effect caused by Sumatra. The slightly higher rainfall along the west coast during this SW monsoon season is largely due to convective storms moving in from the Straits of Malacca

during the night - the "Sumatras", as they are called. (In off-shore areas convective rain falls mostly at night.)

1.2.2 Mean annual rainfall.

The maps of mean annual rainfall (Figs. 1.1 and 1.2) have been compiled based on the period 1950-1968. The long term validity of the average rainfall over this period has been examined by comparison of the mean for this period with the long term mean for 18 stations with records of from 27 to 52 years. It was concluded that over the State of Johor, the average in this period was acceptably close to the longer term average. Hence this 1950-1968 period was used in preparation of the mean annual isohyetal map. Project rainfall stations, operated during 1970, have also been incorporated by utilising comparisons of 1970 DID rainfalls with the mean annual rainfalls at all stations.

The map shows a gradation of mean rainfall from over 140 inches around Endau, Lombong, and possibly part of the east coast of Tanjong Penggerang, to below 80 inches around Segamat and Gemas (Figs. 1.1 and 1.2).

The decrease in annual rainfall from the south to the north west of the State is quite marked. The topographic effects of G. Blumut, G. Panti and G. Pulai, in the central and south west areas, appear to be much stronger than those of Mount Besar and Mount Ophir in the north. The highest totals over the southern lowlands are found some distance inland from the coast, as would be expected in areas of predominantly convective rain (the sea breezes deter storm development by day along the coast). The Segamat area is consistently drier throughout the year, with only slight peaks in the mean monthly rainfalls during the transitional periods. Segamat is sheltered from the NE winds and receives little rain from the weak SW monsoon.

1.2.3 Mean monthly distribution of rainfall.

Six stations (described in Section 1.2.4) have been selected and their mean monthly rainfalls shown in bar chart form (Fig. 1.1). These bar charts give a clear and concise indication of the monthly distribution of the mean annual rainfall around the Project Area.

1.2.4 Further analysis of the rainfall at six stations in or near the Project Area.

The following stations, (listed generally in the north to south direction), were selected because they had at least 20 years of daily records with no obvious anomalies:-

<u>Locations</u>	<u>State Ref. No.</u>
28th Ml. Kluang/Mersing Road	Johor 117
Kluang Estate	Johor 124
Chemara Research Station	Johor 56
Filter House, Kota Tinggi	Johor 7
Nam Heng Estate	Johor 34
Telok Sengat Estate	Johor 101

The data extracted are summarised in diagrammatic form (Figs. 1.3 and 1.4).

1.2.4.1 Monthly rainfall variability.

At all six stations January has the most variable monthly rainfall although it is in the

middle of the NE monsoon period. Values of between zero and 42 inches have been recorded during this month (Fig. 1.4). The range between the upper quartile (values equalled or exceeded 1 year in 4 years) and the lower quartile (values equalled or not exceeded 1 year in 4 years) is 11, 8, 8, 10, 13, 9 inches respectively for stations with median rainfalls of 12, 7, 8, 11, 8, and 10 inches.

In direct contrast to January is June, in the middle of the SW monsoon period. June has an average rainfall which is slightly more than half of January's, yet during this month there has never been less than 2 inches or more than 15 inches recorded at any station. The June range between the upper and lower quartiles is 4, 3, 2, 2, 3, 2 inches respectively.

Although extended periods of heavy rain or droughts are characteristics to be associated with January, June can only be regarded as either slightly wetter or drier than usual, and on at least a few days showers are almost a certainty. (Annual variation of rainfall is proportionally much less than the monthly variation. At Kota Tinggi, the highest recorded annual rainfall during 28 years was 150 inches, and the lowest was 80 inches).

1.2.4.2 Rainfall intensity.

The maximum 24 hour calendar day rainfall for each month over the period of record is shown on Figure 1.3. At each of the six stations in every month of the year there was at least one day when the rainfall exceeded one inch.

The median maximum 24 hour calendar day rainfall varies only slightly between the stations e.g. 5.3 inches (Johor 56), but the monthly values show marked differences. Days of exceptionally high rainfall of 8 inches or more have been recorded only in the period November to February. The highest calendar day value recorded was 14.3 inches in December at Nam Heng Estate. The highest rainfall recorded in 2 days and 4 days for the six stations is tabulated above the calendar day rainfall intensity diagrams.

High rainfalls in many instances are the result of a single storm within one day and lasting perhaps 2 or 3 hours or less. For short periods during these storms the maximum intensity can exceed 3 inches per hour.

Automatic rainfall recorder data for additional stations at Mersing and Sedenak (Johor 4 and Johor 54) for the period September 1968 to March 1970 showed the average length of the rain period per rain day to be 2.2 and 2.6 hours respectively. The average intensity was 0.24 and 0.25 inches per hour. Selected maximum intensity data, including those extracted from DID automatic rainfall recorder charts for the December 1969 storm period, are shown on Figure 1.5. These are shown superimposed over the previous (1958) DID envelope curve for Johor.

1.2.4.3 Mean monthly number of rain days.

These are tabulated above the mean monthly rainfall values (Fig. 1.1). Examination of these shows remarkably little variation in the number of rain days between the drier and wetter months. Rainfall in the wettest months is mainly contributed by a few days of exceptionally heavy rainfall rather than rainfall every day. Division of the mean rainfall figures by the number of rainy days shows the average daily intensity in December to be nearly one inch whilst in June - August it is only about 0.5 inches.

1.2.4.4 Mean monthly diurnal variation in rainfall.

The mean values of rainfall registered by

the Casella Autographic Rain Gauge at Kluang for each hour of the day over the period 1936, 1937-41, were extracted and are presented on Figure 1.6.

From this it can be seen that rainfall throughout the year is generally confined to the afternoon period - two thirds of the yearly rainfall occurs between noon and 6 p.m. This is most marked during the months of transition between the monsoons, March to May, and September to November. During the main NE monsoon period December to February rainfall is more frequent in the afternoon; however, significant amounts are registered throughout the night and in the early morning. The same is generally true of the main SW monsoon period; although July shows the least afternoon rain of any month (43 percent of rain falling between noon and 6 p.m.)

1.3 Winds

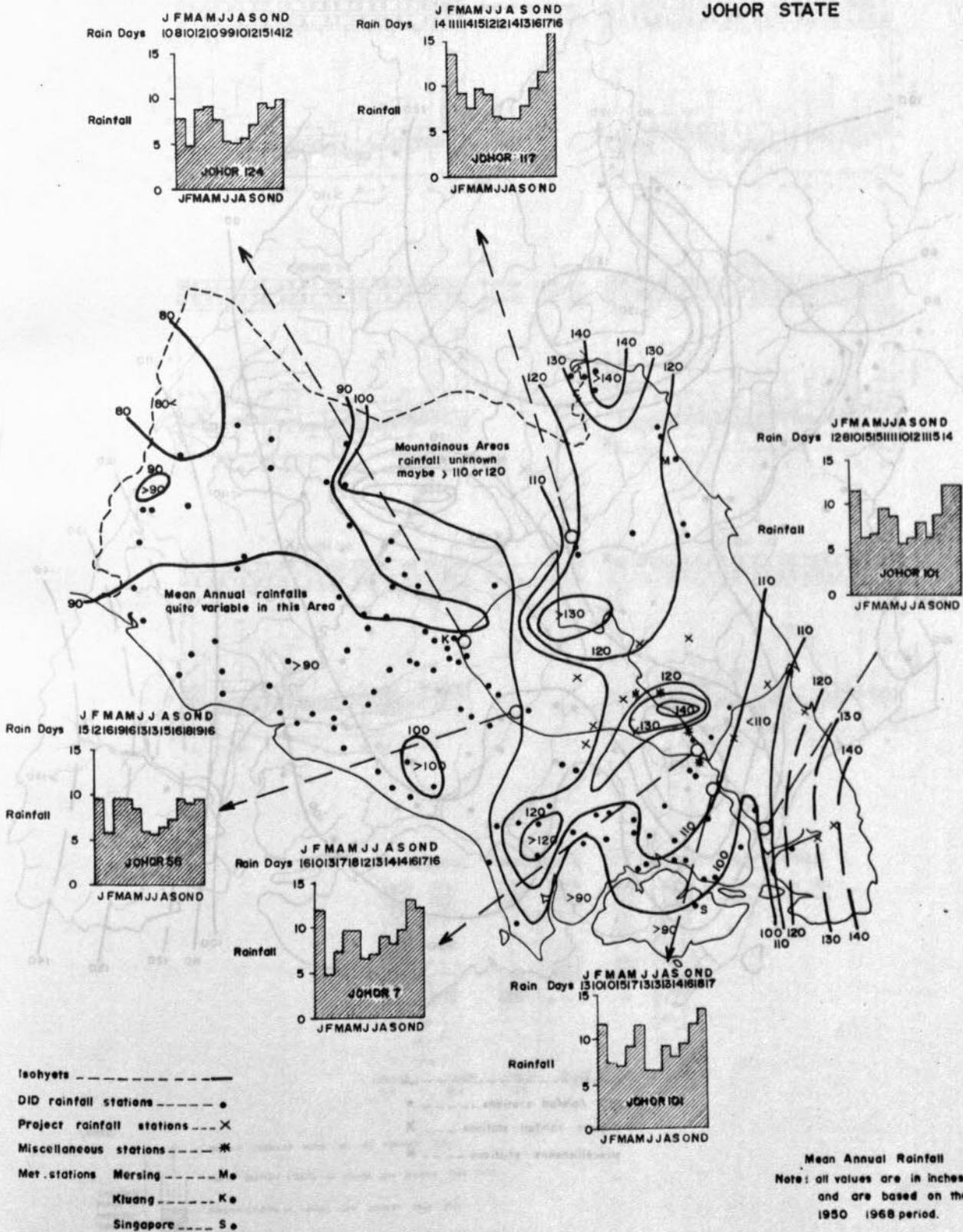
The southern part of West Malaysia lies in the doldrums belt. This is essentially an area of convergence, with a great deal of upward movement of air resulting in an abundance of cloud and precipitation. Destruction of crops inland by wind is not extensive, but local damage, particularly to tree crops, commonly occurs. On the east coast where the winds are stronger, the hazard is greater. Over the land mass of SE Johor for seven out of the twelve months in the year definite monsoon winds prevail. These are strongest on the windward coast and their strength decreases inland to the leeward coast. During the NE monsoon period the winds are generally the strongest.

A monthly analysis of winds at Kluang and Singapore (a combination of data from Kallang and Mount Faber) is shown on Figure 1.7.

The wind regime varies (much like rainfall) in that the monsoon periods may begin over a range of two months. The NE monsoon may start in late November, December or even January. The average annual wind patterns at Mersing, Kluang and Singapore (Kallang) are shown on Figure 1.8. These diagrams show that a N to NE wind prevails at Kluang and Singapore generally from December to March. This is the NE monsoon, which is at its strongest in January and February when winds in excess of 8 mph blow on average for one third of the time or more. It is in the month of January that gusts of wind in excess of 40 mph (usually storm squalls preceding and during heavy rain) are most likely on the east coast and northern parts of the Project Area. From mid March into May is a period of transition with winds from all directions and marked periods of calm particularly in the inland station of Kluang. During May and until September the prevailing wind is from the south at Kluang and the S - SE at Singapore. This is the local manifestation of the SW monsoon. Calms are much more frequent at Kluang during the SW monsoon than during the NE monsoon. Also, gusts of wind (Fig. 1.9) in excess of 40 mph (which have not been recorded during January in Singapore), are in fact most frequent at Kluang in May, at the height of the SW monsoon. Near the west coast violent squalls, (the Sumatras), occur particularly during the night and are not uncommon between May and November. Towards the end of September and until early December is another period of transition with winds from all directions and calms of similar frequency as during the SW monsoon (30 - 40 percent of time at Kluang and 10 - 20 percent of time in Singapore).

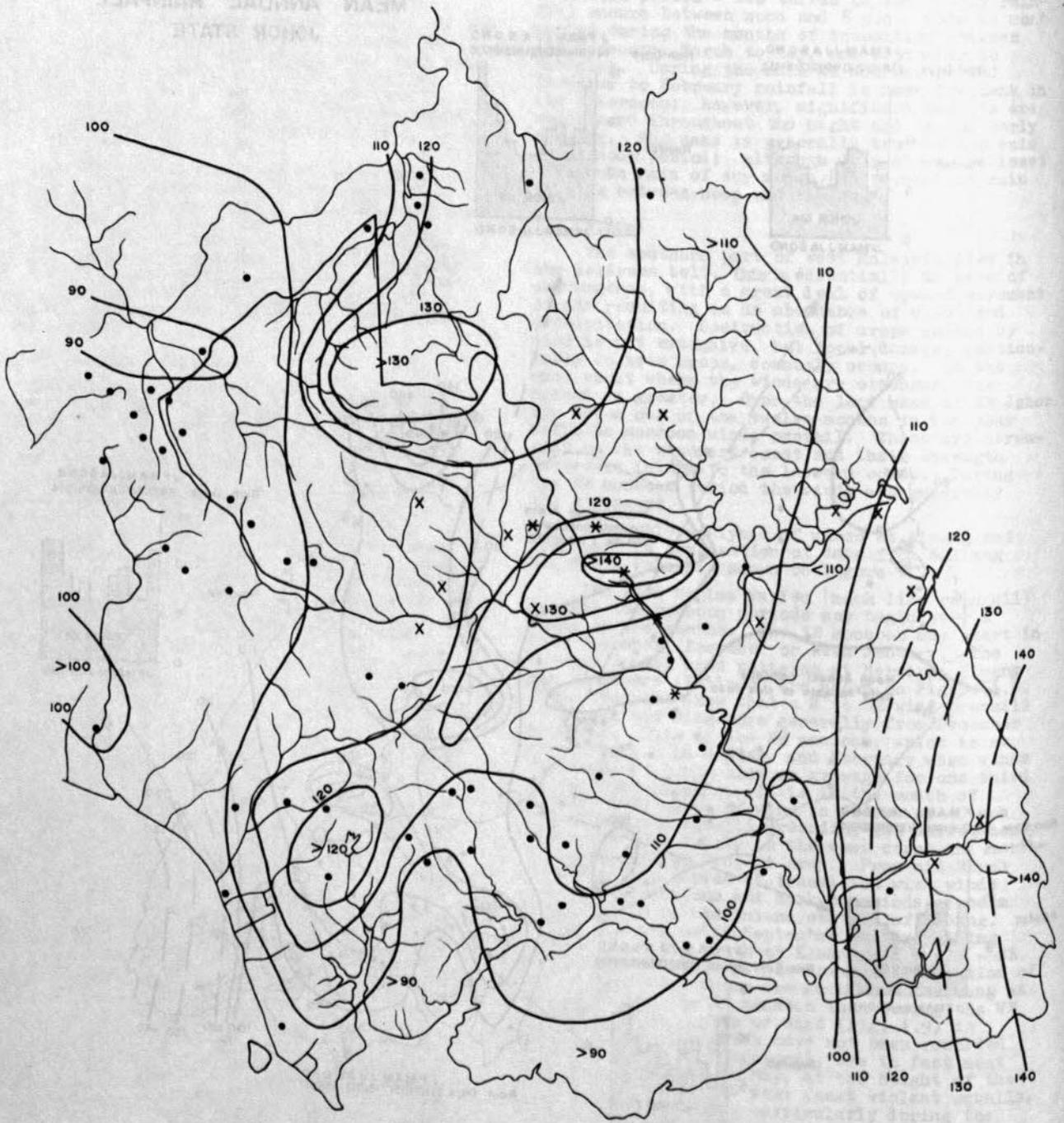
Completely calm periods are rare at Mersing (3.5 percent of time) located on the coast, where onshore breezes occur during the day and offshore breezes occur during the night. Calms are also infrequent (17.2 percent of time) at the Singapore

MEAN ANNUAL RAINFALL
JOHOR STATE



MEAN ANNUAL RAINFALL
PROJECT AREA

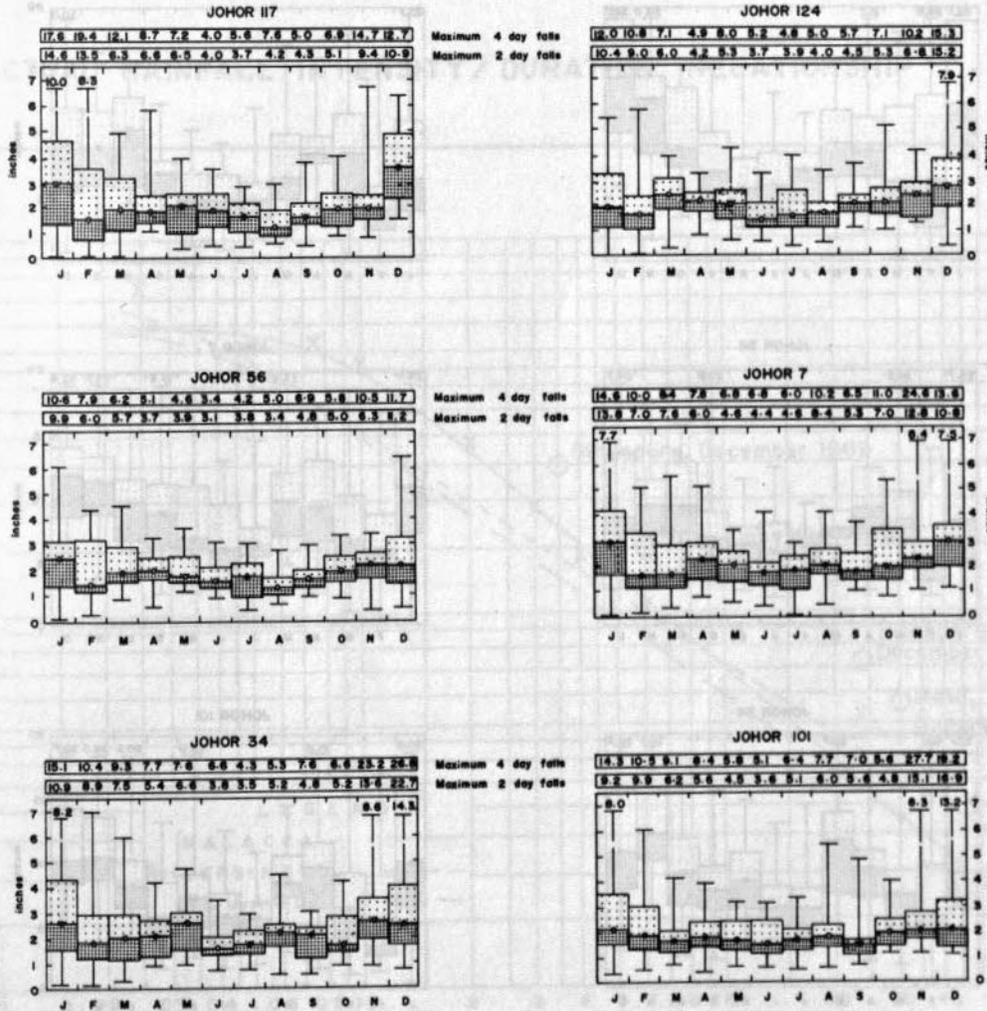
FIGURE 1.2



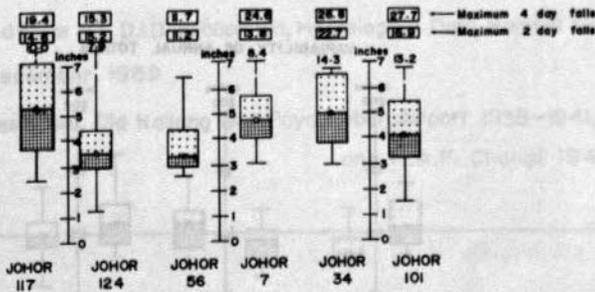
isohyets -----
 DID rainfall stations ----- ●
 Project rainfall stations ----- X
 Miscellaneous stations ----- *

RAINFALL VARIABILITY - Calendar day totals

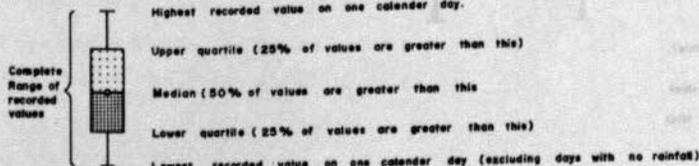
MONTHLY VARIABILITY OF CALENDAR DAY TOTALS (8AM-8AM)



ANNUAL VARIABILITY OF CALENDAR DAY TOTALS

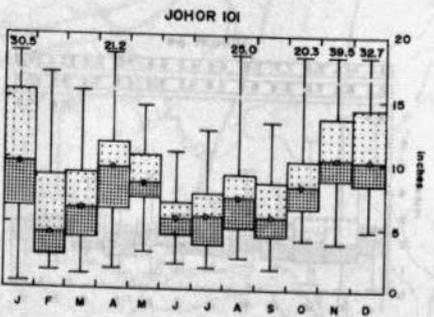
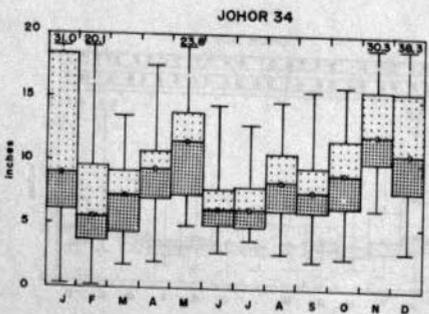
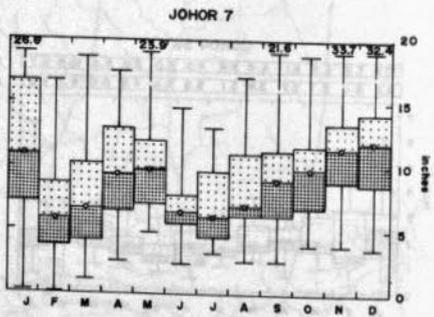
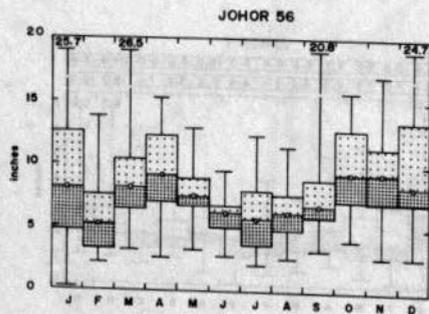
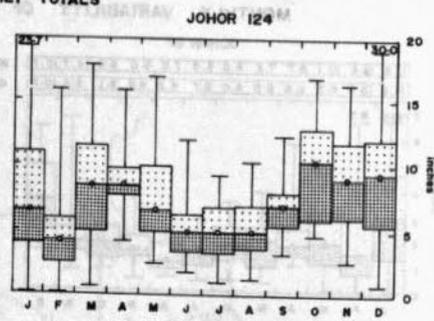
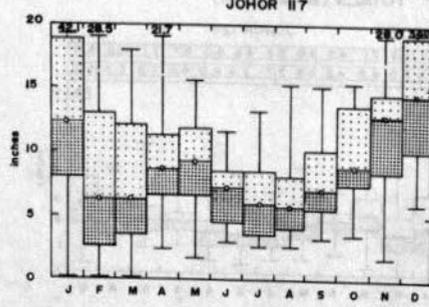


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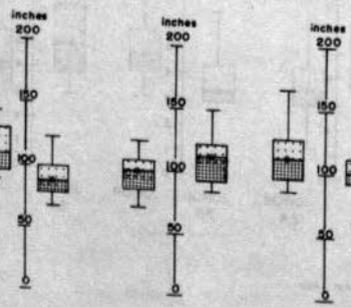


RAINFALL VARIABILITY Monthly and Annual Totals

VARIABILITY OF MONTHLY TOTALS



VARIABILITY OF ANNUAL TOTALS



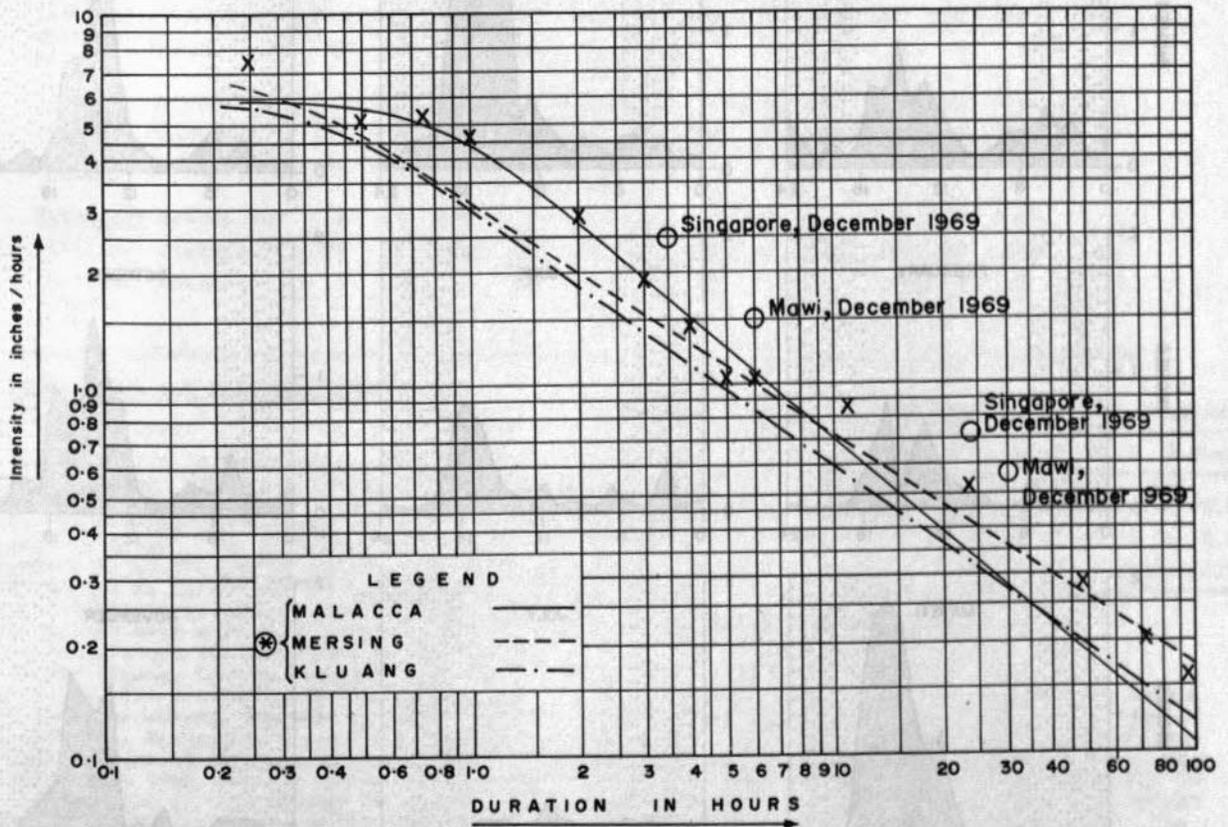
LEGEND

- Highest recorded value
- Upper quartile (25% of values are greater than this)
- Median (50% of values are greater than this)
- Lower quartile (75% of values are greater than this)
- Lowest recorded value

Complete range of recorded values

8888207
14-11-08
1029/01
2/008

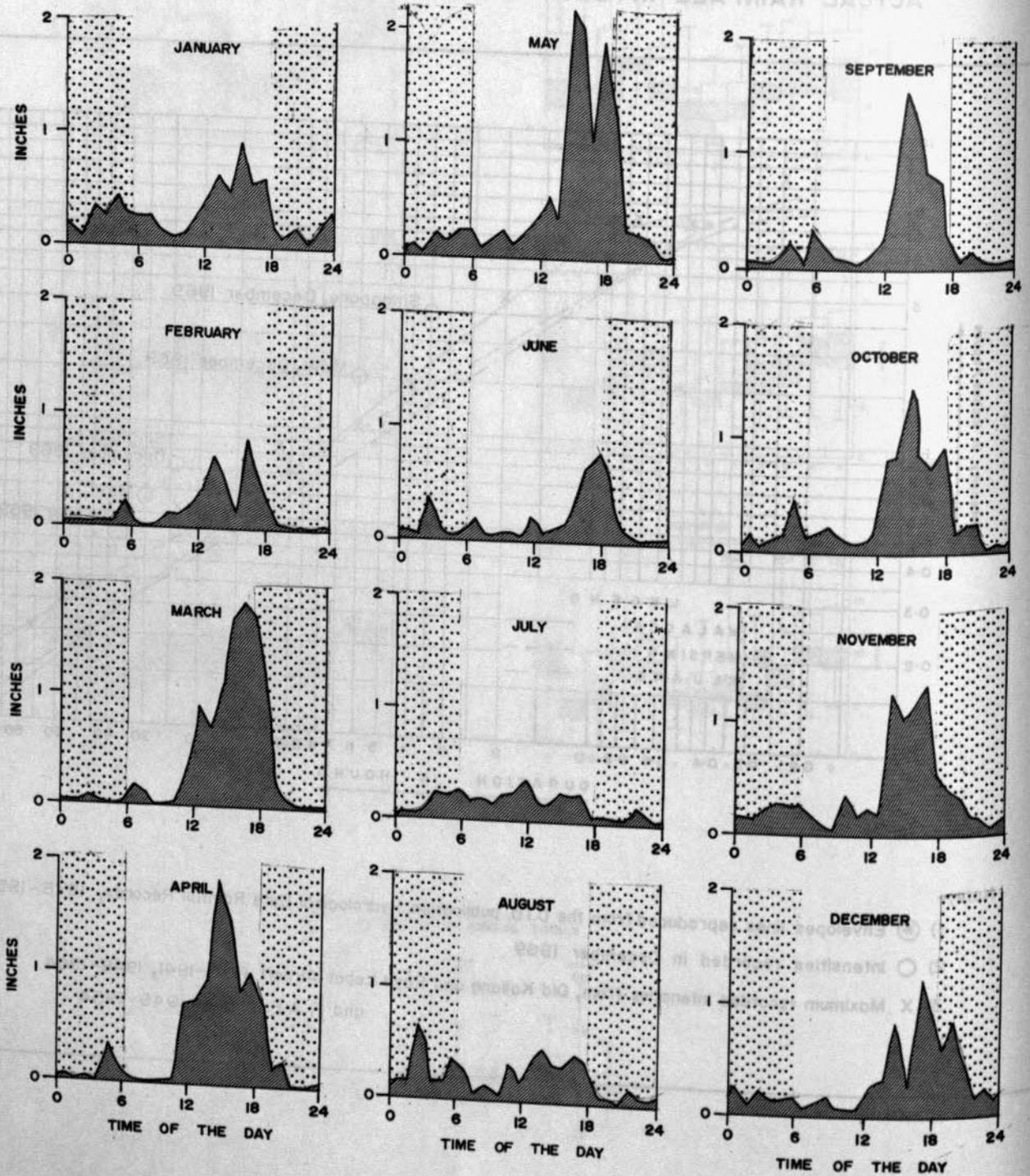
ACTUAL RAINFALL INTENSITY / DURATION RELATIONSHIP



Note:-

- 1) ⊛ Envelopes lines reproduced from the D.I.D. publication, Hydrological Data Rainfall Records, 1878-1958
- 2) ○ Intensities recorded in December 1969
- 3) X Maximum recorded intensities from, Old Kallang and Paya Lebar Airport 1935-1941, 1948-1964 and R.A.F. Changi 1949-1954

AVERAGE MONTHLY DIURNAL VARIATIONS IN RAINFALL-Kluang



stations which are not far from the coast. Kluang, which is well inland, has frequent calms (30.3 percent of time).

Winds in the Project Area can be estimated by comparison of values at Mersing, Kluang or Singapore after consideration of factors such as nearness to the east coast, distance inland, or proximity to the south coast. (Table 1.1)

TABLE 1.1 MEAN WIND SPEEDS AT MERSING KLUANG AND SINGAPORE

Station	Wind speed Units	Months												Annual
		J	F	M	A	M	J	J	A	S	O	N	D	
<u>Mersing</u> (Lowland coastal site)	metres/sec	4.2	3.6	2.5	1.8	1.8	2.0	2.2	2.2	2.2	2.0	2.0	3.0	2.5
	miles/day	224	195	132	99	98	108	116	120	120	107	110	162	133
	knots	11	9	6	5	5	5	6	6	6	5	5	8	6
<u>Kluang</u> (Hill site inland)	metres/sec	2.2	2.5	1.7	1.1	1.2	1.2	1.3	1.3	1.2	1.1	1.2	1.6	1.5
	miles/day	121	132	91	59	63	63	69	70	65	60	63	89	79
	knots	6	6	4	3	3	3	3	3	3	3	3	4	4
<u>Singapore</u> (Kallang Lowland coastal site)	metres/sec	1.4	1.3	0.9	0.7	0.6	0.9	0.9	1.0	0.9	0.7	0.7	1.0	0.9
	miles/day	77	72	49	35	34	47	49	55	48	38	37	51	49
	knots	4	4	2	2	2	2	2	3	2	2	2	3	2

1.4 Temperature and Relative Humidity.

1.4.1 Temperature.

The variation in mean temperature from month to month and between locations in SE Johor is very small. On Figure 1.10 the range of mean monthly temperature for Mersing, Kluang and Singapore is shown. The highest mean monthly temperature is 27.4°C (81°F) at Singapore in June, and the lowest is 24.6°C (76°F) at Kluang in January. There is however a considerable change in temperature over a 24 hour period. The average temperature for each hour of the day is plotted for Kluang, in the centre diagram of Figure 1.10. The extreme recorded temperature values are also shown. For the three meteorological stations, Singapore, Kluang and Mersing, the highest recorded temperature was 96°F at Kluang in March 1940, and the lowest temperature was 64°F recorded at both Kluang and Mersing in January 1935. The auxiliary meteorological station at Kota Tinggi has however recorded 97°F. An increase in the diurnal temperature range of two or three degrees could be expected if extensive areas of forest are replaced by annual crops or grass.

1.4.2 Relative humidity.

The mean relative humidity at Kluang is 86 percent. There is a slight change from month to month, (depending on the rainfall), with February having usually the lowest value of 83 percent and November the highest with 89 percent. As with temperature there is a very considerable diurnal range, (Fig. 1.10). Maximum humidity is reached around 6 a.m., when the temperature often drops to below the dew point. This brings about deposition of dew and fog. The lowest relative humidity recorded at Kluang, in the period 1936 - 41, was 54 percent in February 1940. In this period less than 2 inches of rain had fallen in 60 days. The average dew point at Kluang is 72°F.

1.4.3 Effective temperature.

The Effective Temperature is an index of human comfort. It is calculated from air temperature, relative humidity and wind speed. The effective temperature is the equivalent temperature of still saturated air which will produce the same physical sensation in lightly clad human beings.

At Mersing, on the sea coast, and at inland Kluang, the mean annual effective temperatures are 4.2°C and 3.0°C respectively lower than for

Singapore.

TABLE 1.2 EFFECTIVE TEMPERATURE (degrees Celsius)

Station	J	F	M	A	M	J	J	A	S	O	N	D	Mean
Kluang	17	17	19	21	21	21	21	20	20	20	20	18	19.6
Mersing	14	16	19	21	21	20	19	19	18	19	19	16	18.4
Singapore	20	21	23	24	24	24	23	22	23	23	23	22	22.6

1.5 Sunshine and Radiation

1.5.1 Sunshine.

In SE Johor, away from the windward coasts it is rare for the sky to be completely free of cloud. The period of least cloud cover during the day is approximately from 9 to 11 a.m., when bright sunshine is recorded, on average, for 70 percent of the time. At 4 p.m. there is bright sunshine for only 30 percent of the time. The average percentage of sunshine for each hour of the day is plotted on Figure 1.10, which also shows the average sunshine hours for each month at Kluang. Sunshine hours for Mersing, Kluang and Singapore are given in Table 1.3 for comparison.

February to April have the most sunshine and November to January the least. Mersing on the coast (200 yds. from the beach) has significantly more sun than either Kluang (many miles inland), or Kallang (800 yds. inland).

1.5.2 Radiation

Radiation values for Kluang as estimated from bright sunshine hours using standard McCullochs tables, are shown in Table 1.4

However Wycherley (1970) who has been carrying out radiation measurements at a number of stations in West Malaysia finds that the above figures seem to be between 10 and 20 percent too high. Table 1.5 shows direct radiation measurements obtained at Swee Lam Estate Kulai, in 1969.

TABLE 1.3 MEAN HOURS OF BRIGHT SUNSHINE PER DAY

Station	J	F	M	A	M	J	J	A	S	O	N	D	Mean
Kluang	4.65	7.14	5.68	5.57	6.14	5.48	5.55	5.67	5.24	4.33	4.07	4.63	5.35
Mersing	5.84	7.04	7.25	7.45	7.00	6.46	6.91	5.91	6.12	6.36	5.13	4.18	6.30
Singapore	5.60	6.30	6.08	5.70	5.70	5.56	6.28	5.38	5.48	5.44	4.56	4.58	5.56

TABLE 1.4 AVERAGE RADIATION AT KLUANG

Units	J	F	M	A	M	J	J	A	S	O	N	D	Year
cal/cm ² /day	411	528	475	460	461	425	431	452	452	417	394	402	443

TABLE 1.5 RADIATION AT SWEE LAM ESTATE - 1969

Magnitude	J	F	M	A	M	J	J	A	S	O	N	D	Year	Units
Highest	478	478	494	626	462	412	445	430	478	478	429	445	626	cal/cm ² /day
Lowest	182	215	182	150	166	150	150	84	133	182	133	133	84	cal/cm ² /day
Mean	330	371	355	318	339	296	297	278	315	318	303	266	315	cal/cm ² /day

1.6 Evaporation

Nieuwolt (1965) reviewed the existing data on evaporation obtained from various pans, evaporimeters and reservoirs. He tested the correlation between pan evaporation and various climatic factors and produced monthly evaporation maps of Malaya. From these maps pan evaporation (which is expected to be 10-20 percent higher than the Potential Evaporation E_o) is estimated as shown in Table 1.6

The DID commenced evaporation measurements in 1957, and at a later date established a number of the now widely accepted, standard United States Weather Bureau (USWB) Class A raised pans. Examination of the records at Kluang shows a number of anomalies, which can be attributed splash errors during high rainfall periods. Intense storms can produce splash up to four feet in height. Considerable loss from the pan then occurs, particularly when these storms are asso-

TABLE 1.6 MONTHLY PAN EVAPORATION (after Nieuwolt) IN INCHES

Station	J	F	M	A	M	J	J	A	S	A	N	D	Year
Mersing	4.8	5.7	5.8	5.8	5.6	5.4	5.4	5.6	5.1	4.8	4.2	4.2	62.4
Kluang	4.4	5.6	5.0	5.0	4.8	5.0	5.2	5.4	4.6	4.4	4.2	4.2	57.8
Singapore	5.5	6.2	6.0	6.0	6.0	6.0	6.1	6.0	5.8	5.5	5.2	5.1	69.4

Wycherley (1969) calculated Potential Evaporation (E_o) according to the Penman equation, which is generally accepted as offering the best means of integrating the various meteorological observations. These estimates are shown in Table 1.7

ciated with high wind gusts. Consequently on some days with high rainfall, the evaporation "recorded" is inordinately high. Evaporation figures from the Kluang pan have been used only on days which recorded no rainfall. On days with rainfall of 0.1 inch evaporation has been

TABLE 1.7 POTENTIAL EVAPORATION, E_o (after Wycherley) IN INCHES

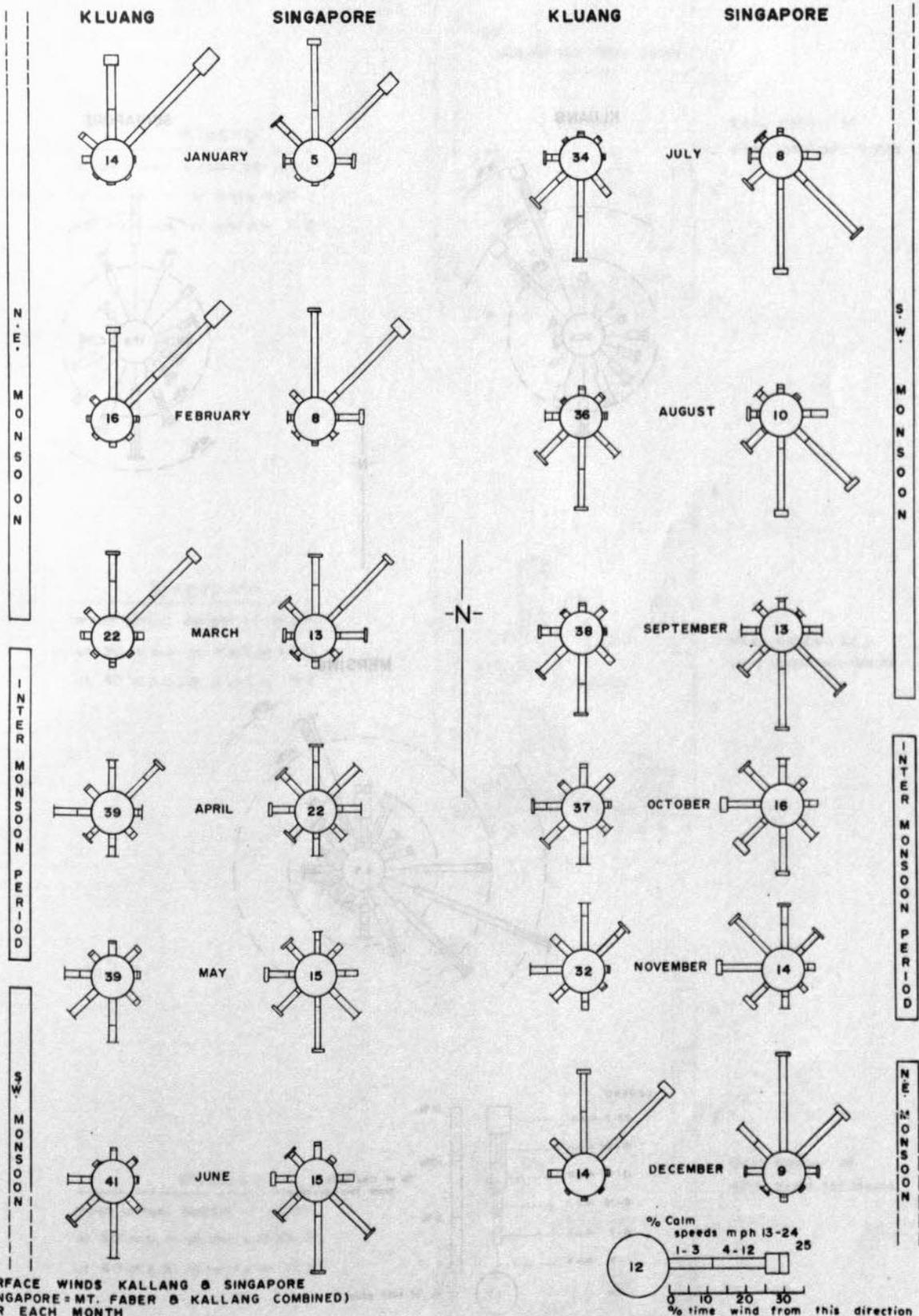
Station	J	F	M	A	M	J	J	A	S	O	N	D	Year
Mersing	7.1	7.1	7.8	7.2	6.9	6.3	6.7	6.5	6.6	6.9	5.8	5.7	80.6
Kluang	5.6	6.8	6.6	6.2	6.3	5.6	5.9	6.2	6.0	5.7	5.1	5.5	71.5
Singapore	6.3	6.1	6.9	6.4	6.3	5.9	6.5	6.3	6.4	6.6	5.6	5.6	74.9

Comparison with Nieuwolt's figures show that the Penman values for open water evaporation are considerably higher than the pan figures of Nieuwolt. Since 1968 Wycherley has been carrying out direct measurements of solar radiation at a number of sites in West Malaysia. Results so far obtained suggest that the estimated radiation derived from bright sunshine hours, (which is used in the Penman calculation when radiation measurements are lacking), produces a considerable overestimate under Malaysian conditions.

assumed to be 0.15 inches and to decrease linearly to 0.0 inches evaporation with rainfall of 3.0 inches or more (derived from data in Hutchinson and Farbrother - 1956). The 5 year mean figures so derived are shown in Table 1.8.

Until more radiation figures are available Potential Evaporation E_o (Table 9) for Kluang has been taken as the average of the Penman estimate, (reduced by 10 percent), and the splash corrected USWB Class A pan figures.

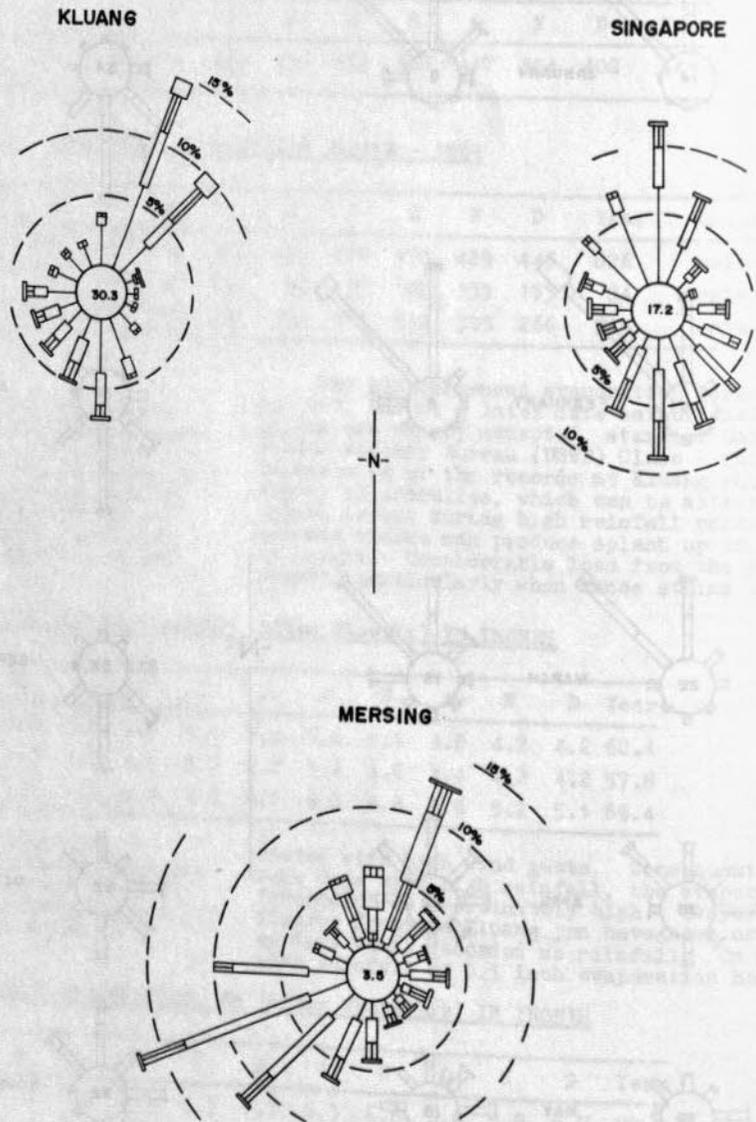
AVERAGE MONTHLY SURFACE WIND SPEED & DIRECTION
Kluang & Singapore



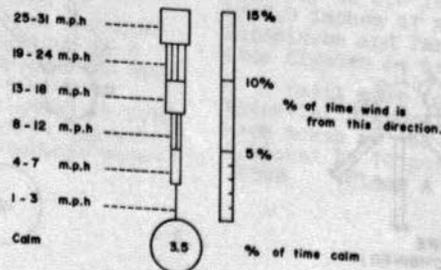
SURFACE WINDS KALLANG & SINGAPORE
(SINGAPORE = MT. FABER & KALLANG COMBINED)
FOR EACH MONTH

FIGURE 1.8

AVERAGE ANNUAL SURFACE WIND SPEEDS AND DIRECTIONS
(Kluang, Singapore and Mersing)

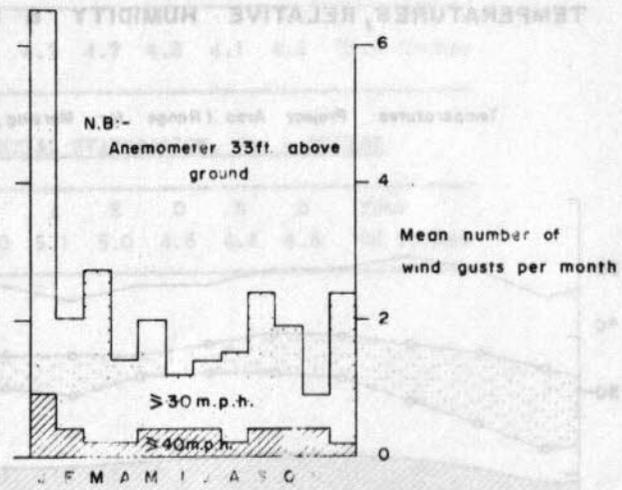


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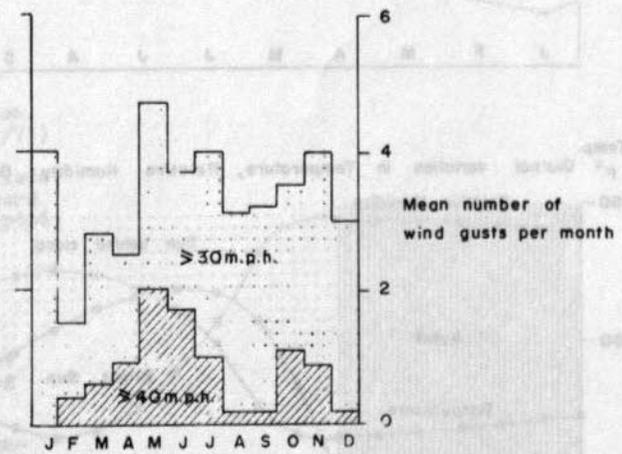


WIND GUSTS - monthly distribution

Kluang
 mean annual number of gusts,
 at 30 m.p.h. or more = 27.1
 at 40 m.p.h. or more = 2.2



Singapore
 mean annual number of gusts,
 at 30 m.p.h. or more = 40.0
 at 40 m.p.h. or more = 4.6



Mersing
 mean annual number of gusts,
 at 30 m.p.h. or more = 52.1
 at 40 m.p.h. or more = 8.5

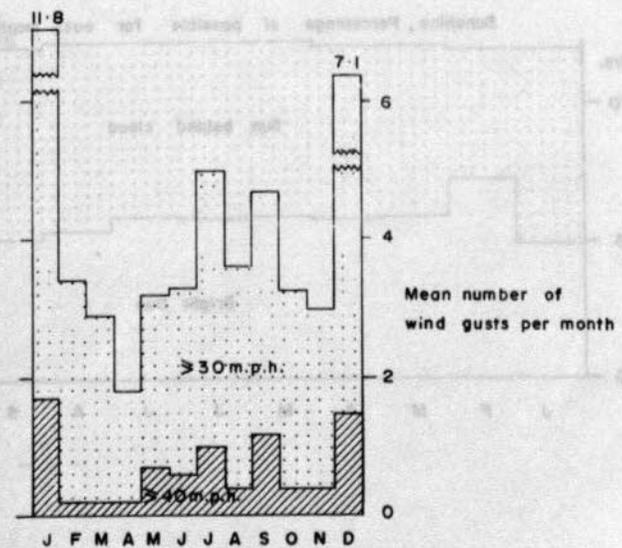


FIGURE 1.10

TEMPERATURES, RELATIVE HUMIDITY & SUNSHINE HOURS

Temperatures Project Area (Range for Mersing, Kluang, Singapore)

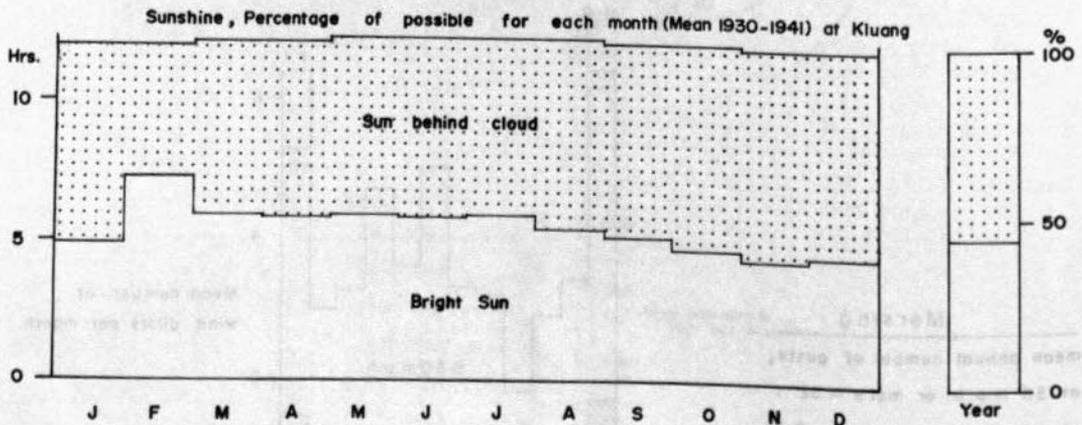
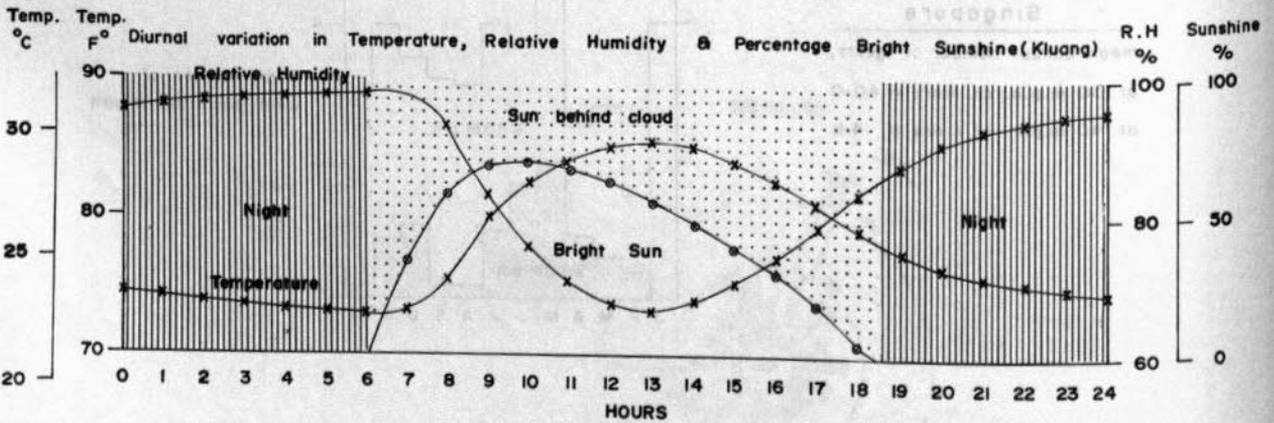
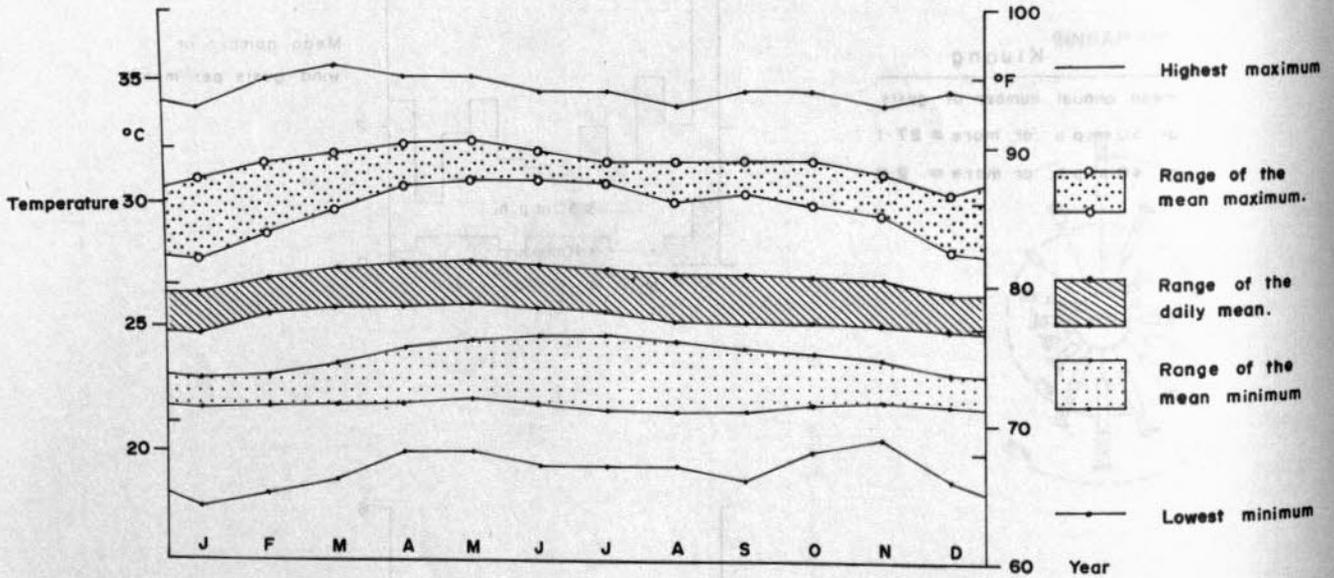


TABLE 1.8 MEAN PAN EVAPORATION - KLUANG

J	F	M	A	M	J	J	A	S	O	N	D	Year
5.1	5.4	5.6	4.5	4.4	4.5	4.5	4.7	4.7	4.2	4.1	4.2	55.9 inches

TABLE 1.9 ADOPTED MEAN POTENTIAL EVAPORATION, Eo, - KLUANG

J	F	M	A	M	J	J	A	S	O	N	D	Year
5.0	5.8	5.8	5.0	5.0	4.7	5.0	5.1	5.0	4.6	4.4	4.6	60 inches

1.7 Thunder and Lightning

At Kluang thunder is recorded on average, 202 days of the year. In the months March to May and October/November thunder is heard on more than half of the days. Figure 1.6 shows that these are the months when rainfall is confined almost entirely to the afternoon period. Lightning discharge is normally to earth rather than between clouds and during some thunderstorms it is quite severe. Lightning risk, compared to other parts of the world, must be considered high.

1.8 Fog

Fog was recorded in the early morning at Kluang on an average of 94 days in the year, April being the month which had by far the greatest incidence (24 days).

1.9 Earthquakes

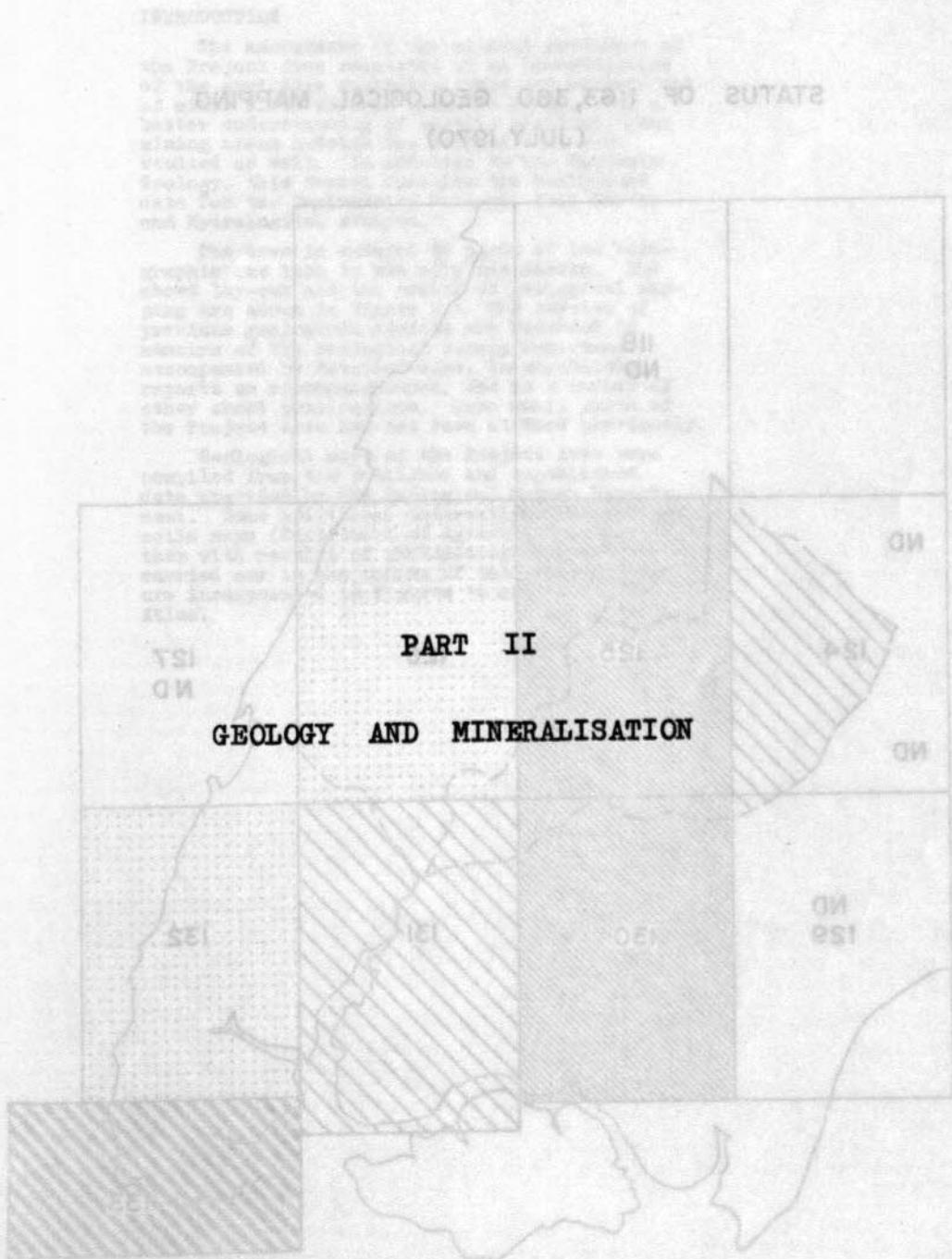
No major earthquakes have been recorded in Johor State although the area is geographically close to Indonesia which has recorded earthquakes. There was a newspaper report (Straits Times 6/2/71) of tremors in Johor Baharu and it was reported that these were felt in some of the high rise flats in the central town area. Certainly these tremors were not severe. Johor State is generally accepted as being in an earthquake free zone.

1.10 General Weather Forecasting.

Watts (1965) concluded that, even with a highly integrated system of weather reporting stations, rainfall was usually so localised that forecasting must always be unsatisfactory during a great part of the year. This conclusion was borne out by an examination of rainfall at two Stations 50 miles apart (Johor 117 and 34). Concurrence of rain days and dry days was not significantly different from a random distribution for most months of the year; only in January to March was there any correlation between these two stations.

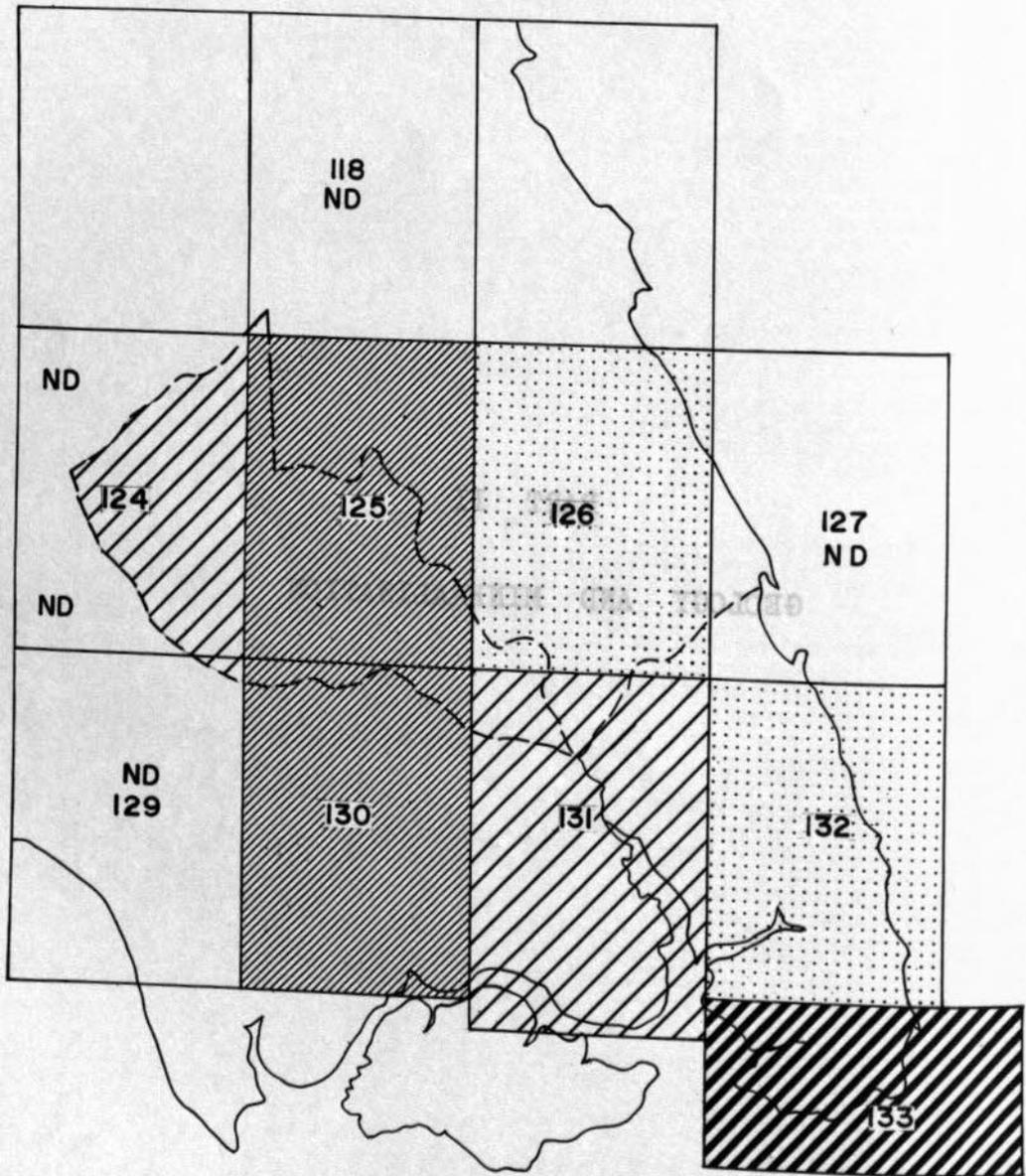
Particular attention should be paid to the possibilities of a flood forecasting and warning system. This could be developed to provide accurate early warnings of flood danger and probable flood levels especially in the lower reaches of the S. Johore. (Supporting Volume 3 Water Resources and Development).

STATUS OF 1:63,500 GEOLOGICAL MAPPING (JULY 1970)



-  Partial with heavy
-  Detailed mapping (contoured)
-  Detailed reconnaissance
-  Preliminary interpretation
-  No data

STATUS OF 1:63,360 GEOLOGICAL MAPPING
(JULY 1970)



- Publish with memoir 
- Detailed mapping (unpublished) 
- Detailed reconnaissance 
- Preliminary interpretation 
- No data 

PART II

GEOLOGY AND MINERAL RESOURCES

INTRODUCTION

The assessment of the mineral resources of the Project Area consisted of an investigation of the available geological maps and reports and of minor field work in selected areas. For a better understanding of certain problems, some mining areas outside the Project Area were studied as well. In addition to the Economic Geology, this report contains the background data for the Engineering Geology, Soil Survey and Hydrological studies.

The area is covered by parts of ten topographic one inch to one mile map sheets. The sheet lay-out and the status of geological mapping are shown in Figure 2.1. The results of previous geological studies are recorded in memoirs of the Geological Survey Department accompanied by detailed maps, in unpublished reports on reconnaissances, and in a number of other short publications. Some small parts of the Project Area had not been studied previously.

Geological maps of the Project Area were compiled from the published and unpublished data provided by the Geological Survey Department. Some additional information from various soils maps (Department of Agriculture) together with results of photogeological work carried out in the course of the present study are incorporated in Figures 10 and 11 in the Atlas.

2.1 Lithological Units

The stratigraphy of the Project Area is summarized in Table I. The oldest rocks outcropping are the slightly metamorphosed argillaceous and arenaceous sediments of the Tanjong Penggerang Region and the Dohol, Linggui and Sedili Formations of the Johor Tengah Region.

The metasediments of the Penggerang Region are considered to be Carboniferous to Triassic in age (Grubb, 1968).

Fossil dating places the Dohol Formation as Middle Permian. The Linggui Formation is assigned to the Upper Permian (Rajah, 1969).

2.1.1 The Dohol Formation.

The Dohol Formation consists of indurated shales and mudstones, spotted shales, slates, phyllites, quartz-mica schists together with black micaceous siltstones, fine to coarse-grained sandstones and grits with occasional conglomerates. Sporadic beds of lavas and tuffs are found at various levels in the Formation.

The Dohol Formation includes the Sumalayang Limestone Member, which is a thick-bedded massive light grey limestone. At the base the limestone is very dark, due to the presence of finely disseminated carbonaceous and argillaceous material. Limited exposures suggest a thickness of approximately 400 feet. The Sumalayang Limestone was the subject of a detailed investigation in view of its economic potential. This was described in a separate report "An Investigation of the Gunung Sumalayang Limestone" submitted in September 1970 and is reproduced at Appendix D to this report.

2.1.2 The Linggui Formation

The Linggui Formation overlies the Dohol Formation and consists mainly of arenaceous rocks variously classified as quartz arenite, quartz wacke, lithic arenite and lithic wacke. Polymict conglomerates occur locally. Amongst the components of the conglomerates, phyllite, sandstone, quartzite, vein quartz, schist and several volcanic rock types were observed.

Throughout the Formation lava flows and tuffs of rhyolitic composition are intercalated with the sediments. The Linggui Formation is probably more than 2,000 feet thick.

2.1.3 The Sedili Volcanic Formation.

This Formation consists mainly of rhyolitic to dacitic extrusives with a considerable proportion of welded tuff. The Formation, estimated to be at least 2,500 feet thick, occurs in the north and east of the Johor Tengah region and in the south and north-west of the Tanjong Penggerang region and is thought to pass laterally into the Linggui Formation.

2.1.4 The Tenang Formation.

The Tenang Formation is probably of Middle and Upper Triassic age. The Formation generally consists of conglomerates, sandstones, shales and interbedded tuffs. In the Project Area, however, only the volcanic facies is represented.

2.1.5 The Pantii Sandstone Formation.

The Pantii Sandstone Formation (Tebak Sandstone of Rajah, 1969) consists mainly of sandstones with occasional bands of shales, mudstone and siltstones. Its colour is variable and may be white, grey, green, yellow, red or brown.

Conglomerates are found at various horizons and in some places at the base of the Formation. Thin coal seams occur locally. Graded and cross bedding are common and lutite clasts are especially characteristic of this Formation. The Formation is regarded as Lower Cretaceous in age, and is estimated to be not more than 1,000 feet in thickness.

Characteristically the Pantii Formation forms mesas, but it is also found in the low ground water of the fault controlled valley of the Sungai Pengeli.

2.1.6 The Layang Layang Formation.

The Layang Layang Formation was divided by Rajah (1969) into the argillaceous Badak Shale Member and the overlying Pengeli Sand Member. The Badak Shales consist of grey, brown and black shales. The Pengeli Sands are essentially unconsolidated white, cream or pale grey quartzofelspathic sands with minor clay horizons. Plant remains suggest a Pliocene to Pleistocene age.

2.1.7 The Granitic Rocks

The Granitic Rocks underlie a large proportion of the area. Several different rock-types are recorded, viz. biotite granite, granite porphyry and granodiorite. Boundaries between the different rock types have not been mapped.

Results of rubidium-strontium age determinations indicate Upper Permian ages.

Field relationships in the Gunung Chemendong area indicate a Tertiary age for some small intrusions of microgranite, quartz porphyry and adamellite.

2.1.8 Superficial Deposits.

Superficial deposits include the Recent river, swamps and beach deposits of clays, sand and gravel together with the various types of soil.

In humid tropical climates chemical weathering greatly affects the bedrock and may extend from the surface to considerable depths. It causes a marked reduction in strength of the rock and the formation of residual soils.

During the Pleistocene epoch the sea level was lowered and valleys were eroded to well below present sea level. As the ice melted the sea flooded onto the land surface; parts of the Johor coastline reflect this drowning which formed the deeply indented estuaries of the S. Johore, S. Lebam and S. Pantii. Therefore, a considerable thickness of soft silts and clays can be expected in these estuaries as they probably occupy the sites of Pleistocene valleys which were subsequently infilled.

On the existing maps Recent, Sub-Recent and Older Alluvium deposits have been distinguished. Several correlations appear problematical in the absence of a uniform classification.

The Recent deposits have particular economic significance in that they contain the alluvial tin deposits and in the case of beach deposits, valuable sands.

2.2 Structure

The Palaeozoic rocks of the Dohol, Linggui and Sedili Formations were strongly folded in a period slightly preceding the emplacement of the bulk of

the granitic rocks. The folds are often tight, steeply inclined and regularly isoclinal.

The dominant strike of the fold belt is NW - SE, but the Dohol Formation has a general NE strike, indicating an earlier folding episode. The folding was accompanied locally by strong faulting.

In the Tanjong Penggerang Region the foliation in the granites is seen to be conformable with the strike trend in the surrounding Metasedimentary rocks.

The complex of the Dohol, Linggui and Sedili Formations together with the granites is in places discordantly overlain by the horizontal to gently dipping strata of the Lower Cretaceous Panti Formation. The beds strike generally about N-S and the low dips are normally to the east.

The Middle to Upper Triassic Tenang Formation rests discordantly on granite. The absence of contact metamorphic phenomena in the rocks of this Formation shows that it is younger than the granites.

2.3 Metamorphism

The rocks of the Dohol, Linggui and Sedili Formations were metamorphosed under conditions pertaining to the greenschist facies. However, the occurrence of staurolite and kyanite in the Tanjong Penggerang Region suggests that locally the conditions of regional metamorphism reached into the amphibolite facies. The regional metamorphism of these Formations probably relates to a general increase in temperature gradient dependant on the wide spread emplacement of the Upper Permian granitic rocks. Around the granite massifs narrow aureoles of contact metamorphism are occasionally found in the sedimentary rocks.

2.4 Geological History

The Project Area is situated in a region which was characterised by a period of crustal buckling and the deposition of series of argillaceous and arenaceous sediments during the Middle and Late Palaeozoic.

The sedimentation was accompanied during certain stages by extrusion of rhyolitic to dacitic lavas and tuffs. These rocks form components of the Dohol, Linggui and Sedili Formations. Interruption in the sedimentation and periods of intermittent erosion are evident from the unconformities between these Formations. Laterally, conditions in the sedimentary basin must have varied considerably as is shown by the way in which the sedimentary Linggui Formation passes laterally into the volcanic Sedili Formation.

The history subsequent to the deposition of the Upper Palaeozoic rocks is one of tectonism and plutonism. A large batholith was gradually emplaced by successive intrusions of various types of granitic rock. The beginning of folding probably coincided with the penetration of the batholith into the basal portion of the geosyncline. During this stage the rocks were regionally metamorphosed within the greenschist facies, although locally the amphibolite facies may have been reached. The occurrence of thermal aureoles superimposed upon the regional metamorphic mineral assemblage may indicate local intrusion of granite into a relatively high portion of the crust. The primary tin mineralisation is thought to be related to the Upper Permian granites.

Erosion of the granite and metasediments preceded the deposition of the Middle and Upper Triassic Tenang Formation which consists normally of conglomerates, sandstones, shales and tuffs. In the Project Area this Formation is mainly

represented by volcanic rocks.

The younger history of the area is preserved only by the rocks of the Panti and Layang Layang Formation with their sandstones and shales. Indications of a Tertiary phase of magmatic activity are found in the Gunong Chemendong Area where some smaller bodies of microgranite, quartz porphyry and adamellite occur.

The Pengeli Sands of the Layang Layang Formations grade into the more recent alluvial deposits of river and beach sands and gravels.

TABLE 2.1

STRATIGRAPHY OF THE PROJECT AREA

AGE	FORMATION/MEMBER	LITHOLOGY	1" Sheets on which Correlated Units Occur
RECENT		Alluvium, swamp and beach deposits; eluvial soils.	
PLIOCENE TO PLEISTOCENE	LAYANG LAYANG FORMATION Pengeli Sands	Older alluvium : angular quartz sand with rounded quartz and quartzite pebbles	
	Badak Shale	Unconsolidated white, cream or pale grey arkosic sands with minor argillaceous layers.	125 and 130
LATE JURASSIC TO EARLY CRETACEOUS	PANTI SANDSTONE FORMATION (= TEBAK FORMATION of Sheet 125)	Dove grey to brown and black clay shale with plant remains.	
MIDDLE TO UPPER TRIASSIC	TENANG FORMATION	Mainly coarse, cross-bedded quartz- sandstone with conglomerate layers. Typically massive, thick-bedded and flat-lying. Occasional thin coal seams.	125
	TENGKIL, LENGGOR AND HLUMUT GRANITES (of sheet 125)	Tuffaceous conglomerate, sandstones, shale and interbedded tuffs.	124
PERMIAN UPPER MIDDLE	SEDILI VOLCANICS	Granites and allied rocks, quartz veins, aplitic and mafic dykes, porphyritic granite, quartz-porphyry, adamellites, granodiorites.	125, 130, 131, 132
	LINGGUI FORMATION (includes the SUMALAYANG LIMESTONE MEMBER)	Fine-grained acid volcanics; ignimbrites tuffs and agglomerates, ranging from rhyolites to rhyodacites, with occasional dacites and basic andesites.	124, 125, 131, 132
PERMIAN UPPER MIDDLE	LINGGUI FORMATION (includes the SUMALAYANG LIMESTONE MEMBER)	Strongly folded mainly psammitic low-grade metasediments, with some pelitic and acid metavolcanic bands	125, 131, 132
		Mainly pelitic metasediments with some psammitic and metavolcanic bands.	

ECONOMIC GEOLOGY3.1 Introduction

Mineralisation known to occur in the Project Area includes tin, bauxite, iron, gold, copper, lead, zinc, rare-earths, molybdenum, titanium and tungsten. Economic rocks and erosion products include limestone, clay, sand and various road-building materials. Tin, iron and bauxite have been worked at various times and at present several tin and bauxite mines are in operation.

The tin mineralisation is primarily related to the late Palaeozoic granitic rocks. Cassiterite occurs in quartz veins and as stringers and disseminations in several of the granites and their country rock. The economic occurrences, however, are found in the alluvial deposits of the rivers which have eroded the parent rocks.

The presently operational bauxite workings are all in the Tanjong Penggerang Region. The bauxite deposits represent the decomposition products of several types of the older rocks.

3.2 Mining and Prospecting

The various areas that had been prospected and mined prior to the commencement of the present study were compiled from data provided by the Mines Department and the Geological Survey on maps at one inch to one mile scale generalised reductions of which appear as Figures 10 and 11 in The Atlas. Individual borehole and prospecting pit sites were plotted. Relatively high mineral values observed were plotted on transparent overlays to the geological maps to show the relation between mineralisation and the distribution of geological units.

Since data about the total volume of ground worked are virtually absent it has not been possible to estimate the potential and reserves of the present mines and prospects. The contribution of this study to the project is therefore mainly a collation of existing data and the indication of areas of further interest.

3.3 Metallic Minerals3.3.1 Tin.

There are nine tin fields in or near the Project Area. Total cassiterite production was 30,011 piculs for the year in 1969, from 34 mines with a labour force of about 1,500 (Table 2.1). The tin fields of the Johor Tengah Region are as follows (the number of operating mines in 1970 is given in brackets):- S. Tempenis (2), S. Tengkil (includes lower S. Linggiu) (15), S. Lebak (3), S. Panti (5); With S. Penaga (1) and the mines on the S. Merbau and S. Susor Rotan (tributaries of the S. Dohol) (3) being just outside the Project Area. In Tanjong Penggerang there are mining fields on S. Seluyut Simpang (2), Upper S. Seluyut (2) and S. Rengit (3).

The cassiterite is produced by the hydraulic, gravel pump and palong method. In the case of Pelepah Kanan Mine, the cassiterite bearing ground is excavated with face shovels prior to sluicing; cassiterite is extracted by tabling and magnetic separation of other heavy mineral constituents.

In the survey of tin prospecting records, reports have been examined on 65/21 of the areas allocated for prospecting from 1923 to 1969 inclusive. Table 2.2 shows the number of prospecting permits issued in each area by years and also the issue of mining licences. The methods

of collating all the data have been mentioned previously, and the tabulated data are shown in Appendix A. Appendix B shows production of individual mines and the average labour force for the last four years.

Figures 12 and 13 in the Atlas show high values of cassiterite outside the areas of present mining land. This information is taken from two sources:-

- a) Prospecting reports of private prospectors, where values greater than 0.25 katis per cubic yard (kpcy) were considered significant.
- b) Prospecting results obtained by the Geological Survey, where two different standards have been used in describing values of cassiterite. Values of cassiterite greater than 0.15 kpcy or greater than five percent cassiterite in samples of heavy mineral concentrates weighing more than one gram, were considered significant. The two Geological Survey standards are not directly comparable. Results can only be quoted in kpcy if a standard dulang was used to obtain the heavy mineral concentrates (i.e. a known volume of sediment was treated). The figures quoted as percentages were obtained before the standard dulang came into use, and therefore the volume of original sediment treated is not known.

The occurrence of high cassiterite values in the active sediment is no indication of payable values at depth or vice versa. However the complete or virtual absence of cassiterite in active sediments means that there is little chance of finding payable amounts at lower levels in the alluvium. It is normal practice to examine the surface material first and the results obtained can be used to set priorities for further exploration (i.e. - those areas showing the highest values should be examined first, etc.).

Figures 12 and 13 (Atlas) show that many of the high values of cassiterite occur near existing mining fields. In most cases they occur in the alluvium upstream from the producing area. No doubt those areas which are payable will be taken into the existing mining land as work proceeds.

The collation of data by this study has shown other areas where high values of cassiterite occur, or where the geological environment for the formation of valuable deposits is particularly favourable. These are situated mainly in the Johor Tengah Region.

The upper S. Linggiu⁽¹⁾ south of Gunung Blumut (Figures in brackets refer to localities marked on Figs. 12 and 13 in the Atlas) shows five high values of cassiterite determined by the Geological Survey and two by private prospectors (pp. 5/36). The high values are upstream from an area of swamp alluvium and it is probable that there is very little cassiterite downstream from there. The area is virtually unprospected and the source of this mineralisation is obscure. It is not derived from the nearest known contact zone which is some three miles to the north. The S. Linggiu in this area lies in an easterly trending fault-controlled valley and it is possible that the mineralisation is related to this structure. Alternatively the cassiterite may be derived from the outer mineralised zone of the granite or from a small undiscovered roof pendant.

TABLE 2.2

MINERAL PRODUCTION 1965-1969

	1965		1966		1967		1968		1969	
	OUTPUT	STAFF	OUTPUT	STAFF	OUTPUT	STAFF	OUTPUT	STAFF	OUTPUT	STAFF
TIN (PIKULS)	25,026	941	37,958	1,274	85,965	1,339	39,400	1,237	30,011	-
IRON (TONS)	12,278	41	35,569	-	56,038	-	103,269	92	-	-
BAUKITE (TONS)	843,172	392	976,016	424	885,389	337	28,968	354	1,056,068	-
TOTAL NUMBER OF RETURNS	42	36	59	50	64	46	60	43	46	-

- NOTE:**
- (i) Staff figures do not give the complete picture, many annual returns give production only not staff but they do indicate the magnitude.
 - (ii) See Appendix B for details of returns by mines.
 - (iii) One Picul = 100 Katis = 133.33 lbs. = 60.48 Kilos.

TABLE 2.3

RECORDED PROSPECTING PERMITS AND MINING LICENCES BY YEARS

YEAR	JOHOR TENGAH		TANJONG PENGGERANG	
	PROSPECTING PERMITS	MINING LICENCES	PROSPECTING PERMITS	MINING LICENCES
1923				
1928	4	4		
1929	1	-	1	1
1930				
1933	2	2	6	3
1934	1	-	6	2
1935	1	-	2	3
1936			1	-
1937	4	-	1	1
1938	1	-		
1939				
1940	1	-	2	-
1941	2	-	7	-
1945	1	-	4	-
1948				
1949			1	-
1950			2	1
1951	1	-	5	1
1952	2	-	1	1
1953			3	-
1954	1	-	5	-
1955	3	-	5	-
1956		1	4	-
1957	1	-	4	-
1958		-	4	1
1959	4	12	12	-
1960	19	3	9	-
1961	33	4	22	2
1962	16	2	33	-
1963	12	4	22	1
1964	15	3	7	-
1965	7	8	24	2
1966	28	2	7	-
1967	27	-	13	2
1968	41	-	64	7
1969	5	-	74	2
			64	-
			4	1
TOTALS	233	33	418	33
COMBINED TOTALS	PROSPECTING PERMITS : 651.		MINING LICENCES : 66	

The upper tributaries of the S. Chenas⁽²⁾ show three high values determined by the Geological Survey. No contact zones are known in the vicinity. The tributaries drain into a large area of swamp alluvium around Kuala Pengeli/Chenas. Further prospecting is recommended particularly in the northern part of the swamp alluvium. Currents through swamps are sluggish and therefore have a poor carrying capacity. For this reason it is not usual to find heavy minerals (like cassiterite) which have been taken in by the headwaters of drainage system, downstream from an area of swamp.

The headwaters of the S. Pengeli⁽³⁾ show one high tin value south of Bt. Batu Tongkit. This may be related to the same mineralisation as that mentioned above. In addition five high values of tin were found by a private prospector (pp. 103/64) on the S. Pengeli approximately one and half miles upstream from Kuala Chenas. These latter values seem to be partly in Recent alluvium and partly in ground underlain by the Layang Layang Formation. It is possible however that the boreholes were wrongly plotted in the prospecting report and that all the holes are actually in alluvium. The boundary of the alluvium in this area is accurately known from soil survey traverses carried out by government soil scientists.

Twenty five high values of cassiterite were found in pp. 66/61 on the S. Sebol⁽⁴⁾. According to the geological map most of the tributaries of this river drain the Panti Sandstone Formation which contains no primary cassiterite mineralisation. It is unlikely that the cassiterite has come from the nearest granite shown in the map, which is some four miles to the northwest. The boundaries on the geological map are extremely tentative in this area due to poor exposure. It is more likely that the cassiterite results from a mineralised contact zone which is exposed to erosion and not covered by Panti Sandstone as shown. This theory is supported by evidence from a tin mine further north. The tributaries transporting cassiterite in this case have come from the same general area and again do not, according to the geological map, drain any granite or contact zone areas. It is probable therefore, that the boundary of the Panti Sandstone Formation in this vicinity is further north than is shown on the official one inch geological map.

High values in alluvium adjacent to the S. Sayong (pp. 70/61) 1.5 miles upstream from Kuala Linggiu⁽⁵⁾ may be related to the same mineralised zone as the above occurrence and are worthy of further investigation.

Two high cassiterite values have been found in tributaries of the S. Tebak north of Kuala Linggiu⁽⁶⁾. It is likely that these are spurious; there are no contact zones in the area drained by these tributaries and the granite is thought by Rajah (1969) to be at a considerable depth in this vicinity. Results are pending on pp. 1/69, which is also in this area.

In the easterly flowing tributaries of the S. Linggiu north of Kuala Tempenis⁽⁷⁾ high cassiterite values have not been recorded to date. In this area metasediments occur overlying granite. The westerly flowing tributaries are more promising and show two high values in streams which are fairly near a contact zone. This area of the Linggiu could also be important because it drains a known tin bearing area, and has a tributary the S. Sentroh which drains a contact zone to the northwest (largely outside the Project Area).

The S. Jengeli is worth investigation, the tract of alluvium is extensive and prospecting to date has been very sporadic and was carried out long ago. A report on PL 29/28 mentions promising

values of cassiterite in deep alluvium in one area (this could be similar to deep alluvium found in Linggiu Tin Field), and recommends further prospecting. The main river is situated in a fault-controlled valley with Panti Sandstone to the west. The latter probably covers a contact zone. Tributaries from the west (S. Jengli Kanan, S. Jengeli Kiri) rise in the same general area as a mineralized area mentioned above. In addition it is considered that the S. Sentroh originally formed the headwaters of the S. Jengeli. River capture by a western tributary of the S. Linggiu has taken place. As the S. Sentroh is eroding a contact zone to the north, any cassiterite mineralisation eroded from that area would have originally been deposited in the S. Jengeli. It is considered unlikely that any valuable alluvial deposits will have resulted from the eastern tributaries of the S. Jengeli, since, judging from the geological map, any contact zones in this area will be deeply buried.

The alluvium of the S. Sedili (outside the Project Area) appears to be worth further investigation. Many of the headwaters are eroding contact zones. The Ulu S. Sedili, south of Bt. Pachat is particularly important, as it drains the same contact zone as that which forms the source of the S. Tempenis tin field.

Prospecting is warranted in the S. Madek (outside Project Area). Tin mining was carried on here in the past and high values have been recorded by the Geological Survey.

In the Tanjong Penggerang Region, tin mines operate along the S. Seluyut and the S. Rengit. In addition high cassiterite values have been recorded by private prospectors in four areas between S. Metangor and S. Sebina⁽¹⁵⁾. They appear to be related to a contact (possibly faulted), between granite and volcanics. A fifth area of high values is south of land for which mining permission has been applied, in the headwaters of the S. Sedili Kechil⁽¹⁶⁾. This area is adjacent to a granite/metasediment contact.

The Tanjong Penggerang Region has never been a large tin producer, but there is considerable evidence that cassiterite prospecting could reveal profitable deposits. The areas mentioned above are worthy of detailed prospecting. The close association of known tin deposits with contacts between granites and meta-sediments is most striking. Tracts of alluvium laid down by rivers draining these contact zones are extensive and should be investigated. Those draining the possibly faulted contact zone between the belt of metasediments and the granite are likely to be the most important (see also section on gold deposits).

It is not possible to define any areas of special interest for cassiterite in the west of the Johor Tengah Region. Only one significant cassiterite value was found. This occurs on the boundary of the Project Area, near MP 82 on the road northeast from Kluang. Chong (1970) regards the granite which covers most of the area as being similar to the tin bearing granites found by Rajah (1969) to the east. The lack of cassiterite in the present drainage system, may be related to deep erosion of the granite in Pre-Cretaceous times. There is evidence that the area was covered by the Cretaceous Panti Sandstone, and if the granite in the area was originally intruded at a relatively high level, the outer mineralized zone would have been stripped off and the valuable minerals lost before Panti Sandstone times. It may not be coincidental therefore, that in other areas like Gunong Panti, where the Panti Sandstone overlies granite, no alluvial deposits with high values of tin have been found.

3.3.2 Aluminium.

Bauxite mining is confined entirely to the

the Tanjong Penggerang Region, and, until recently, to the south of that area. Work commenced in the mid-thirties, and carried on through the Japanese occupation to the present day. Though there have been a number of small mining companies involved, from time to time, production and shipping are now in the hands of two companies, South East Asia Bauxites Ltd., and Ramunia Bauxite Ltd. (or its associate company Century Mining Sdn. Bhd.).

Grubb (1968) produced a regional geological map of the main bauxite area (one inch sheet No. 135) and carried out a detailed investigation of the bauxite occurrences, their mode of formation, methods of mining, future prospects, etc. The deposits were classified as residual or alluvial. The former is the most important in terms of the tonnage available for exploitation.

The residual deposits occur as cappings on low lying hills between 50 and 200 feet. They result from the leaching by groundwater of iron, silica etc., from parent rocks which contain a significant amount of aluminium. Alluvial bauxite deposits result from the erosion and transportation and redeposition of residual material. Alluvial bauxites occur as thin sheets on the lower slopes of hills and the surrounding low swampy areas.

The process of producing residual deposits by the leaching of certain constituents from the underlying parent material is a common phenomenon in tropical climates with heavy rainfall; the general term for this process is laterisation. The product of this tropical weathering may be bauxitic laterite (consisting predominantly of alumina) or ferruginous laterite (mainly iron oxides) or any mixture of these two. The silica content varies according to the composition of the parent material and the degree of leaching. Accumulation of residual bauxites is controlled by a number of interrelated factors. The most important of these are:-

- Nature of the parent rock, in particular its abrasion, pH, composition, texture, granularity, joining and degree of fracturing. These factors control the rate of leaching.
- Total rainfall and its seasonal distribution.
- Fluctuations in the position of the water table, and the nature of the topography.
- Temperature, which governs the formation of humus. At high temperature, humus is destroyed faster than it accumulates. Large humus accumulations often restrict groundwater circulation and decrease pH.
- pH of meteoric waters. It is noteworthy that higher grade bauxite tends to be found on lalang-covered hills, rather than those covered by primary or secondary jungle, where the pH is lower.

Grubb's investigation has shown that, for the Tanjong Penggerang Region, the most significant facts related to bauxite formation are:-

- Economic deposits of mixable grade material are frequently associated with extremely fine grained extrusive rocks, especially rhyolite.
- Bauxite developed from basalt or basic hypabyssal rocks is usually high in silica and extremely high in iron.
- Bauxite derived from schist or shale is generally high in iron and silica.
- Bauxite originating from acid plutonic or hypabyssal rocks generally contains too much silica to be of economic interest.

- Bauxite is seldom found in deposits rich in kaolin, and, when found, usually has a high silica content.
- Deposits of residual bauxite are found mainly as cappings on hills below 200 feet in elevation.
- Economic deposits of alluvial bauxite have been found to occur mainly along the coastal plain.

The past and present mining and prospecting areas are shown in Figure 13 in the Atlas. Total production is currently running at approximately one million tons per annum. Century Mining Sendirian Berhad, (an associate company of Ramunia Bauxite), has commenced development work in three new areas north of Sungei Papan (17). A fourth area in this vicinity will also be worked by Century Mining. Production from the new deposits was expected to begin in September 1970, and will probably rise to 10,000 tons per week. It is expected that known reserves will last for approximately five years, though smaller areas may possibly be found adjacent to the main deposits and work may continue for longer than this period. Recent production for Ramunia Bauxite is:-

	1965	1966	1967	1968	1969	Jan-May 1970
Tons -	190,957	88,886	276,737	387,257	412,680	121,881

South East Asia Bauxites Ltd., currently hold six mining permits in the South of Tanjong Penggerang covering some 3,570 acres (M.L's 480,476, 477,478, 479 and MC 467). Their production has fluctuated in recent years as can be seen from the figures given below:-

	1965	1966	1967	1968	1969	Jan-May 1970
Tons -	488,287	667,863	505,906	391,789	643,388	356,291

No definitive figures for reserves are available but it seems likely from the prospecting reports that production could be maintained at the present level for at least ten years.

It is common for mining companies to work after the time they have estimated for the extraction of proved reserves. Small areas which can be worked cheaply are frequently found which were not included in the original estimates. How long this is likely to extend the life of the mines is impossible to estimate at present. It is also possible that deposits which are at present of reject grade, will prove to be workable in years to come, due to improvements in beneficiation and smelting processes.

The prospect of finding large areas capable of producing similar amounts of bauxite to that found in the Southern part of the Tanjong Penggerang Region is considered negligible, since considerable prospecting has been carried out with negative results.

The newest area of bauxite extraction (17), north of S. Papan, is at present still problematical. Three of the deposits occur over metasediments but the exact nature of the parent material is not known. According to the geological map the fourth deposit is derived from granite. It is likely, that all other factors being favourable for bauxitisation, the parent material in these four areas is sufficiently different from the main bulk of the granite or metasediments to have permitted a high grade bauxite deposit to be formed. The usual products of laterisation on these parent materials are high in iron or silica.

With regard to the Johor Tengah Region, although large areas of favourable parent material occur, in particular the Sedili Volcanics, other environmental factors are too unfavourable to have permitted the formation of commercial bauxite deposits. Rajah (1969), discussing Sheet No. 125,

which covers a large part of the area, has remarked that evidence of laterisation processes is not common.

Workable deposits may occur in the area southeast of Kota Tinggi, and north of the S. Santi estuary. Here volcanic rocks, similar to those found further south, occur and, as far as can be seen, other factors influencing bauxitisation are not unfavourable. Bauxite was worked from similar material near Kuala Kim Kim, further west, across the Kuala Sungai Johore where 14,325 tons were produced in 1938.

Other areas of Tanjong Penggerang are not regarded as having much potential. Here granite and metasediment parent materials are only likely to give rise to small localised deposits of marginal grade which are most likely to contain objectionable amounts of iron and/or silica.

3.3.3 Iron.

The areas that have been prospected for iron, the location of expired and current mining permits and producing mines are shown in Figures 12 and 13 (Atlas). Iron mining in the Project Area probably dates from the 1930's.

There are eight deposits in or near the Project Area which have at various times been considered as potential mines. Despite considerable prospecting and reinvestigation of these by numerous companies over many years very little extraction has been done.

Pelelah Kanan (1°50'N - 103°50'E) (9): This site is on a south-eastern spur of Gunung Muntahak, and the deposit occurs on two small foothill ridges. It was first discovered by H. Maegawa in 1933 and in the period up to 1941 was extensively prospected by the Ishihara Sangyo Kosi Company.

The geology and genesis of the deposit have been discussed in detail by Bean (1969). The hill in which the deposit occurs is formed of a roof pendant of quartzite and calc-silicate hornfels overlying granite porphyry. A lens shaped body of haematite-magnetite forms the hill capping and has prevented the erosion of the underlying metamorphic rocks. The main body has a maximum thickness of 250 feet and consists of grey to brown haematite in reddish-brown limonitic clay; magnetite and martite are also disseminated in the clay. The junction with the underlying decomposed metamorphic rocks is irregular and no contact of the deposit with granite porphyry has been observed. The metamorphic rocks below the ore body contain patches of magnetite and cassiterite which are particularly abundant in and near quartz veins which cut the country rock. Detrital deposits consisting of boulders of haematite and magnetite, the latter often altered to haematite and martite, occur on the crest and flanks of the hill. Cassiterite is disseminated throughout the deposit; it is rarely below 0.1 percent tin and frequently above 1.0 percent. According to Bean, the cassiterite occurs as discrete crystals and there is no chemical combination with the iron minerals.

The deposit has been examined during the present study, which supported Bean's conclusion that Roe's (1941) theory that the deposit is due to the secondary enrichment of disseminated primary magnetite in the metamorphic rocks is untenable. The Wilbourn (1936) and Burton (1959) theory of injection of iron-rich solutions from a granitic parent magma seems to be much more satisfactory.

Drilling, pitting and underground drif-

ting showed a considerable deposit of haematite cassiterite ore. During the second world war 300 pikuls of tin ore concentrates were produced by open cast mining methods. After the war the area was re-prospected but no further extraction was done due to the difficulty of separating cassiterite from haematite. In 1957 ground sluicing on the site of the old mine was commenced and has continued ever since. Several reinvestigations by a number of companies failed to find a complete solution to the problem of separating the two major constituents of the deposit.

The mining rights for iron in the area have been allowed to lapse, but tin is still being worked. As far as is known only 12,500 tons of iron ore have been produced since the mine opened, and this as a by-product of tin mining.

Currently the massive iron deposit is being removed and stockpiled. The softer parts of the deposits, the limonitic clay and decomposed calc-silicate hornfels, are being extracted with face shovels and slurried to a cassiterite separation plant. The solid material is crushed and the cassiterite is concentrated on a jiggling table and by two stages of magnetic separation.

Roe (1941) reported that two million tons of iron ore (minimum 55 percent Fe, maximum 10 percent SiO₂), had been proved, with larger reserves of a lower grade ore. Other workers have thought his figures were optimistic. The deposit has recently been investigated by German scientists and engineers on behalf of Metallgesellschaft. The result of their investigations are not known.

The mode of occurrence rules out any extensions of the known deposit near the surface. The topographic expression of the deposit is sure to have stimulated the search for similar deposits in the area, presumably with little success.

Pelelah Kiri (1°49'N - 103°50'E) (10): This site is 1.5 miles south of Pelelah Kanan and was found as a result of prospecting in 1933.

The ore is similar to the detrital ore found at Pelelah Kanan. The larger boulders consist of martitized magnetite while smaller material is mainly martite and limonite. It seems likely that the primary body consisted mainly of magnetite, that it was similar to that at Pelelah Kanan and has been completely eroded away. Iron deposits in this area are mentioned in the Annual Report of the Geological Survey for 1922. The northern end of the ridge separating S. Seluang and S. Sisek is said to consist of ore, and boulders of haematite/magnetite occur from here to Ulu Pelelah Kiri.

Cassiterite is found throughout the deposit and surrounding hornfels and clays; the average analysis shows 0.1 percent tin. This with 0.1 percent phosphorus and 0.1 percent arsenic makes the ore unsaleable without beneficiation or blending. The area is not currently held under any mining lease. Two old mining permits (M.L.'s 502 and 506A, M.C.'s 863 and 858 respectively), have expired. No work was done in ML 506A but there are conflicting reports on ML 502. It is understood that no work has been done but production figures were 700 and 10,550 tons in 1967 and 1968.

Susor Rotan (1°52'N - 103°50'E)⁽¹¹⁾: This deposit consists, like that of Pelepah Kiri, entirely of detrital material. It has similar contamination by tin and arsenic (each approximately 0.17 percent), and is not marketable in its present form. The iron content, though variable, often exceeds 60 percent. Flinter (1963) considers that the primary deposit was of replacement magnetite in quartzite; this makes it similar to the primary mineralisation found at Pelepah Kanan.

Some 230 acres are currently held under Mining Certificates in two adjacent lots (M.C.'s 603 and 634). Between 1963 and 1968 when mining ceased, 73,836 tons were produced in M.C. 603. Bean's figure of 138,978 tons for 1965 is probably erroneous and may refer to other deposits in addition to Susor Rotan. The Mines Department report that an application has been made to mine cassiterite in MC 603. This will presumably consist, like Pelepah Kanan, of separating cassiterite from the residue of the iron mining operation or from the country rocks of the iron deposit. No production has been recorded against M.C. 634.

The Bukit Permatang area (1°59'N - 103°52'E)⁽¹²⁾: This area comprises two deposits which are outside the Project Area. The true thickness is not known, but is a minimum of nine feet. Exploration has shown the deposits to consist entirely of detrital material. The genetic relationships of the iron minerals is not known, but analyses suggest that the deposit is a very high grade magnetite or haematite. The iron content is around 68 percent for the two samples which have been analysed, with silica at 1.3 percent, sulphur and phosphorus at 0.005 percent and an absence of tin. The grade of the deposits suggests a mode of formation similar to that of Susor Rotan or Pelepah Kanan, but here the absence of objectionable materials could render the ore workable. It is obvious that the analytical results given above are unlikely to be typical of the entire deposit, but the fact that a primary deposit has not been proved to be absent beneath or near the detrital material makes the area worthy of further investigation.

The area is currently under M.C.'s 642 and 584 which total 250 acres. Preliminary operations for mining were begun in 1961. The recorded production figures are:-

	1967	1968	1969
MC 584 - Metal Mining Company	2800 tons	4995 tons	-
MC 642 - Sharikat Lombong Sedili Sdn. Bhd.	30181 tons	84086 tons	-

The reasons for the cessation of production are not known. It is not known whether a primary ore body was found or whether all the ore is residual. The M.C.'s 584 and 642 expire in 1975 and 1995 respectively. They employed 13 and 65 men at peak production.

Sungei Haus (1°55'N - 104°00'E): This deposit is just north of the Project Area. The ore here occurs as thin lateritic cappings (altered metasilstones and phyllites) on small hills which protrude from swamps. The deposit consists of limonite with an extremely variable iron content which at best is only medium grade (39 - 56 percent Fe); silica varies from 4.06 to 26.06 percent;

phosphorus is variable up to 0.48 percent, with alumina and titanium also high, (see report A99).

The area is covered by two adjacent current mining permits (M.C. 585, M.L. 486), which total 486 acres. The licence expires in June 1981.

Bukit Twatow and Tanjong Penawar^{(13) & (14)}: (1°30'N - 104°15'E and 1°31'N - 104°16'E respectively): These deposits like that at Sungei Haus, are almost certainly hill cappings of residual material after metasediments. Ferruginous laterites and bauxites are commonly found in this part of Johor as residual deposits on high ground. Though it has not been conclusively proved, it is highly unlikely that a primary iron deposit exists. The area has been prospected twice (reports A.91 and A.102) and the deposit is at best only medium grade (50 - 56 percent iron with 0.46 - 0.65 percent phosphorus). (The two prospecting reports show considerable differences in their estimates of the volume of ore present).

It is probable that small residual ferruginous laterite deposits, similar to those at Sungei Haus, Bukit Twatow and Tanjong Penawar will be found in areas underlain by metasediments, but it is unlikely that deposits of this type will be workable in the foreseeable future. The material is chemically and physically too variable to be usable in modern iron making practice. The trend is increasingly towards using ores, not only of high purity, but also those which show as little variability as possible. The proposal to build an integrated iron and steel plant locally (i.e. in Singapore) will not necessarily affect the situation. In the long run it would be more economical to import high quality ore, rather than use small quantities of the local materials, no matter how cheap they are.

The cassiterite-bearing iron-ore deposits are potentially very valuable as they have a high iron content. The deposits do however, seem to be rather small by present day iron ore mining standards. In order to remove the cassiterite, the ore would have to be crushed, and a finely particulate ore suitable for pelletising would be produced. This is in accordance with most modern iron and steel making processes. In a finely divided form the ore could be slurried and pumped to a port or railhead and this would reduce transportation costs. The cassiterite would be a valuable by-product and may serve to make the whole process more economic. The viability of these deposits depends on the development of a method for separating cassiterite. Unfortunately the team of German experts investigating Pelepah Kanan deposit left in April, shortly after the present study began, and their findings are not known. The Susor Rotan deposit is similar to Pelepah Kanan and therefore the same observations apply.

The reasons for the closure of the Bt. Permatang deposits are not known. This deposit contains a high quality ore, and assuming that little systematic exploration has been done, some work to determine the nature of the deposit should be done.

3.3.4 Copper.

Showings of chalcopyrite, bornite and malachite have been observed by Rajah near the Sungei Meranti roof pendant (outside the Project Area). They occur in quartz veins along with wolframite in the Lenggor Granite just southeast of Bt. Harimau. Analysis of these minerals by the Geological Survey has shown traces of gold. Grubb (1968) records the presence of very minor amounts

of chalcopyrite in rhyolitic lavas near Tanjong Pasang in the South of Tanjong Penggerang. This occurrence is not likely to have any significance.

The first mentioned copper mineral showings are worthy of further investigation possibly by stream sediment geochemistry.

Significant amounts of copper were found in the analyses of the Bt. Twatow and Tanjong Penawar iron deposits. It is not known whether the mineralisation is related to granites (there are none in the immediate vicinity), or whether the copper was deposited along with some of the argillaceous metasediments at the time of their original deposition. The occurrence is worthy of further examination.

3.3.5 Lead.

Galena has been noted in the heavy mineral concentrates from the S. Tengkil and from the contact aureole of the Madek metasediments with the Lenggong Granite. Chone (1970) found galena disseminated in granite near the upper reaches of the S. Kahang, northwest of Bt. Bitu Tengkit. The latter two areas should be investigated using stream sediment geochemical methods.

3.3.6 Zinc.

Sphalerite is associated with galena in the Madek metasediments. Any investigation for lead should also include zinc.

3.3.7 Gold.

Traces of gold in river alluvium have been found associated with three rivers in one area of Tanjong Penggerang. The annual reports of the Geological Survey for 1930 and 1935 mention occurrences of gold, with cassiterite and staurolite, in the S. Lebam and S. Papan (near Kanga Papan) respectively. The annual report for 1963 states that gold was worked on S. Santi till 1942.

Prospecting was carried out in four areas of S. Papan. Although mining permission was given there is no record of gold production. The heavy mineral assemblage is cassiterite, gold, zircon, tourmaline, staurolite, ilmenite, alucite, anatase, monazite, rutile and corundum. Certain of these minerals suggest that the river is draining an area of metasediments which show a higher grade of metamorphism than the average. The possibility of a higher grade metamorphism in this area due to shearing along the contact of the granite with the metasediments, has been referred to previously. It is likely that the gold, which originates from the granite, is associated with this area of more highly metamorphosed rocks. Figure shows that very little official prospecting has been done in this area. Further work is required. Traces of gold were also mentioned in the annual report for 1922. They occur in cassiterite bearing gravels at Senopa Mine, Sungei Pelepah, near Kuala Linggiu. (Nothing further is known about this occurrence).

3.3.8 Rare-earths.

Monazite, xenotime and allanite occur in detrital heavy mineral concentrates and are constituents of amang (heavy mineral by-product from tin mining).

Monazite is a complex phosphate of cerium. Uraniferous monazite (cheralite) also occurs but neither are known in economic quantities.

Xenotime (yttrium phosphate) is found in heavy mineral concentrates, very commonly in the S. Tengkil area. It is not known whether commercial quantities exist.

Allanite is an accessory mineral of certain granites. It contains some cerium lanthanum and thorium. It does not occur in workable quantities.

3.3.9 Molybdenum.

Traces of molybdenite were found in the cassiterite bearing alluvium worked by Linggiu Tin Mines Ltd., in Ulu Tongkil, overlying a granite bedrock. This mineral breaks down easily and therefore will not have been transported far from its source. Further investigation using geochemical techniques would be worthwhile.

3.3.10 Titanium.

Minerals of this metal, leucoxene, rutile, anatase and brookite are all fairly common in amang. Ilmenite is the major component of most tin mining heavy mineral waste. According to the Mines Department no amang is marketed from tin mines in the Project Area. There are, therefore, presumably dumps of this material which could be collected and possibly treated. High values of ilmenite were recorded in a stream northeast of Sayong Village, but in the absence of tin these will not be economically workable.

3.3.11 Tungsten.

The principal mineral, wolframite, has been recorded from a number of localities. One occurrence with copper minerals near Bt. Harimau has been mentioned previously, the second is in stream sediment concentrates in the vicinity of Bt. Harimau.

Tungsten and tin are commonly associated in mineral deposits, and a search for tungsten could be made using stream sediment geochemistry.

3.4 Non-Metallic Minerals

3.4.1 Road Building Materials.

Granite is the most widely used road metal. This is partly because of its widespread occurrence, but also because it is the most durable and has the best friction characteristics of all the rocks known in the Project Area. Existing quarries are run by the Public Works Department and these together with quarries which are no longer working are shown in Figure 14 of the Atlas.

Potentially any land underlain by granite could provide road building materials. In practice it is obviously cheaper to work where the superficial material is thinnest and where the surface of the granite is unweathered. It is also undesirable to have to work below the general ground level. Areas of high ground underlain by granite, which should provide sources of road metal are shown in Figure 14.

Other materials which could be used for road metal are tuffs and sandstones. The areas underlain by these materials are shown in the geological maps (Figures 10 & 11 of the Atlas). Second class roads, plantation and estate roads have been traditionally made with compacted ferruginous laterites. These are cheap to lay and require very little skilled maintenance. Most of the hills underlain by the belt of metasediments which extends northwest from Tanjong Punggai (Tanjong Penggerang) have lateritic cappings. The extent or suitability of these laterites for road building is not known. Chong (1970) has recorded a laterite deposit in Johor Tengah, two miles north of S. Sayong village.

The bauxite mining in Tanjong Penggerang has produced or revealed large amounts of reject grade material which is not too dissimilar from ferruginous laterites and could be used for the building of minor roads. Utilisation of this material also has the added advantage that it would make possible the removal of unsightly dumps, and could lead to the levelling and eventual rehabilitation of an area which is likely otherwise to become an unsightly barren waste.

It should be noted that no field investigations for road metals have been made. Therefore, further evaluation must be made of the areas indicated before quarry sites can be established.

3.4.2 Sand.

Almost the entire east coast of the Tanjong Penggerang Region, apart from those parts where solid rock forms the coastline, can be regarded as a possible quartz sand producing area. The superficial deposits, (sometimes soil or peat covered), consist of beach sand and extend up to two and a half miles inland in the north, the average width of sand probably being about three-quarters of a mile. The deposits were formed from a series of parallel strand lines along a coastline of emergence. The maximum depth of sand is not known, but it thickens from the older rocks in the west towards the sea. Twenty feet or more of sand was measured at one locality about half a mile from the present shore-line. Present day sands show an abundance of comminuted shells, while the older (more westerly) deposits are poor in shell fragments. This is undoubtedly due, at least in part, to the leaching action of acid groundwaters. In certain areas, (e.g. Jason's Bay), the recent sand tends to be contaminated with silt sized particles of material other than quartz, which have been carried to the sea by the Sungai Sedili Besar and have drifted southwards due to long-shore currents. Inland from Jason's Bay however, some highly pure sands occur and these represent older beach deposits that have probably had detritious material leached out. Sand is being worked sporadically 1.5 miles west of Sedili. There is no record of this working.

High quality silica sands, such as those used in the glass and chemical industries, show sporadic occurrence but have been extracted from the area for at least twenty years. These sands have to be of such high purity that they should be essentially monomineralic in quartz. Permissible trace impurities are variable according to use but will be less than 0.05 percent Fe₂O₃, 0.2 percent Al₂O₃, 0.05 percent MgO and 0.01 percent alkalis. Grain shape is not an important factor though high angularity promotes melting. Size frequency distribution of grain size is critical and can only vary between narrow limits. Uniform grain size is important for ensuring even melting in the glass tank. If the proportion of fines is too high they are carried over in flue gases and tend to fuse on the checkerwork. On the other hand, sand which is too coarse often survives in the melt. There are a number of standard specifications (three in the U.S.A.) for grain size. The British Standard is fairly typical:-

Residue in 16 mesh - Nil
Residue in 26 mesh - Not more than 2 percent
Residue in 36 mesh - Not more than 10 percent
Residue in 100 mesh - Not more than 10 percent
Residue in 120 mesh - Not more than 5 percent

Several traverses of the beach deposits have been carried out and sand samples taken in the course of the soil survey. A visit was also made to producing sand pits during the geological study.

Augering at fairly closely spaced intervals along certain traverses, has indicated that high quality sands tend to occur in areas where the post-depositional environment is of a particular type. The water table is in general quite high and in our experience never below four feet. In areas covered by jungle, a thin soil is developed and the leaf litter and humus zones are deeper than in those areas which are covered by sparse belukar or lalang. In the latter areas, the grass is found growing virtually on sand. Sands overlain by peat are heavily iron and humus

stained and are not suitable for glass manufacturing. Usually the best sands tend to occur on slight ridges which are raised above the general ground level.

Traverses in jungle areas have shown that high quality sand is very sporadic in area and depth, there are frequent intercalations of clay, and sands are heavily stained by iron or humus acids. Of about 20 holes put down in such areas only one contained sand of reasonable quality. This was less than three feet thick and was underlain by sand stained chocolate-brown. The dark staining is usually coincident with the water table; in some cases incipient 'hard-pan' development was observed at the same horizon. The above features are indicative of leaching, by humic acids, of material from the upper levels of the sand and subsequent redeposition at the water table. The dark brown staining at this horizon is due mainly to humic acids with iron compounds probably playing a minor role.

It is significant that the good quality sands examined, and those which have been mined, all come from thinly vegetated areas. The quality of sand in one of the pits currently worked decreases rapidly away from the lalang covered areas. Even in the latter areas, the sand is never very thick (maximum observed 4'6"). At a level which probably coincides with the water table the sand becomes stained and unsuitable for glass or chemical manufacture. It has been found however that stained sand becomes marketable if it is lifted above the water table and left to leach for two or three years.

At present three pits are producing high quality sand, with a further pit working intermittently one and half miles west of Sedili. There are two sand pits, one of 177 acres south of Tanjong Punggai, and the other of 51 acres west of Sungai Sepang. Together they produce some 60 tons per day with a labour force of about 50. Stockpiles of 10,000 tons exist and monthly shipments average 1000 tons. A simple beneficiation, sieving and washing plant removes the organic material and the coarser sand fraction from a small proportion of the sand. This is bagged and sold for the manufacture of sodium silicate. A third deposit, of 180 acres is being worked by Sharikat Rasudin Sendirian Berhad, which commenced the removal of 5000 cubic yards of sand in April 1970. Production rates are not known but are unlikely to exceed 50 tons per day.

Applications have been made to work sand in four areas and there is an application for permission to re-open a deposit, near S. Pawang Kechil south of Tanjong Penawar, where operations were suspended due to financial difficulties.

Supplies of sand for general purposes, building etc., are virtually unlimited in this area. For the reasons explained high quality sands are only likely to be workable in selected areas. Jungle areas will not be productive for, even where sand quality is good, clearing the vegetation will require heavy machinery and this will inevitably lead to contamination of the sand with soil and organic matter. The possibility of using sand of essentially glass making quality but of reject grade due to colour should be investigated. Sands of this type are quite acceptable to manufacturers of certain abrasives like silicon carbide, provided the refractory materials like alumina are low. Sand deposits should continue to provide a small source of revenue and employment in the area. The possibility of finding enough sand for a small indigenous glass making industry is worth investigating, but detailed prospecting of the area would be necessary. A local requirement for cheap glass containers etc., will probably be an important factor in the economics of such an industry.

No occurrence of heavy mineral sands associated with beach deposits are known and the possibilities of finding any economic deposits can be discounted. Riverine deposits of these materials have been discussed in an earlier section of this report.

3.4.3 Clay.

Although clay deposits are widespread in the Project Area, until recently none of sufficient size or quality to be workable have been discovered. However what may be a fairly large deposit on the west bank of the Sungei Papan near the bauxite mine jetty has been examined. The clay here extends from the water level in the river to a height of at least ten feet. In hand specimen it is of good quality, though the overall grade can only be assessed by chemical analysis of samples collected from drill or auger holes. An application has been made for permission to work this deposit over some 430 acres.

The origin of this clay is not known. According to the geological maps it overlies granite and therefore could have resulted from the decomposition, in situ, of that material. At the jetty however the clay appears to be alluvial in origin. Faint traces of stratification were found. Bauxite deposits resulting from the weathering of aluminous rocks (granites or argillaceous metasediments in this area) occur nearby. The low lying, frequently swampy, margin of a large estuary like the Sungei Papan is likely to be an acid environment owing to the presence of large amounts of decaying vegetation and resulting humic acids. In this situation the deposition of alluvial kaolin would be favoured rather than bauxite (Fordon and Tracey 1952).

Kaolin was found to a depth of 40 feet in a similar low lying area when the dockyard on Singapore Island was under construction (Geological Survey Annual Report 1935). A similar clay is also found on the Johor side of the Straits.

The possibility of finding good quality clay along the low lying coastal and estuarine areas of South Tanjong Penggerang is good and these areas should be prospected. Kaolinite has also been observed in the course of the study, in the Sungei Tempenis tin mine area. Here veins of kaolinite, resulting from the alteration of granite veins (possibly soon after intrusion of the granite), occur. Though the clay is very pure the quantity is too small to make commercial extraction feasible.

3.4.4 Building stone.

Crushed granite and certain of the volcanic rocks can be used as concrete aggregate. The almost limitless variation in texture and colour of the granites, in particular such types as the pink Tengkil granite porphyry, are ideally suitable as dimensional or ornamental stones. Large quantities of granite are exported from many countries in the world, and there seems no reason why semi-finished or finished stone should not be exported from this part of Malaysia. In Singapore the demand for ornamental facing stone would seem to be very great.

3.4.5 Felspar.

Felspar is used in the manufacture of glass, enamel, pottery, floor and wall tiles, and for refractory cements etc. Abundant potash felspars, essentially orthoclase and microcline, occur in many porphyritic granites; however it is doubtful whether commercial extraction will ever be feasible. The iron minerals which these rocks contain are objectionable impurities and are costly to remove.

3.4.6 Limestone.

An occurrence of limestone two miles outside the Project Area has been described earlier and was the subject of a special report where its importance as a source of agricultural lime was discussed. In view of the possible agricultural importance of this deposit it should not be used for road-metal (Appendix D).

3.4.7 Mineral fuels.

Carbonaceous plant remains and very thin stringers of coal have been observed in some of the more argillaceous horizons of the Panti Sandstone Formation. Deposits of this type are common in continental sandstone deposits but rarely occur in workable quantities.

There is little likelihood of finding any deposits of hydrocarbons like oil and gas. It is possible that oil formation and reservoir environments could have existed when the Permian marine sediments, like the Dohol Formation, were accumulating. However, the intense folding and faulting to which these rocks have been subjected, plus erosion and intrusion by granites, leaves no chance of their containing commercial amounts of petroleum deposits. The remaining rock formations and structures in the area bear no similarity to those found in major oilfields.

3.5 Conclusions on the Economic Potential

Two maps of each area have been prepared. One pair of maps displays the existing mining and prospecting and indicates areas worthy of further prospecting for metallic mineral deposits. The third map deals in a similar manner with non-metallic minerals (Figures 12-14 of the Atlas).

In Figures 12 and 13 the limits of those areas are shown for which prospecting permits have at some time been issued. These boundaries delineate the outer limits of prospected areas and may be built up from several smaller prospected areas. Within the areas, zones where prospecting drilling is known to have taken place are mapped. Similarly, high value mineral occurrences are indicated. Existing alienations under mining certificates are also mapped indicating whether they apply to bauxite, tin or iron.

It is considered that the division of the Project Area into graded categories with regard to mining potential would serve no useful purpose. Large areas are virtually unexplored and attempts to define mineral potential are therefore valueless. Areas which are worthy of further investigation, based on present information, have been discussed previously and are summarized in the sections following. More detailed geological and prospecting work will be required before a final assessment can be made. Any such assessment would require considerable expenditure in time and money, and it is obviously unwise to allow mineral exploration to obstruct the use of land for other purposes, except in those areas (e.g. dam sites), where irrevocable decisions regarding land utilization have to be taken. Exploration by private or government agencies can be allowed to proceed at any time in the future without affecting the then current use of land. It would devolve on the agencies concerned to compensate land owners for loss of revenue due to mining. This type of arrangement is operated quite successfully by most of the countries in the world.

3.5.1 Tanjong Penggerang.

It will be seen from the map of the Tanjong Penggerang Region (Fig. 13) that prospecting has been widespread and has covered much of the potential areas of mineralization. Although some high cassiterite values have been recorded, the majority of the prospecting does not appear to

have identified any really significant areas for mining. The past prospecting does not cover all the areas which, on geological evidence, could give rise to mineral deposits and there is some justification, therefore, in recommending prospecting in the remaining area. As indicated before, the geological evidence is such that cassiterite prospecting could reveal profitable deposits in the area, particularly in alluvium resulting from rivers which traverse the main granite/metasediment contact zones. The map (Fig. 13) indicates the main alluvial areas which should be subjected to detailed prospecting. Certain high cassiterite values in the area between Sungai Metangor and Sungai Sebina are particularly important and are certainly worthy of further investigation.

Two areas that on geological evidence could contain bauxite deposits have been indicated; however, both these are on land already alienated and developed as rubber or oil palm estates.

It is considered unlikely that the lateritic iron deposits at Bt. Twatow and Tanjong Penawar will have any economic significance in the foreseeable future. The copper found in analyses of these deposits is interesting and could be followed up. The results may have resulted from sample contamination and would therefore not be significant.

As the residual amang from tin mining operations has not been marketed, dumps of this material must exist in mining areas, and these are worthy of economic assessment.

The non-metallic mineral deposits of the Tanjong Penggerang Region are shown in Figure 14. Areas for further investigation as sources of granite and lateritic roadmetal are shown. Reject grade bauxite, from past and present mining operations, could be used as a building material for minor roads and should be investigated. Constructional grade sand deposits are widespread on the east coast and prospecting for glass sand grades should be restricted to lalang covered ground in the same area.

The occurrence of kaolin clay under low lying ground in the south is widespread. Prospecting of such areas, particularly near the estuaries of the larger rivers is considered worthwhile.

3.5.2 Johor Tengah.

In the past, prospecting for cassiterite has been concentrated in the eastern half of the area, largely as extensions to proven tin fields. Within this eastern half, the upper stretches of the Lingliu valley are considered to be worth further prospecting. Although prospecting permits have been issued in the past for some parts of this valley, the sparse sampling and the geological evidence would indicate that further prospecting is justified. The upper reaches of the S. Chenas (2) should also be prospected as should the areas near the S. Sayong, marked (4) and (5), and the main alluvium of the S. Jengeli (8).

Zones where prospecting is not recommended either on geological evidence or topographic considerations have been indicated on the map (Fig. 12). It is possible that some streams passing through these zones and draining from the granite in their upper reaches could yield tinbearing sediments when prospected. However the likelihood of any economic deposits is very low.

In the western half of the area there is a large granite mass and it is possible that these granite areas contain mineralized zones which were difficult to distinguish during field mapping. The official geological map which covers most of the area (sheet No. 124) is a reconnaissance map only, and therefore cannot be expected to provide definitive clues to mineralization. However a

Large number of stream sediment samples have been analysed for their heavy mineral and trace element content. The heavy minerals are disappointing, showing one significantly high value of cassiterite and one of ilmenite. The data from the trace element work have yet to be compiled by the Geological Survey. The mineral potential of the western Johor Tengah Region can only be determined by opening the area to prospectors. The prospects for alluvial cassiterite deposits, on present evidence, are very poor. Other factors, including the need to preserve a silt-free water supply from the catchment area serving Kluang, would be important considerations which might preclude mining operations.

It is concluded that the iron deposits in the area have little potential due to their small size, relative inaccessibility and high content of impurities. The tin/iron deposits will only be viable if a method of removing the tin can be found. The iron deposit at Bt. Permatang should be checked for size and grade; present information suggests previous investigations have been incomplete.

It is considered unlikely that workable bauxite deposits will occur in the area. The environment for their formation is not favourable.

The potential of other base metal occurrences, copper, molybdenum, tungsten, lead, zinc, etc., cannot be determined without further exploration. Reconnaissance drainage geochemistry will be the most effective method in the first stages of any further work.

The economic viability of amang dumps at past and present tin mines in the area should be investigated. There is no record of any amang having been marketed.

Areas likely to contain outcropping granite suitable for road construction are shown in Figure 14. No large scale laterite deposits, suitable for secondary roads are known.

RECOMMENDATIONS4.1 Prospecting and Clearance

At a meeting held on 29th December, 1970 in the State Secretariat under the chairmanship of the Commissioner of Lands and Mines, it was agreed that Consultants would submit their proposals for prospecting to the Geological Survey for early consideration.

The proposals together with supporting reports, maps and suggested time-table were forwarded to the Director General of the Department of Geological Survey on 9th January, 1971. These were subsequently agreed by the Department and forwarded to the Commissioner of Lands and Mines Johor on 5th February, 1971, for what ever action he deemed desirable in respect of prospecting and clearance.

Additional information concerning possible phasing of development was requested by the Commissioner of Lands and Mines at the Draft Project Report Review Group meeting on 15th February 1971 and a copy of the time-table incorporating the information was forwarded on 21st February 1971. This is reproduced as Appendix C to this report.

4.2 Gunong Sumalayang Limestone - Summary of Recommendations

A detailed report of this additional study which is located outside the Project area is attached at Appendix D and the following is a summary of the recommendations.

The main requirement was to prove, by core drilling and surface exploration the existence of a workable deposit. This was duly carried out and the mineral reserves are estimated at 30 million tons. It is possible that detailed investigations to the north-east and south of the proven area examined will reveal further extensions of the deposit.

It would appear appropriate that consideration be given to the economics of exploiting the deposit for the following purposes:

Industrial Uses

Lime/soil stabilisation for road construction.

Cement

Ornamental stone

Agricultural Uses

Ground lime with or without small quantities of added magnesium carbonate.

Further investigations into the use of limestone for soil stabilisation in road construction should be accorded priority, as there is a possibility that savings might be achieved on a State wide basis when compared with the traditional method of using crushed granite for base and surface formations. As for agricultural lime there could be long term advantages to certain perennial and annual crops as land is opened up in the State provided that other uses for the limestone can be envisaged.

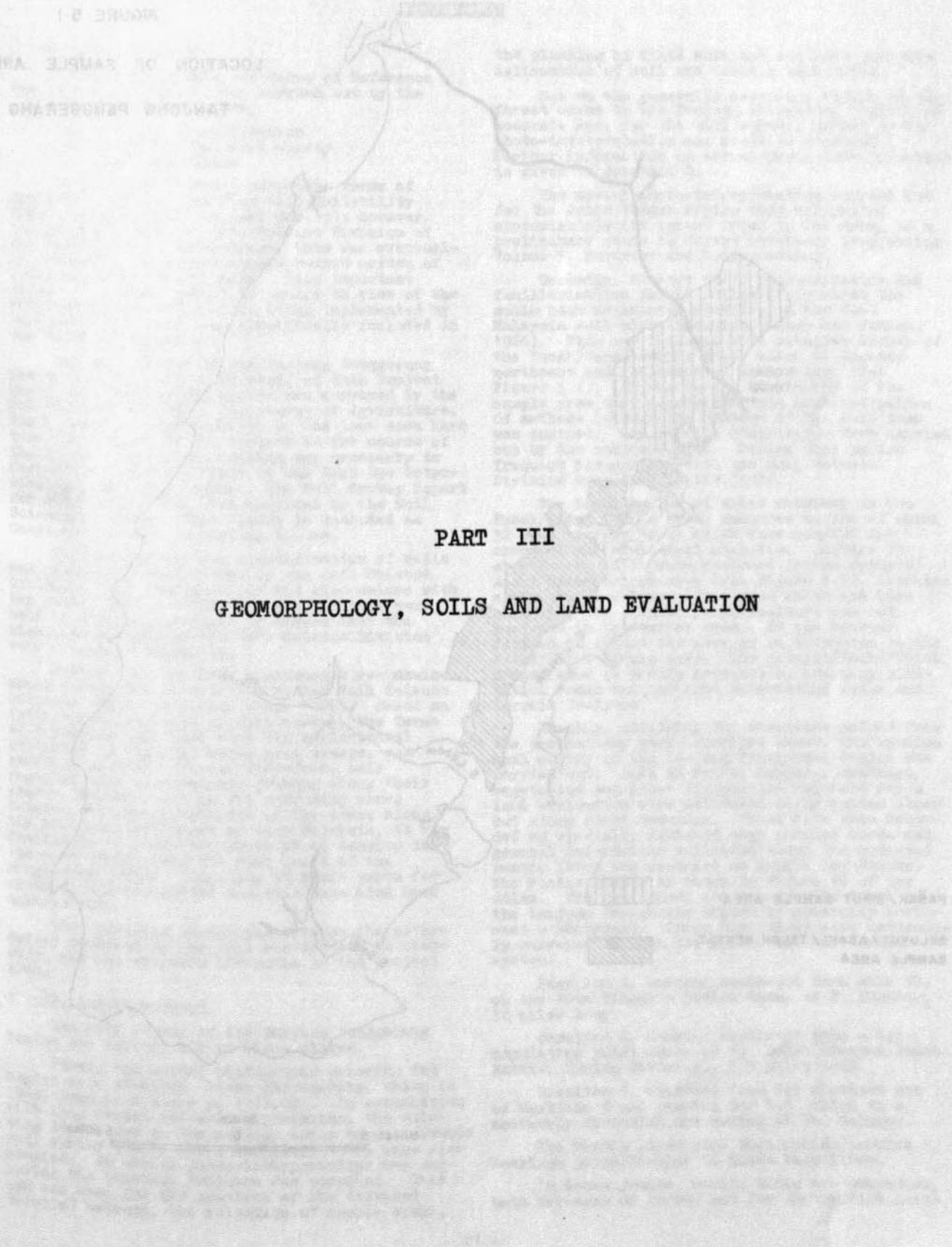
It is noted that Pan Malaysian Cement are believed to have tested the economic viability of the deposit as a cement raw material but that it was doubtful if any attempt was made to accurately estimate tonnage available. In view of the proven volume this possibility should be re-examined in association with locally based industries as a long term prospect.

If industry express as interest then the

next step would be to examine the ground between area A and B (Fig. 2 in Appendix D) to establish methods of working, quarry face alignment, drainage, access, depth of over-burden etc. The latter, taking 80 feet the average depth, is provisionally estimated at 3 million tons. When re-examining the depth of over-burden the use of seismic reflection geophysical techniques is advised as it would eliminate the necessity of removing the vegetation from the area. Removal would be required if development drilling techniques were used. The whole operation should be conducted under the joint direction of an experienced quarry engineer and a geophysicist.

Pending further investigation and in order to prevent speculation, consideration might also be given to the gazetting of the area as a reserve.

LOCATION OF SAMPLE AREAS
TANJONG PRIGERANG

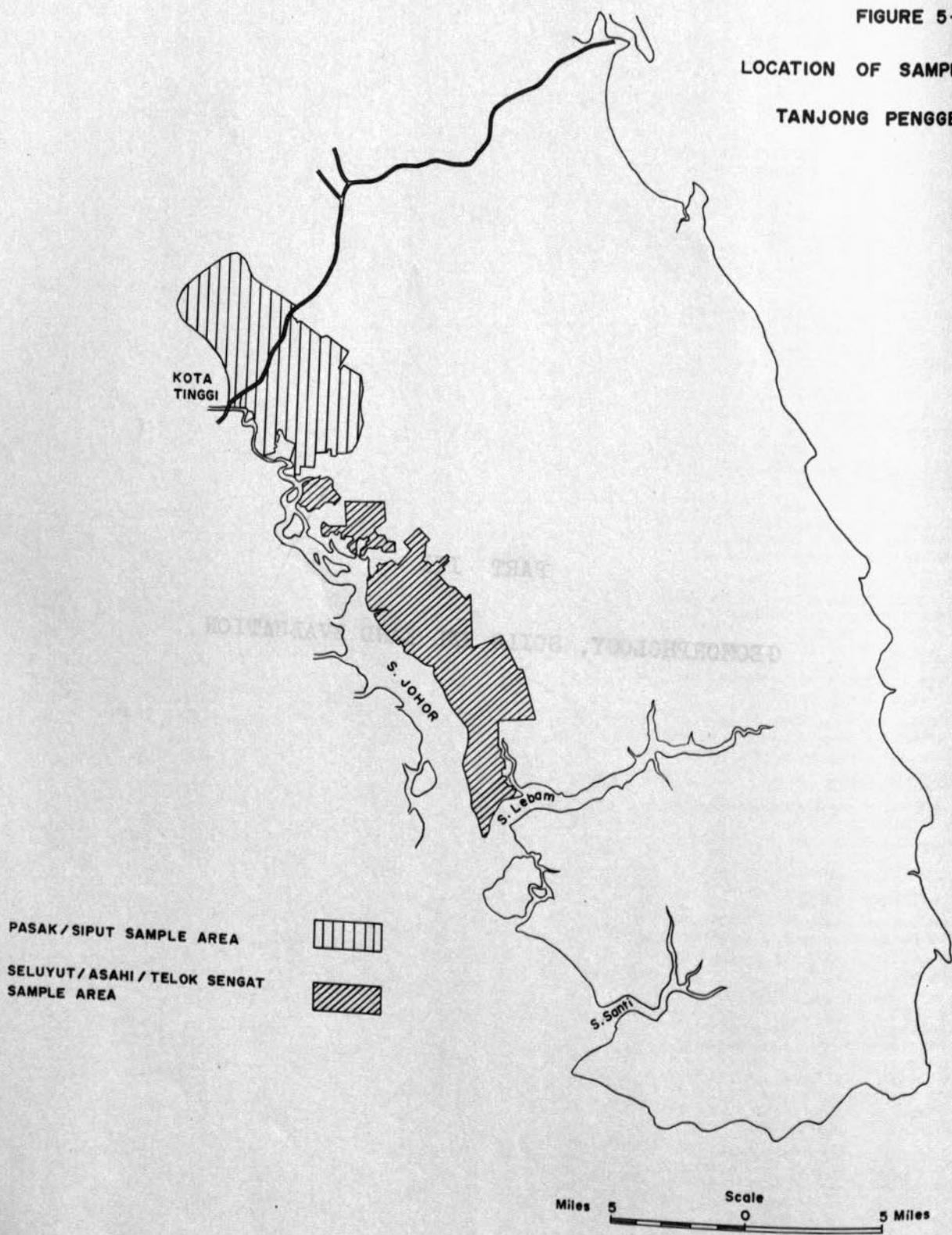


PART III

GEOMORPHOLOGY, SOILS AND LAND EVALUATION

FIGURE 5-1

LOCATION OF SAMPLE AREA
TANJONG PENGGERANG



PART III GEOMORPHOLOGY,
SOILS AND LAND EVALUATION

INTRODUCTION

1 THE STUDY APPROACH.

In accordance with the Terms of Reference the following studies were carried out by the soils team of this Project:

- (a) Terrain classification
- (b) Semi-detailed soil survey
- (c) Land evaluation

It had been intended under the Terms of Reference that the existing Soil Suitability Classification would be used for (c); however, in agreement with the Soil Science Division of the Department of Agriculture, this was eventually discarded and a more comprehensive system of land evaluation established. This important change of systems became necessary in view of the crop diversification policy being implemented by Government and which was specifically included in the Terms of Reference.

The soil survey of the Tanjong Penggerang Region was carried out by staff of this Project while the Johor Tengah Region was surveyed by the Soil Science Division, Department of Agriculture. Familiarisation observations in the last area have been carried out by the Project in the course of the study. This spot checking was necessary to facilitate the compilation of the Land Use Potential Maps for this Region. The Soil Survey Report for Johor Tengah has been compiled by the Soil Science Division. This report is included as Chapter 7 of this Supporting Volume.

The terminology and classification of soils and terrain is that in use by the Soil Science Division. Soil correlations and discussions with the Senior Soil Scientist of the Division were held at regular intervals to ensure that the standards set out by the Soil Science Division were strictly adhered to.

During 1963 and 1964 a schematic reconnaissance survey was carried out by the Soil Science Division (Null, Acton and Wong, 1965). Based on information collected by this survey, the Terms of Reference envisaged that the agricultural potential of the east coast peat swamps, was severely limited. These, therefore, only required some confirmatory probing along their edges. However, due to the confusing views between the characteristics of the peats along the west and east coast of West Malaysia, it was decided to increase the observation density in the peat areas along the east coast of the Penggerang Region. Sampling of these peats for chemical and mechanical analysis have also been carried out.

The following paragraphs discuss the methodology employed by the soil survey team to classify, map and evaluate the soils of the Project Area.

2 SOIL SURVEY METHODS.

The soil survey of the Tanjong Penggerang Region was carried out in three stages.

First, the aerial photographs covering the Region were studied; these photographs, taken in 1966, were at a scale of 1:25,000. In conjunction with this aerial photo-interpretation, the existing literature on the geology and a reconnaissance soil survey (Null, Acton and Wong, 1965) were also studied. An aerial photo-interpretation map analysing the physical features was compiled. This map was used for the location of the traverse (rentis) network, the selection of sample areas,

the planning of field work and the more accurate delineation of soil and terrain boundaries.

Due to the generally secondary nature of the forest cover in the Tanjong Penggerang Region, an accurate and, for the soil survey, useful aerial photo-interpretation map could be produced. Further information on aerial photo-interpretation is given in Appendix H.

The aerial photo-interpretation carried out for the Johor Tengah Region only delineated approximately the forest types in the area, as a preliminary study to forest inventory (Supporting Volume 5, Forestry and Conservation).

Secondly, a short field reconnaissance and familiarisation period followed, in which the soils team acquainted itself with the West Malaysia soil classification (Leamy and Panton, 1966). This was followed by a detailed survey of the Pasak/Siput Sample Area, which is located northeast and southeast of Kota Tinggi (See Figure 5.1). It was during the Survey of the sample area that correlation and standardization of methods between the members of the soil team was ensured. All profile description were carried out by the combined team. During this period frequent discussions with the Soil Science Division were held in the field.

The total number of sites examined in the Pasak/Siput Sample Area, amounted to 354 of which 32 were profile pits, which were sampled for chemical and mechanical analysis. Another 75 observation sites were recorded in the Seluyut/Asahi/Telok Sengat Area (see Figure 5.1), situated along the S. Johore. This area which had been alienated for plantation agriculture was not included in the survey area. It was however decided to regard the area as an extension to the Pasak/Siput Sample Area. The Seluyut/Asahi/Telok Sengat Area is easily accessible, has many plantation roads and has some interesting soils and terrain features.

Finally, utilising the knowledge gained from the preliminary work described above, the routine soil survey of the Tanjong Penggerang Region was carried out. Data on soils, terrain, drainage, vegetation and other information required for a land evaluation were collected along rentis lines cut along fixed bearings. These data were recorded on specially designed edge punched cards and general information collected along the surveyed rentis lines was recorded on Rentis Log Sheets. The Rentis Layout is shown in Figure 15 of the Atlas. The geological and topographic trend of the Tanjong Penggerang Region is generally north-west - southeast. Three base lines were accurately surveyed to form the spines for the rentis system:

Baseline A, running southeast from mile 37, on the Kota Tinggi - Sedili Road, to T. Penawar, 32 miles long.

Baseline B, running southeast from a triangulation point south of Kg. Bahru (Sungei Papan Estate, Sening Division), 3.5 miles long.

Baseline C, starting from the southern end of Baseline B and running for 5.5 miles in a southerly direction and ending at Bt. Gelugor.

The rentis lines were then cut on compass bearings perpendicular to these base lines.

In dense jungle, rentis lines are essential, both for ease of access and for the precise loca-

tion of observation sites (Steele, 1967). In the extreme south of the Tanjong Penggerang Region only a few rentis lines were cut because road access was adequate and the existence of mines and cultivated land did not require a similar density of observation as the rest of the area.

The soil pattern in the Region is very complex throughout (Figure 19 of Atlas). This had already been envisaged during the compilation of the aerial photo-interpretation map. Based on this information the survey rentis lines were cut at 1 mile intervals throughout the Region, with the exception of the area south of the S. Lebam, where the rentis interval on Baseline C has been increased to 1.5 mile. The Terms of Reference recommend that the rentis lines be at one mile intervals in the areas with a complex soil pattern and at wider intervals in the areas with a simpler soil pattern, as the opinion was held that sufficient information would be available from the 1965 reconnaissance soil map (Null, Acton and Wong, 1965). During the field work and subsequent mapping the soils team came to the conclusion that in certain complex areas, such as north and east of the S. Lebam, a closer rentis line interval would have been advantageous.

The soils were examined using a 5 cms. (2 inch) bi-partite soil auger (Edelman model); augering was to a depth of 120 cms. (47 inches). The main features of soil morphology in identifying soil series from auger inspections were colour including mottling, texture, consistency and the presence or absence of laterite, quartz grit and weathered rock. Augering was supplemented by observations of logging track exposures, the roots of fallen trees and to some extent the appearances of the soil surface. Field procedures were to auger whenever a change of soil series was apparent or suspected, with an upper limit of quarter of a mile between observation sites. Supplementary observations or check bores have also been used where required.

Soil pits 150 cms (60 inches) deep were dug at representative sites, these pits were described and sampled according to diagnostic horizons. Auger borings to a depth of 120 cms (47 inches) in the bottom of the soil pit provided additional information on parent rock and other characteristics required for soil classification. Soil samples collected were analysed for chemical, mechanical and moisture properties.

According to accepted international standards a semi-detailed soil survey without the application of aerial photo-interpretation should have an observation density of 12 to 25 sites per square km. (100 ha) or 25 to 75 per square mile (Vink, 1963). In this Project aerial photo-interpretation has been used to some extent, therefore a density of 10 to 25 sites per square mile would be acceptable.

The total number of recorded observation sites for the routine survey amounts to 1771 of which 67 are profile pits; all the latter and also some bores were sampled.

A total of 329 miles of rentis line were traversed for the purpose of the routine survey, and the total area surveyed amounts to 460 square miles (including sample areas). The blanket average observation density is 3.5 per square mile; this average however excludes a large number of check bores, which have been used for mapping purposes; had they been officially recorded they would have almost doubled the above average. The average density also covers the peat swamp areas in the east and south east of the Region, where the observation density is obviously much lower. Excluding these areas the average density amounts to 5 per square mile. The majority of observation sites were located along the rentis lines. For the 329 miles of surveyed rentis

lines a total of 1481 observation sites have been recorded, which gives an average of 4.5 per rentis mile also excluding a large number of check bores.

3 MAP COMPILATION.

The Soils (Map No. 7 and 8) and Terrain Classification (Map No. 3 and 4) maps were compiled at a scale of 1:25,000 and then reduced to the scale of 1:63,360 (one inch to one mile) using the West Malaysia Topographic Map Series L7010 as base. In constructing the Soils and Terrain Classification maps the rentis lines were drawn on the 1:25,000 scale topographic maps and observation site numbers with their appropriate soil series name plotted along them as intercepts. Soil and terrain class boundaries were then interpolated between the rentis lines, while paying careful attention to stream courses and contourlines. In many instances the aerial photographs proved to be very useful in drawing mapping unit boundaries.

The compilation and final drawing of the Soils (Map No. 5 and 6) and Terrain Classification (Map No. 1 and 2) maps for the Johor Tengah Region has been carried out by the Soil Science Division, Department of Agriculture, Kuala Lumpur.

The soil series is used as the mapping unit, with depth, textural and other phases appended where appropriate. Mapping units too small to be mapped individually have been mapped as associations of soil series.

The Land Use Potential Maps (Map No. 9, 10, 11 and 12) of both Regions have been compiled by the Project from the Soils and Terrain Classification maps at the same mapping scale.

Limitations on the accuracy of soil mapping arise from four factors: the accuracy of the base map, the location of rentis lines, the position of changes in soil series along the rentis lines, and the interpolation of boundaries between rentis lines. The total error from the first three factors is thought to be less than 350 yards. From the fourth factor inaccuracy in boundaries of up to the distance of the rentis separation, one mile, may occur.

4 SPECIAL SAMPLE AREAS.

Two sample areas, the S. Semberong and S. Dengar Sample Areas were located in river valleys to examine the degree of variability within such areas.

A third detailed survey area, the S. Pengeli Sample Area was located in an area that was mapped as consisting mainly of Harimau Series soils by the semi-detailed soil survey. This sample area was studied to examine the variation within this mapping unit.

A detailed description of the three areas is given in Appendix E of this Report.

5 METHODS OF SOIL ANALYSES.

All routine chemical and mechanical analyses were carried out by the Soil Laboratory of the Department of Agriculture, Kuala Lumpur and the methods of analyses used are those currently in force by the Soil Laboratory.

The soil moisture and trace element analyses however have been carried out in Hunting Technical Services Ltd. laboratories in England.

The soil moisture samples were collected from profile pits representing a number of the major soil series. Soil cores were taken from each of the major diagnostic soil horizons, using a core sampling device similar to the one described in the USDA Handbook 60 (1954). Duplicate, undisturbed samples of the moist soil were taken, sealed with polythene and then placed into air-

tight aluminium containers. In the laboratory the cores were saturated with water and subjected to various pressures, initially in the porous plate apparatus for the pressure range from zero to one atmosphere and subsequently in the pressure membrane apparatus for the pressure range from one to fifteen atmospheres.

The soil moisture determinations and the available water capacities of certain soils are discussed more fully in Appendix B of this Report.

Samples for trace element analyses were collected in special sample bags (Kraft paper bags) from soil pits representing major soil series.

The samples were analysed by the direct current (DC) arc spectrographic methods and the total quantity of each element present was expressed in parts per million (ppm) of the air-dried soil. The method used was essentially a semi-quantitative one and the reliability of the results is ± 25 percent of the quoted figure.

The elements investigated were lead, tin, gallium, bismuth, vanadium, molybdenum, copper, zinc, titanium, silver, nickel, zirconium, cobalt, manganese and chromium.

The detection and estimation of an element depends upon the limit of sensitivity of the particular method used. The elements, bismuth and silver were present in concentrations below the minimum required for accurate measurements.

Further discussions concerning trace elements are given in Chapter 6.3, Soils and Appendix G, Trace Elements, of this Report.

GEOMORPHOLOGY5.1 Topography

The geology of the Tanjong Penggerang Peninsula has been described in Chapter 2. Granite is dominant over much of the area, with volcanic rocks in the south and along the west side. Sedimentary rocks form a spinal ridge down the peninsula and outcrop along the east coast. Terraces of older alluvium also occur, but there are no wide tracts of recent freshwater mineral alluvium. Peat swamps are extensive behind the beaches of the east coast and mangrove swamps line the tidal channels in the south-west.

The dominant topographical feature of the peninsula is the central spinal ridge running from about Mile 32 on the Sedili road south-eastwards to Tanjong Punggai (Terrain Classification, Map No.3 and 4). This ridge has a distinct single crest in the central area, with a peak of 611 feet MSL (above Mean Sea Level) at Bukit Tangga Tujoh. North-westwards from this point, the ridge crest is lower, with peaks below 350 feet, and the ridge frequently narrows to less than half a mile width. Further north-westwards the ridge is again pronounced, with peaks at Bukit Kayu Mati (415 feet) and Bukit Tambun Tulang (629 feet), and also becomes split by valleys of the S. Mupor and a tributary of the S. Seluyut, which are controlled by the regional strike of the metasediments. The Sedili road crosses a gap in the ridge, beyond which it broadens out into the Pantl range of hills.

South-east from Bukit Tujoh, the ridge becomes doublecrested again (being split by the strike valley of the S. Papan Kechil), and decreases in elevation until it is lost as a distinct relief feature. From here it is marked only by a string of widely spaced isolated hills of 200 to 300 feet elevation (Bukit Ulu Papan, Bt. Kangkar Papan, Bt. Lebam and Bt. Tuatau), terminating finally in the low headland of Tanjong Punggai.

This ridge is formed by metasediments believed to be of Permian age. The sediments are mainly slightly metamorphosed shales, carbonaceous shales and siltstones, with some interbedded sandstones especially in the north. Quartz veins are common and in places form "quartz reefs" that cap some hills, such as a hill of about 280 feet elevation south of Bukit China, near Pasak. Igneous rocks lie to either side of the ridge and the contact between igneous and sedimentary rocks is often very narrow. Several streams follow this contact zone, notably the S. Layau Kiri. The sedimentary rocks are more strongly metamorphosed in the S. Papan-Lebam area, and the isolated hills mentioned above appear to be formed by more strongly metamorphosed and resistant rocks along the granite boundary.

In the south-east, carbonaceous shales, silty shales, siltstones and fine sandstones predominate, with abundant quartz veins and some conglomerates, and these lithological types outcrop in a secondary ridge along the east coast north to Tanjong Sedili Kechil. A series of parallel minor ridges form the numerous promontories along this coast, being of greatest elevation in the north (Bukit Gemoh, 232 feet, and Bukit Marjorie, 228 feet). Further south, most of the hills including the higher hills such as Bukit Siti (318 feet) are flat-topped and capped by laterite. Similar rock types also outcrop to the west of the S. Sedili Kechil peat swamp area, northwards to the Sedili road (near Mile 41), forming the low, gently undulating spurs of 50 to 150 feet such as Easter Hill (154 feet).

Over the rest of the Tanjong Penggerang Peninsula, the bedrock is igneous, consisting of granites and volcanic rocks of varying composition. In this Region, igneous rocks form rolling terrain of generally less than 250 feet elevation, but there is a tendency for the volcanics to form isolated, steep sided conical hills in the south, such as the 600-foot peaks of Bukit Belungkor, Bt. Penggerang and Bt. Pelali. In places the granites also form rounded hills of medium elevation, such as Bukit Benut East (410 feet) and Bukit Wah Ha (451 feet), west and east of the spinal ridge respectively.

The granites are generally rather coarse-grained, with a high quartz content, but may, based on soil profile characteristics, range from coarse-grained biotite granites to finer-grained adamellites and granodiorites. The volcanic rocks are very variable, consisting mostly of ashes and tuffs ranging from rhyolite and dacite to andesite in composition.

The older alluvium that is widespread in South Johor (Burton, 1964) occurs in only limited areas in the peninsula, forming gently undulating low hills along the north side of the Lebam and near Kota Tinggi. South of Telok Sengat it forms a more rugged and dissected area of hills up to 190 feet MSL. Composition is varied and ranges from clays to beds of 1 quartz pebbles, but most were derived by alluvial and colluvial processes from the surrounding granite hills, and quartz gravel is abundant. Subrecent alluvium is common along many of the larger valleys, occurring up to elevations of about 50 feet, and consists of strongly leached quartz sands.

The recent river and stream alluvium is similarly variable in composition, its texture depending on source of derivation and nature of river flow. Alluvium derived from granite is commonly sandy and that from shales is clayey, although heavy clays are rare. Most of the valleys are narrow and there are no wide areas of river floodplain in the peninsula. Saline alluvium in the mangrove zones along rivers in the south-west is generally clay or silty clay with a high organic content.

Along the east and south coasts there are extensive peat swamps, formed in wide lagoonal basins behind and advancing coastline. The former coastline followed the inland margin of the peat swamps, where old beach deposits have been found. Beach sands underlie most of these peat swamps, except along valleys, and outcrop in places as arcuate bands through the swamps. General elevation of the peat swamp is from 5 to 30 feet above sea level, and the depth of peat ranges to at least 10 feet in places, with quite sharp transitions from beach ridges to deep peats.

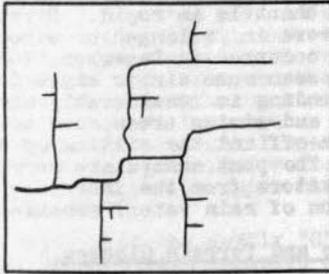
The east coast beaches are mainly sandy, but the grade and purity of the sands varies depending upon proximity to river mouths and sources of derivation. The beaches extend inland as a series of parallel beach ridges and swales that dip down beneath the peat. Raised beaches occur in places inland, some up to 30 feet above sea level.

5.2 Drainage

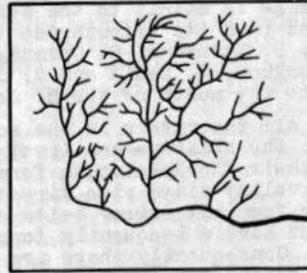
The spinal ridge only forms the principal watershed of the peninsula along its highest sections, near Bukit Tangga Tujoh and in the north at Bukit Tambun Tulang. Between these two areas, the S. Seluyut rises well to the east of the ridge at Bukit Wah Ha, and flows west. Its passage through the ridge is deeply incised. Further south, the

FIGURE 5.2

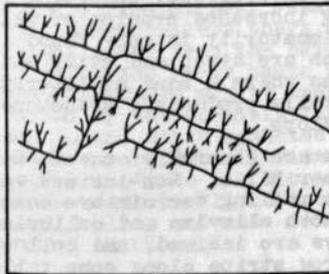
DRAINAGE PATTERNS



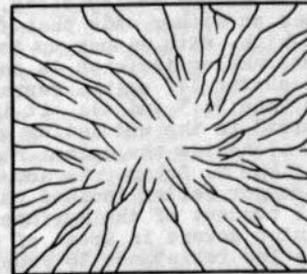
A) RECTANGULAR



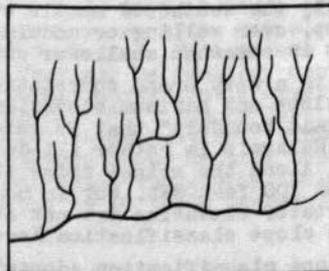
B) SUB-DENDRITIC



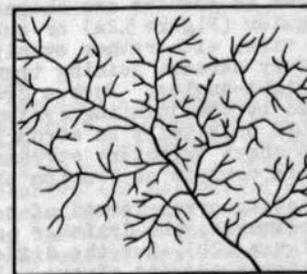
C) TRELLIS



D) RADIAL



E) SUB-PARALLEL



F) DENDRITIC

S. Lebam and most of its tributaries cut right through the line of the sedimentary ridge, and the watershed lies within half-a-mile of the east coast south of Tanjong Lompat. Further south the watershed swings sharply west again, and then south to Bukit Pelali.

The northwest of the area is drained by tributaries of the S. Sedili Besar, the S. Mupor and S. Semalok. On the west side, the S. Seluyut, S. Temon and S. Layau Kiri are tributaries of the S. Johor. In the east, the S. Gembot, S. Bahan and S. Sedili Kechil formerly reached the sea at points three to four miles inland of the present coastline, where their valleys now issue into peat swamps. The coast has since advanced to its present position but the three rivers are still deflected at their original mouths by the former beach ridges. In the south, drainage is mainly to the west, through the S. Lebam (and its tributaries the S. Semenchu, S. Papan, S. Chemaran, S. Chemangar and S. Sening), S. Belungkor, S. Santi and S. Sebina. These all issue into the mouth of the S. Johor.

The mouths of all the rivers in the southwest are "drowned", i.e. the relative sea level has risen and flooded their floodplains to form long estuaries, and the valley sides rise directly from the river banks, or from the narrow belts of mangrove swamps that have subsequently formed to line the channels. Consequently there are no floodplains except at the estuary heads, and the rivers are of a size that is out of all proportion to the size of their drainage basins.

In contrast to these drowned valleys, valley rejuvenation is widespread in the peninsula and accounts for the deeply incised valleys of most of the tributary streams. Incised valleys have a narrow, flat and often swampy valley floor, and very steep footslopes on either side that form banks up to 35 feet high, with slopes up to 45 degrees. Areas where valley incision is severe are marked with the suffix "v" on the Terrain Classification Maps (Map No. 3 and 4); it is particularly widespread in the undulating granite terrain west of and alongside the spinal ridge, and locally south of the S. Lebam. In some granite areas of stronger relief incised valleys occupy up to some 15 percent of the surface area. Valley incision is also severe in areas of older alluvium, due to the low resistance to erosion of these deposits. Incision has not reached much of the spinal ridge and other high ground, but the valleys are here deep and steep independently of the current cycle of erosion. Also most valleys draining into peat swamps are not incised, and are smoothly concave in valley form, or have flat floodplains with gentle footslopes.

Drainage patterns in granite are characteristically rectangular (Figure 5.2a) or sub-rectangular in plan view, with rather evenly-spaced, short tributary streams joining trunk streams at rounded right-angles. Such a drainage pattern is controlled by the jointing system of the granite, and would originally be strongly rectangular, but the short tributary streams develop rather arcuate courses as erosion proceeds.

In gently undulating areas formed of sedimentary rocks or metasediments, the drainage pattern is sub-dendritic (Figure 5.2b), but the differences from the granite patterns are not always well marked, and this feature is not always sufficiently reliable to be used for mapping the geology from aerial photographs. Probably the joint patterns in metamorphosed rock are rather similar to those in granite.

Trellis pattern of drainage (Figure 5.2c) is quite well developed along the spinal ridge is well developed, and results from trunk streams following the strike of rock strata with low resistance to weathering. Numerous short sub-

diary streams flow down the dip or scarp slopes of the adjacent more resistant strata that form the ridges. The isolated, steep volcanic hills have radial drainage (Figure 5.2d), but the gently undulating areas of volcanic rocks have drainage patterns very similar to those on granite. Sub-parallel drainage (Figure 5.2e) is sometimes encountered on older alluvium, particularly where it is tilted, but a dendritic type (Figure 5.2f) is more general. Drainage pattern can sometimes be used on the aerial photographs for differentiating granite areas from older alluvium.

In forest terrain the stream and smaller river channels seem to be sufficiently large to carry most of the high flows that result from normal rainy periods, but rate of rise and fall within the channels is rapid. River flooding is however severe in prolonged or exceptional wet spells, as occurred in December 1969 when flood debris was seen some six to eight feet above bank level. Flooding is considerably more serious in cultivated and mining areas, due to increased rate of run-off and the silting-up of stream channels. The peat swamps are very poorly drained, and flood waters from the interior (or from local accumulation of rain water) subside only slowly.

5.3 Slopes and Terrain Classes

The relief over most of the peninsula is mature or sub-mature, being undulating to hilly with smooth slopes. Slopes are mature in the sense that they lack irregularities and have reached a state of equilibrium in erosion; geological erosion is comparatively slow. However, valley incision indicates that a phase of rejuvenation is in progress, upsetting the equilibrium and causing increased erosion of valley sides. Otherwise immaturity is only found in the higher hills, which are steep and still actively eroding, and in areas where a band of laterite is present, which generally produces a pronounced break in the upper slope.

Slopes are generally convex, but are regular on the higher hills. Non-incised valleys in undulating to rolling terrain are concave, and formed of both alluvium and colluvium. However, most valleys are incised, and colluvium is restricted to narrow strips along some valleys, and the foot of slopes along swamp edges.

Rock outcrops are rare, occurring principally as tors or isolated masses of weathered rock standing prominently at hill tops. They occur on some of the higher granitic and volcanic hills. Rock outcrops also occur locally along the spinal ridge, in incised valleys, and widely along the coast, but generally the weathered mantle overlying bed-rock is deep, over rolling or undulating terrain, although it is somewhat shallower over shales.

There is a very broad correlation between degree of slope and maximum elevation, although the "steeland boundary" that is referred to widely in West Malaysia is rather ill-defined in the peninsula. Along the spinal ridge it occurs between 100 and 200 feet MSL, but in many places hills of greater elevation are not steep according to the slope classification described below.

The slope classification adopted for the terrain class mapping follows that in general use in West Malaysia (Leamy and Panton, 1966), as follows:-

Terrain Class	Degrees	Complex Slopes	
C1	0- 20	Level or nearly level	
C2	2- 60	Undulating	
C3	6-120	Rolling	
C4	12-200	Hilly	Agricultural Limit
C5	20-250	Steep	
C6	over 250	Very steep	

The upper limit to class 4 has been set at 20 degrees which has been raised from 18½ the present limit of legally permitted cultivation, to 20 degrees to conform more with the natural slope range, which lies more easily at 20 degrees (Leamy and Panton 1966). The only modification is the addition of the suffix "V", used in classes 2, 3 and 4 to indicate severity of valley incision; in such areas, valleys are incised to depths of the order of 20 to 35 feet, and even sometimes 40 feet.

It must be stressed that the terrain class mapping units are based on average hill slopes or complex slopes, and disregard the steeper slopes of convex hilltops. Occasionally in areas of sedimentary rocks or laterite, the gentle upper slopes were found during field traverse to be sufficiently broad to delineate on the maps as a lower terrain class unit than the hill sides, but such instances are few, and were not encountered in granitic or volcanic areas where hill forms are more strongly convex. One reverse case has been mapped in an area of old alluvium south of Telok Sengat, where incised valleys are so numerous that they dominate the area and little of the original hill slope remains; incised valley sides are here averaged with the gentle upper slopes to derive the terrain class 4.

It should be noted that the suffix "C" for the terrain classes has not been included on the Terrain Class Maps for practical reasons only, but as indicated earlier the terrain class mapping units are based on complex slopes.

Terrain Class 1

The land is level or nearly level, 0 to 2 degrees. Such terrain is confined to river alluvium, mangrove, swamps, peat swamps and beaches. Along larger valleys there is generally a slight slope from the better drained levees along the river banks to the backswamps, while surfaces may be uneven due to hummocks formed by the accumulation of debris by termites and other agencies around tree bases. Most sub-recent alluvium and beaches are mapped in Class 1. Slopes exceeding 2 degrees occur locally between beach ridges and swales, and some raised beaches are mapped as Class 2.

Terrain Class 2

Apart from some raised beaches and sub-recent alluvium, slopes of 2 to 6 degrees are typical of the very low undulating terrain of up to 100 feet and occasionally 150 feet MSL. It occurs in both igneous and sedimentary areas as well as older alluvium, and has quite a wide distribution, principally bordering peat swamp areas and along the S. Johore and S. Lebam. Valleys are shallow and although they may be incised, depth of incision is rarely sufficiently severe to warrant the suffix "V". Figure 3a illustrates a typical cross-section. Slopes of less than 2 degrees occur on hill tops and valley bottoms, while the short, incised valley sides may be 20 to 30 degrees.

Terrain Class 3

Class 3 is rolling terrain and is the most widespread of the nonalluvial terrain classes. Figure 3b illustrates the typical range of slopes, with 6 to 12 degrees predominating except on crests and valley bottoms. Valleys are incised in most areas and Class 3V is widely mapped (Figure 3c). All main rock types including older alluvium occur in this class, and hill crests lie between 100 and 250 feet MSL.

Terrain Class 4

Hilly terrain with predominantly 12 to 20 degrees slopes is illustrated in Figure 5.3d. It occurs in more discrete units than Class 3, being associated with isolated higher hills or ridges of 150 to 300 feet and sometimes 350 feet elevation. Some lower hills also have slopes in this class, these usually being rather steep-sided and flat-topped hills with laterite cappings (Figure 5.3e). Most Class 4 units along and to the west of the spinal ridge are mapped as Class 4V, but in most instances in the east and south, incision is not strong. Tors occur on some igneous hill tops.

Terrain Class 5

Steep land with 20 to 25 degrees slopes is confined to the spinal ridge and some granite hills around Bukit Wah Ha and Bukit Benut East. South of the S. Lebam it occurs only on the isolated conical volcanic hills and Bukit Lebam. It occurs mainly between 100 and 400 feet elevation, either as discrete units, with some peaks up to 500 feet MSL or as the lower slopes of Class 6. Rock types range from metasediments to granite and volcanics, and tors and rock outcrops are common. Hill tops and ridge crests are narrow. Class 5V is not mapped, since valley sides are normally steep whether or not they are incised. Figure 5.3f illustrates a typical cross-section through a granite area.

Terrain Class 6

Very steep terrain, illustrated in Figure 5.3g, includes all slopes in excess of 25 degrees. It is confined to the higher sections of the spinal ridge and the higher volcanic hills in the south, with crests from 300 feet MSL upwards, although slopes in this class occur as low as 100 feet on some of these hills. Hill crests are very narrow and rock faces and tors are common. Valleys are frequent and deep. Slopes in both classes 5 and 6 are unstable and erosion is rapid.

The cross-sections on Figure 5.3 are schematic, and are not based on actual traverses. They illustrate representative slope forms of the various terrain classes. In Figure 5.3a and f, both incised and non-incised valleys are illustrated in each cross-section, but this rarely occurs in practice, the valleys being all of one or the other form. The sections show the approximate proportions of land within a given terrain class having slopes in the range assigned to that class.

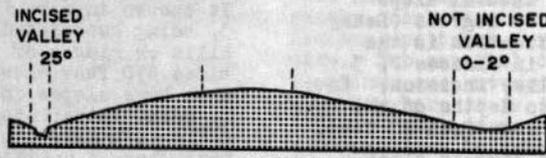
5.4 Erosion

In a tropical environment weathering is rapid and a deep mantle of weathered material is formed at the surface. The removal of this mantle by erosion is also rapid and on steeper land it is more progressive and may exceed weathering so that soil profiles may be shallow. In the undulating and rolling terrain of the peninsula the terrain is mature and slopes are rounded, and rate of erosion is reduced. Only when the cycle is upset, in this case by a lowering of base level resulting in valley incision, is the rate of erosion increased again. Thus geological erosion is most rapid in steep lands and valleys. An important additional factor is accelerated erosion induced by forest clearance; the forest affords protection against erosion but when cleared, the soil surface is more directly exposed to eroding agents and normal geological erosion is accelerated. It becomes imperative that protective measures against erosion are taken to reduce loss of soil

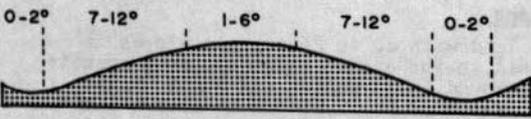
SCHMATIC CROSS SECTION

FIGURE 5-3

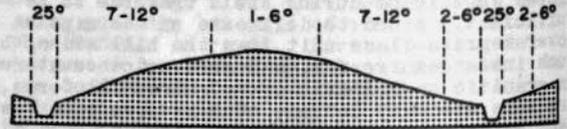
TERRAIN CLASS 2



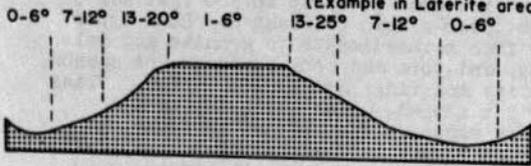
TERRAIN CLASS 3



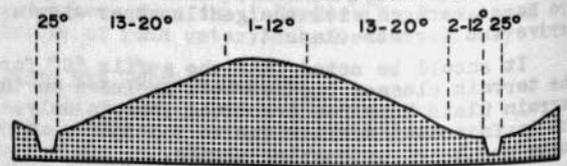
TERRAIN CLASS 3V



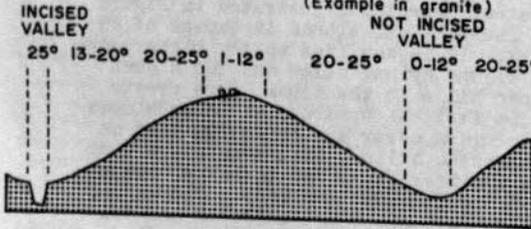
TERRAIN CLASS 4
(Example in Laterite area)



TERRAIN CLASS 4V



TERRAIN CLASS 5
(Example in granite)



TERRAIN CLASS 6
(Example in meta-sediments)

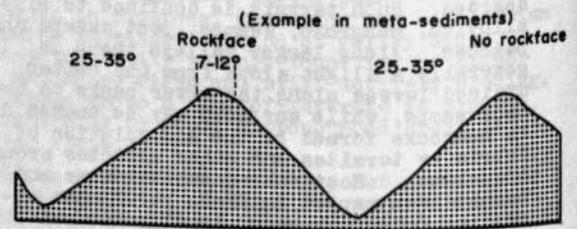
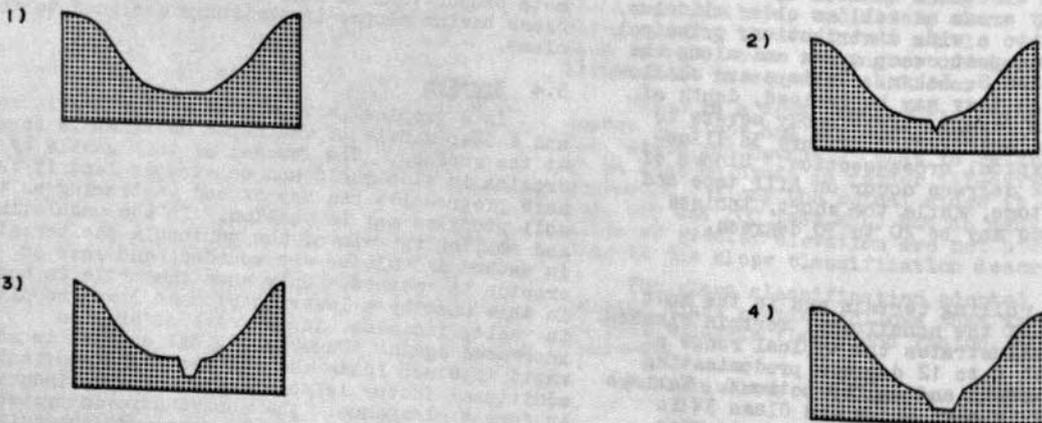


FIGURE 5-4

PROGRESSION OF VALLEY INCISION



- 1) Non-incised, flat floored valley, smooth slope. Colluvial foot slope.
- 2) Narrow, incised valley. Pronounced break of slope. Former valley floor forms a lip, or small terrace.
- 3) Incised, flat floor valley. Maximum depth of incision. Lip reduced.
- 4) Valley floor widens, with no further depth of incision. Lip disappears. No colluvial remains.

by sheet erosion and the loss of land by gully erosion and landslides. A very important side effect is the increase in flood hazard, due to rapid run-off over a bare soil surface and the silting-up and scouring-out of stream beds, with the consequent upsetting of stream flow regime and biological environment. Protective measures taken are principally the construction of terraces and the practise of contour ploughing and planting, and the rapid growth of a ground cover after forest clearance, to protect the soil surface from rain impact and to reduce run-off. The construction of individual platforms, such as in oil palm schemes should be discouraged since this does not sufficiently reduce erosion hazards; although from a financial point of view platforms are cheaper to establish than terraces.

Erosion in the area is primarily an invisible process since it takes the form of gradual depletion of the soil surface, and soil creep. Gully erosion and major landslides are infrequent and thus awareness of the rate of erosion is reduced. Landslides do occur in steep lands, and a major slide occurred on Bukit Belungkor in the December 1969 storms. Small scale landslides are quite common along the backs of terraces and along the sides of incised valleys. Numerous slides of this form were seen in December 1969, mostly but not all in cultivated land. It has been recorded during this study that a rainfall intensity of the order of 3 inches per hour can be expected to affect the surface structure of exposed soils when they are not adequately protected.

The rate of loss of soil by rain-drop impact and run-off can be appreciated from the torrents of brown, sediment-laden water running down slopes in sheets during a heavy rainstorm (Supporting Report 3, Water Resources and Development), with the accumulation of soft silt and sand in hollows or behind obstacles such as felled tree trunks. The upper soil layers are removed from slopes and eventually re-deposited in stream channels and flood-plains.

Valley incision progresses upstream by headward erosion. The point of upstream erosion forms a "nickpoint", above which valley slopes are much gentler. Erosion is rapid at the nickpoint and landslides forming miniature cirques were seen commonly, in both forest and cultivated land. Small rocky falls are found at some nickpoints. Nickpoints are very common in terrain classes 4 and 5 but generally have not yet reached much of the spinal ridge. Erosion is rapid along the incised slopes downstream from the nickpoint, but upstream the slopes are mature and stable. As the nickpoint advances upstream, so these mature slopes will become incised and subject to increased erosion; forest clearance will increase the rate of this advance. Incised and non-incised valley forms are illustrated in Figure 5.4.

A considerable proportion of the peninsula has been used in the past for shifting cultivation. Some of these areas have regenerated forest, but clearings with only a dense fern growth are common. Near S. Chemangar on rentis line AE28 (Figure 15 of Atlas) is some evidence that Marang soils are shallower by 2 to 4 inches (5 to 10 centimetres) in these clearings, indicative of past sheet erosion. Confirmative evidence is difficult to obtain, since areas adjacent to the clearings also have secondary growth, not primary forest. Laterite soils however present clear evidence of past erosion for in the cleared areas the laterite is often seen to form a pavement at the surface, the soil above it having been removed. A laterite pavement was seldom seen in relatively undisturbed forest areas.

There is also evidence of an earlier cycle of small scale erosion that may have now ceased or slowed down. This is difficult to observe in

the field but shows clearly on aerial photographs in estates where vegetative cover is thin. On the photographs it takes the form of rounded to linear patches of dark grey tones adjacent to very light to white grey tones. Such a pattern has also been observed in Spain, where it was found that the dark tones were formerly shallow concave depressions and the light tones slightly convex areas, representing an original land surface. A phase of slope-smoothing then followed, the convex areas being eroded and the transported material redeposited in the depressions. This cycle finished when the final slope was smooth (to the extent that differences in slope form were difficult to detect in the field), but differences in soil depth were considerable, and could be mapped in detail from the photographs.

A similar tract was inspected in the project area in Guntong Estate, where four auger holes (sites C197 - C200) were made in adjacent sites. Sites C197 and C199 in light-tones, slightly convex areas proved to have reddish, medium to heavy textured AB or B horizons at the surface, the A horizon being absent. Sites C198 and C200 in dark-toned, slightly concave areas proved to have 4 to 7 inches (10 to 17 centimetres) of browner, light-textured A horizon at the surface overlying the redder AB and B horizons. All sites were on middle to upper slopes, the light-toned patches being very slight spurs with 12 to 14 degrees slopes, the dark-toned patches being slight depressions between spurs with 7 to 11 degrees slopes. In adjacent areas, the dark-toned form distinct linear lines across the contour, i.e. shallow valleys. It is not postulated that the mechanics of the process are precisely similar to those in Spain, and possibly erosion from the spurs is more important than re-deposition in the depressions. But it may be assumed that the process is widespread over the peninsula and is probably still active, especially following forest clearance; it may account for marked variations in crop growth and yield over very small areas.

5.5 Summary

A postulated geomorphological history is presented in summary. It represents the history as applied to the Tanjong Penggerang peninsula only, and is not a complete summary of all events that occurred, but rather an attempt to relate existing features of the terrain to geomorphological events.

The Pleistocene period was a period of several cycles of submergence and emergence of the land surface. Older alluvium was deposited in a wide alluvial and littoral zone, to an elevation of at least 230 feet MSL and probably higher, and would have covered most areas of the peninsula, with the present high ground standing out as islands.

During the post-Pleistocene emergence, some tilting of the older alluvium occurred. The main drainage system originated on the older alluvium land surface, and this developed independently of underlying geological structures. Hence the S. Seluyut rises at Bukit Wah Ha and flows west, formerly over an older alluvium cover, but as this became removed, the river became superimposed transverse to the spinal ridge, cutting its way down across the geological strike. Its tributaries became orientated along the strike, to form the series of strike valleys and ridges that are found on the spinal ridge. It is postulated that the irregularities of the main watershed arose in this way, i.e. the development of the drainage system on an older alluvial cover and the subsequent super-imposition on the underlying structure, with some modifications due to tilting and warping. At this stage of emergence, the sandy, valley-side, sub-recent alluvium was deposited as true river terraces, up to elevations of around 50 feet MSL, the material being largely derived

from older alluvium and most of the latter being completely removed.

At the time of deposition of sub-recent alluvium, the coastline in the east was well inland of its present position, the sea covering the land that is now under peat swamp. The ridges along the present coast were islands in this sea. With further emergence, the coastline advanced, the beaches were left inland as raised beaches, and peat formed in the poorly-drained lagoonal basins between the beach ridges, eventually covering most of these as well. The courses of rivers in the northeast are still controlled by these old beach-lines. Emergence eventually attained approximately the present levels, and a long cycle of erosion produced the now mature topography of the rolling and undulating terrain; this process is still in progress in the steep lands.

Subsequently some adjustments to the base level of erosion have taken place. Further emergence took place to initiate a phase of rejuvenation of the terrain and valley incision commenced. Incision began at the river mouths, to depths of the order of 30 feet (i.e. that of some raised beaches). It is postulated that the base level of erosion dropped to below its present level, and that at least local, partial recovery took place, resulting in the "drowning" of the river valleys in the south-west (e.g. the S. Johore, S. Lebam, Johore Straits). However once incision was initiated it would continue its upstream progress despite this recovery of base level. Incision ceased in the lower reaches, where valley floors are flat and swampy, but erosion will continue until the valley sides are once again smooth, without breaks of slope. The effects of these adjustments in level on the eastern side of the peninsula are not clear. Valleys flowing into the peat swamps are generally not incised, and presumably the peat swamps themselves acted as a buffer, absorbing the changes in level. Once the coast had advanced to its present position, the eastern half of the peninsula appears to have had a more stable geomorphological history than the west.

SOILS6.1 Soil Genesis

6.1.1 Introduction.

For the purposes of this study, the term soil is as defined in Handbook 18 of the U.S. Department of Agriculture (Soil Survey Staff, 1951).

Since soils are the equilibrium products of the main factors of soil formation, i.e. climate, soil organisms, parent material, topography, time and to some extent human influence, each must be considered as it exists at present and as it is thought to have existed in the past.

6.1.2 Climate.

Climate is the sum total of various factors like rainfall, temperature, amount of sunshine and humidity. These factors are separately measured at some height above the soil and vegetation surface, and are not direct measurements of climate at the soil surface or within the soil. A distinction should be made between overhead climate and soil climate. However the latter is seldom measured and a close relationship between overhead and soil climate has to be assumed in discussion of soil genesis. In very general terms soils in the Project Area exist, and have formed, in a climatic environment characterised by high rainfall fairly equally distributed throughout the year, uniformly high temperatures and high humidity. There is no season in which rainfall is consistently less than 2.4 inches per month and the area may be regarded as falling within Mohr's rainfall Group I, i.e. an area which is continuously wet or at least moist (Mohr and Van Baren, 1959). This means that there will be a surplus of rain above evaporation throughout most of the year. The environment will be one of net downward movement of water within the soil body. The prevailing high temperatures coupled with the generally high soil moisture content result in conditions highly favourable for chemical weathering of rock and soil parent material.

6.1.3 Parent Material.

Soil parent material is usually the weathered products of solid rock, either occurring more or less in situ above the unaltered rock or such weathered material which have been moved and deposited by water and described as either alluvium or colluvium. Within the Project Area occur plutonic granites and, possibly, granodiorites, volcanic tuffs (both fine grained rhyolites and coarser agglomerates and breccias), weakly metamorphosed shales and sandstones, more strongly metamorphosed carbonaceous shales, and metamorphic rocks such as schists and phyllites. Of the transported materials, colluvium occurs only in very limited areas usually in gently sloping, concave hill foot positions. Riverine alluvia occur both as recent deposits in valley bottoms and as sub-recent terraces of pre-existing valleys and base-levels. Recent marine and estuarine alluvia occur as narrow strips along the coastline and along estuaries, with older beach deposits confined largely to the east and southern coasts.

Deposits of the older alluvium occur in three main areas, south-east of Kota Tinggi, south and east of Telok Sengat and north of the S. Rengit. This latter occurrence has been rather tentatively established on the basis of soil characteristics alone.

Granite occupies a large part of the Tanjong Penggerang, particularly west of the metasediment ridge, which forms the central spine of the area.

East of the ridge granite is extensive only in the northern third of the area. All outcrops seen during the course of the soil survey of the area indicate that the granite is a coarse grained variety, with large crystals of both quartz and feldspars. No medium or fine grained granites have been noted, but they may well occur locally. There is no direct evidence for the presence of the more basic granodiorites and quartz diorite, but soil characteristics suggest that these may occur south of the S. Lebam.

The volcanic rocks are rather variable, both in nature and mode of occurrence. In the area north of the S. Lebam, the finer textured rhyolites appear to predominate. Exposures of unweathered rock are, however, few and far between; the nature of the underlying rock has been inferred in most cases from soil characteristics. Along the Kota Tinggi - Sedili road the volcanic rocks are associated with the metasediments, but further south appear to occur as windows in the larger granite area. South of the S. Lebam, the volcanic rocks occupy a more continuous area and appear rather variable in nature. Fine textured rhyolites appear to occur rather more locally, and the main volcanic rock is a coarser, more sandy tuff. Coarse breccias and more basic andesitic tuffs are also reported from this area (Grubb, 1968).

The rocks of the central spine have been called metasediments. The degree of metamorphism is rather weak, the rocks retaining their original sedimentary appearance. Both sandstones and shales occur, the latter predominating. Very few sandstone exposures occur, but such as have been seen indicate that the grain size is highly variable, with the finer sandstones occurring more frequently than the coarser sediments, especially towards the northern part of the area. The shales are mainly rather silty and dark coloured with low iron contents. In exposures they show a tendency to fracture into sharply defined blocks rather than flat plates.

The contact between these metasediments and the main granite masses is sharp, with very little evidence of thermal metamorphism. South of the S. Papan, the contact area is marked by a few relatively high, steep sided hills. Quartz veins within the metasediments occur with considerable frequency and are a feature of many soil profiles.

Metamorphic rocks (in this case mainly micaeous schists and phyllites) have been noted only in one large area, the drainage basin of the S. Papan. Quartzites, phyllites and rather weak schists have been noted within the main metasediment area, but the occurrences are small and very localised.

The other main zone of metasediments stretches from Tanjong Sedili Kechil in the north to Tanjong Punggai in the south. These differ from the sediments of the central ridge in being highly carbonaceous and probably more strongly metamorphosed. Quartz veins occur in great profusion and are a very common constituent of the soil skeleton. Only south of the S. Lebam do these sediments have an obvious contact with igneous rocks.

From the view point of soil genesis two factors appear to be of considerable importance. Virtually all the rocks within the area are acid. Two very local exceptions have been recorded. One is the occurrence of a small area of andesitic tuff mentioned above; the other is a very small area of calc silicate hornfels at Bukit Kutong west of the S. Santi. The nature of this rock was determined from thin sectioning carried

out by the Geological Survey (Fatteh Chand priv. com. 1970). The second major factor appears to be the texture of the rock. The first controls the broad chemical characteristics of soils produced under the prevailing climatic conditions, the second to a large degree has dictated the physical properties of the soils.

The present climatic conditions of high rainfall and high temperatures i.e. continuously hot humid conditions with excess of rainfall over evaporation are ideal for rapid chemical weathering of rocks. Under these conditions, there is rapid metamorphism of the rock forming minerals by processes of hydration and oxidation. This produces hydrated silicates of alumina, iron, residual quartz and other resistant minerals, if the process proceeds to a logical conclusion. In the case of basic rocks, the amount of iron and alumina produced is high, but in the acid rocks, these amounts are relatively small. However, the form that the final weathering products take depends on whether the solution of the rock takes place at or near a water-table. When this occurs the products of katomorphism gibbsite and limonite, can be resitified to give lateritic earths. These earths can become very hard on wetting and drying due to movement and crystallisation of the iron oxides. The presence of this hardened oxide is very common in most soils within the project area, so that some process like this must have been involved. However, there is considerable doubt as to whether these so called laterites are the products of the present cycle. In most cases, the iron and aluminium oxide concretions occur in the nature of stonelines with an orientation parallel to the present slope. If these concretions were the result of a pedological process associated with a fluctuating water-table, this water-table is unlikely to have been related to the present topography and should have given rise to horizons at an angle different to that of the present topographic outline. Secondly, most concretionary material shows distinct signs of abrasion, and appears to have been moved in the past by the normal processes of geological weathering. Therefore, most concretionary material may simply be an inert part of the present soil skeleton derived from a previous pedologic cycle.

An interesting feature is the relationship between the prevalence of concretionary material and rock type. Concretions are most commonly associated with the finer textured rocks and may be an expression of their lower permeability. The presence of concretions in granitic derived soils is uncommon and it may be that, if a fluctuating water table is a prerequisite of the process of laterisation, granite may prove too permeable to produce and maintain such conditions. It has been suggested that the coarse texture of granite may slow up the movement of the leachate solution allowing longer contact between silica and aluminium hydrates, resulting in the formation of kaolin (Mohr and Van Baren, 1959).

Parent material rock (Law Wei Min and Leamy, 1966), is likely to be an important factor in determining the nature of the soil. Other than affecting the processes mentioned above, it also appears to control the depth to which these processes have operated. The weathering profile is generally much shallower on shales than it is on granite and sandstones for the same kind and degree of slope. This is likely to be a function of the lower permeability of finer textured rocks, particularly those with horizontal or near horizontal bedding.

6.1.4 Topography.

The topographic features of the area have been described in detail in Chapter 5.1,

Geomorphology. Because of the dominance of convex and straight simple slopes the drainage of nearly all hill soils is sufficient to prevent any long term saturation of the soils: aerobic conditions, therefore, predominate. Only on flat, alluvial materials are anaerobic conditions found. Exceptions to this occur on some gently sloping foot-slope areas where fluctuating water-tables exist.

One important function of slope is its control of soil depth. Where slopes are steep i.e. greater than 16 to 18 degrees, soils are generally rather shallow. An equilibrium exists between soil wastage from the surface and soil renewal at the bottom of the weathering profile. The steeper the slope, the more delicate is this equilibrium. On slopes of over 25 degrees, the products of weathering are very quickly removed, especially on shales where renewal appears to be rather slow. This results in partially weathered rock occurring at the surface. In the case of granite, this is usually expressed by tor formation, i.e. large blocks and boulders exposed on the surface. This also indicates a basic difference in the way in which the rocks weather.

Figure 6.1 illustrates the relationship between parent rock, slope and soil series.

6.1.5 Time.

Soils are often described as immature, mature or senile. This is an indication of the stage which the pedologic process has reached, and is a reflection of the period during which the processes have been allowed to operate undisturbed. Much of the area has a mature topography so that the soil forming processes have been operative for a considerable period of time. This is not the case where slopes are steep and disturbance of the process is frequent. Under such conditions, the time during which pedologic formation has been operative is short. Recent alluvial deposits are also examples in which soil formation has been of very short duration, and does not keep pace with renewal of fresh material during floods. Time in the pedological sense is relative rather than absolute.

6.1.6 Vegetation.

Under conditions of high rainfall, humidity and temperature, the natural climax vegetation is tropical rain forest. This produces a particular environment which has been maintained in all probability for a very long period of time in this area. The dense vegetative cover helps to maintain a very equable soil climate and affords a high degree of protection from the normal erosion factors. The forest cover, therefore, exerts considerable influence on the existing equilibrium, and removal of it does constitute a serious change in this equilibrium. Furthermore, the movement of soluble bases, downward movement of water and supply of organic matter in the soil are all factors of this equilibrium which are largely controlled by the surface vegetation.

One important result of the continuous occurrence of a forest cover is that, while helping to maintain an overall equilibrium, tree fall does result in periodic disturbance of the upper 2 feet or so of the soil profile. This may have considerable effect on the nature of the horizons used in the classification and grouping of soils.

6.2 Soil Classification

6.2.1 Introduction.

The main characteristics of the soils are the result of the factors described in the foregoing section viz. high intensity of weathering operating in conditions of excess of rainfall over evaporation for a considerable period of time.

The net result is highly weathered, highly leached soils. Examination of the available chemical analyses reveals that all sedentary soils have very low base saturation percentages (Table 6.1) and cation exchange capacities (Table 6.4 and 6.5).

TABLE 6.1 PERCENTAGE BASE SATURATION DETERMINED FROM AVERAGE PROFILE VALUES

NO. OF PROFILES	SOIL SERIES	AVERAGE	RANGE
25	RENGAM	5	3-9
3	JERANGAU	4	4-5
10	YONG PENG	3	2-5
8	HARIMAU	6	4-9
6	SERDANG	6	4-9
6	MARANG	5	3-7
6	BUNGOR	5	3-6
3	POHOI	5	5-6
5	DURIAN	5	3-7
9	MALACCA	4	3-6

Note:- Lowest value recorded for any horizon 1
Highest value recorded for any horizon 17

Some traces of weatherable minerals have been noted in soil profiles, particularly a mica-like mineral, probably muscovite, in soils derived from sedimentary and metamorphic rocks. This has also been noted in some granite and volcanic derived soils. Physically, with a few important exceptions, the soils are characterised by fairly compact blocky sub-soil horizons of only moderate porosity. Most show moderately to strongly developed clay skins on the ped faces. However, clay increases from A to B horizon positions in the profile are rather small and gradual. Many soils contain concretionary material at variable depths in the profile: this material has generally been called laterite in Malaysia and the term will be used although a great deal of confusion is associated with it throughout the world.

These various soil characteristics have been used in arriving at a genetic classification. According to the classification of Pantun (1964), all sedentary soils within the area studied fall into two main Great Groups, the Red Yellow Podzolics and Laterite soils. The classification of West Malaysian soils is under review at the moment with increasing use being made of the limits and diagnostic horizons laid down in supplement to the 7th. Approximation of the Soil Classification System developed by the Soil Survey Staff of the United States Department of Agriculture (1967). The Red Yellow Podzolic Group is incorporated into the Ultisol Order in this classification. This Order requires the presence of an argillic horizon. Hence there should be a difference in clay content between the argillic horizon and the overlying A horizon of at least 8 percent when the A horizon contains 40 percent or more of clay, and this increase should be achieved within a vertical depth of 30 cm. (12 inches). The particle size analyses of the soils show that this increase is either less than 8 percent or is reached only gradually. From this view point the soils do not fulfill the requirements of the Ultisol Order. However, it is possible that the surface horizons are not true A horizons. Most show some transitional B horizon characteristics so that a well defined increase between A and B horizons might not occur. Further analyses of the distribution of the fine clay fraction, silica sesquioxide ratios and

micro-pedological studies are necessary to resolve the problem.

Another major classification problem has been the role and importance of the concretionary laterite which occurs so widely in the area. In earlier classifications this material was considered to be of considerable genetic significance and used at high levels of classification to designate such soils as lateritic soils. As mentioned before, there are serious objections to considering the laterite to be a result of present day conditions. It appears that all of this material within the area has been derived from a past period of pedological and geological activity, and should, therefore, be considered as a resistant, inert part of the present soil parent material. Apart from the evidence that much of it appears to have been considerably modified and aligned by normal erosion process, most profiles show that the upper and often lower boundaries of the laterite horizon do not coincide with natural pedogenic horizon boundaries. Laterite soils are included in the Oxisol Order of the Seventh Approximation Soil Classification (1960) which requires the presence of an oxic horizon which has:-

1. Hydrate oxides of iron and alumina, often amorphous, 1:1 lattice clay and highly insoluble minerals.
2. Less than 10 me/100g base saturation.
3. A cation exchange capacity (CEC) less than 16 me/100g.
4. No traces of primary aluminosilicate or ferro-magnesian minerals.
5. Only traces of water dispersible clay.
6. Over 15 percent clay in the fine earth fraction.
7. No or very few clay skins and, at most, a gradual increase of clay with depth.
8. Very low plasticity, weak structure, high friability and porosity.

Very few of the soils appear to meet most of the requirements of an Oxisol, but analyses are not sufficiently complete to classify these soils with confidence.

In fact most of the soils within the area appear to lie uneasily between these two concepts. The frequency of occurrence in which clays appear to be difficult to disperse by normal means is unusual for true Vertisols but the degree of clay stability is too low for soils of the Oxisol Order. The lack of a good clay bulge in all soils would mitigate against inclusion in the Ultisol Order, but the degree of clay skin development appears too high for Oxisols. Both CEC and base saturation percentages are within the limits set for the oxic horizon, but the common occurrence of muscovite would tend to exclude most soils from the Oxisols. It may be that the present pedological cycle has been imposed on a parent material at least in part derived from a past cycle which was oxisol in nature. Similar observations have been made concerning some soils derived from argillaceous parent materials (Law Wei Min and Leamy, 1966).

In the light of the difficulties described above, no attempt has been made to classify the sedentary soils of the area in terms of the upper categories of a genetic classification. Classification has been restricted to grouping soils into associations, series and phases following the accepted definitions of these units laid down by Leamy and Pantun (1966) and Law Wei Min and Selvadural (1968). Further amendments have been made where necessary (Law Wei Min Priv. comm. 1970).

PARTICLE SIZE DISTRIBUTION

FIGURE 6-2

LEGEND

Range
Maximum value
Upper quartile
Median
Lower quartile
Minimum value



Percentage fine earth

- Clay
- Silt
- Fine Sand
- Coarse Sand

Percentage total soil

- Gravel and Stones

RENGAM SERIES (12 profiles)

Horizons

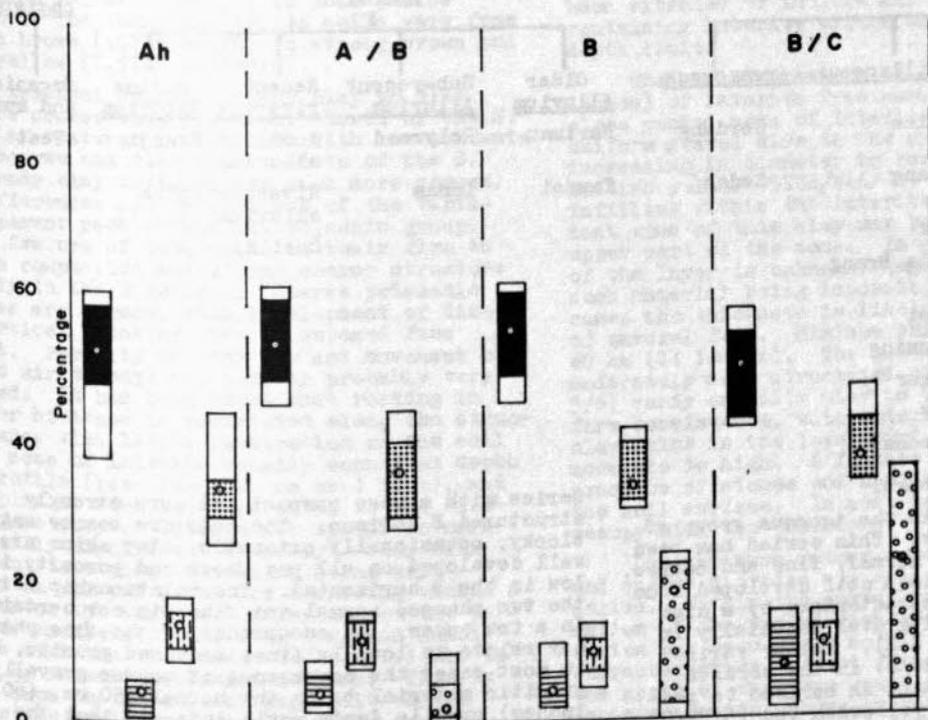
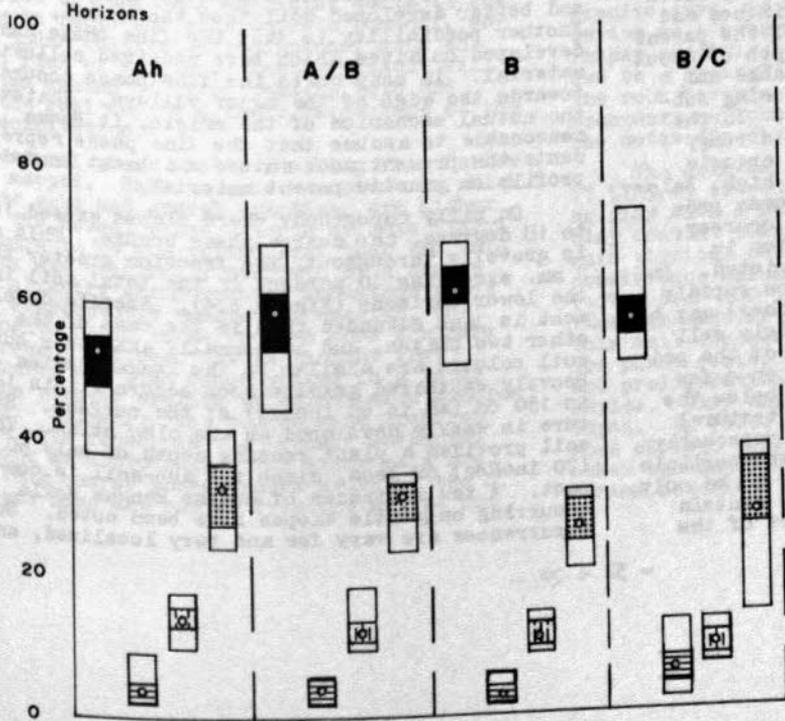


FIGURE 6.3

RENGAM SERIES, fine sandy clay phase (9 profiles)

Horizons

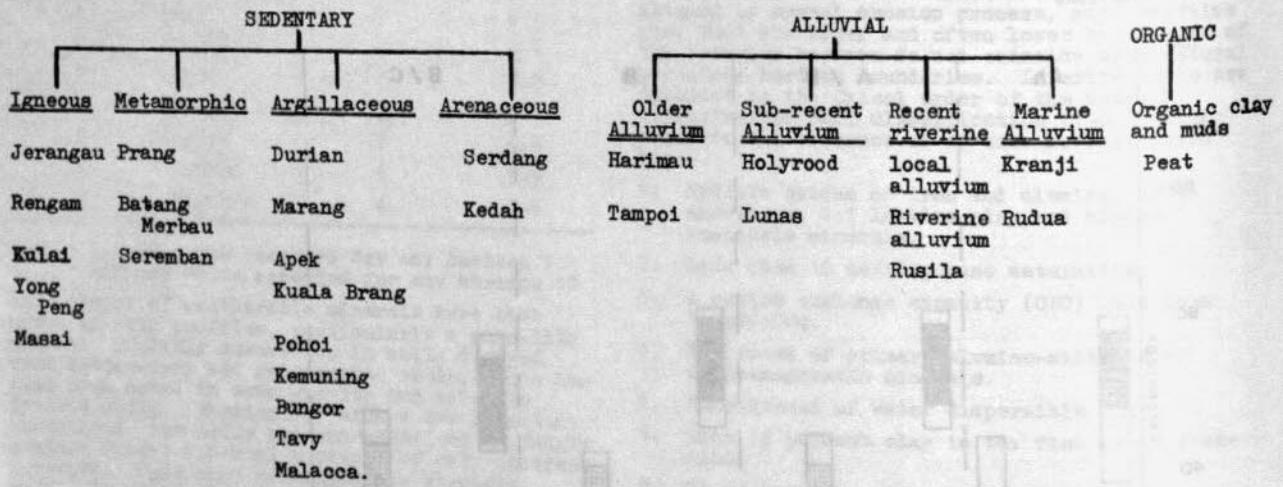


At this level, the classification depends heavily on groupings according to parent material/rock (Law Wei Min and Leamy, 1966). However, parent material is an important factor in the soil forming process, and the system is reasonable from this point of view. Also, the main mapping unit used is the soil series which is a grouping of soils with similar profile characteristics developed in the same or similar parent materials. Where direct evidence of the underlying rock is lacking, parent rock has been inferred from profile characteristics known to be associated with that rock type. The basic grouping of the soils of the area is shown in Table 6.2 below.

requirements of an argillic horizon, according to the definition of an argillic horizon given in the U.S.D.A. 7th Approximation Soil Classification (1960).

The fine textural phase of the Rengam series differs from the normal or modal profile in containing significantly less of the coarse soil fraction. Content of gravel is nil throughout the profile. The clay content is higher than in the modal profile, especially in the B horizon, while the content of coarse sand decreases from the A to B horizon (Figure 6.3). Soil colours are similar to the Rengam Series described above. Horizonation is more obvious than in the normal

TABLE 6.2
BASIC SOIL GROUPING



6.2.2 Soils on Igneous Rocks.

The main series within the igneous group of rocks is the Rengam Series. This series has been divided into three phases normal, fine and coarse. The normal Rengam Series is a soil developed from coarse grained granite, characterised by a high content of coarse sand and gravel especially in the lower subsoil (Figure 6.2). Colour varies from brownish yellow (10YR6/8) in the horizon immediately below the organic Ah horizon to reddish yellow (7.5YR6/8) or yellowish red (5YR5/8) in the subsoil. The particle size analysis diagram (Figure 6.6) indicates that the coarser than 2 mm fraction (normally quartz grit) increases rather abruptly in the B horizon. In many cases this increase occurs over only a few inches and may indicate some past colluviation of the parent material. The upper horizons to a depth of about 35 to 40 cm (14 to 16 inches) are friable and moderately well structured, the peds being sub-angular in outline and medium in size. In the Ah horizon, structure is occasionally strong, fine sub-angular blocky to crumb when organic matter content and faunal activity is high. Below about 40 cm (16 inches), the soil becomes progressively more compact and structure coarser. Occasionally, the increase in compaction is abrupt, and rooting is obviously restricted. In these lower horizons porosity decreases rapidly and aeration below about 60 cm (24 inches) may be only moderate. Clay skins are moderately well developed in this soil, covering most of the ped faces in the B horizon, and occurring on a few faces even in the horizon immediately below the surface Ah horizon. In the field the textural increase from A to B horizons appears reasonably marked, but this is not borne out by the particle size analysis which shows the increase to be only 3 percent. Since the surface horizons contain over 40 percent clay, this is far short of the

series with a more compact and more strongly structured B horizon. The peds are coarse angular blocky, occasionally prismatic, clay skins are well developed on all ped faces and porosity is low in the B horizon(s). The relationship between the two phases, normal and fine, is not certain. In a few cases, the occurrence of the fine phase may relate to locally finer textured granite, but in most cases the occurrence of coarse gravelly granitic material below the normal 150 cm. (60 inches) profile depth would indicate that the parent material is, in fact, the same in both cases. The fine phase normally occupies the more gentle topographic positions within the granite areas and may represent a more severely weathered and better developed soil than the normal. Another possibility is that the fine phase has developed on sites which have received colluvial material. In many cases the fine phase occurs towards the edge of the major valleys. Whatever the actual mechanics of the origin, it seems reasonable to assume that the fine phase represents the present most mature and least eroded profile on granite parent material.

On hilly topography where slopes exceed 16 to 18 degrees, the coarse phase occurs. This soil is gravelly throughout, the fraction greater than 2 mm. exceeding 40 percent of the total soil in the lower horizons (Figure 6.4). Profile development is less advanced than in the case of the other two phases, and is normally shallower but heavily weathered granite rock occurs within 120 to 150 cm (48 to 60 inches) of the surface. Structure is weakly developed as are clay skins. The soil provides a plant rooting depth of only 50 cm. (20 inches) or less, since the sub-soil is compact. A few instances of coarse Rengam soils occurring on gentle slopes have been noted. Such occurrences are very few and very localised, and

it has been assumed that they are the product of locally accelerated erosion due to past cultivation. In this survey, and arbitrary depth of 50 cm has been used to distinguish the coarse sandy clay phase from the normal profile: if gravel occurs within this depth, then the soil is recognised as belonging to the coarse sandy clay phase.

The Rengam Series thus represents a range of soils of different stages of maturity, and indicates the importance of the factors of time and topography within a uniform parent material.

The volcanic rocks of the area produce soils of the Yong Peng and Kulai Series. The characteristics both chemical and physical of these series are very similar and they will be considered together. The main differentiating feature is colour. Soils of the Kulai Series are paler in colour than those of the Yong Peng Series, varying from yellow (10YR7/6) to pale yellow (2.5Y 7/4). The Yong Peng Series soils vary from yellowish brown (10YR5/6-5/8) to strong brown and reddish yellow (7.5YR6/8-5YR6/6).

The textural range is sandy clay to clay with a low coarse sand fraction. North of the S. Lebam, clay textures predominate with low contents of both coarse and fine sand. South of the S. Lebam, sandy clay textures are much more common. These differences are reflections of the variation in parent rock within the volcanic group. The main feature of both soils is their firm to very firm compaction and strong coarse structure especially in the B horizon. Coarse prismatic structures are common, with development of distinct vertical cracking when an exposed face dries out. Porosity is very low and movement of water and air through the peds is probably very restricted. It has been noted that rooting in the deeper horizons is restricted along the structural planes with little penetration of the soil peds. A zone of laterite usually occurs at depth in the profile (less than 120 cm or 4 feet), and in deep pits is seen to be parallel to the existing surface slope. It does not appear to mark a genetically significant boundary. Clay skin development is strong, the skins being well developed on all ped faces and occurring within a few inches of the surface. A feature of the particle size analysis of the Yong Peng and Kulai Series is that the clay seems to be difficult to disperse by normal dispersion methods. This is apparent from the occasional high silt values quoted in the analytical results which are probably due to silt size clay particles.

From observation of the effect of heavy rain on these soils, it appears that the surface infiltration rate of Yong Peng and Kulai soils is low, resulting in rapid and considerable run-off, especially under cultivated conditions, with an attendant risk of erosion. Another result will be that the amount of water passing into and through the soil may be a small percentage of the total precipitation.

A textural phase within the Yong Peng Series has been mapped. This is a coarse phase in which the coarse sand and gravel fractions are higher than for the normal phase. North of Kota Tinggi this appears to be due to the fact that the volcanic rock was originally overlain by a coarse grained, slightly metamorphosed sandstone which has been subsequently removed by erosion, the only remnants being large rounded core boulders on the present surface. It is thought that coarse quartz has been concentrated in a layer within the present profile by normal slow erosion processes. Normally, the coarse sand fraction decreases with depth, as the present weathered parent rock is approached. The other main area of Yong Peng coarse phase occurs south of the S. Seluyut and here the coarse fraction may be due

to either dilution from associated granite or a degree of recrystallisation of quartz in the glassy volcanics as a result of injection by granite. Apart from the higher content of the coarse fraction, the soils are essentially the same as for the normal phase. On two hill tops south of the S. Santi, the shallow phases of both the Kulai and Yong Peng Series have been mapped. In these weathered rock occurs within 50 cm (20 inches) of the surface due to high erosion.

Associated with soils of the Yong Peng and Kulai Series are soils which contain large amounts of concretionary laterite within 60 cm (24 inches) of the surface. These have been included in the Masai Series. It should be pointed out that in the classification of Leamy and Panton (1966), this series is defined as being derived from granodiorite and quartz diorite. In this survey, the definition of the series has been extended to include all igneous derived soils containing laterite within the 60 cm (24 inches) depth limit.

The series consists of 40 to 50 cm (16 to 20 inches) of laterite free sandy clay overlying a close packed zone of laterite which is of rather uniform gravel size in the surface rapidly increasing in diameter to boulder size with depth. Reddish yellow (5YR6/6-6/8) clay occurs as an infilling within the laterite zone. It is thought that some of this clay may be alluvial in the upper part of the zone. In most cases, the depth of the layer is unknown, augering and digging in such material being impossible. However, in many cases the thickness is likely to be of the order of several feet. Minimum thickness recorded was 60 cm (24 inches). The laterite free soil is moderately well structured strong brown (7.5YR 5/6) sandy or silty clay to clay of friable to firm consistence, with moderately well developed clay skins in the lower part. Porosity is moderate to high. A feature of this soil is the presence of stones and boulders of laterite on the soil surface. In most cases the Masai Series occupy hill top positions.

Derived from rather more basic granodiorites and quartz diorites are soils of the Jerangau Series. Within the survey area no direct confirmation of the parent rock was possible, and the series has been named solely on the soil profile characteristics. Apart from one small area in the north of the area south of the S. Bahan, the Jerangau Series occurs only south of the S. Lebam. Here it occurs in close association with soils of the Rengam Series over much of the area, and it has not proved possible to separate the two at the scale of survey. Around the edges of the main granite mass, it has been possible to map the series as a separate unit. The reason for this rather specific location is unknown. It may be due to a gradual increase in the base status of the rock towards the periphery or due to some secondary enrichment of the rock on contact with the metasediments.

The soil is a very deep uniform strong brown (7.5YR5/6) to reddish yellow (5YR6/6) sandy clay or clay with a much lower coarse sand and higher clay content than soils of the Rengam Series. The main physical characteristic is the very friable consistence which extends to considerable depth (often over 120 cm or 4 feet). Structure is weak, fine sub-angular blocky and porosity is very high. This soil obviously provides an excellent medium for plant roots, and pits showed a greater number and proliferation of roots than for any other series. Clay skins are at best only weakly developed. On field evidence, this soil shows much more obvious oxisolic characteristics than do the other igneous derived soils. Soils of the Masai Series described above occur in association with

Jerangau Series soils and usually occupy hill top positions as they do when associated with Yong Peng Series soils.

6.2.3 Soils on metamorphic rocks.

Three series have been described on metamorphic rocks in the area. Two of these, the Batang Merbau and Seremban Series are closely related. Both are derived from micaceous schists with some phyllite and vein quartz admixture. The Batang Merbau Series consists of brownish yellow (10YR6/6) to yellowish brown (10YR5/6) friable A horizons of fine sandy clay loam and fine sandy clay overlying a reddish yellow (7.5YR6/6) or strong brown (7.5YR5/6) fine sandy clay and clay sub-soil. Sub-soil horizons are friable to firm with a fairly high degree of porosity, and structure is moderate medium sub-angular blocky. Vein quartz often occurs towards the bottom of the profile, which is micaceous throughout especially in the lower sections.

Soils of the Seremban Series differ from those of the Batang Merbau Series in containing lateritic material in the subsoil. The depth to this laterite is rather variable, but generally occurs within 60 to 70 cm (24 to 28 inches) of the surface. In most cases, the laterite is mixed with large amounts of weathered vein quartz and shows a strong impress of the original parent rock. The laterite free surface horizons are very similar to those of the Batang Merbau Series soils. The Seremban Series usually occupy rather higher positions than do soils of the Batang Merbau Series, but the relationship is not very strongly held.

The third member of the metamorphic derived soils, the Prang Series, is associated with a small, very localised occurrence of calc silicate hornfels north and west of the S. Santi. The profile is a very uniform, friable, yellowish red (5YR5/6-5/8) fine sandy clay, the depth depending on slope. Where slope is in excess of 18 degrees, the weathered fine textured rock occurs within 120 cm (48 inches) and the profile becomes firm at this depth. No profile pit was examined in this soil, but the structure is thought to be moderately well developed. This soil may be rather oxisolic in nature.

6.2.4 Soils on argillaceous rocks.

The varied nature of the argillaceous rocks of the area is reflected in the large number of series that have been identified. Some of these series have parent materials which are of composite origin, usually mixtures of sandstone and shale where the original rocks are interbedded.

On the central metasedimentary ridge two series have been mapped separately and in association, the Kemuning and Durian Series. The former occupies the steeper, higher areas of the ridge, the latter the lower, less steep positions. The Kemuning Series is a greyish brown (10YR5/2) to light greyish brown (10YR6/2) clay of firm consistency with a moderately developed coarse structure which is seen to be prismatic in long-exposed sections. The dark coloured, weakly metamorphosed shale parent material occurs within 90 cms (36 inches) and approaches very close to the surface when slopes exceed 25 degrees. This soil is one of the younger in terms of pedological age.

Soils of the Durian Series occupy less steep positions than do soils of the Kemuning Series. The A horizon is yellow (10YR7/6) clay, moderately well structured overlying a very firm yellow clay with a strongly developed coarse prismatic and angular blocky structure (Figure 6.5). The very compact horizon is usually reached within about 40 cm (16 inches) and constitutes a considerable barrier to root development, the few roots in the horizon being confined to the fine cracks between the individual peds. Porosity within the peds is very low and movement of water and air is likely

to be very restricted; clay skins are well developed in the B horizon. Laterite occurs within the profile and the depth appears to be a function of slope; on steeper slopes, i.e. slopes in excess of about 14 degrees, the laterite band occurs at depths of between 50 and 100 cm (20 and 40 inches). This is the normal or modal series. When the laterite band occurs below 100 cm (40 inches) the soil is considered a deep phase. The laterite band is rather variable in thickness, and is often rather close packed.

In the east of the area, Durian Series soils occur in association with soils of the Malacca Series. This latter series very commonly occupies hill top positions and the occurrence of this soil is often marked by a sharp increase in slope (Eyles, 1967). Malacca is a series characterised by a considerable thickness of very coarse laterite occurring within 60 cm (24 inches) of the surface and often outcropping at the surface itself. The soil surface is generally littered with stones and boulders of lateritic material. The overlying laterite free soil is a brownish yellow (10YR6/6-6/8) to reddish yellow (7.5YR 6/6-6/8) fine sandy clay, of friable to firm consistency and moderately well developed structure. In most cases, the Malacca Series appears to be the rather eroded remnants of a fossil lateritic soil. The parent rock of most Malacca Series is likely to be shale.

A second lateritic series occurs within the group of soils derived from argillaceous parent materials. This is the Tavy Series, a soil with a laterite-free surface horizon of 30 to 45 cm (12 to 18 inches). The laterite layer consists generally of gravel and stone size material, rounded and close packed. The thickness of the layer is usually 60 cm (24 inches) or less and is occasionally underlain by mottled sub-soil material. The presence of mottled material below the laterite zone is much less frequent than has been reported for other areas of West Malaysia. The laterite-free zone is yellowish brown (10YR5/6-5/8) to strong brown (7.5YR5/6-5/8) fine sandy clay loam or fine sandy clay, friable with moderate, medium sub-angular blocky structure. The soil is more compact below the laterite zone. Clay skins occur in the lower part of the laterite-free zone and in the upper part of the lateritic horizon.

The Tavy Series occurs in a rather complex series of associations with other series of the argillaceous parent rock group. In the south eastern part of the area, Tavy is associated with the Malacca Series. In this situation, the Tavy Series soils occur immediately downslope of the Malacca Series capping the hill tops. Here, the rather thin laterite band of the Tavy Series appears to be the result of the erosion product of the more massive laterite of the Malacca Series which has been moved down slope by the normal process of slow colluviation. Sequences have been noted where the laterite band increases in depth further downslope in soils of the Durian Series.

A second, and most common mode of occurrence is on hill tops associated with other soils of sedimentary origin. This is similar to the occurrence described for the Malacca Series and probably represents either the eroded remnants of a more extensive laterite or the gradual exposure at the surface of laterite by erosion and loss of the overlying laterite-free soil. A third form of occurrence is found in the northern part of the area in association with soils of the Durian and Bungor Series. In this area slopes are generally in excess of 20 degrees. A laterite band occurs ubiquitously throughout the area, and the main series have this band within 100 cm (40 inches) of the surface. Local differences in the degree of erosion on these slopes result in very varying depths of the laterite below the surface.

FIGURE 6.4

PARTICLE SIZE DISTRIBUTION

RENGAM SERIES, Coarse sandy clay phase (4 profiles)

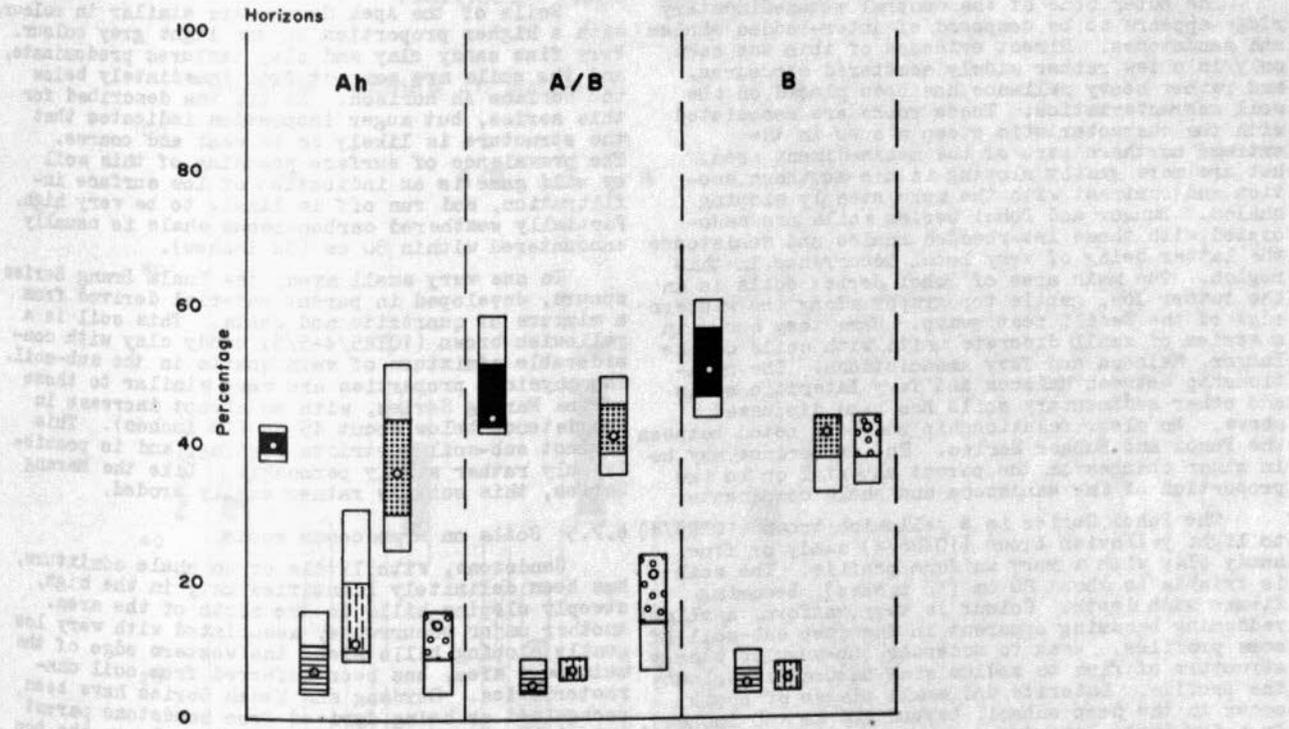
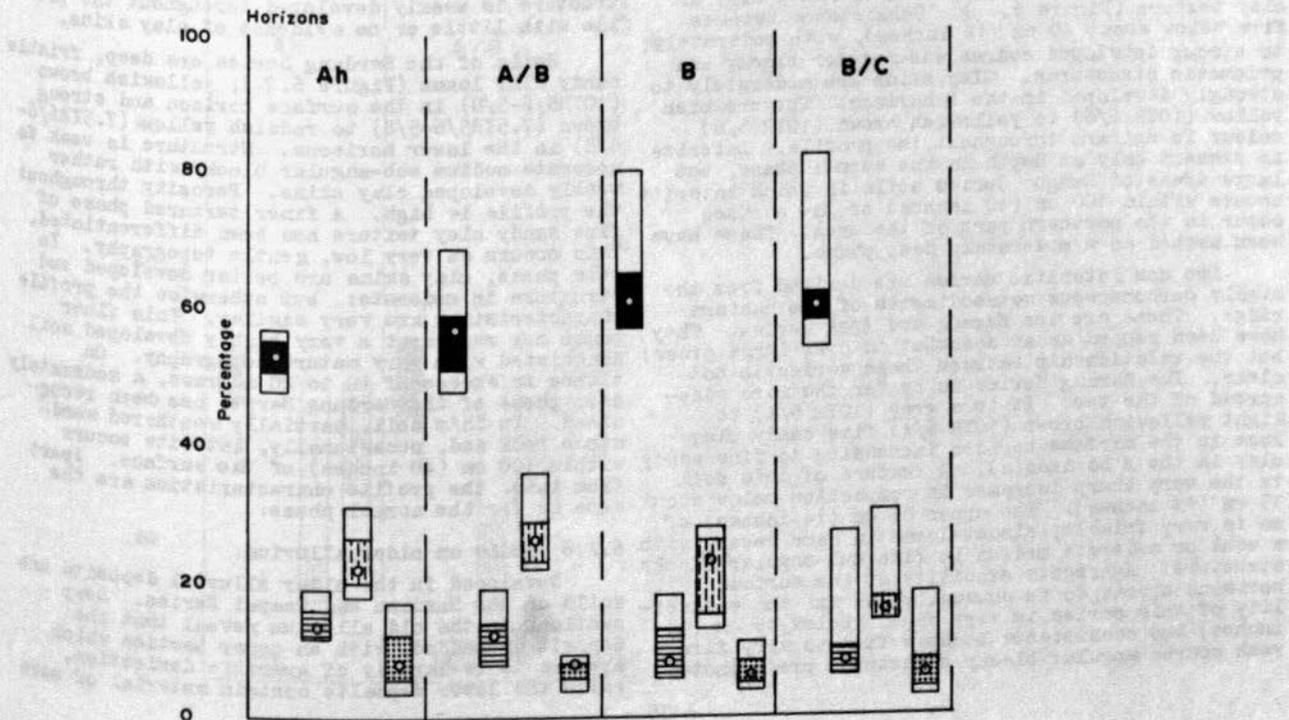


FIGURE 6.5

DURIAN SERIES (5 profiles)



Where the laterite is consistently within 60 cm (24 inches) of the surface, Tavy Series soils have been recognised. It is a feature of this area that the surface of the laterite is rather level and is orientated parallel to the land surface. Colluviation appears to be or to have been important.

The outer zone of the central metasedimentary ridge appears to be composed of inter-bedded shales and sandstones. Direct evidence of this was seen only in a few rather widely scattered exposures, and rather heavy reliance has been placed on the soil characteristics. These rocks are associated with the characteristic steep slopes in the extreme northern part of the metasediment area, but are more gently sloping in the southern section and contrast with the more steeply sloping shales. Bungor and Pohoi Series soils are associated with these interbedded shales and sandstones the latter being of very local occurrence in this region. The main area of Pohoi Series soils is on the rather low, gentle topography along the western edge of the Sedili peat swamp. Here they occur in a series of small discrete units with soils of the Bungor, Malacca and Tavy associations. The relationship between Malacca and Tavy lateritic soils and other sedimentary soils has been discussed above. No clear relationship has been noted between the Pohoi and Bungor Series. The difference may be in minor changes in the parent material or in the proportion of the sandstone and shale components.

The Pohoi Series is a yellowish brown (10YR5/4) to light yellowish brown (10YR6/4) sandy or fine sandy clay with a very uniform profile. The soil is friable to about 80 cm (32 inches), becoming firmer with depth. Colour is very uniform, a slight reddening becoming apparent in the deep sub-soil of some profiles. Weak to moderate sub-angular blocky structure of fine to medium size occurs throughout the profile. Laterite and small pieces of shale occur in the deep subsoil beyond 100 cm (40 inches). In a few bores laterite occurred within this depth, but too infrequently to justify delineating a moderately deep phase, which is probably the result of the rather gently sloping topography associated with the Pohoi Series. Clay skins are only weakly developed in this soil.

Soils of the Bungor Series are more compact in the B horizon than are those of the Pohoi Series. The former has a sandy clay loam to sandy clay or clay texture (Figure 6). Consistence becomes firm below about 40 cm (16 inches), with moderately to strong developed coarse sub-angular blocky and prismatic structures. Clay skins are moderately to strongly developed in the B horizon. The brownish yellow (10YR 6/6) to yellowish brown (10YR 5/6) colour is uniform throughout the profile. Laterite is present only at depth in the normal phase, but large areas of Bungor Series soils in which laterite occurs within 100 cm (40 inches) of the surface occur in the northern part of the area. These have been mapped as a moderately deep phase.

Two non lateritic series are derived from the highly carbonaceous metasediments of the eastern ridge. These are the Marang and Apek Series. They have been mapped as an association over large areas; but the relationship between these series is not clear. The Marang Series is by far the more widespread of the two. It is a grey (10YR 5/1) to light yellowish brown (10YR 6/4) fine sandy clay loam in the surface horizon increasing to fine sandy clay in the B horizon(s). A feature of this soil is the very sharp increase in compaction below about 35 cm (14 inches). The upper 35 cm (14 inches) or so is very friable, almost loose in some cases, with a weak or moderate medium to fine sub-angular blocky structure. Aggregate stability of the surface horizons appear to be unusually low and the erodability of this series is very high. Below 35 cm (14 inches) the consistence becomes firm to very firm; weak coarse angular blocky structures predominate.

Clay skins are weakly to moderately well developed. In most profiles there is a high content of weathered vein quartz which decreases with depth. This vein quartz appears to have been concentrated in bands by past colluviation. Porosity in this zone of compaction is very low and rooting is very seriously restricted.

Soils of the Apek Series are similar in colour, with a higher proportion in the light grey colour. Very fine sandy clay and clay textures predominate, and the soils are compact from immediately below the surface Ah horizon. No pit was described for this series, but auger inspection indicates that the structure is likely to be weak and coarse. The prevalence of surface poaching of this soil by wild game is an indication of low surface infiltration, and run off is likely to be very high. Partially weathered carbonaceous shale is usually encountered within 80 cm (32 inches).

In one very small area, the Kuala Brang Series occurs, developed in parent material derived from a mixture of quartzite and shale. This soil is a yellowish brown (10YR5/4-5/6) sandy clay with considerable admixture of vein quartz in the sub-soil. The physical properties are very similar to those of the Marang Series, with an abrupt increase in consistence below about 45 cm (18 inches). This compact sub-soil restricts rooting, and is possibly only rather slowly permeable. Like the Marang Series, this soil is rather easily eroded.

6.2.5 Soils on arenaceous rocks.

Sandstone, with little or no shale admixture, has been definitely identified only in the high, steeply sloping hills in the north of the area. Another major occurrence, associated with very low gently sloping hills along the western edge of the main peat area, has been inferred from soil characteristics. Serdang and Kedah Series have been recognised as being derived from sandstone parent material. The Kedah Series occurs only on the top of a few very steeply sloping hills in the north of the area. This soil is regarded as a rather immature soil in terms of pedological development. It is a yellowish brown (10YR5/6) to strong brown (7.5YR5/8) sandy clay rather friable in the top but more compact in the sub-soil. Pieces of partially weathered sandstone and vein quartz occur in the sub-soil below about 60 cm (24 inches). Structure is weakly developed throughout the profile with little or no evidence of clay skins.

Soils of the Serdang Series are deep, friable sandy clay loams (Figure 6.7), yellowish brown (10YR5/6-5/8) in the surface horizon and strong brown (7.5YR5/6-5/8) to reddish yellow (7.5YR6/6-6/8) in the lower horizons. Structure is weak to moderate medium sub-angular blocky with rather weakly developed clay skins. Porosity throughout the profile is high. A finer textured phase of fine sandy clay texture has been differentiated. This occurs on very low, gentle topography. In this phase, clay skins are better developed and structure is moderate; but otherwise the profile characteristics are very similar. This finer phase may represent a very highly developed soil associated with very mature topography. On slopes in excess of 18 to 20 degrees, a moderately deep phase of the Serdang Series has been recognised. In this soil, partially weathered sandstone rock and, occasionally, laterite occurs within 100 cm (40 inches) of the surface. Apart from this, the profile characteristics are the same as for the normal phase.

6.2.6 Soils on older alluvium.

Developed in the older alluvial deposits are soils of the Harimau and Tampoi Series. Deep sections in the old alluvium reveal that the deposit is bedded, with an upper section which appears to be largely of granitic derivation, while the lower deposits contain material of more

FIGURE 6.6

PARTICLE SIZE DISTRIBUTION

BUNGOR SERIES (6 profiles)

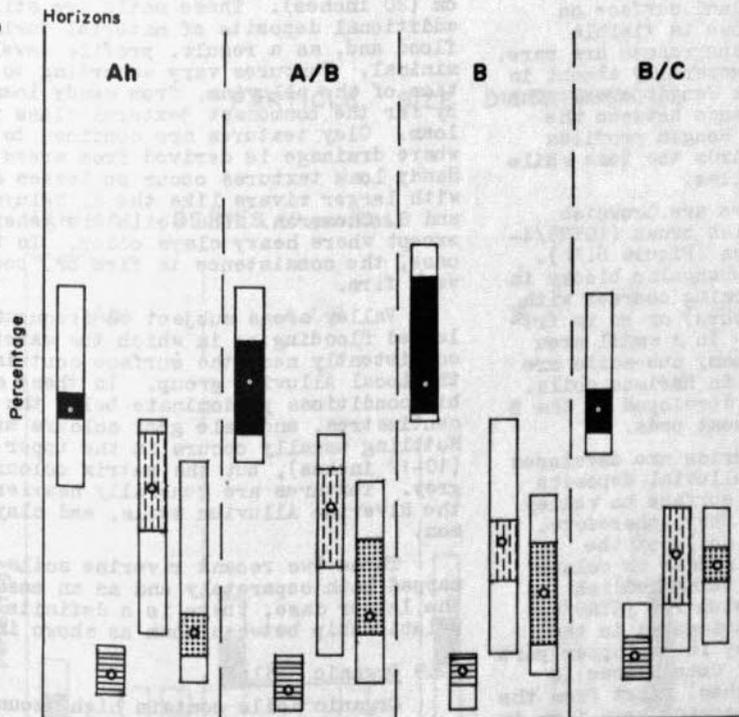
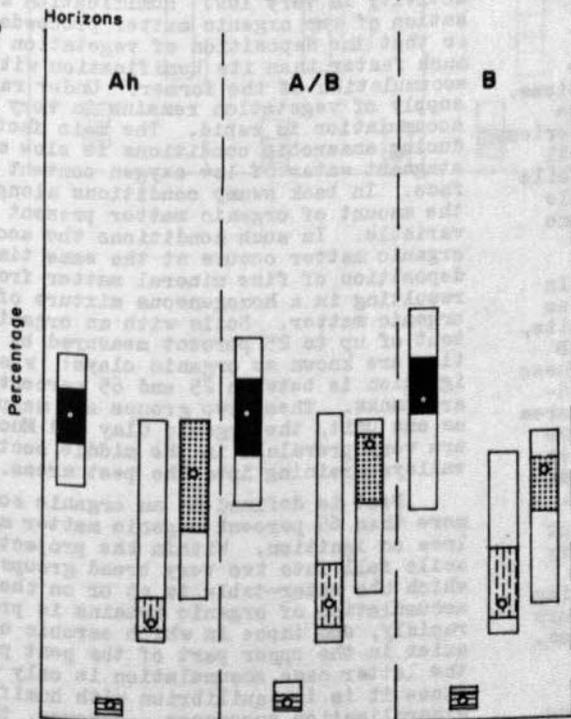


FIGURE 6.7

SERDANG SERIES (6 profiles)



sedimentary origin. This sedimentary derived alluvium approaches the surface only in areas bordering valleys and in positions towards the base of hills.

The main characteristics of the Harimau Series are very similar to those of the Rengam Series, and differentiation between them is very difficult in the absence of deep sections. Only very weak sorting is apparent within the normal soil inspection depth in soils of the Harimau Series and is paralleled in the Rengam Series by a weak sorting due to colluvial processes. On the higher positions, the old land surface on which the deposits were laid down is visible within the profile, but such occurrences are rare. Rounded gravel and stones are generally absent in the profile except in the Telok Sengat area. The most commonly occurring difference between the two series is in colour. Most Rengam profiles show a reddening in colour towards the base while this is absent in Harimau profiles.

Soils of the Harimau Series are brownish yellow (10YR6/6-6/8) to yellowish brown (10YR5/4-5/6) sandy or coarse sandy clays (Figure 6.8). Structure is moderate medium subangular blocky in the top 40 cm (16 inches), becoming coarser with depth. The upper 40 cm (16 inches) or so is friable becoming firm with depth. In a small area immediately north of the S. Lebam, sub-soils are very firm. Porosity is medium in Harimau soils. Clay skins are moderately well developed in the B horizon covering the faces of most pedis.

The soils of the Tampoi Series are developed in the lower materials of the alluvial deposits where they have approached the surface on valley edges and in low lying sites. They, therefore, occur at lower levels than the soils of the Harimau Series. They are much redder in colour than the Harimau Series soils, being reddish yellow (7.5YR6/6-6/8) to yellowish red (5YR5/6-5/8) and strongly mottled or variegated in the sub-soil. Texture is sandy clay in the upper part of the profile and clay below. Consistence is firm in the upper 40 cm (16 inches) apart from the Ah horizon which is friable, becoming very firm in the sub-soil. Structures are moderate medium sub-angular blocky and clay skins are moderately well developed. Porosity is generally very low.

6.2.7 Soils on sub-recent alluvium.

Sub-recent alluvia occur as low terraces associated with present and past drainage systems. Two soils series have been delineated in these deposits. The major series is the Holyrood Series, a very well drained rather coarse textured soil with little or no profile development. The soils are generally pale brown (10YR6/3) to very pale brown (10YR8/3) sandy loams or sandy clay loams with a high coarse sand content, and are very friable throughout the profile. Structure is weakly developed and porosity is very high. In rare instances, particularly where the terraces are associated with lower lying organic deposits, there are soils in which there is a distinct B horizon of iron and/or humus accumulation. These soils appear to be humus podzols of the ground-water podzol type. They are of insufficient area to constitute a separate mapping unit, and have been included with soils of the Holyrood Series with which they are closely associated, although they belong to quite different genetic groups.

On the lower lying parts of the sub-recent alluvium occurs the Lunas Series. This is very similar to the Holyrood Series except for the higher water-table associated with its low lying topographic position. Very weak mottling occurs where the water-table is subject to fluctuation.

6.2.8 Soils on recent alluvium.

Recent riverine deposits occur only in the

narrow valley bottoms of the drainage systems. The soils of these valley bottoms have been divided into two groups largely on the basis of their drainage characteristics. One group, the Riverine Alluvium, includes all recent riverine deposits which are imperfectly drained or better. This group of soils is subject to regular flooding of short duration, such that anaerobic conditions occur intermittently in the profile. Therefore, strong mottling or variegation is present in the profile. Constant reducing conditions occur only deeper in the profile, at depths of at least 50 cm (20 inches). These soils are still receiving additional deposits of material during periods of flood and, as a result, profile development is minimal. Textures vary according to the derivation of the alluvium, from sandy loam to clay. By far the commonest textural class is sandy clay loam. Clay textures are confined to valleys where drainage is derived from areas of shale. Sandy loam textures occur on levees associated with larger rivers like the S. Seluyut, S. Papan and S. Chemaran. The soils are generally friable except where heavy clays occur. In the latter case, the consistence is firm or, occasionally, very firm.

Valley areas subject to frequent and prolonged flooding or in which the water-table is consistently near the surface contain soils of the Local Alluvium group. In these soils anaerobic conditions predominate below the surface few centimetres, and pale grey colours are common. Mottling usually occurs in the upper 25 to 30 cms (10-12 inches), but the matrix colour is pale grey. Textures are generally heavier than for the Riverine Alluvium soils, and clays are common.

These two recent riverine soils have been mapped both separately and as an association. In the latter case, there is a definite topographical relationship between them as shown in the diagram.

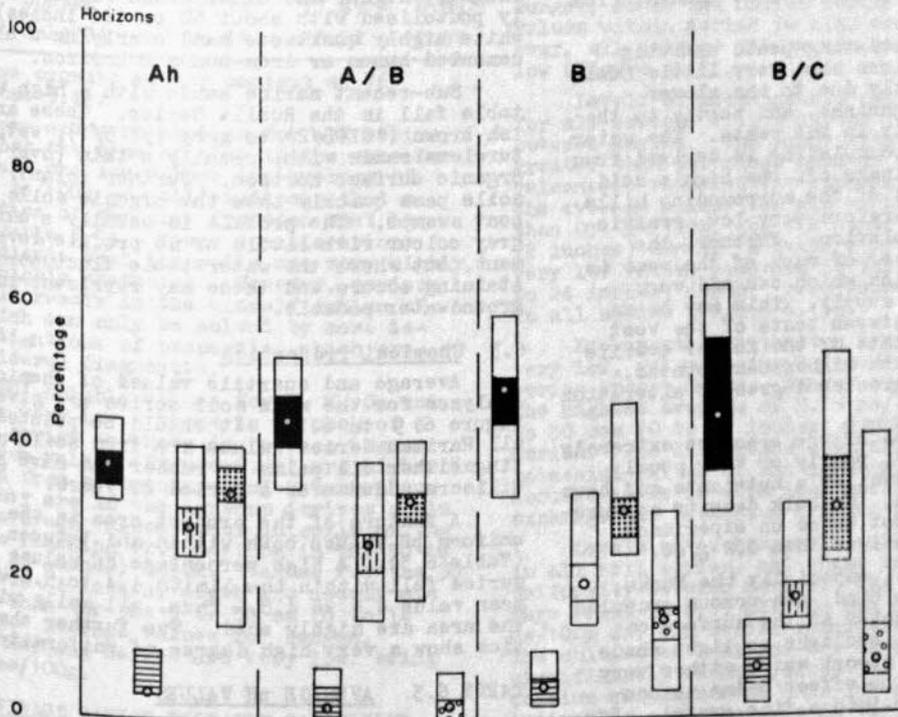
6.2.9 Organic Soils

Organic soils contain high amounts of organic matter derived from the surface vegetation. The accumulation of organic matter occurs under severe anaerobic conditions in which bacteriological activity is very low. Humification and mineralisation of the organic matter proceeds very slowly, so that the deposition of vegetation debris is much faster than its humification with a resulting accumulation of the former. Under rain forest the supply of vegetation remains is very high and accumulation is rapid. The main factor in producing anaerobic conditions is slow moving or stagnant water of low oxygen content on the surface. In back swamp conditions along many valleys the amount of organic matter present is very variable. In such conditions the accumulation of organic matter occurs at the same time as the deposition of fine mineral matter from flood water, resulting in a homogeneous mixture of mineral and organic matter. Soils with an organic matter content of up to 25 percent measured by loss on ignition are known as organic clays: when the loss on ignition is between 25 and 65 percent, the soils are mucks. These two groups are mapped together as one unit, the Organic Clay and Mucks. They are very prevalent in the middle sections of the valleys draining into the peat areas.

Peat is defined as an organic soil containing more than 65 percent organic matter measured by loss on ignition. Within the project area peat soils fall into two very broad groups, those in which the water-table is at or on the surface and accumulation of organic remains is proceeding rapidly, and those in which aerobic conditions exist in the upper part of the peat profile. In the latter case accumulation is only very slow since it is in equilibrium with humification and mineralisation processes. However, the very low

PARTICLE SIZE DISTRIBUTION

HARIMAU SERIES (8 profiles)





pH values of the aerobic peat results in a very low microbial activity, and humification and mineralisation is, consequently, very slow. Certainly the very low cation exchange capacity values recorded for peat horizons which are predominantly aerobic would indicate that the degree of humification is very low, although the physical properties are better than in the anaerobic organic soils. Maximum depths of peat are in excess of 10 feet, and the transition from shallow to deep peat (less than 100 cm or 40 inches) is very rapid. The areas of peat less than 100 cm (40 inches) deep are too small to be delineated at the scale of mapping. The main area of peat in which aerobic conditions occur in the upper part of the organic profile lies between the S. Bahan and the northern boundary of the project area. The depth of aerobic conditions is limited by the permanent water-table, which usually occurs between 20 and 60 cm (8 to 24 inches) from the surface.

The actively accumulating peats existing under anaerobic conditions show very little humification. This is partly due to the slower action of anaerobic organisms, and partly to the very low nutrient supply in the peats. The water in which the peat is accumulating is derived from rainwater and from drainage off the highly acid, nutrient depleted soils of the surrounding hills. Nutrient supply is, therefore very low, restricting the microbial population. Further, the underlying mineral matter of much of the peat is sand of marine derivation which can add very little to the nutrient supply. This may be an important difference between peats of the West and East coast: the peats of the former overlie marine clays of very much higher base status, which may encourage a greater degree of alteration of the organic matter.

In short, the peats of the area are extremely acid (pH less than 3.5), poorly or very poorly humified, very low in available nutrients and have very low bulk densities. No bulk density measurements have been made, but based on experience values are likely to be less than 0.2 g/cc.

Some organic soils, especially the Mucks, show a tendency to form hard, non-porous granules of up to 1.5 cm in diameter at the surface on drying out under direct sunlight or light shade. Once dry, the granules absorb water either very slowly or not at all, the effect being to convert this surface layer into a fine gravel. If this process is allowed to proceed to depth, the already serious limitations to agricultural use will be intensified.

6.2.10 Soils on marine alluvium.

Marine alluvia occur as both recent and sub-recent material. The former is represented by strips of mangrove along tidal rivers and streams flowing into the broad estuary of the S. Johore. Very little mangrove occurs along the east and south coasts apart from very small areas towards the mouths of the S. Sedili Kechil and S. Punggai. Soils of the mangrove areas are included in the Kranji Series. These are dark coloured slightly organic clays and sandy clays on the surface, overlying grey structureless clays containing partially decomposed mangrove remains. The sub-soils often smell of hydrogen sulphide. The soil surface is often very uneven due to the activities of the mudlobster, which bring up sub-surface material onto the surface, usually above high tide level. Soils of the Kranji Series are strongly saline in the lower estuarine positions, becoming weakly saline towards the limits

of saline tidal intrusion. Salinity increases with depth from the surface.

On sub-recent beach materials along the east and south coasts are soils of the Rudua and Rusila Series. Owing to the rapid succession of beach ridges and intervening lower lying swales, it is not always possible to map the series as separate units. In such cases an association has been recognised. In general, however, the drier beach ridges dominate behind the present beach passing into lower lying areas of marine sands towards the peat margins. Soils of the Rudua Series are found on the drier ridges. This is a deep, structureless sand in which the water-table occurs at depth. Immediately behind the present beach there is very little profile development, but further inland the soils are iron-humus podzols of the ground-water podzol type. In a few locations slightly higher and older beach ridges are strongly podzolised with about 60 cm (24 inches) of a white highly quartzose sand overlying a black, cemented humus or iron-humus B horizon.

Sub-recent marine sands with a high water-table fall in the Rusila Series. These are greyish brown (10YR5/2) to grey (5Y 5/1), wet, structureless sands with, usually a thin (over 15 cm) organic surface horizon. Further inland, these soils pass quickly into the organic soils of the peat swamps. The profile is usually a uniform grey colour with little or no profile development, but where the water-table fluctuates, iron staining occurs and these may represent incipient groundwater podzols.

6.3 Chemical Properties

Average and quartile values of chemical analyses for the main soil series are given in Figure 6.9 to 6.15. It should be pointed that all Harimau Series values are from soils supporting either oil palms or rubber and have had fertilisers added over a period of years.

A feature of the project area is the very uniform pH values both within and between series (Table 6.3). A high percentage of values for all series fall within the limits 4.4 to 5.0 with a mean value 4.6 to 4.8. Thus, all soils within the area are highly acid. Two further characteristics show a very high degree of uniformity. These

TABLE 6.3 AVERAGE pH VALUES

NO. OF PROFILES	SERIES	AVERAGE	EXPECTED RANGE
25	RENGAM	4.8	4.4-5.1
3	JERANGAU	4.7	4.4-5.0
10	YONG PENG	4.7	4.6-4.9
8	HARIMAU	4.7	4.4-4.9
6	SERDANG	4.8	4.7-5.0
6	MARANG	4.8	4.7-4.9
6	BUNGOR	4.6	4.3-4.9
3	POHOI	4.6	4.4-4.8
5	DURIAN	4.8	4.5-5.1
9	MALACCA	4.9	4.7-5.1

Note: Lowest value recorded for any horizon 3.8
Highest " " " " " 5.4

are cation exchange capacity (C.E.C.) and base saturation percentage. Highest C.E.C. values always occur in the Ah horizon, indicating the

importance of organic matter in raising C.E.C. (Table 6.4).

TABLE 6.4 AVERAGE CATION EXCHANGE CAPACITIES FOR Ah HORIZON
in me/100 grams of soil

NO. OF SAMPLES	SOIL SERIES	AVERAGE	RANGE
24	RENGAM	13.8	30.29 - 3.95
2	JERANGAU	16.88	23.10 - 10.70
8	YONG PENG	13.09	17.12 - 7.08
8	HARIMAU	11.57	15.47 - 8.39
4	SERDANG	6.91	9.05 - 4.77
5	MARANG	15.10	27.82 - 10.21
5	BUNGOR	13.50	17.28 - 8.23
3	POHOI	14.27	16.30 - 11.19
4	DURIAN	13.34	17.45 - 9.05
6	MALACCA	10.51	22.22 - 8.07

Note: Average organic matter content of 16 horizons 3.4%.

Sub-soil values are very similar for all series, indicating that the type of clay is the same for all series, and the low values (an average of less than 10 me/100g of soil) indicate that a large proportion of the clay fraction must be kaolinitic (Table 6.5). These considerations appear to indicate that the soils are very highly leached and highly weathered. However, serious problems still remain in the classification of the soils which can only be solved by more detailed investigations of properties which are, or can be, considered diagnostic.

The 6N HCl soluble values for P, K, Ca and Mg are low or very low. There is as much of a range within series as there is between them. Total potassium values (Figure 6.9) are higher in soils derived from sedimentary and metamorphic rocks than they are in the igneous derived soils. The highest average values occur in soils of the Durian Series reaching 12.5 me/100g in the 30 to 60 cm (12 to 24 inches) depth. Values for the 30 to 60 cm (12 to 24 inches) depth are nearly always greater than for the 0 to 30 cm (0 to 12 inches) depth. Average values for Rengam, Jerangau and Serdang Series are very low, being less than 1 me/100g.

TABLE 6.5 AVERAGE CATION EXCHANGE CAPACITIES FOR SUB-SOIL HORIZONS
in me/100 grams of soil

NO. OF PROFILES	SERIES	AVERAGE	EXPECTED RANGE
25	RENGAM	5.82	3.73 - 9.55
3	JERANGAU	6.53	5.54 - 7.57
10	YONG PENG	8.60	5.38 - 12.51
8	HARIMAU	7.21	4.86 - 9.49
6	SERDANG	4.97	3.90 - 6.75
6	MARANG	6.61	5.65 - 8.67
6	BUNGOR	6.56	4.58 - 8.56
3	POHOI	6.72	5.60 - 7.82
5	DURIAN	6.41	5.60 - 7.28
9	MALACCA	7.74	5.27 - 11.61

Note: Lowest value recorded for any horizon 2.63
Highest " " " " " 21.40

Total phosphorus values are higher in the 0 to 12 inches depth than in the 30 to 60 cms (12 to 24 inches) depth, the highest average values occurring in the Jerangau Series (200 p.p.m. and 155 p.p.m. respectively for the 0 to 30 cm and 30 to 60 cm depths). In all other series, the average values are less than 125 p.p.m. There is no significant difference between the igneous and sedimentary derived soils in terms of their total phosphorus content. It is obvious that the content of total phosphorus for all soils is low or very low (Figure 6.10).

As would be expected, total calcium is uniformly very low in all series. The values for all series lie within the range 0.8 to 1.5 me/100g with little difference between the 0 to 30 cm (0 to 12 inches) and 30 to 60 cm (12 to 24 inches) depths (Figure 6.11).

There is rather more variability in the distribution of total magnesium values between series. The lowest values occur in the Rengam, Jerangau and Serdang Series and the highest values in the Bungor, Pohoi and Durian Series. The range of values within series is also considerable. However, all average values are still low or very low (Figure 6.12).

Levels of exchangeable cations are very low for all series, with a narrow range of values between series. The range within a series is greater than the range between series. Lowest values are recorded for exchangeable magnesium, the average values for all series being less than 0.1 me/100g. for the upper 0 to 30 cm (0 to 12 inches) depth. A feature of all soils is the very low values recorded in the 30 to 80 cm (12 to 24 inches) depth; zero values commonly occur in all series (Figure 6.13).

Exchangeable potassium levels are similarly very low, values being 0.1 me/100g or less in all series except Marang, Bungor and Malacca Series. The highest average of 0.16 me/100g is in the 0 to 30 cms (0 to 12 inches) depth of the Bungor Series. The difference apparent in the total potassium values of the igneous and sedimentary derived soils is much less obvious in terms of exchangeable potassium (Figure 6.14).

Levels of exchangeable calcium are very low in all soil series, and there is considerable uniformity between series. The most common average value is 0.16 me/100g and the minimum 0.10 me/100g for all series considered (Figure 6.15). The cultivated soils of the Harimau Series show significantly higher values for both exchangeable calcium and magnesium than for any other series, indicating some increase in the soil levels from the fertiliser treatments. There does not appear to be any build up of potassium, however, and this may indicate that the supply of potassium in the fertiliser applications is insufficient.

Apart from the actual levels of plant nutrients present in the soil, the ratio of one to another is important in plant and animal nutrition. Some ratios are shown in Table 6.6. These indicate considerable variation between series. Calcium/magnesium ratios are low except in soils of the Serdang and Pohoi Series. It is thought that a ratio of between 3 and 10 is suitable for most annual crops (Joffe, 1949). A low calcium/magnesium ratio is desirable for oil palm and rubber particularly the latter. The potassium/magnesium ratio is very variable, being highest on the whole on soils derived from sedimentary parent materials. In the case of the Serdang to a lesser degree Pohoi Series, the ratio is probably too high for optimum nutrient balance. The potassium/calcium ratio is less than 1 for all series except the 0 to 30 cm (0 to 12 inches) depth in the Bungor Series, where it is 1.14. For many crops, this is too low.

CHEMICAL ANALYSIS
for selected soil series

LEGEND

Maximum value

Upper quartile

Median

Lower quartile

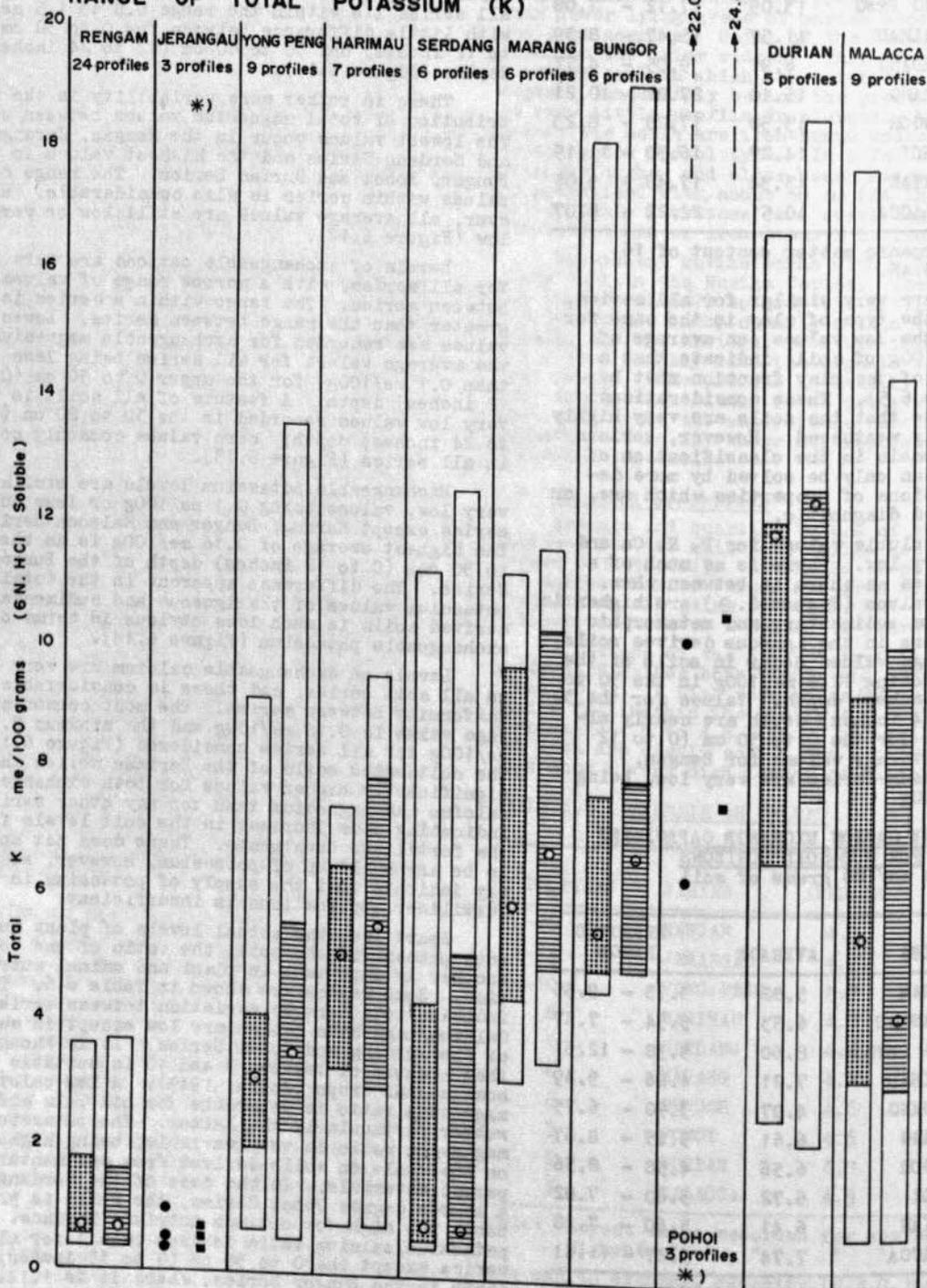
Minimum value



0-30 cms or ●

30-60 cms or ■

RANGE OF TOTAL POTASSIUM (K)



Note: *) Insufficient data for construction of columnar diagrams.

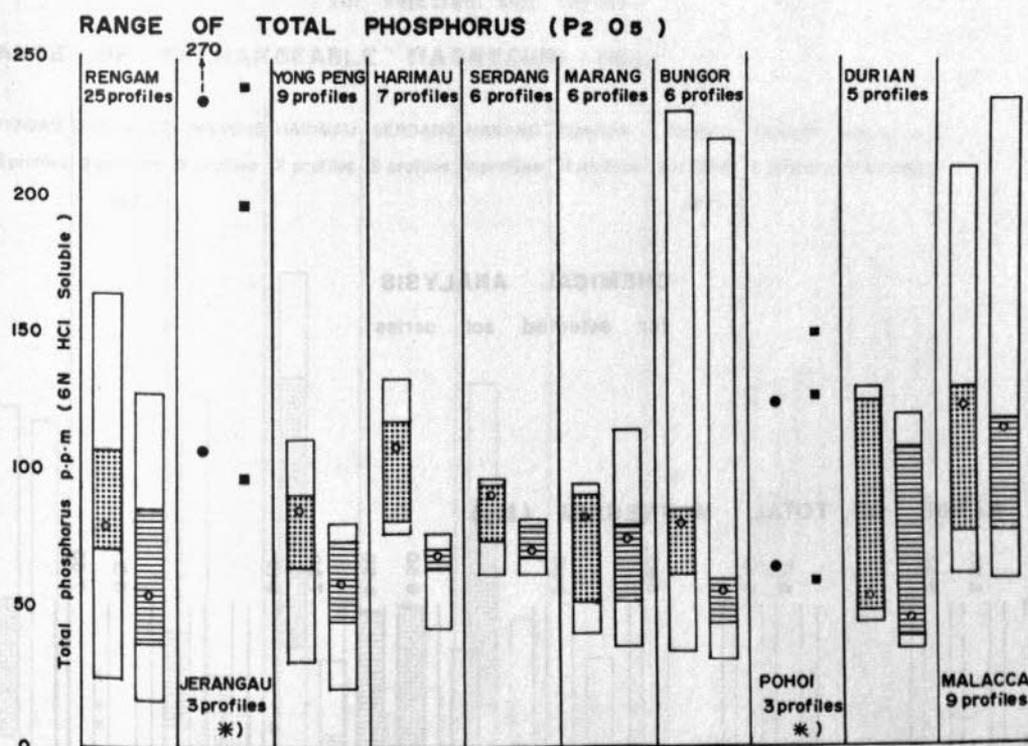
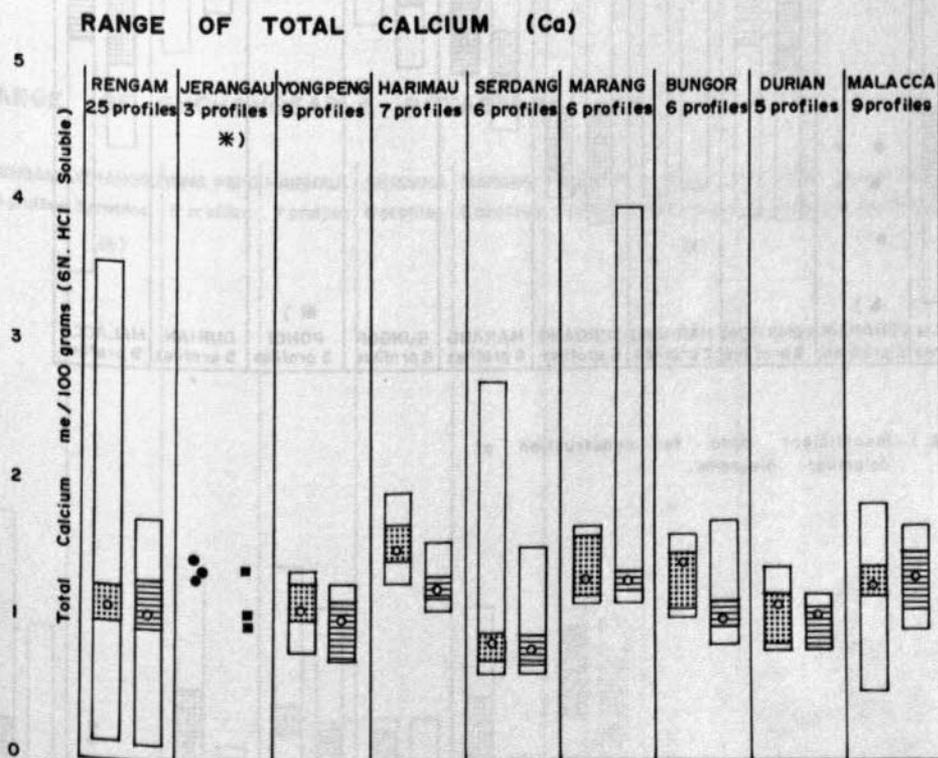
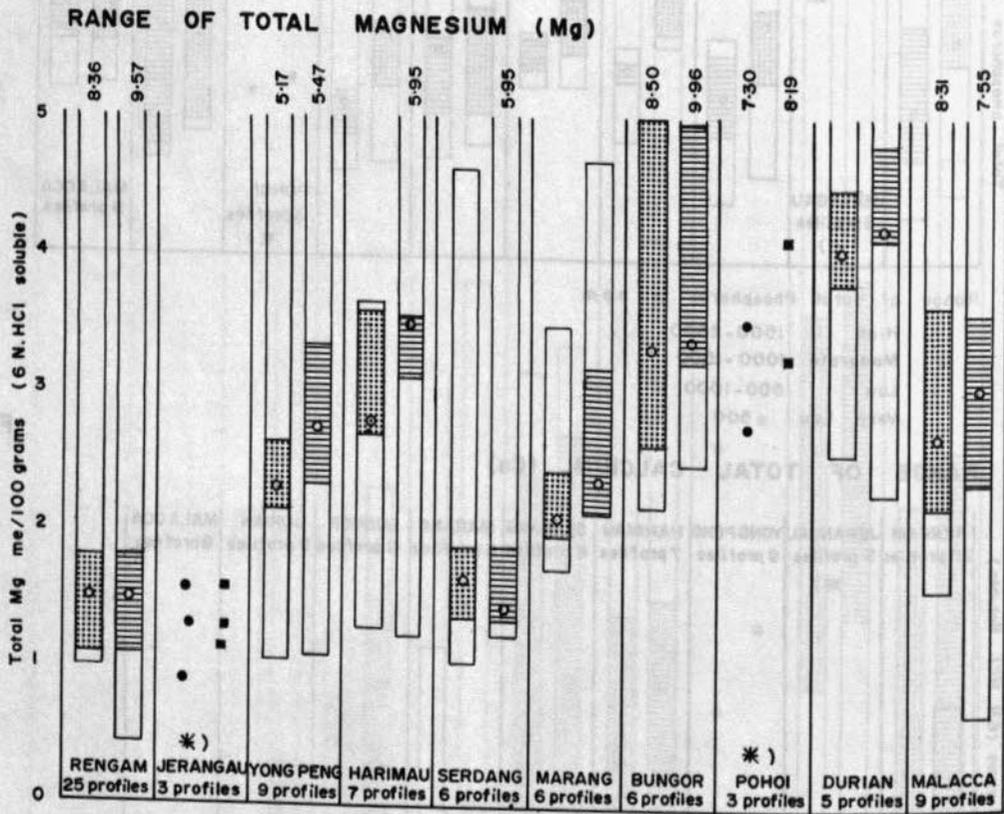


FIGURE 6.II



CHEMICAL ANALYSIS
for selected soil series



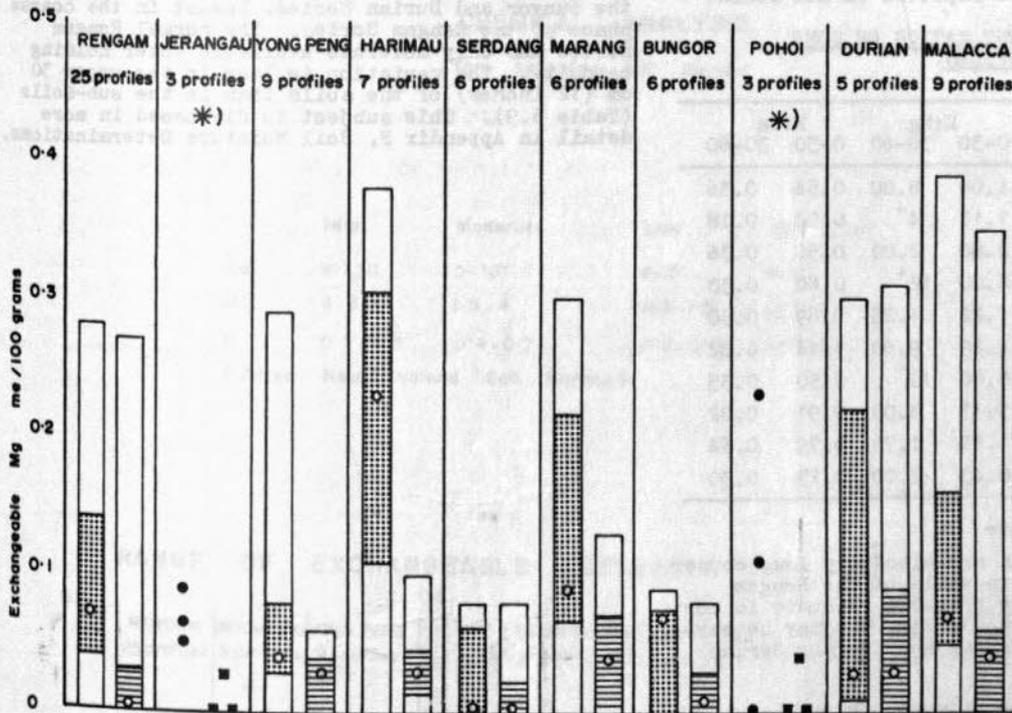
Note: *) Insufficient data for construction of columnar diagrams.

CHEMICAL ANALYSIS

FIGURE 6.13

for selected soil series

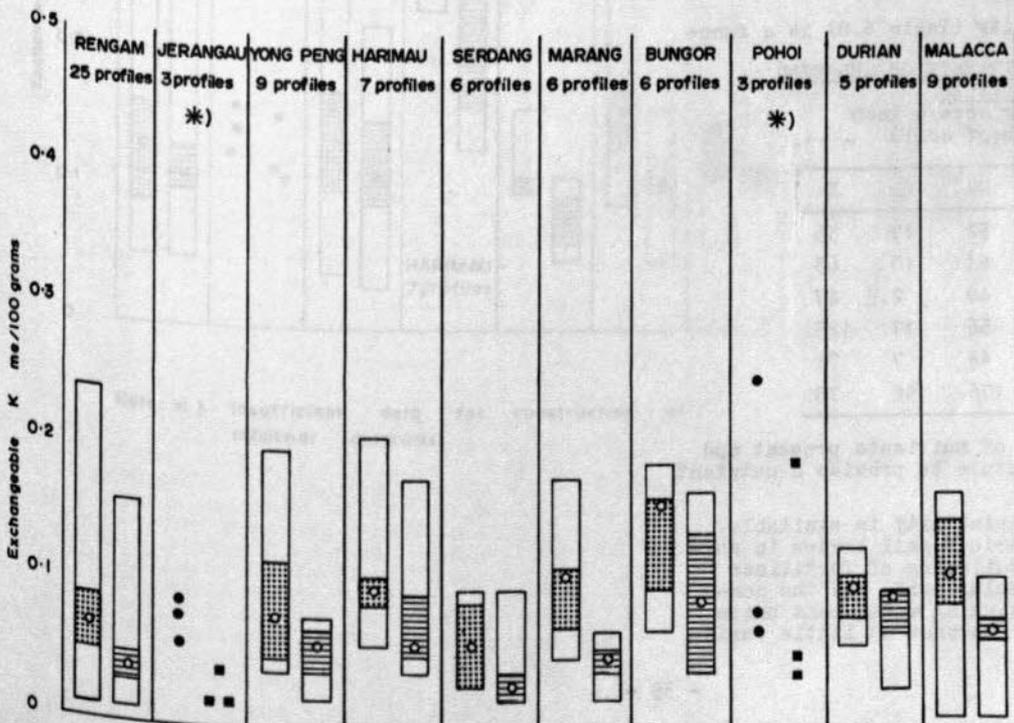
RANGE OF EXCHANGEABLE MAGNESIUM (Mg)



Note: *) Insufficient data for construction of columnar diagrams

FIGURE 6.14

RANGE OF EXCHANGEABLE POTASSIUM (K)



The very low levels of macro-nutrients in all soils of the project area are paralleled by low contents of some important micronutrients, especially copper, manganese and cobalt. The last does not appear to be important for plant growth, but is important in animal nutrition as is copper. Manganese levels appear to be seriously low and response to this element could be expected on all soils.

TABLE 6.6 MACRO NUTRIENT RATIOS OF SOME SELECTED PROFILES.

	Ca:Mg		K:Mg		K:Ca	
	0-30	30-60	0-30	30-60	0-30	30-60
RENGAM	1.85	22	1.00	8.00	0.54	0.36
JERANGAU	2.17	30 ⁺	1.17	4 ⁺	0.54	0.18
YONG PENG	4.00	3.67	2.00	2.00	0.50	0.36
SERDANG	20.00	30 ⁺	12.00	12 ⁺	0.60	0.38
MARANG	1.78	3.75	1.22	1.25	0.69	0.50
BUNGOR	2.00	11.00	2.29	9.00	1.14	0.82
POHOI	16.00	30 ⁺	8.00	10 ⁺	0.50	0.33
DURIAN	3.67	3.67	3.33	3.00	0.91	0.82
MALACCA	2.00	2.75	1.57	1.75	0.79	0.64
HARIMAU	1.91	6.67	0.43	2.00	0.23	0.30

+ approximate

Copper and cobalt levels are also very low, copper being particularly low in soils of the Rengam Series. Zinc levels are probably adequate in most of the sedimentary derived soils, but may be marginal in soils of the Rengam and Serdang Series (Table 6.7).

TABLE 6.7 AVERAGE TRACE ELEMENTS LEVELS
(in parts per million)

SERIES	Cu	Mn	Zn	Co
RENGAM	<2	18	75	<5
DURIAN	19	23	200	<5
SERDANG	<5	23	75	<5
BUNGOR	<2	15	100	<5
MALACCA	5	43	150	<5

Nutrient availability (Table 6.8) is a func-

TABLE 6.8 AVAILABLE NUTRIENTS OF SELECTED PROFILES
(in lbs per acre/6 inch depth of soil)

SOIL SERIES	Ca	Mg	K
RENGAM	52	17	55
YONG PENG	64	10	63
SERDANG	40	2.5	47
BUNGOR	56	17	125
DURIAN	44	7	78
HARIMAU	176	56	78

tion of both the amount of nutrients present and the availability of moisture to provide a nutrient solution.

In general, the variability in available nutrients between the various soil series is sufficient to justify the tailoring of fertiliser applications to a particular soil, and the consequent advantage of designing management units to fit the soil pattern, so that as little varia-

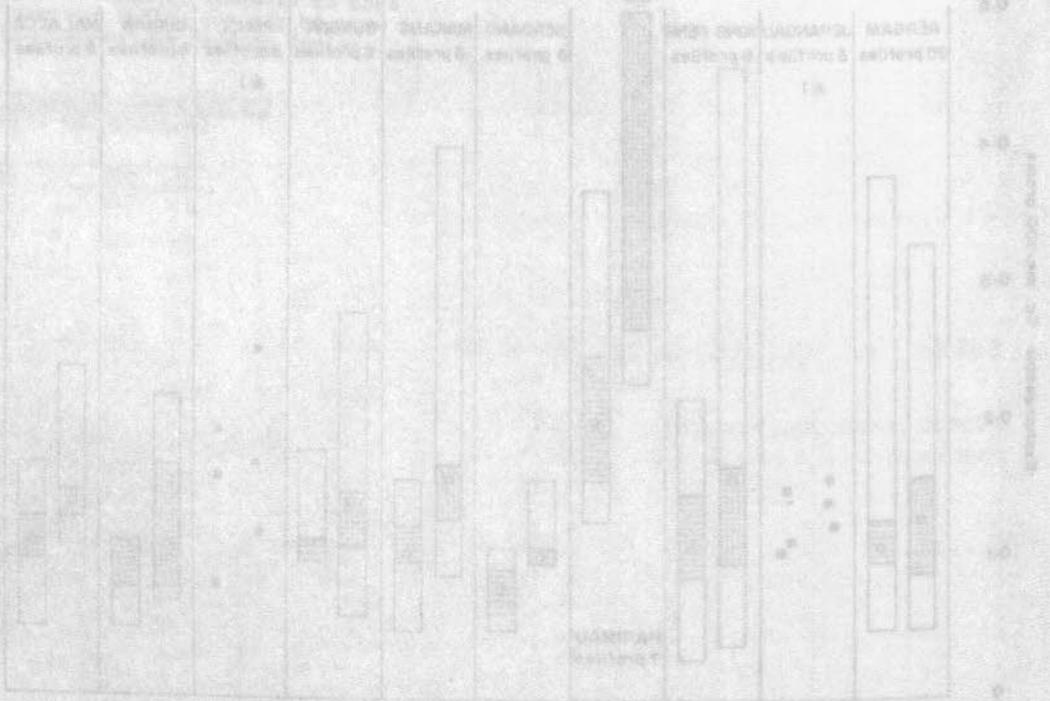
tion as possible occurs within each unit (Ng and Selvadurai, 1967; Guha, 1968).

The available water holding capacity of the various soil series shows considerable variability, and this could be an important factor in determining yields. Highest available water holding capacities occur in the finer textured soils of the Bungor and Durian Series, lowest in the coarse phase of the Rengam Series. The normal Rengam Series has only moderate available water holding capacity. The variation is less in the upper 30 cm (12 inches) of the soils than in the sub-soils (Table 6.9). This subject is discussed in more detail in Appendix F, Soil Moisture Determinations.

TABLE 6.9

AVERAGE CALCULATED VALUES OF AVAILABLE WATER CAPACITY
in inches per foot of soil
(After Salter and Williams, 1967 IV)

	SOIL SERIES	0 - 12 cm		12 - 24 cm		24 - 36 cm		TOTAL 0-36 in
		AVERAGE	RANGE	AVERAGE	RANGE	AVERAGE	RANGE	
11	RENGAM	1.70	1.50-1.80	1.60	1.35-1.75	1.50	1.30-1.70	4.8
3	RENGAM (coarse)	1.40	1.15-1.60	1.10	1.05-1.20	1.00	1.10-1.00	3.5
10	RENGAM (fine)	1.75	1.60-1.85	1.75	1.65-1.80	1.75	1.65-1.85	5.25
9	YONG PENG	1.90	1.7-2.25	1.85	1.60-2.20	1.65	1.20-2.10	5.4
8	HARIMAU	1.80	1.65-2.15	1.60	1.35-2.15	1.60	1.25-2.00	5.0
6	SERDANG	1.70	1.50-2.15	1.70	1.50-2.10	1.65	1.20-2.15	5.05
6	BUNGOR	2.05	1.65-2.40	2.00	1.70-2.35	1.95	1.70-2.35	6.00
5	DURIAN	2.25	2.15-2.35	2.25	2.20-2.40	2.20	2.10-2.35	6.70



THE SOIL SURVEY OF THE JOHOR TENGAH REGION

The following chapter is a re-print of the report by the Soils Science Division of the Department of Agriculture. Some figures have been omitted but only because they are duplicated elsewhere in the report or the Atlas.

7.1 Introduction

The Johor Tengah Region is one of the areas selected for further and more comprehensive investigations because of the high potential for agricultural development. The selection was based on information gathered during the Reconnaissance Soil Survey of West Malaysia (Law & Selvadurai, 1968). This programme was completed by mid-1967 and by then the whole country had been mapped on a broad scale, with the general soil pattern on land with average slopes of less than twenty degrees determined; while land with average slopes of more than twenty degrees was mapped as steep-land complex and considered unsuitable for normal agriculture and to be left under a permanent forest cover.

The broad scale of examination in the reconnaissance soil survey does not allow for the detailed planning for the development of areas of good potential for agriculture. The Jengka Triangle is one such area in which more detailed examinations of the soils, terrain and forest resources had been carried out, and a Master Plan for the development of the area produced (TAMSHUNTING, 1967). A similar study for the Johor Tengah and Tanjong Penggerang was proposed.

The semi-detailed soil survey of the Johor Tengah Region was in progress when a Consortium of Consultants headed by Hunting Technical Services Limited was commissioned to carry out the feasibility study for both the regions. The soil survey carried out by the Soils Science Division of the Department of Agriculture, West Malaysia will form the basis for the preparation of the Land Use Potential Map of the Master Plan for the Johor Tengah Region.

The Johor Tengah Region was surveyed on a reconnaissance scale by Null et al (1965). According to the soil suitability classification by Leamy & Panton (1966) and modified by Wong (1966), the greater portion of the region consisted of Class I soils, which are suitable for a wide range of crops including oil palm and rubber.

The semi-detailed soil survey consisted of two phases. Phase I was started in May 1967, but due to lack of funds and the frequent demands made on the staff to carry out surveys of other development projects in the country, progress was frequently interrupted. Phase II was started in March 1969, and the soil survey of the whole region was completed by February 1970. Phase I and Phase II were surveyed by staff of the Soil Science Division aided by supporting staff of the Soil Survey Unit stationed at Ayer Hitam, Johore. The Senior Soil Scientist correlated the soils in the region.

7.1.1 Location.

The Johor Tengah Region lies between the north latitude 1° 44' and 2° 14', and east longitudes 103° 20' and 103° 54'. The area is bounded by the Kluang-Rengam-Layang Layang road in the west; the Sungai Sayong down to Kota Tinggi in the south; the watershed from Kota Tinggi to Gunung Blumut and on to Kahang village in the east; and the Kahang-Kluang road in the north. The region was divided into areas designated Phase I and Phase II respectively as these areas were surveyed by different persons, although for cartographic convenience the final maps (Sheets 1 and 2) were made to overlap the two phase areas.

The Johor Tengah Region is covered by parts of the New Series Topographical Map Sheets 117, 118, 124, 125, 126, 129, 130 and 131, on a scale of one inch to one mile printed by the Directorate of National Mapping, Malaysia. Only the forested areas within the region were surveyed and these consisted of the Kluang, Rengam and Panti Forest Reserves, the Endau-Kota Tinggi Wild Life Reserve and State land. The soils in the cultivated areas were not examined. The area surveyed covers 324,550 acres.

7.1.2 Method of survey.

Jeepable roads and tracks were used both for access as well as for field examinations. Soils were examined at a quarter of a mile intervals unless noticeable changes in the soils warranted a closer examination.

In the inaccessible forested land where the slopes were less than 20°, rentis2 were cut along set compass bearing. The rentis network was planned basing on the soil pattern reported by Null et al (1965). As the soil pattern was relatively simple, rentis2 were spaced at one mile intervals. In the Endau-Kota Tinggi Wild Life Reserve the rentis2 were not strictly at one mile intervals. This deviation from the normal rentis spacing was possible largely due to the presence of a well distributed network of jeepable tracks, allowing for the same intensity of examinations to be affected even where the rentis2 were spaced at more than one mile apart. Closer examinations were required in areas where the soil pattern was more complicated. Rentis2 were cut by 5- or 6-men teams at the rate of approximately one mile a day by a team. The rentis2 were chained using a 66 feet long link chain and marked by short numbered pegs at one chain intervals.

The rentis2 were planned to cut across the predominant strike of the geological formations, which was roughly in a north-south direction. Rentis2 were mainly in an east-west direction, except for doubling back, avoiding the steep-land areas or for access routes (Fig. 7.1).

Soil pits were dug at a quarter of a mile intervals along the rentis2 for full soil profile descriptions and for collecting soil samples for analyses. Closer examinations along the rentis were made wherever necessary (e.g. when changes in the soils were noted) using a 2-inch screw auger during the early part of the survey and a 4-inch Jarrett auger when this was introduced later.

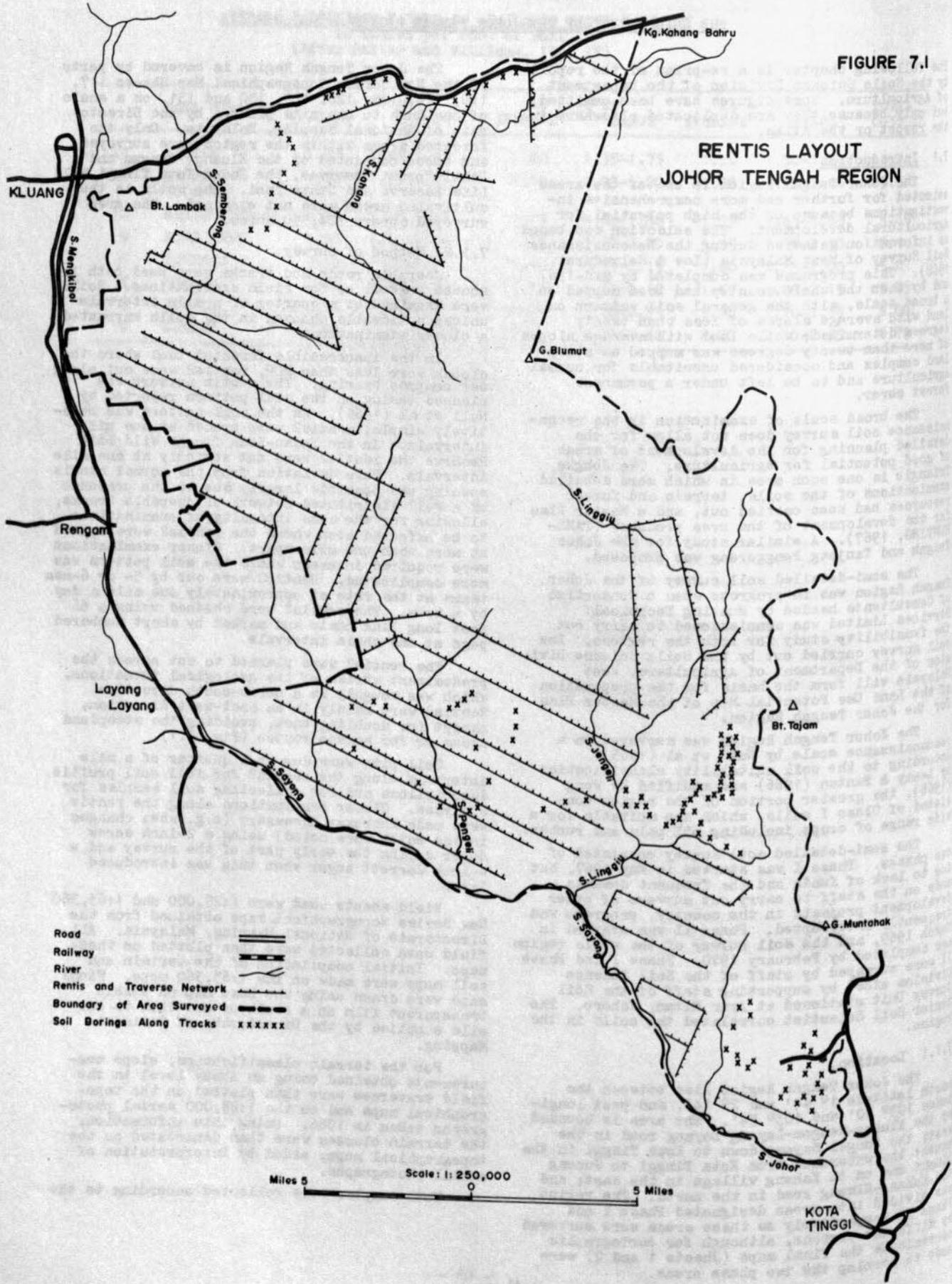
Field sheets used were 1:25,000 and 1:63,360 New Series topographical maps obtained from the Directorate of National Mapping, Malaysia. All field data collected were then plotted on these maps. Initial compilation of the terrain and soil maps were made on the 1:63,360 maps. Final maps were drawn using the base map on stable transparent film on a scale of one inch to one mile supplied by the Directorate of National Mapping.

For the terrain classification, slope measurements obtained using an Abney level in the field traverses were then plotted on the topographical maps and on the 1:25,000 aerial photographs taken in 1966. Using this information, the terrain classes were then demarcated on the topographical maps, aided by interpretation of aerial photographs.

Soil samples were collected according to the

FIGURE 7.1

RENTIS LAYOUT JOHOR TENGAH REGION



horizons down the profiles. These were then air-dried and the following analyses carried out:-

- a) Mechanical analyses for particle size distribution
- b) pH in water and KCl
- c) Carbon and Nitrogen content and the C/N ratio calculated
- d) 'Easily soluble' Potassium and Phosphorus
- e) Cation Exchangeable Capacity
- f) Exchangeable Sodium, Potassium, Calcium and Magnesium
- g) "Total" Fe_2O_3 , P, K, Ca, Mg by 6N HCl digestion.

A summary of the methods of analyses is given in Appendix I.

7.1.3 Units of mapping.

The main objective of this survey is to describe the soils and to determine the pattern of distribution and the suitability of these soils for agricultural development. The basic unit of soil mapping used in this survey is the Soil Series, defined as a grouping of soils of similar profile characteristics viz:- in horizon arrangement, degree of development of the profile, colour, texture, derivation from the same or similar parent material, under the same or similar temperature and moisture regimes (Leamy & Panton, 1966; Soil Survey Staff, 1951). Where the main characteristics are essentially similar and the variations are of minor importance but distinct, phases of the soil series have been established rather than separating these soils as soil series. Where possible, and because of the significance to agricultural practices in this country, depth phases of the soil series have also been established similar to those in Soil Survey Staff, 1951.

In some areas, it is not possible to map the soil series, even on this scale of survey. The soil association is used, and the name of the association consists of the member series, with the dominant one named first. Association is limited to two soil series which can be separated in more detailed surveys.

Other units of convenience have also been used. These are easily recognisable landscape units where

- a) the soils vary in characteristics over short distances but have been subjected essentially to one dominant pedogenic process e.g. Riverine Alluvium, Local Alluvium etc.,
- or b) the potential for normal agriculture is low e.g. Steepland, Disturbed Land etc.

7.2 The Environment

Introduction.

The factors of soil formation are the parent material on which the soil is formed, on the topography it is sited, under the climate it is formed and is weathering, modified by the vegetation, over a period of time. The influence of any one of these soil forming factors may be dominating, but all the factors acting together have created the soil in a state of equilibrium. Any change in the delicate balance achieved by nature will start off anew, the process to achieve a new equilibrium. Man is the chief culprit in converting virgin forest land for agriculture and other uses. Each of the factors existing in the surveyed area are outlined below.

7.2.1 Parent materials.

The main bulk of the region consists of acid igneous rocks mainly of granitic composition. The rest of the region is made up of sandstones, shales and conglomerates in the north and meta-sediments in the Panti Forest Reserve in the vicinity of Kota Tinggi. The S. Johore in the south drains an area of older alluvium (Burton, 1964). Another area of older alluvial deposits is located in the north. Volcanic deposits of rhyodacitic composition are found overlying other rocks in the north-east. The river basins are filled with recent deposits along the floodplains and subrecent deposits on low lying terraces towards the fringes of the floodplains.

The wide range of rock formations and sediments have given rise to a wide range of parent materials. Apart from the recent riverine alluvium, the parent material consists of the weathered mantle overlying the geological formations (Law and Leamy, 1966). Igneous rocks generally have a very thick mantle overlying the solid rocks, while the rest of the geological formations have a thinner mantle. On steeper slopes, the mantle becomes even thinner. The Riverine Alluvium is still accumulating because of the intense activity of the drainage systems.

The physical composition of the parent rocks has a dominating influence on the physical characteristics of the soils formed. The coarse-grained granites give rise to coarse sandy clay loam to coarse sandy clay textured soils. Generally, in granite derived soils, the clay content increases with a decrease in the sand grains, but there is an increase in quartz grains of gravel size down the profile. Silt content is very low in these soils. Sandstones and conglomerates produce sandy to gravelly textured soils. Shales produce clay textured soils with a higher silt content than those formed from granites and sandstones. The acid volcanic rocks are rather fine-grained and the soils formed are clayey. The older alluvium produces coarse sandy clay loam to sandy clay textured soils, although finer textured soils are also found. The Riverine Alluvium varies greatly in texture being sandy on the levees and more clayey in the backwater areas, and the soils formed vary accordingly in texture.

The general chemical properties of the soils formed, however have tended to approach a low common range because of the intense weathering and extreme leaching. The majority of the sedentary soils are well leached of nutrients and hence low in exchangeable cations and base saturation. The recent alluvial soils, because of the frequent additions from floods, contain weatherable minerals, accounting for their slightly higher base exchange and base saturations.

7.2.2 Topography.

The physiography of the region can be divided into four broad units based on the landform viz:-

- a) The floodplains
- b) The undulating land
- c) The rolling to hilly land
- d) The steepland complex.

Each of the units above contains slopes of a certain range. Single slopes are very rare in any one place as the landform surface consists of a combinations of short slopes facing different directions. As such, the dominant average values of the slopes are used, in the terrain classification outlined by Leamy and Panton (1966) (Table 7.1).

TABLE 7.1 SLOPES AND TERRAIN CLASSES

Angle of slope	Terrain Classes	
	Single slopes	Complex slopes
0 - 2°	Level or nearly level, A ₁	Level or nearly level, C ₁
2 - 6°	Gently sloping, A ₂	Undulating, C ₂
6 - 12°	Strongly sloping, A ₃	Rolling, C ₃
12 - 20°	Moderately steeply sloping, A ₄	Hilly, C ₄
20 - 25°	Steeply sloping, A ₅	Steep, C ₅
More than 25°	Very steeply sloping, A ₆	Very steep, C ₆

Abney level readings taken during field traverses were used to produce the terrain classification map (Map 1 and 2 and Fig. 17 in the Atlas). The soils are limited to a certain range in terrain and the relationship between soils, terrain and landform is as follows:-

a) The floodplains

The larger rivers in the region are very sluggish and meander through the area. The tributaries draining into these main channels from the higher and steeper areas are juvenile and downcutting is still evident. These subsidiary channels carry sediments into the major streams and rivers. Coarser sediments are deposited on the levees and in the upper reaches of the rivers, while finer sediments are deposited in the backwater areas or carried further downstream. Riverine Alluvium Association and Local Alluvium consisting of variable soils are found on the floodplains. Organic soils are found in the depressional areas in the floodplains. Soil development is minimal because of the frequent additions from floods. The terrain is generally nearly level with depressions.

b) The undulating land

The undulating land consists of stable surfaces which are in equilibrium with the environmental agencies. There is little evidence of erosion or deposition. The terrain is generally undulating, and the landform consists of low well rounded hills with gentle slopes and rather wide valley floors drained by sluggish streams. Included in this unit are the subrecent and older alluvial terraces. This unit forms the major portion of the area surveyed. Soil development in the terraces is more advanced than in the floodplains, while soil development on the remaining areas of the undulating terrain has attained full maturity in profile development.

c) The rolling to hilly land

Dissection is more severe in this unit and erosion is still an active force. The slopes are steeper and shorter compared to those on undulating terrain, varying from 6 to 20 degrees. The rolling terrain consists of well rounded hills with narrower valleys than those found in the undulating terrain. Steeper slopes rise sharply from this rolling surface to form the isolated steep hills. The hilly land generally forms the foothills to the mountainous ranges, with the characteristic short slopes and steep-sided gullies. Mature profiles are found on the rolling terrain, while truncation of the upper portions of the profiles are common on the hilly terrain.

The solum is generally less deep on the hilly terrain.

d) The steepland complex

The slopes are generally more than 20 degrees. The steepland areas of the Gunong Blumut and elsewhere had not been examined in any great detail because of the low potential for agriculture. Steep terrain occupies the greater portion of the complex while the very steep terrain occurs only on the higher mountains. Because of the steep slopes, soil erosion is severe especially so on the coarse textured, loose to friable soils of the granite and sandstone masses. Soil development is interrupted by frequent removals from the upper portions of the profiles even under the cover of the permanent forests.

The terrain classes mapped in the Johor Tengah Region are summarised in Table 7.2

TABLE 7.2 ACREAGES OF TERRAIN CLASSES

Angle of Slope	Terrain Class	Acreage	Percentage
0 - 2°	Level or nearly level	49,830	15.4
2 - 6°	Undulating	77,150	23.8
6 - 12°	Rolling	106,735	32.9
12 - 20°	Hilly	34,790	10.7
20 - 25°	Steep	48,195	14.8
Over 25°	Very steep	7,850	2.4
Total:		324,550	100.0

7.2.3 Climate.

The annual mean temperatures in the region is generally below 80°F, with Kluang having 77.7°F being the lowest known value on land below 500 feet above sea level in the country, and Kota Tinggi having 80.0°F (Dale, 1962).

The greater portion of the region falls within the Southwest rainfall region, with the area around Kota Tinggi falling within the East rainfall region (Dale, 1959). In the Southwest rainfall region, the rainfall distribution is relatively even. The mean monthly totals vary between 5 to 10 inches with the bulk of the rain falling during the monsoon periods (i.e. NE Monsoon from November to March, and SW Monsoon from May to September), although the intermonsoonal months of April and October/November are the wettest months. Minima are experienced in February and July. The mean annual rainfall is around 90 to 120 inches in the area surveyed. Kluang forms the base of a drier 'belt extending for 175 miles north-westwards' into central Malaya where the average annual total is less than 90 inches (Dale, 1959).

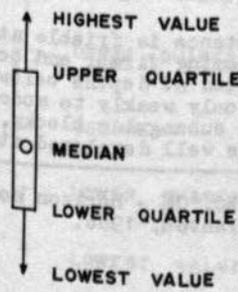
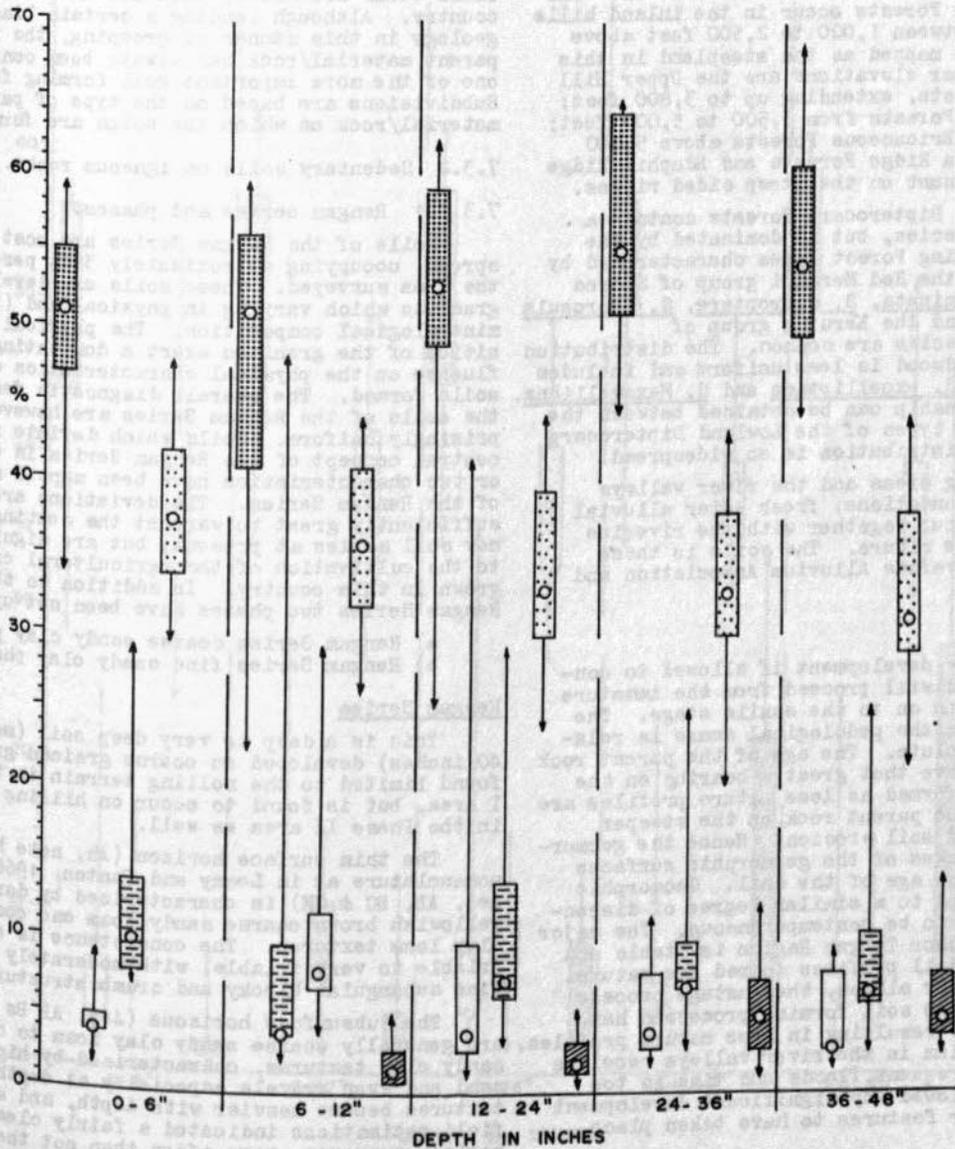
In the East rainfall region, the rainfall distribution is less even. The bulk of the rainfall is again during the monsoon months, the wettest months being December/January while the drier months vary from April to June/July.

Dry spells, during which less than 0.01 inches of rain falls per day for a number of consecutive days, of more than 21 days are rare. Dry spells of a week's duration are most frequent in February in Kluang. The monsoon months are more liable to dry spells than the intermonsoon periods. In the East rainfall region, dry spells are frequent during February to April (Dale, 1960).

The high temperatures and rainfall on the mature profiles have resulted in well weathered and well leached soils. Even the juvenile riverine alluvial soils are affected. These are shown up in the low values of the cation exchange capacity, base exchange, pH, base saturation percent in these soils. The high rainfall and the

FIGURE 7.2

**PARTICLE SIZE DISTRIBUTION
RENGAM SERIES
(15 Profiles)**



- CLAY
- SILT
- FINE SAND
- COARSE SAND
- GRAVEL & STONES

great intensity of the rainfall over relatively short periods of time cause severe soil erosion. This is especially so in soils with sandy textures, poor structures and loose consistency. Sheet erosion is especially severe on the granite and sandstone derived soils, and less on the shale derived soils.

7.2.4 Vegetation.

The 1967 Schematic Forest Type Map produced by the Forest Department showed the area surveyed dominated by the Lowland Dipterocarp Forests covering the undulating, rolling and the hilly land of the foothills up to an average elevation of approximately 1,000 feet above sea level. The Hill Dipterocarp Forests occur in the inland hills and mountains between 1,000 to 2,500 feet above sea level, areas mapped as the steepland in this survey. At higher elevations are the Upper Hill Dipterocarp Forests, extending up to 3,800 feet; the Montane Oak Forests from 3,500 to 5,000 feet; and the Montane Ericaceous Forests above 5,000 feet. The Seraya Ridge Forests and Edaphic Ridge Forests are dominant on the steep sided ridges.

The Lowland Dipterocarp Forests contain a vast array of species, but is dominated by the Red Meranti-Keruing Forest Types characterized by the presence of the Red Meranti group of *Shorea* of which *S. accuminata*, *S. macroptera*, *S. Leprosula* and *S. ovalis*, and the Keruing group of *Dipterocarpus* species are common. The distribution of the heavy hardwood is less uniform and includes *S. atrinervosa*, *S. excelliptica* and *S. Maxawelliana*. No clear relationship can be obtained between the soils and forest types of the Lowland Dipterocarp Forests as the distribution is so widespread.

In low-lying areas and the river valleys frequented by inundations, fresh water alluvial swamp forests occur together with the riverine forests along the rivers. The soils in these areas are the Riverine Alluvium Association and Local Alluvium.

7.2.5 Time.

Soil profile development if allowed to continue undisturbed will proceed from the immature to mature and then on to the senile stage. The period of time in the pedological sense is relative and not absolute. The age of the parent rock do not seem to have that great a bearing on the age of the soil formed as less mature profiles are formed on the same parent rock on the steeper slopes because of soil erosion. Hence the geomorphology and the ages of the geomorphic surfaces will determine the age of the soil. Geomorphic surfaces subjected to a similar degree of dissection are assumed to be contemporaneous. The major portion of the Johor Tengah Region is stable and mature, and the soil profiles formed are mature. However, on steeper slopes, the wastage process is dominant and the soil forming processes have been interrupted, resulting in less mature profiles. The recent alluvium in the river valleys receives additions from frequent floods and time is too short to have allowed any significant development of any particular features to have taken place.

7.3 Soils.

7.3.1 Introduction.

A soil is formed as the result of the action and interaction of any one or a combination of the five soil forming factors. The soil exists in a state of equilibrium and any change in the equilibrium will result in a change to restore a new equilibrium. Soil survey attempts to map the soils as they exist at present, by describing the characteristics in the field.

The basic unit of mapping is the Soil Series which is also the basic unit of soil classification at the lowest category in West Malaysia

(Leamy and Panton, 1966; Leamy, 1966, Law 1970). Soil classification in West Malaysia is under review at present, and attempts have been made to adopt the diagnostic horizon limits set down in the 7th Approximation and Supplement (Soil Survey Staff, 1960 and 1968). No attempt is made in this report to classify the soils mapped in the Johor Tengah Region into higher categories of classification.

The terms 'sedentary soils' and 'alluvial soils' refer to the development of the soils on parent materials formed in situ on the underlying parent rocks or on materials transported by rivers and deposited elsewhere respectively. These terms are widely used and understood in the country. Although lending a certain bias to geology in this manner of grouping, the role of parent material/rock has always been considered one of the more important soil forming factors. Subdivisions are based on the type of parent material/rock on which the soils are formed.

7.3.2 Sedentary soils on igneous rocks.

7.3.2.1 Rengam series and phases.

Soils of the Rengam Series are most widespread, occupying approximately 38.4 percent of the area surveyed. These soils are developed on granites which varying in physical and (?) mineralogical composition. The physical composition of the granites exert a dominating influence on the physical characteristics of the soils formed. The overall diagnostic features of the soils of the Rengam Series are however, surprisingly uniform. Soils which deviate from the central concept of the Rengam Series in only one or two characteristics have been mapped as phases of the Rengam Series. The deviations are not sufficiently great to warrant the setting up of new soil series at present, but are significant to the cultivation of the agricultural crops grown in this country. In addition to the normal Rengam Series two phases have been set up:-

- a) Rengam Series coarse sandy clay phase
- b) Rengam Series fine sandy clay phase

Rengam Series

This is a deep to very deep soil (more than 40 inches) developed on coarse grained granites found limited to the rolling terrain in the Phase I area, but is found to occur on hilling terrain in the Phase II area as well.

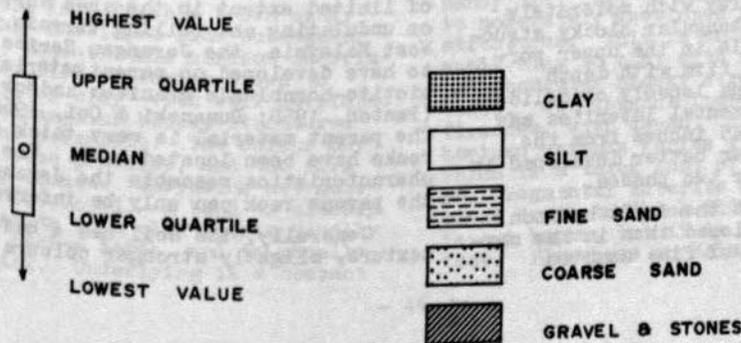
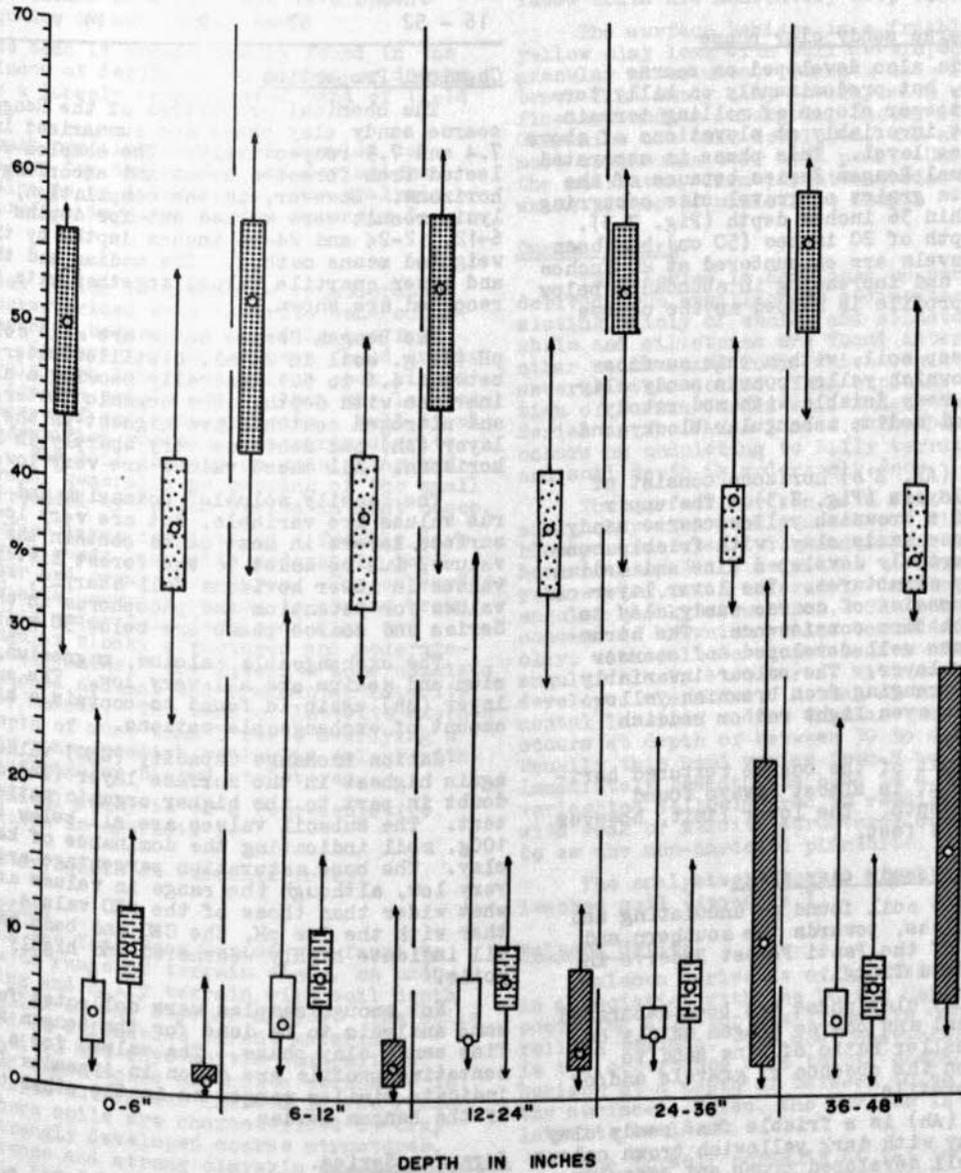
The thin surface horizon (Ah, note horizon nomenclature as in Leamy and Panton, 1966 i.e. Ah, Ae_j, AB, BC & CM) is characterized by dark yellowish brown coarse sandy loam and coarse sandy clay loam textures. The consistence is always friable to very friable, with moderately developed fine subangular blocky and crumb structures.

The subsurface horizons (Ae_j, AB Bs and BC)⁺ are generally coarse sandy clay loam to coarse sandy clay textures, characterized by high coarse sand and even gravels especially at depth. The textures become heavier with depth, and although field estimations indicated a fairly clear Ae/Bt horizon sequence, more often than not the mechanical analyses showed that the increase in clay from the A to B horizons is not that abrupt (Figure 7.2).

The consistence is friable at the top two feet or so, becoming firmer and occasionally slightly compacted at depths below that. The structures are only weakly to moderately developed medium and fine subangular blocky, becoming coarser and less well developed at depth. The

⁺ Ah, Ae_j, Ab, BC, CM - horizon nomenclature as in Leamy and Panton, 1966.

PARTICLE SIZE DISTRIBUTION
RENGAM SERIES COARSE SANDY CLAY PHASE
 (13 Profiles)



colours vary from brownish yellow to yellowish brown (10YR 6/8 to 10YR 5/6-8), turning to strong brown (7.5YR 5/6) or reddish yellow (7.5YR 6/6), and often yellowish red (5YR 5/8) at depths. Isolated cases have been recorded where the strong brown colours are found at shallower depth than normal, normally in profiles on steeper slopes. Clayskins are moderately well developed covering most of the ped surfaces especially in the B horizons; and weakly developed covering some of the peds only, in horizons above and below.

Laterite concretions are not altogether absent, occurring only as a loosely packed thin band at depths.

Rengam Series coarse sandy clay phase

This phase is also developed on coarse grained granites, but predominantly on hilly terrain or on the steeper slopes of rolling terrain class, and almost invariably at elevations of above 250 feet above sea level. This phase is separated out from the normal Rengam Series because of the presence of quartz grains of gravel size occurring in abundance within 36 inches depth (Fig. 7.3). The arbitrary depth of 20 inches (50 cm) has been used, i.e. if gravels are encountered at 20 inches from the surface and increasing in abundance below that depth, the profile is mapped as the coarse phase.

This is a deep soil, with a thin surface layer of dark brownish yellow coarse sandy clay loam, friable to very friable with moderately developed fine and medium subangular blocky and crumb structures.

The subsoil (AB, B's) horizons consist of two contrasting layers (Fig. 7.3). The upper layer consists of a brownish yellow coarse sandy clay loam to coarse sandy clay, with friable consistence and moderately developed fine and medium subangular blocky structures. The lower layer on the other hand, consist of coarse sandy clay to gravelly clay with firm consistence. The structures are also less well developed and coarser than in the upper layer. The colour invariably becomes stronger, ranging from brownish yellow to strong brown to even light red or reddish yellow with depth.

The upper limit of the coarse textured horizon is variable, but is almost always found within 36 inches depth. The lower limit, however, extends to beyond 4 feet.

Rengam Series fine sandy clay phase.

This is a deep soil found on undulating and rolling terrain class, towards the southern and eastern portions of the Panti Forest Reserve in the vicinity of Kota Tinggi.

The fine sandy clay phase has been separated out from the normal and coarse Rengam mainly on the relatively smaller ratio of fine sand to coarse sand and on the absence of gravels and/or stones down the profile.

The topsoil (Ah) is a friable fine sandy clay loam to sandy clay with dark yellowish brown colour and moderately well developed crumb and granular structures. This is underlain by a yellowish brown to strong brown fine sandy clay with moderately developed fine and medium subangular blocky structures. Consistence is friable in the upper portions, but becomes gradually firm with depth. Occasionally a rather thin and loosely consolidated band of nodular and fragmental laterites may be found at depths of 38 to 45 inches from the surface. Clayskins are rather better developed in the B's compared to the other two phases.

It is also observed that the Ae/Bt horizon sequence is rather less developed than in the normal Rengam soils. The ratio of fine sand to

coarse sand in the subsoil horizons in this phase is found to be 1.5 or less (Table 7.3), whereas in the normal Rengam Series the ratio is always greater than two.

TABLE 7.3 PARTICLE SIZE DISTRIBUTION
(Representative Profile)

Depth (in.)	Clay	Silt	Fine Sand	Coarse sand
0 - 2	47	5	17	31
2 - 16	52	4	19	25
16 - 52	57	2	19	22

Chemical Properties

The chemical properties of the Rengam Series coarse sandy clay phase are summarized in Figs. 7.4 and 7.5 respectively. The samples were collected from forested areas and according to soil horizons. However, in the compilation, the analysis result were worked out for depths of 0-6, 6-12, 12-24 and 24-36 inches depths by the weighted means method. The median and the upper and lower quartile values together with the range recorded are shown.

The Rengam Series soils are acid soils, with pH (10 g. soil in 25 ml. distilled water) ranging between 4.1 to 5.1 generally showing a slight increase with depth. The organic matter, carbon and nitrogen contents are highest in the surface layer (Ah) and decrease very sharply in lower horizons. All these values are very low.

The "easily soluble" potassium and phosphorus values are variable, but are very low. The surface layers in most cases contain the highest values, due no doubt to the forest litter, as the values in lower horizons fall sharply. Median values for potassium and phosphorus in the Rengam Series and coarse phase are below 30 ppm.

The exchangeable calcium, magnesium, potassium and sodium are all very low. The surface layer (Ah) again is found to contain a higher amount of exchangeable cations.

Cation Exchange Capacity (CEC) values are again highest in the surface layer (Ah) due no doubt in part to the higher organic matter content. The subsoil values are all below 10 m.eq./100g. soil indicating the dominance of kaolinitic clay. The base saturation percentage are again very low, although the range in values are somewhat wider than those of the CEC values. Together with the low pH, the CEC and base saturation all indicate highly weathered and highly leached soils.

Not enough samples were collected for the same analysis to be done for the Rengam Series fine sandy clay phase. The values for a representative profile are given in Appendix I, which indicate similar ranges as in the other two phases of the Rengam Series.

Jerangau Series.

This is a moderately deep to very deep soil, of limited extent in the area surveyed, and found on undulating and rolling terrain. Elsewhere in West Malaysia, the Jerangau Series has been found to have developed on parent materials derived from biotite-hornblende granites and/or granodiorites (Panton, 1958; Dumanski & Ooi, 1966; Law, 1967). The parent material is very thick and no parent rocks have been located here. The diagnostic characteristics resemble the Jerangau Series, and the parent rock can only be inferred.

Generally, the soil has a heavier and finer texture, slightly stronger colours and more

strongly developed and finer structures than that of the Rengam Series, which has developed on acid granites.

The topsoil (Ah) which normally forms the first 3 to 6 inches of the soil profile, is composed of friable dark brownish yellow clay loam and clay, with moderately developed subangular blocky and crumb structures. This horizon is underlain by a deep, uniform clay subsoil of strong brown colour (7.5YR 5/8) and possessing a well developed fine and medium subangular blocky structures. Clayskin development is moderate. In most of the profiles examined, the subsoil extends of 50 inches or more. The development of Ae/Bt sequence is not easily seen.

Laterite band is occasionally found in the subsoil horizons at depths of 40 inches or deeper, occurring as a loosely consolidated band of 12-14 inches thick.

Not enough profiles have been sampled to allow the values for the median and deviations from the median to be determined. The analysis of a modal profile is given in the Appendix I.

Masai Series.

The Masai Series is a shallow to moderately deep soil characterized by a laterite band occurring at a depth of between 14 to 24 inches from the surface. No parent rock has been found during the survey, although laterized parent rock pieces do indicate igneous origin rather than the layered and platy nature of sedimentary rocks. Null et al (1965) has identified rocks of leucogranodiorite composition. The soil located on undulating and rolling terrain, generally as capping of the small hillocks surrounded by Rengam Series in most cases.

The surface layer consists of a friable dark yellowish brown sandy loam with moderately developed granular and crumb structures. The subsurface soil is a friable brownish yellow to strong brown sandy clay with moderately developed fine and medium subangular blocky structures and moderately developed clayskins. The laterite zone consists of closely packed nodular and fragmental laterite set in a clay matrix. The band of laterite extends down to a depth of more than 3 feet, overlying a gravelly clay zone, reddish yellow in colour with weak coarse subangular blocky structures.

The chemical analysis of a representative profile is given in Appendix I.

7.3.3 Sedentary soils on volcanic rocks.

Yong Peng Series

Soils of the Yong Peng Series are found to occur on a wide range of terrain class, on undulating rolling and hilly terrain with soil depth becoming shallow on the steeper slopes. The soils are developed on tuffaceous parent materials mainly of dacitic and rhyodacitic composition. Occurrence of these soils are quite extensive in the Phase I area but rather limited in the Phase II area. These soils are characterized by clay textures, strongly developed coarse structures, firm consistence and strong clayskin development, especially in the B horizons.

The surface soil is a friable brown sandy clay loam with weakly developed fine subangular blocky structures. Beneath this horizon is friable to firm and very firm yellowish brown to brownish yellow "gritty clay" with well developed medium and coarse subangular blocky structures which tend to become prismatic. The colour may become stronger in some profiles, and the firm consistence is very common. Clayskins are moderately to strongly developed. A band of closely packed nodular laterite in a clay matrix usually occurs at 30 to 45 inches depth, and is usually 10 to 18 inches thick. Underlying is a compact

strong brown "gritty" clay which is highly mottled. Fragments of partially weathered tuffaceous material are often found in this horizon.

7.3.4 Sedentary soils on sedimentary rocks.

Munchong Series.

Soils of the Munchong Series covers a small area and are found mainly on undulating and rolling terrain. These soils are mapped alone or in association with the Serdang, Durian and Bungor Series, because of interbedding in the shale derived parent material with coarser sediments. These soils are moderately deep to deep.

The surface horizon is a friable brownish yellow clay loam with well developed crumb and granular structures. Beneath is a friable strong brown fine sandy clay to clay with well developed fine and medium subangular blocky structures. Clayskins are well developed, and are found almost continuous over most peds. Underlying is the moderately firm parent material horizon in which pieces of shales are found.

Durian Series.

This series is developed on parent material derived from argillaceous sedimentary rocks consisting mainly of shales and siltstones. Usually shale and siltstones are found interbedded with other sedimentary rocks which could give rise to several other soils. This explains the association of Durian Series with Bungor and Munchong Series in the Phase I area. The Durian Series occurs on undulating to hilly terrain classes, and soil depth is moderately deep.

The surface horizon is a friable brown fine sandy clay with weakly developed fine subangular blocky structures. The underlying subsurface horizon (Ae/AB) is a friable to firm brownish yellow clay, with moderately developed medium subangular blocky structures. The subsoil horizons consist of brownish yellow to reddish yellow firm clay, with well developed medium and coarse subangular blocky structures, with rather strongly developed clayskins. A band of nodular and fragmental laterite and/or angular quartzite commonly occurs at depth of between 30 to 40 inches. Usually this band varies from 8 to 18 inches thick. Immediately beneath the band is a firm, highly variegated yellowish red to reddish yellow clay, with weak or massive structures commonly referred to as the non-hardened plinthite.

The analysis indicates a well weathered and leached soil (Appendix I).

Malacca Series.

Malacca Series is of limited extent and occurs in association with the Durian Series, generally occupying hill-top positions, in undulating and rolling terrain. The most characteristic feature is the occurrence of a thick, compact laterite horizon at a depth of between 10 to 20 inches from the surface. Often, the surface is littered with laterite boulders.

The topsoil normally of 1-3 inches thick, is comprised of friable dark brownish yellow fine sandy clay loam to sandy clay loam, with weakly to moderately developed fine subangular blocky structures. This is underlain by a strong brown sandy clay to clay with moderately developed medium subangular blocky structures and firm consistence. Consistence increases in its degree of firmness, with depth. The depth to which this horizon extends varies from 10 to 20 inches, below which is a thick band of closely packed nodular and fragmental laterite set in clay matrix. The exact depth to which this laterite horizon extends is not known, but it is certainly of more than 3 feet. Elsewhere in Malaya the laterite horizon

has been found to extend to a depth of 5 to 8 feet, overlying a firm, highly variegated clay.

In a small stretch close to S. Linggiu, the Serdang Series is found associated with soils of the Bungor Series. Close association of these two different soils probably result from the close interbedding of shale and quartzite, from which they are derived. Serdang soils are also found associated with soils of the Munchong Series. In general however, the extent over which Serdang soils are found associated with other series is rather small.

The surface soil is a friable, dark yellowish brown loamy sand to sandy loam with weakly developed fine and medium subangular blocky structures. This overlies a friable yellow to strong brown sandy clay loam to sandy clay, possessing weakly to moderately well developed fine and medium subangular blocky structures. Beneath this, the soil changes gradually to a moderately firm parent material horizon in which small pieces of sandstone and shale are found.

7.3.5 On metamorphic rocks.

Prang Series Lateritic Phase.

This is a shallow to moderately deep soil developed from schist parent material. The soil is of limited extent and is found on undulating and rolling terrain.

The topsoil is a friable strong brown silty clay with moderately developed fine subangular blocky structures. This is underlain by an equally friable soil of yellowish red silty clay with moderately developed fine and medium subangular blocky structures. Usually in normal Prang Series, the subsoil is of considerable thickness (Wong, 1966; Law, 1967) but in this lateritic phase, its thickness is greatly reduced by an intervening band of closely packed nodular and fragmental laterite set in clay matrix. Usually this band occurs at 24 inches depth, thus resulting in a soil of moderate depth only.

B. Alluvial Soils.

7.3.6 On older alluvium

Harimau Series

The soils of the Harimau Series are moderately deep to deep on undulating and rolling terrain, being shallower on steeper slopes. The soils are formed on materials transported and deposited under littoral-estuarine fluvial conditions during the Pleistocene, during which time the sea level was about 250 feet higher than the present level (Burton, 1964). Deposition of subrecent and recent alluvia took place after that. It is important to note that soils of the Harimau Series found in this area are always located below the 250 feet contour.

Ample evidence have been recorded during the course of the survey in the S. Sayong area in particular, to show that the Harimau Series lies unconformably over an older peneplaned shale surface. This is especially obvious at places where soil profile are relatively shallow. Peneplanation must have occurred prior to the rise of sea-level during the Pleistocene.

Close to the Rengam Series areas however, it is very unlikely that the Harimau Series is wholly of older alluvium origin. Part of it must have been developed from resorted colluvial granitic parent material which probably occur near the base of granite hills.

The topsoil consists of a friable dark yellowish brown loamy sand to sandy loam, with moderately developed fine subangular blocky structures. This is underlain by a friable yellowish

brown to yellow sandy clay loam or sandy clay with weakly to moderately developed medium subangular blocky structures. At depths of 38 to 50 inches there usually occurs a compact gravelly horizon whose thickness varies from a few inches to two feet. Gravels within this horizon usually show pronounced roundness and are mainly comprised of quartzite and mudstone (Null et al, 1965; Dumanski and Ooi, 1966). Granite gravels are also found, but rather rarely. At several soil pits, the gravelly horizon overlies shale parent material of different pedogenic origin. Very often, the boundary between these two different pedogenic horizons is demarcated by stonelines consisting of iron stained shale fragments. The effective depth of the Harimau Series therefore depends very much on the thickness of the gravelly horizon and at what depth it occurs.

In most profiles, there is some degree of grain size variation of the sand fraction of the subsoil. In many, it is found that there is a gradual coarsening of grain size down the profile. In others, such occurrence can be traced for only a short distance down the profile, after which there is an abrupt change towards the finer grade.

Close resemblances of the Harimau Series to that of the Rengam Series created a lot of difficulty in mapping. The grain size distribution shows much more fine sand and coarse sand and less clay than the Rengam Series, although separation by field estimation in some profiles is rather difficult. For practical purposes, the following criteria have been found to be useful in distinguishing the Harimau soils from those of the Rengam:-

- a) Occurrence of gravels and coarse sand showing pronounced roundness.
- b) Occurrence of underlying horizon of different pedogenic horizon.
- c) Presence of stonelines, made up mainly by iron-stained shale fragments.

Chemical Properties

These are acid soils, with pH (H₂O) ranging between 4.1 and 5.1; the organic matter, carbon and nitrogen contents are highest in the Ah horizon and decrease very sharply in lower horizons. All these values are low and comparable to those in the Rengam Series.

The "easily soluble" potassium values are very low and similar to those of the Rengam Series, while the "easily soluble" phosphorus median values are slightly higher in the subsoils in the Harimau Series.

The exchangeable calcium is higher in the subsoils of the Harimau Series, while the magnesium however is noticeable lower than in the Rengam Series; the exchangeable potassium is limited to lower values, although the sodium is similar.

The CEC is slightly lower than the Rengam, although the base saturation is similar. The low pH, CEC, base saturation, and exchangeable cations indicate weathered and leached soils; and the effect of an extra cycle in the weathering is indicated by the lower magnesium and potassium values when compared with the Rengam Series, a sedentary soil which has undergone only one cycle of weathering.

Ulu Tiram Series.

Apart from the Harimau Series, this is another soil developed on older alluvium. Soils of the Ulu Tiram Series are of moderate depth and are found on rolling terrain. The profiles resemble those of the Harimau Series in the upper portions, but have much coarser subsoils.

The topsoil is characterized by a friable dark brown sandy loam, with moderately developed

CHEMICAL PROPERTIES RENGAM SERIES (15 Profiles)

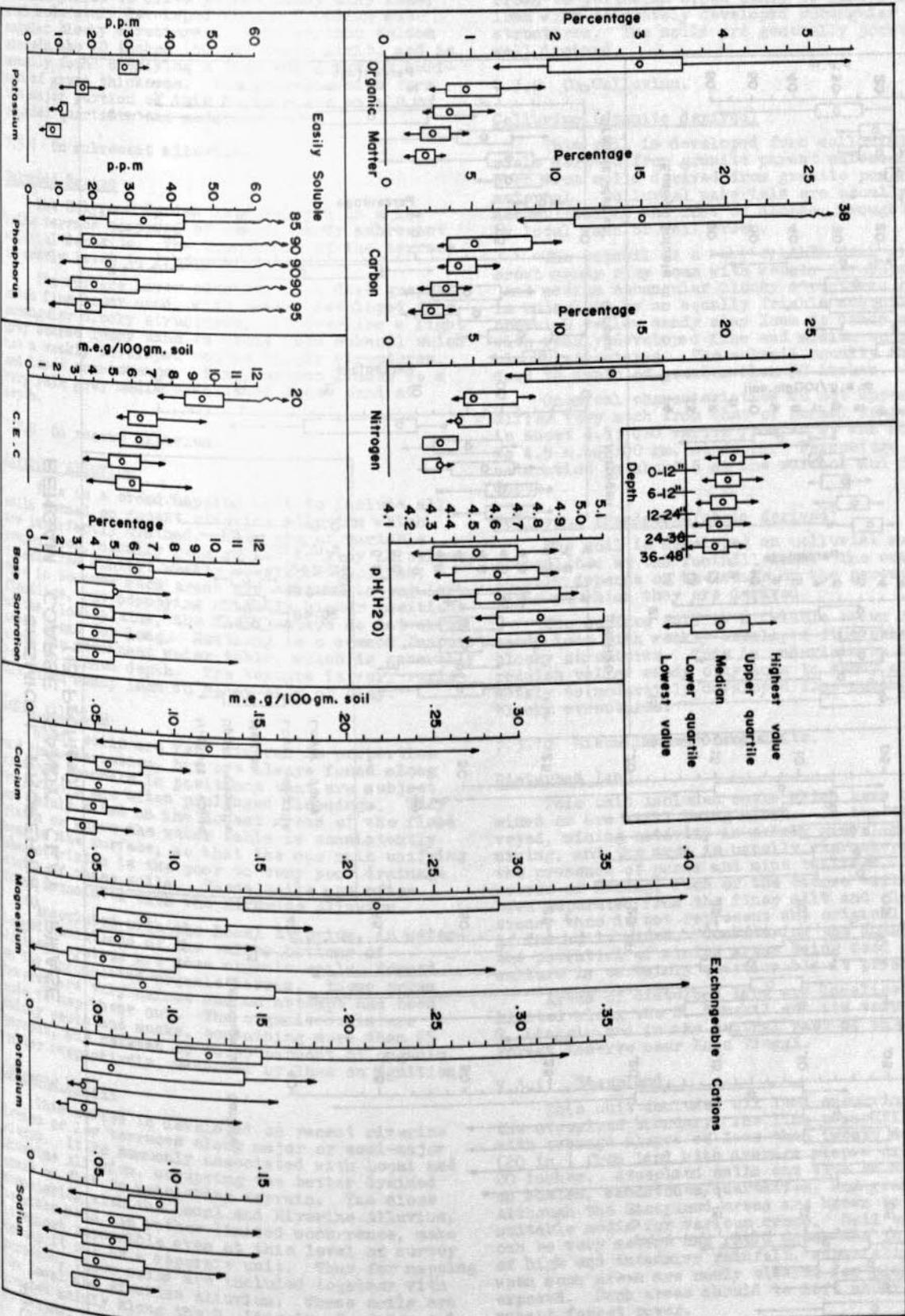
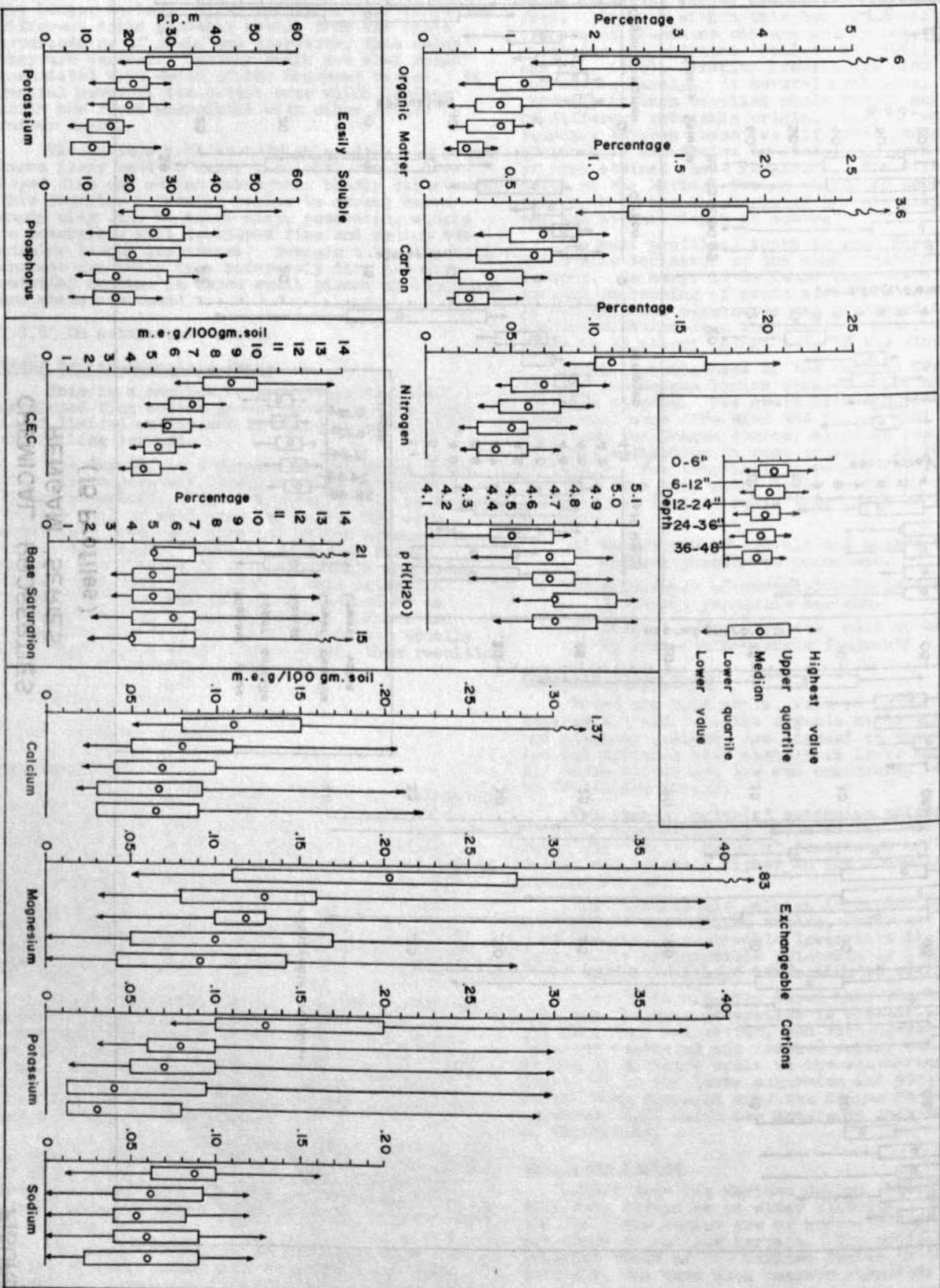


FIGURE 7.4

CHEMICAL PROPERTIES RENGAM COARSE SANDY CLAY PHASE (13 Profiles)

FIGURE 7.5



medium crumb structures. Underlying this is a friable yellow to olive yellow sandy clay loam, with moderately developed fine and medium subangular blocky structures. This horizon seldom exceeds the 20 inches (50 cm) depth limit, and is usually found overlying a firm and gravelly horizon of great thickness. The gravels which form the major portion of this horizon are mainly of rounded quartzite and mudstone.

7.3.7 On subrecent alluvium.

Holyrood Series

The Holyrood Series is developed on a low lying terrace composed of coarse sandy subrecent alluvial deposits. The topography of the terrace is nearly level to gently sloping.

The surface layer consists of a dark greyish brown fine loamy sand, with weakly developed fine subangular blocky structures. It overlies a light grey coarse loamy sand to sandy loam subsoil which has a weakly developed coarse blocky structures, and loose consistence. This horizon grades to a very pale grey undifferentiated loose sand at depth.

7.3.8 On recent alluvium.

Riverine Alluvium.

This is a broad mapping unit to include all soils formed on recent riverine alluvium which are imperfectly drained. They are of variable composition, usually pale yellow to grey in colour, friable and exhibit weakly developed profiles. This is because such areas are subject to regular floodings, but occupying slightly higher positions of the flood plains, the flood waters do not cover these areas for long. Mottling is a common feature above the permanent water table, which is generally below 20 inches depth. The texture is very variable, from sandy loam to sandy clay or clay.

Local Alluvium.

These soils are very diverse in properties and characteristics, but are always found along drainage channels in positions that are subject to periodic and often prolonged floodings. They are mainly sited on the lowest areas of the flood plains or where the water table is consistently near to the surface, so that the one main unifying characteristic is the poor to very poor drainage status of these soils. These soils are often found associated with the Riverine Alluvium.

Associated with the Local Alluvium, in waterlogged conditions of the valley bottoms of drainage systems are some organic soils, formed on the accumulated organic debris. These areas however are very narrow and no attempt has been made to map these out. The organic soils are mainly peats and mucks, containing more than 65 percent, and between 65 to 35 percent of organic matter respectively, measured by loss on ignition.

Telemona Series

This series is developed on recent riverine levees or low terraces along major or semi-major rivers. It is commonly associated with Local and Riverine Alluvium, occupying the better drained areas on flat to undulating terrain. The close association with the Local and Riverine Alluvium, together with its rather limited occurrence, make it almost impossible even at this level of survey purposes, these soils are included together with the Local and Riverine Alluvium. These soils are located mainly along the S. Linggiu, S. Johor and S. Kahang.

The surface soil is a friable dark brown sandy loam to sandy clay loam, with weakly developed angular blocky and crumb structures. The

subsurface soil is a friable, light yellowish brown to yellowish brown sandy to fine sandy clay loam with moderately developed subangular blocky structures. The soils are generally porous and well drained.

7.3.9 On Colluvium.

Colluvium (Granite derived)

This soil is developed from colluvial materials derived from granite parent material or even from soils derived from granite parent material. Colluvial materials are usually accumulated at the foot of slopes, brought about by local wash or soil creep.

The topsoil is a very friable dark greyish brown sandy clay loam with weakly developed fine and medium subangular blocky structures. This is underlain by an equally friable subsoil of brownish yellow sandy clay loam to sandy clay with weakly developed fine and medium subangular blocky structures. The subsoil usually extends down to depth of greater than 50 inches.

Chemical characteristics do not appear to differ very much from that of normal Rengam. pH is about 4.5; CEC varies from 11 at the surface to 4.5 m.eq/100 gm. at depth. Percentage base saturation is about 5 at the surface and 3 at depth.

Colluvium (Sandstone/shale derived)

The soil is developed on colluvial material accumulated at the foothill zone. The composition largely depends on the soils or the parent materials on which they are derived.

The surface soil is a friable brown fine sandy loam with weakly developed fine subangular blocky structures. This is underlain by a friable reddish yellow sandy clay loam to sandy clay with weakly to moderately developed fine subangular blocky structures.

7.3.10 Miscellaneous land units.

Disturbed land.

This unit includes soils which have been mined or are still being mined. In the area surveyed, mining activity is mainly gravel-pump mining, and the area is usually characterized by the presence of ponds and mine tailings. In the course of mining, much of the coarse tailings have been separated from the finer silt and clay fractions, thus do not represent the original make up of the soils mined. Considering the damage done, the potential of mining areas being used of agriculture is certainly questionable at present.

Areas of disturbed land are localized, being limited along the S. Tengkil and its tributaries, S. Linggiu and in the central part of the Pantii Forest Reserve near Kota Tinggi.

7.3.11 Steepland.

This unit includes all land occurring above the steepland boundary, the line separating land with average slopes of less than twenty degrees (20 in.) from land with average slopes exceeding 20 inches. Steepland soils can thus be developed on shales, sandstones/quartzites, and granites. Although the Steepland areas are known to be of suitable media for various crops. Soil erosion can be very severe and rapid under the influence of high and intensive rainfall, especially so when such areas are newly cleared for planting or exposed. Such areas should be left under a permanent forest cover.

7.3.12 Soil distribution.

The soil pattern is rather simple where soils are developed on igneous rocks and on older

alluvium. The Rengam Series and phases cover 38.4 percent of the region, occupying the greater portion of the area west of the S. Linggiu, and in the Southeast corner. The Harimau Series are located mainly in the South and cover 12.3 percent of the region.

The river valleys and flood plains are filled by the Riverine and Local Alluvium (8.1 percent), while the Steepland which is not recommended for agricultural development are centred around Gunung Blumut, Gunung Muntahak and Bukit Tajam (17.4 percent).

The remaining 23.8 percent of the region are covered by soils developed on sedimentary and volcanic rocks. The pattern is more complex because of the complex nature of the parent rocks.

Table 7.4 shows the soil distribution and Figure 18 in the Atlas distribution pattern.

TABLE 7.4 SOIL DISTRIBUTION

Symbol	Mapping Unit	Acreage	Percent of total
RGM	Rengam Series	106,650	32.9
RGM/c	Rengam Series coarse sandy clay phase	12,815	3.9
RGM/f	Rengam Series five sandy clay phase	5,275	1.6
JRA	Jerangau Series	535	.2
MSI	Masai Series	1,065	.3
YGP	Yong Peng Series	11,690	3.6
YGP/md	Yong Peng Series moderately deep	295	.1
MUN	Munchong Series	50	<.1
MUN/md	Munchong Series moderately deep	500	.2
DRN	Durian Series	24,490	7.5
MCA	Malacca Series	265	.1
BGR	Bungor Series	4,165	1.3
SDG	Serdang Series	8,205	2.5
SDG	Serdang Series moderately deep	1,995	.6
SDG/S	Serdang Series shallow	9,635	3.0
SDG/md-BGR	Serdang Series moderately deep - Bungor Association	320	.1
SDG/md-MUN/md	Serdang Series moderately deep - Munchong Series moderately deep Association	1,365	.4
DRN-BGR-MUN	Durian - Bungor - Munchong Association	4,480	1.4
PRG	Prang Series lateritic phase	485	.1
HMU	Harimau Series	37,160	11.4
HMU/md	Harimau Series moderately deep	2,800	.9
UTM	Ulu Tiram Series	508	.5
HYD	Holyrood Series	1,670	.5
RVA - LAA	Riverine - Local Alluvium Association	21,750	6.7
LAA	Local Alluvium	4,450	1.4
COL/G	Colluvium (Granite derived)	425	.1
COL/SS	Colluvium (Sandstone-shale derived)	830	.3
DLD	Disturbed Land	3,200	1.0
STP	Steepland	56,335	17.4
Total:		324,550	100.0

LAND EVALUATION8.1 Introduction.

The Terms of Reference require planning for a maximum diversified cropping pattern, based on climatically adaptable crops.

There are various classification systems by which the suitability or capability of land resources can be indicated on the basis of their physical and chemical properties. The systems considered in this study are listed below:

- a) WONG, I.F.T. Soil Science Division, Research Branch, Division of Agriculture, Min. of Agric. and Co-operatives, Malaysia, January, 1970. A Soil Suitability Classification for Malaysia.
- b) KLINGEBIEL, A.A., and MONTGOMERY, P.H. Agricultural Handbook 210. Soil Conservation Service U.S. Dept. of Agriculture. September, 1961. Land-Capability Classification.
- c) DENT, F.J., Soil Survey Division Report No.76, Land Development Department, Ministry of National Development, Bangkok, April, 1969. General Land Suitability For Crop Diversification in Peninsular Thailand.
- d) GALLUP, D.L., SRILAK KASHEMSANTA AND AVUDH PIMPAND. Soil Survey and Land Classification Div. Report No.60 (1967) Land Development Department. Soil Survey Interpretation Handbook For Northeast Thailand. Part II Land Capability Classification.
- e) Natural Resource Capability Section, Economic Planning Unit, Prime Minister's Department, Malaysia (1967). Land Capability Classification in West Malaysia. An Explanatory Handbook. (with Supplement).

8.2 A Comparison of Some Classification Systems

The classification system developed by Wong (1970) is intended to cover East and West Malaysia. The general principles adopted for this system are:

- (1) the criteria used for the assessment of a soil should be the properties currently possessed by that soil;
- (2) the seriousness of a limitation should be a function of the severity with which crop growth is inhibited; and
- (3) the suitability of a soil for crop growth is better when a wider range of crops can be cultivated on it than on another soil."

If the above principles are followed, then the soils are classified according to the crop selection limiting factors currently found on these soils. This system does not consider in which way and at what expense these limiting factors can be remedied, but is concerned with indicating the degree of seriousness of the limitations affecting crop selection and crop growth on a sustained yield basis.

The Soil Suitability Classification for Malaysia is similar, in its approach to land evaluation, to the Land Capability Classification developed by Klingebiel and Montgomery (1961), Haantjens (1963) and Andriess (1966) and also has subclasses indicating the kind of limitations to crop selection and growth.

The system does not claim to be a soil suitability classification for specific crops e.g. padi, tapioca, cocoa, sugar cane, oil palm, rubber etc. Specific crops require specific interpretations of the soil mapping and terrain class units.

The Land Capability Classification developed by Klingebiel and Montgomery (1961) groups soils and terrain characteristics according to their degree and seriousness of limitations to obtain a sustained crop production and also according to their risks of soil damage if mismanaged. There are eight capability classes and the risks of soil damage or limitation in use become progressively greater from Class I to VIII. Each capability class can be divided into subclasses according to the kind of limitations. Four general limitations are recognized:

- | | |
|------------|---------------|
| 1) erosion | 3) soil depth |
| 2) wetness | 4) climate |

Others can be introduced if required.

Dent (1969), in his General Land Suitability for Crop Diversification in Peninsular Thailand, follows similar principles of grouping soil units into suitability groups as Wong (1970) and Klingebiel and Montgomery (1961). Dent uses a 5-class system and includes wet rice cultivation in Class IV of his system. Subclasses to indicate the kind of limitations are not used.

Gallup, Srilak Kashemsanta and Avudh Pimpand (1967) in their Land Capability Classification follow the same basic principles as Klingebiel and Montgomery (1961), but a split is made between upland crops and paddy. The first section is divided into 8 classes the second into 5 classes. Subclasses to indicate the kind of limitations are used for both sections of the classification system.

The Land Capability Classification developed by the Natural Resources Capability section of the Economic Planning Unit (1967) is a more comprehensive system and includes mining land as Class I; only Class II and III are agricultural classes, Class IV and V are used for forest and reserves respectively. Generally the same basic principles are used for the Classes II to IV as the systems described earlier.

8.3 The South East Johor Project System

In this project, consideration had to be given to the suitability of soils for a diversified cropping pattern, annual as well as perennial. To allow for this a different and more comprehensive system than Wong's (1970) Soil Suitability Classification for Malaysia had to be developed. As has been pointed out earlier Wong's Classification does not claim to be a soil suitability classification for specific crops, since this requires specific interpretations of soil and terrain units.

This emphasis on specific crops determined that none of the classification systems described could be used and a more suitable system was therefore devised for this project. It is based on the optimum soils and terrain conditions under which certain crops will give optimum growth and maximum yields. Each crop will only thrive within a certain range of physical and chemical soil conditions. Some crops are more tolerant of adverse conditions than others. If the capabilities of the soils for these crops are to be established then the tolerance range for each crop or group of crops must be known.

To simplify the system, crops with similar soil requirements have been grouped together and groups with the same growing period have been combined further to form main groups. Table 9 sets out the optimum criteria for each group of crops. These criteria have been established in close co-operation with the Soil Science Division of the Division of Agriculture, Malaysia. It must be emphasized that the criteria used are those for soils in a natural state, in other words no human interference has taken place. The range of crops listed in Table 8.1 has been selected primarily on the basis of climatic suitability but consideration was also given to economic importance. It is not claimed that all the climatically adaptable crops have been included in the table.

TABLE 8.1 OPTIMUM CRITERIA FOR GENERALISED CROP GROUPS
(Soils in natural state)

Main Group	Crops and Crop Group Coding	Criteria
GROUP A	1:	Slope: 0 to 2°
Annual Crops	Rice	Drainage: Well; moderately well; imperfectly well; and poorly drained Effective soil depth: Over 30 cm (1 ft.) Soil texture: heavier than sandy clay loam. Workability: No stones; and submerged timbers in peat; no other restrictions apart from texture Depth to acid sulphate layer: Over 30 cm (1ft.) from soil surface. Thickness of peat layer: Less than 30 cm (1 ft) Salinity: Less than 4 mmhos/cm at 25°C in top (1 foot) of soil.
	2:	Slope: 0 to 6°
	Ground nuts Vegetables, Tobacco.	Drainage: Very well, well, moderately well; and imperfect. Effective soil depth: over 30 cm (1 ft) Soil texture: excluding sands and poorly structured heavy clays. Workability: no stones; no other restrictions apart from texture. Depth to acid sulphate layer: over 60 cm (2 ft) Thickness of peat layer: Less than 30 cm (1 ft) Over 120 cm (4 ft) for most vegetables. Salinity: Less than 4 mmhos/cm at 25°C in top 60 cm (2 feet) of soil.
	3:	Slope: 0 to 6°
	Tapioca, Yams, Sweet Potatoes.	Drainage: Very well, well, moderately well and imperfect. Effective soil depth: over 60 cm (2 ft)
	4:	Slope 0 to 6°
	Pulses, Maize, Sorghum.	Drainage: Very well, well, moderately well, and imperfect. Effective soil depth: over 30 cm (1 ft) Soil texture: excluding loamy sand and lighter textures and poorly structured heavy clays. Workability: no stones; no other restrictions apart from texture. Depth to acid sulphate layer: over 60 cm (2ft) Thickness of peat layer: Less than 30 cm (1ft) Salinity: Less than 4 mmhos/cm at 25°C in top 60 cm (2 ft) of soil.
	5:	Slope: 0 to 12°
	Semi-perennial Crops	Drainage: Well, moderately well and imperfect, and poor for some species. Soil texture: generally excluding sand and loamy sand; a limited number of species can thrive on sand and loamy sand. Effective soil depth: over 30 cm (1ft) Workability: no stones; no other restrictions apart from texture. Depth to acid sulphate layer: over 60 cm (2 ft) Thickness of peat layer: depending on variety of grass; but peat with a thickness of more than 30 cm (1 foot) is unsuitable for grazing. Salinity: Less than 4 mmhos/cm at 25°C in top 60 cm (2 ft) of soil.

Main Group Crops and Crop Group Coding Criteria

Soil texture: excluding sands and poorly structured heavy clays.

Workability: no stones; no other restrictions, apart from texture.

Depth to acid sulphate layer: over 90 cm (3 ft)

Thickness of peat layer: Less than 30 cm (1 ft) only tapioca on more than 30 cm (1 ft).

Salinity: Less than 4 mmhos/cm at 25°C in top 90 cm (3 ft) of soil.

4:

Slope 0 to 6°

Pulses,
Maize,
Sorghum.

Drainage: Very well, well, moderately well, and imperfect.

Effective soil depth: over 30 cm (1 ft)

Soil texture: excluding loamy sand and lighter textures and poorly structured heavy clays.

Workability: no stones; no other restrictions apart from texture.

Depth to acid sulphate layer: over 60 cm (2ft)

Thickness of peat layer: Less than 30 cm (1ft)

Salinity: Less than 4 mmhos/cm at 25°C in top 60 cm (2 ft) of soil.

GROUP B

5:

Slope: 0 to 12°

Semi-perennial Crops

Grasses

Drainage: Well, moderately well and imperfect, and poor for some species.

Soil texture: generally excluding sand and loamy sand; a limited number of species can thrive on sand and loamy sand.

Effective soil depth: over 30 cm (1ft)

Workability: no stones; no other restrictions apart from texture.

Depth to acid sulphate layer: over 60 cm (2 ft)

Thickness of peat layer: depending on variety of grass; but peat with a thickness of more than 30 cm (1 foot) is unsuitable for grazing.

Salinity: Less than 4 mmhos/cm at 25°C in top 60 cm (2 ft) of soil.

Main Group	Crops and Crop Group Coding	Criteria	Main Group	Crops and Crop Group Coding	Criteria
	6: Bananas, Sugar cane, Ramie, Papaya.	Slope: 0 to 12° Drainage: Well, moderately well and imperfect. Soil textures: excluding loamy sand and lighter textures. Effective soil depth: over 90 cm (3 ft) Workability: no stones. Depth to acid sulphate layer: Over 90 cm (3 ft) Thickness of peat layer: Less than 30 cm (1 ft) Salinity: Less than 2 mmhos/cm at 25°C in top 90 cm (3 ft) of soil.			Thickness of peat layer: Less than 90 cm (3 ft) Salinity: Less than 2 mmhos/cm at 25°C in top 150 cm (5 ft) of soil.
	7: Pineapple.	Slope: 0 to 12° Drainage: Very well to imperfect. Soil texture: excluding loamy sand and lighter textures. Effective soil depth: Over 30 cm (1 ft) Workability: no stones Depth to acid sulphate layer: Over 60 cm (2 ft) Thickness of peat layer: no restrictions if drained. Salinity: Less than 2 mmhos/cm at 25°C in top 60 cm (2 ft) of soil.		10: a. Coconut b. Cinnamon c. Rubber d. Brazil nut e. Tea f. Cashewnut g. Guava h. Durian k. Bamboo	Slope: 0 to 20°; (Bamboo 0 to 25°). Drainage: Very well to moderately well. Soil texture: excluding sandy loam and lighter textures (except for cashew nut which is very low demanding) Effective soil depth: over 90 cm (3 ft) Workability: stony soils are excluded for most crops of this group. Depth to acid sulphate layer: over 150 cm (5 ft) Thickness of peat layer: Less than 90 cm (3 ft) Salinity: Less than 2 mmhos/cm at 25°C in top 150 cm (5 ft) Some crops such as coconut in this group can thrive under higher salinity conditions.
GROUP C	8: Coffee, Cocoa, Pepper, Citrus, Gambier, Avocado.	Slope: 0 to 12° Drainage: Very well; well and moderately well. Soil texture: excluding sandy loam and lighter textures. Effective soil depth: over 120 cm (4 ft) Workability: no stones. Depth to acid sulphate layer: Over 150 cm (5 ft) Thickness of peat layer: Less than 60 cm (2 ft) Salinity: Less than 2 mmhos/cm at 25°C in top 150 cm (5 ft) of soil.		11: Forest under controlled exploitation with regeneration, bamboo included.	Slope: 0 to 25° Drainage: no restrictions (bamboo very well to imperfect). Soil texture: no restrictions, although light textured soil will prove problematic for certain forest tree species. Effective soil depth: over 60 cm (2 ft) Workability: not applicable. Depth acid sulphate layer: over 150 cm (5 ft). not applicable for mangrove) Thickness of peat layer: no restrictions. (bamboo less than (3 ft)). Salinity: Less than 4 mmhos/cm at 25°C in top 150 cm (5 ft).
	9: Oil palms, Arecanut, Mangosteen, Rambutan.	Slope: 0 to 20° Drainage: Well to moderately well. Soil texture: excluding sandy loam and lighter textures. Effective soil depth: over 120 cm (4 ft). Workability: stony soils are excluded. Depth to acid sulphate layer: over 150 cm (5 ft).		12: Forest and other reserves.	No restriction.

Notes to Table 9:

- As agricultural research advances the above criteria may have to be revised.
- Peat is organic matter with loss on ignition of more than 65 percent.
- A soil with a pH of about 3.3 or less on

the air dry soil and a soluble sulphate content in the air-dried soil exceeding 0.1 percent is termed acid sulphate (Coulter, 1968).

d) It is strongly recommended that oil palms and in general most tree crops, should not be grown on peat which exceeds a depth of 3 feet. Due to poor anchorage in such material over a number of years trees gradually incline which will result in declining yields (Coulter, 1967).

Contrary to the criteria established by the Soil Science Division of the Division of Agriculture, Malaysia the depth ranges for organic horizon have been changed and brought in line with the soil depth phases for upland soils: shallow - 2.5 to 50 cm (10 to 20 inches) of organic matter moderately deep - 50 to 100 cm (20 to 40 inches) of organic matter deep - over 100 cm (40 inches) of organic matter.

This change is based on the fact that peat, (organic horizons), however well humified and underlain by a heavy soil, is a problem soil not only from a drainage point of view but also with regard to anchorage of deep rooting tree crops. The parameters mentioned above are based on an estimation of the remaining depth of organic matter after drainage. This to some extent will be a continuing soil limitation. The depth of peat before drainage is transient only. The nature of the peat will also be important. In future classifications some distinction should be made between humified peats and raw, poorly humified peats especially since the latter are usually woody. The characteristics of the peats in the Project Area are further discussed in Section 6.2.9, Organic Soils.

8.4 Land Use Potential Classification

8.4.1 Introduction.

The tolerance ranges for the crops listed in Table 9 form the basis for the Soil Series Suitability for Crop Groups and this in turn has been used to produce the Land Use Potential Maps (Maps No. 9, 10, 11 and 12).

To avoid accelerated erosion after forest clearing, shallow soils on slopes steeper than 12 degrees have been excluded or designated marginal for agricultural development. It must be emphasized that in deciding the depth criteria for soils on sloping terrain considerable weight has been put on the remaining depth of the soil after terracing; this should not be less than 24 inches. In general, before terracing soil depth should not be less than 90 cm or 3 feet (Law Wei Min, priv. Comm. 1971). Terracing of shallow soils on steep slopes will introduce serious erosion due to back-cutting of the terraces. The protection of soils on slopes steeper than 20 degrees has been discussed in Chapter 5 Geomorphology, Section 5.4 Erosion.

8.4.2 Soil series suitability for crop groups.

In the following paragraphs each soil series occurring in the Project Area is discussed, its important characteristics given and the selected crop groups listed for each slope range, appropriate to each soil series. Marginally suitable crops (in brackets) are shown as well as suitable crops and certain exclusions are explained.

"Marginally suitable" implies certain obstacles to success which require additional capital input and or special managerial efforts if the projected yields and profitability are to be maintained. No serious soil limitations exist where land is classified as "suitable".

A comparative rating for each crop group based on performance on any particular soil series would not be possible without extensive agronomic trials. The order given is therefore numerical

and no indication of preference. Similar studies would also be required for marginal crop groups to decide how much additional input such as special soil treatment, additional fertilisers etc. would be required to produce a satisfactory yield and to gain experience in the managerial efforts (terracing, erosion control etc.).

Yong Peng Series

On dacite and rhyodacite. Yellowish brown to reddish yellow; sandy clay loam to clay; moderately to well developed fine and medium subangular blocky structures; firm to very firm consistency; deep soil (Over 100 cm or 40 inches).

This series is generally compacted and coarse structured from a depth of 25 to 45 cm (10 to 18 inches), a lateritic layer if present, only occurs below 100 cm (40 inches).

<u>Slope range</u>	<u>Crop Group Selection</u>
2 - 6°	(4), 5, (6), 7, 9, 10
6 - 12°	5, (6), 7, 9, 10
12 - 20°	9, 10
20 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

The compactness and generally heavy textures precludes this soil from a wide range of crops, resulting in a crop group selection which is practically the same as that for Yong Peng Series, moderately deep phase.

Yong Peng Series, coarse phase

The profile of this phase of the Yong Peng Series soils is similar to the Yong Peng Series described above, the difference being that quartz grit occurs within a depth of 60 cm (24 inches).

This soil has a similar agricultural potential as the Yong Peng Series.

Yong Peng Series, moderately deep phase

The series description is the same as for the Yong Peng Series above, but due to the occurrence of lateritic stones and gravel, this phase is a moderately deep soil (50 to 100 cm or 20 to 40 inches).

This series is generally compacted and coarse structured from a depth of 25 to 45 cm (10 to 18 inches), the lateritic layer which commonly occurs commences at a depth of about 60 cm (24 inches) and varies in the thickness from 5 to 30 cm (2 to 12 inches).

<u>Slope range</u>	<u>Crop Group Selection</u>
2 - 6°	(4), 5, (6), 7, (9), 10
6 - 12°	5, (6), 7, (9), 10
12 - 20°	(10)
20 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

The compactness, shallowness and generally heavy textures preclude this soil from a wide range of crops, and it is also marginal for groups 4, 6, 9 and, sometimes, 10 especially from a managerial point of view. Its shallowness may create problems with terracing, especially on slopes between 12 and 20 degrees therefore group 9 has been excluded for this slope range.

Kulai Series

On rhyolitic tuffs or rhyolites. Pale yellowish brown, strong brown at depth; loam

to silty clay; subsoil firm, compacted, with weak angular blocky structure.

<u>Slope range</u>	<u>Crop Group Selection</u>
2 - 6°	(4), 5, (6), 7, (9), 10
6 - 12°	5, (6), 7, (9), 10
12 - 20°	(10)
20 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

Rooting of the natural vegetation is shallow due to compactness of the soil between 50 and 100 cm (20 and 40 inches). Hence the soil is regarded as moderately deep, and is only suitable for a narrow range of crops. Groups 4, 6, 9 and, sometimes, 10 are marginally suitable. On slopes between 12 and 20 degrees the soil is often shallow, less than 50 cm (20 inches), therefore, group 9 is excluded on this slope range.

Small areas of Kulai coarse phase have been mapped in the Tanjong Penggerang Region. This phase contains coarse sand at a depth of approximately 60 cm (24 inches). The crop group selection is the same as the Kulai Series mentioned above.

Jerangau Series

On biotite - hornblende granite and granodiorite. Strong brown; fine sandy clay to clay; well developed fine and medium subangular blocky structures; friable; deep soil (depth over 100 cm or 40 inches).

<u>Slope range</u>	<u>Crop Group Selection</u>
2 - 6°	2, 3, 4, 5, 6, 7, 8, 9, 10
6 - 12°	5, 6, 7, 8, 9, 10
12 - 20°	9, 10
20 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

Physically a soil with negligible limitations to crop growth, only slope limiting crop selection.

Rengam Series

On granite. Yellowish brown to reddish yellow; sandy clay; weakly to moderately developed fine and medium subangular blocky structures; friable; deep to very deep soil (depth over 100 cm or 40 inches);

<u>Slope range</u>	<u>Crop Group Selection</u>
2 - 6°	(2), 3, 4, 5, (6), 7, (8), 9, 10.
6 - 12°	5, (6), 7, (8), 9, 10
12 - 20°	9, 10
20 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

Limitation mainly on slope; however the groups 2, 6 and 8 are considered marginal due to unfavourable physical soil conditions, such as weak to moderate developed structures and increasing firmness at around 50 cm (20 inches). For group 2 the texture is too heavy.

Rengam Series, coarse sandy clay phase

On granite. Brownish yellow to reddish yellow; coarse sandy clay to gravelly clay; weakly to moderately developed medium and coarse subangular blocky structures; friable becoming firm with depth; deep to very deep

soil (depth over 100 cm or 40 inches).

No impenetrable layers occur but a high percentage (of the soil volume) of gravel and grit restricts rooting to the first 50 cm (20 inches) of the profile, therefore available water would be relatively low.

<u>Slope range</u>	<u>Crop Group Selection</u>
2 - 6°	(4), 5, 7, (9), 10
6 - 12°	5, 7, (9), 10
12 - 20°	10
20 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

The coarse nature of this soil is the reason for exclusion of all crop groups with high soil requirements, with group 4 and 9 as marginal. Other limitations are on slope only. Group 9 has been excluded for the slope range 12 to 20 degrees as terracing would create extra managerial difficulties due to the occurrence of grit and gravel at 50 cm (20 inches) depth.

Rengam Series, fine sandy clay phase

On fine-grained granite. Yellowish brown to strong brown, fine sandy clay to clay; moderately developed fine and medium subangular blocky structures; friable, becoming firm and compacted with depth; deep to very deep soil (depth over 100 cm or 40 inches).

No true impenetrable layers occur but the compactness of the soil restricts rooting of natural vegetation to the top 50 cm (20 inches) of the profile.

<u>Slope range</u>	<u>Crop Group Selection</u>
2 - 6°	(2), (3), 4, 5, (6), 7, (8), 9, 10
6 - 12°	5, (6), 7, (8), 9, 10
12 - 20°	9, 10
20 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

Crop groups 2, 3, 6 and 8 are marginal due to unfavourable physical soil conditions. Further limitations are on slope.

Masai Series

On fine-grained granite and granodiorite. Effective soil depth is 25 to 50 cm (10 to 20 inches) due to the occurrence of a laterite layer up to 90 cm (36 inches) deep. This layer, however, is gravelly and bouldery, not massive, and is penetrable by primary roots. Laterite stones and boulders commonly cover the soil surface.

<u>Slope range</u>	<u>Crop Group Selection</u>
2 - 6°	4, 5, 7, 10
6 - 12°	10
12 - 20°	(10)
20 - 25°	forest, 11
Over 25°	forest reserve, 12

Limitations to crop selection are effective soil depth and slope. The occurrence of lateritic stones and boulders restricts soils cultivation. On slopes between 12 and 20 degrees terracing becomes impossible due to soil depth, therefore group 10 is marginally suitable.

Prang Series

On basic schist or hornfels. Yellowish red; friable silty clay to clay; well developed fine and medium subangular blocky structures with weak horizonation. Laterite may be present at depth, a deep soil (depth over 100 cm or 40 inches).

<u>Slope range</u>	<u>Crop Group Selection</u>
2 - 6°	(2), 3, 4, 5, 6, 7, 8, 9, 10
6 - 12°	5, 6, 7, 8, 9, 10
12 - 20°	9, 10
20 - 25°	forest, 11
Over 25°	forest reserve, 12

Limitations to crop selections is on slope only.

Prang Series, lateritic phase

This soil is similar to the Prang Series described above but a compacted, nodular lateritic band occurs at 60 cm (24 inches) depth, friable; a shallow soil (25 to 50 cm or 10 to 20 inches deep).

<u>Slope range</u>	<u>Crop Group Selection</u>
2 - 6°	4, 5, 7, (9), 10
6 - 12°	5, 7, (9), 10
12 - 20°	(10)
20 - 25°	forest, 11
Over 25°	forest reserve, 12

The lateritic phase of this series has been considerably downgraded, the laterite band precluding it from many crops. Group 9 and 10 are marginally suitable for this reason.

Seremban Series.

On quartz - mica schists intermixed with phyllites and vein quartz. Mainly found on undulating to hilly terrain. Greyish brown to yellowish brown friable to firm fine sandy clay loam overlying reddish yellow to yellowish red firm fine sandy clay. Structures are moderate medium subangular blocky. Quartz gravels and angular pebbles together with laterized pieces of parent material commonly occur between 50 and 100 cm (20 and 40 inches).

<u>Slope range</u>	<u>Crop Group Selection</u>
2 - 6°	2, (3), (4), 5, 7, 10
6 - 12°	5, 7, 10
12 - 20°	10
20 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

A moderately deep soil. The laterised parent material is not massive, but available moisture could be too low for certain crops. Due to its shallowness, the groups 3 and 4 are marginally suitable, group 9 unsuitable since laterite often occurs above 50 cm (20 inches) depth.

Batang Merbau Series.

On schists. A friable yellowish brown, silty clay loam overlying a firm clay loam to silty clay with weak subangular blocky structures; mica is often present in the profile. Normally a moderately deep soil (50 to 100 cm or 20 to 40 inches).

<u>Slope range</u>	<u>Crop Group Selection</u>
2 - 6°	(2), (3), (4), 5, (6), 7, (8), 9, 10
6 - 12°	5, (6), 7, (8), 9, 10
12 - 20°	9, 10
20 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

A soil suitable for a limited range of crops, it is marginal for groups 2, 3, 4, 6 and 8 due to unfavourable physical soil conditions, such as a firm consistency and heavy textures. Also structures are weak which results in unstable soil aggregates.

Serdang Series.

On sandstones, quartzites or conglomerates. Textures are generally coarse sandy loam to sandy clay loam or sandy clay depending on parent material. Colours vary between strong brown, yellowish brown or brownish yellow; weak to moderate fine and medium subangular blocky structures; profile friable throughout. Depth over 100 cm (40 inches).

<u>Slope range</u>	<u>Crop Group Selection</u>
2 - 6°	(2), 3, 4, 5, (6), 7, (8), 9, 10
6 - 12°	5, (6), 7, (8), 9, 10
12 - 20°	9, 10
20 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

A deep, friable and commonly sandy soil, with a low available water capacity for many crops when the sand fraction is coarse. Groups 2, 6 and 8 are marginal due to this low water holding capacity. There are no other physical limitations except slope.

Serdang Series, sandy clay phase.

This soil is similar to the Serdang Series described above, the fine sand fraction however is much higher. Textures vary between fine sandy clay loam to sandy clay.

<u>Slope range</u>	<u>Crop Group Selection</u>
2 - 6°	2, 3, 4, 5, 6, 7, 8, 9, 10
6 - 12°	5, 6, 7, 8, 9, 10
12 - 20°	9, 10
20 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

This phase of the Serdang Series has a higher available water capacity and is therefore suitable for a wide range of crops.

Serdang Series, moderately deep phase.

The description is the same as for the Serdang Series above. Soil depth is between 50 and 100 cm (20 and 40 inches), due to the occurrence of partly weathered parent material.

<u>Slope range</u>	<u>Crop Group Selection</u>
2 - 6°	(2), 3, 4, 5, (6), 7, 10
6 - 12°	5, (6), 7, 10
12 - 20°	forest and bamboo, 11
20 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

Crop Group selection is limited by depth of soil and available water capacity. Groups 2 and 6 are marginal.

Serdang Series, shallow phase.

The description is the same as for the Serdang Series, but soil depth is less than 50 cm (20 inches).

Slope range	Crop Group Selection
2 - 6°	5, (6)
6 - 12°	5, (6)
12 - 20°	forest, 11
20 - 25°	forest reserve, 12
Over 25°	forest reserve, 12

Soil depth is the overriding limiting factor for crop group selection.

Kedah Series

On quartzite and conglomerate ridges. Sandy loam to sandy clay; strong brown; weak to moderate structures. Laterite concretions and laterised shale pieces may be present when interbedded shales occur in the parent material. The series only occurs on slopes steeper than 20 degrees.

This soil series is only suitable for group 12 forest and other reserves.

Bungor Series.

On shale and sandstone. Brownish yellow to yellowish brown; fine sandy clay loam to fine sandy clay; moderately to well developed fine and medium subangular blocky structures; continuous clay skins; friable; deep to very deep (depth over 100 cm or 40 inches).

Slope range	Crop Group Selection
2 - 6°	(2), 3, 4, 5, (6), 7, 8, 9, 10
6 - 12°	5, (6), 7, 8, 9, 10
12 - 20°	9, 10
20 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

Groups 2 and 6 are termed marginal due to physical soil characteristics such as texture.

Bungor Series, moderately deep phase.

The description of this phase of the Bungor Series is the same as that for Bungor Series mentioned above. Laterite or laterised parent material occurs between 50 and 100 cm (20 and 40 inches).

Slope range	Crop Group Selection
2 - 6°	(2), 3, 4, 5, (6), 7, (9), 10
6 - 12°	5, (6), 7, (9), 10
12 - 20°	10
20 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

Crop limitations only due to depth of the soil, otherwise the crop group selection is the same as for the Bungor Series described above.

Kuala Brang Series.

On shales or shales interbedded with quartzites. Yellowish brown to brownish yellow fine sandy clay loam; weak to moderate

subangular blocky structures; consistency friable becoming firm with depth; shallow to moderately deep soil. (Less than 100 cm or 40 inches).

The parent material consisting of shale and vein quartz is reached within 3 feet depending on slope. On steep terrain this soil is very shallow.

Slope range	Crop Group Selection
2 - 6°	(2), (3), (4), 5, 7, (9), 10
6 - 12°	5, 7, (9), 10
12 - 20°	forest and bamboo, 11
20 - 25°	forest reserve, 12
Over 25°	forest reserve, 12

This soil is moderately deep on easy terrain, but shallow to very shallow on steeper terrain. Due to its variable depth this series is suitable only for a narrow range of crops.

Marang Series.

On shales, interbedded with sandy lenses and vein quartz or siltstones. Generally occupying upper slopes and associated with Apek Series. Pale yellow to light grey, friable fine sandy loam, overlying a yellow firm and compacted fine sandy clay loam subsoil, which is mottled. The parent material is light grey with reddish mottles and is sticky. Soil depth is very variable and ranges from shallow to moderately deep and deep.

Slope range	Crop Group Selection
2 - 6°	(4), 5, 7, 10
6 - 12°	5, 7, 10
12 - 20°	forest and bamboo, 11
20 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

This series is generally a shallow soil with a compact and often coarse-textured subsoil suitable for only a narrow range of crops. Group 4 is marginal due to the variable soil depth.

Marang Series, deep phase.

The description is the same as for Marang Series mentioned above; but the compacted subsoil occurs below 100 cm (40 inches).

Slope range	Crop Group Selection
2 - 6°	2, 3, 4, 5, 6, 7, 9, 10
6 - 12°	5, 6, 7, 9, 10
12 - 20°	9, 10
20 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

This phase of the Marang Series is suitable for a wide range of crops, although structures are weak and therefore soil aggregates may be unstable which could make it only marginally suitable for the cultivation of annual crops.

Kemuning Series.

On carbonaceous shales and silt stones, generally only occurring on upper slopes of hilly to steep terrain. Greyish brown uniform clay loam to clay; firm in consistency and moderate medium subangular blocky structures. Soil depth seldom exceeds 90 cm (36 inches).

Slope range Crop Group Selection

2 - 6°	4, 5, 7, 10
6 - 12°	5, 7, 10
12 - 20°	forest and bamboo, 11
20 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

A moderately deep and heavy textured soil, often stony, with a low available water capacity, and hence unsuitable for many crops. Its often shallow nature on steeper slopes restricts terracing; therefore group 10 has been excluded from slopes between 13 and 20 degrees.

Durian Series.

On shale. Brownish yellow; silty clay to clay; moderate to well developed coarse angular blocky and prismatic structures; firm and compact; moderately deep soil. A band of laterite 6 to 9 inches thick may occur at a depth of 50 and 100 cm (20 to 40 inches).

A moderately deep soil due to compactness of the heavy clay horizon in the subsoil.

Slope range Crop Group Selection

2 - 6°	(3), 4, 5, (6), 7, (9), 10
6 - 12°	5, (6), 7, (9), 10
12 - 20°	10
20 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

Durian Series, deep phase.

The description is as for Durian Series, but soil depth is over 100 cm (40 inches).

This phase of the Durian Series Soils has the same crop suitability as the profile described above. This is due to the compactness at shallow depth.

Munchong Series.

On shales or mildly metamorphosed shales. Brownish yellow to strong brown or redder (colour normally uniform to 120 cm or 4 feet depth); silty clay loam to silty clay; moderate to strong fine and medium blocky structures, with moderate clay skins; friable top but increasing in firmness with depth.

Slope range Crop Group Selection

2 - 6°	2, 3, 4, 5, 6, 7, 8, 9, 10
6 - 12°	5, 6, 7, 8, 9, 10
12 - 20°	9, 10
20 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

Physically this soil has no limitations and is suitable for a wide range of crops (Chandapillai and Yeow, 1969), the only limiting factor being slope.

Munchong Series, moderately deep phase.

Description as for Munchong Series above, but 50 to 100 cm (20 to 40 inches) deep, due to nodular laterite and fragmented parent material.

Slope range Crop Group Selection

2 - 6°	2, 3, 4, 5, (6), 7, (9), 10
6 - 12°	5, (6), 7, (9), 10
12 - 20°	10
20 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

Limitations mainly on soil depth and slope. Group 9 is marginally suitable, but is excluded from this soil on slopes between 12 and 20 degrees since terrace construction is restricted due to soil depth.

Apek Series.

On silty shales. Occurs on the lower slopes, and is associated with the Marang Series. Grey, loose, weakly crumbed fine sandy to silty loam, over compacted light grey and mottled fine sandy clay loam with weak structures. Soil depth is normally less than 90 cm (36 inches).

Slope range Crop Group Selection

2 - 6°	(4), 5, 7, 10
6 - 12°	5, 7, 10
12 - 20°	(10)
20 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

Only suitable for a narrow range of crops due to its compactness and relatively shallow rooting depth. Group 4 is marginally suitable.

Pohoi Series.

On carbonaceous shales. Brown or olive brown clay loam to fine sandy clay, with moderate medium blocky structures, becoming coarser with depth; consistency is friable but becomes firmer with depth. Laterite and shale fragments may be present (depth over 100 cm or 40 inches).

Slope range Crop Group Selection

2 - 6°	2, 3, 4, 5, 6, 7, 8, 9, 10
6 - 12°	5, 6, 7, 8, 9, 10
12 - 20°	9, 10
20 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

Physically a soil with few limitations, suitable for a wide range of crops. Limitations mainly on slope.

Malacca Series.

On shale. The top 25 to 50 cm (10 to 20 inches) is a strong brown, firm, sandy clay to clay with moderately developed medium subangular blocky structures. This overlies at a depth of less than 50 cm (20 inches) a thick, massive, compacted laterite band. The soil surface is characteristically covered with lateritic stones and boulders.

Slope range Crop Group Selection

2 - 6°	5, (10)
6 - 12°	forest, 11
12 - 20°	forest, 11
20 - 25°	forest reserve, 12
Over 25°	forest reserve, 12

The shallow, compacted laterite precludes this soil from most crops. Group 10 is marginal due to depth of soil. Soil depth is also insufficient for terracing on steeper slopes.

Tavy Series.

On argillaceous sediments (shales). The top 30 to 45 cm (12 to 18 inches) is friable, sandy clay loam, yellowish or strong brown with weak to moderate subangular blocky struc-

tures. This overlies a laterite band of less than 60 cm (24 inches) thick, consisting of well rounded nodules changing to angular and subangular fragments, embedded in a yellowish red to red fine sandy clay or silty clay matrix, with moderate medium subangular blocky structures. The laterite band overlies a variegated parent material of massive clay.

<u>Slope range</u>	<u>Crop Group Selection</u>
2 - 6°	2, (3), (4), 5, 7, (9), 10
6 - 12°	5, 7, (9), 10
12 - 20°	(10)
20 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

A shallow soil less than 50 cm (20 inches) deep, unsuitable for many high demanding perennial crops and marginal for some semi-perennial crops. Groups 3, 4 and 9 are marginal, while group 9 has been excluded and 10 termed marginal for the 12 to 20 degrees slope range.

Harimau Series.

On older alluvium. Yellow to yellowish brown; sandy clay loam to coarse sandy clay; weakly to moderately developed fine and medium subangular blocky structures; friable; moderately deep to very deep.

<u>Slope range</u>	<u>Crop Group Selection</u>
2 - 6°	(2), 3, 4, 5, (6), 7, (8), 9, 10
6 - 12°	5, (6), 7, (8), 9, 10
12 - 20°	9, 10
20 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

The physical characteristics are very similar to those of the Rengam Series soils.

Harimau Series, moderately deep phase.

The description is the same as for Harimau Series above, but the depth is between 50 and 100 cm (20 and 40 inches). In Johor Tengah the older alluvium derived soil occurs as a thin capping lying on older land surfaces, which commonly consist of shale. A gritty, gravelly or stony horizon occurs at the shale surface, and this horizon generally obstructs rooting.

<u>Slope range</u>	<u>Crop Group Selection</u>
2 - 6°	(2), 3, 4, 5, (6), 7, (9), 10
6 - 12°	5, (6), 7, (9), 10
12 - 20°	(9), 10
20 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

The coarse nature of this series restricts rooting and available moisture, thus excluding a number of crops with high requirements. Groups 2, 6, and 9 are marginally suitable for these reasons.

Da Tiram Series.

On older alluvium. The profile consists of about 24 inches of yellowish brown, friable sandy loam to sandy clay loam with weak structures, overlying a firm, compact, coarse sandy loam or gravelly loam. The depth is 50 to 100 cm (20 to 40 inches).

<u>Slope range</u>	<u>Crop Group Selection</u>
0 - 2°	4, 5, 7, (10)
2 - 6°	4, 5, 7, (10)
6 - 12°	5, 7, (10)
12 - 20°	(10)

The coarse and compact nature of this series precludes it from a wide range of crops. Group 10 is marginal. The depth and texture of this soil is very variable, and in some cases group 3 can be grown, whereas in others, where the texture is coarse throughout, even groups 4, 5 and 10 would be unsuitable.

Tampoi Series

On older alluvium. This soil is associated with the Harimau Series and occupies the lower and more moist positions. It is a red sandy clay to clay, with coarse blocky structures and a firm consistency (depth 100 cm or 40 inches).

<u>Slope range</u>	<u>Crop Group Selection</u>
0 - 2°	4, 5, (6), 7, (9), (10)
2 - 6°	4, 5, (6), 7, (9), (10)
6 - 12°	5, (6), 7, (9), 10
12 - 20°	(9), 10

A soil which has certain characteristics similar to the Harimau Series, but its texture is heavier and drainage poorer. Groups 6 and 3 and sometimes are marginal for these reasons.

Holyrood Series

On sub-recent alluvium. Very friable, yellowish brown weakly developed sandy loam to sandy clay loam.

<u>Slope range</u>	<u>Crop Group Selection</u>
0 - 2°	(2), 3, 4, 5, (6), 7, (10)
2 - 6°	(2), 3, 4, 5, (6), 7, (10)
6 - 12°	5, (6), 7, (10)

The very sandy texture makes it, without proper management, a poor medium for crop growth. For this reason the groups 2, 6 and 10 are classed as marginal, this series is however suitable for sugar cane.

Lunas Series.

On sub-recent alluvium. This soil is associated with the Holyrood Series and occurs in depressions where the water table is high. It is a pale grey sandy loam to sandy clay loam with weak structure.

<u>Slope range</u>	<u>Crop Group Selection</u>
0 - 2°	(3), (4), 5, (7)
2 - 6°	(3), (4), 5, (7)
6 - 12°	5, (7)

The very sandy texture and poor drainage makes this series a poor medium for crop growth, unless carefully managed.

Local Alluvium

On recent alluvium. A poorly drained soil with variable textures, but commonly heavy; varying degrees of gleying occur. Liable to frequent and serious flooding.

<u>Slope range</u>	<u>Crop Group Selection</u>
0 - 2°	(1), 5

Only group 5, grass is suitable and then only for certain species. Due to drainage requirements and flooding hazards group 1, is classed as marginal.

With soil improvements and flood protection the following crop groups could be successfully grown on the following slope range 0-2 degrees : 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, provided the soil texture is not too coarse for the required crop.

Riverine Alluvium

On recent alluvium. Texture is variable, and the soil is well to moderately well drained. Weak profile development occurs on the better drained members. Liable to occasional flooding.

<u>Slope range</u>	<u>Crop Group Selection</u>
0 - 2°	(1), (2), 3, 4, 5, (6), 7, (9), 10
2 - 6°	(2), 3, 4, 5, (6), 7, (8), 9, 10

On the 0 to 2 degrees slope range, rubber which is included in group 10 should be regarded as marginally suitable due to its deep rooting habit. Coconuts however are suitable on that slope range. Oil palms which is included in group 9 is termed marginal because of flooding risks.

With soil improvements, such as drainage and flood-protection the crop group selection could be as follows:

0 - 2	1, 2, 3, 4, 5, (6), 7, (8), 9, 10
2 - 6	2, 3, 4, 5, 6, 7, 8, 9, 10

Kranji Series

On marine alluvium, and located as narrow fringes along the coast and estuaries. The profile consists of a thin top of friable, dark greyish brown organic clay with weak structures, overlying a permanently waterlogged greenish-grey sticky and structureless clay, with sulphurous smell and plant remains at depth. The salt content in this soil can be high enough to preclude crop growth.

Without protection against marine intrusion this soil is unsuitable for agricultural development. It is marginally suitable for controlled forest exploitation and suitable as forest reserve.

Rudua Series

On old beach ridges, which run parallel to the present beach. The top soil is loose sand stained with humus, overlying a light grey to white horizon and in turn overlying a slightly compacted and cemented iron-humus horizon. A soil very low in nutrients and imposing special problems to crop growth.

Rusila Series

This series occurs in association with the Rudua Series and occupies the lower slopes and depressions of the old beach. The dark grey topsoil of loose sand overlies a light grey sand or loamy sand, in turn overlying an iron-stained horizon generally above the water-table, which commonly is very high. Peat of varying depth occurs in the lowest and waterlogged sites.

The Rudua and Rusila Series have very low agricultural potential, due to sandy textures and very low available water capacities in addition to the high water table and peaty

nature of the Rusila Series.

<u>Slope range</u>	<u>Crop Group Selection</u>
0 - 2°	5, (7), 10a, 10f
2 - 6°	5, (7), 10a, 10f

Organic Clays and Mucks

Muck: These are organic soils with a loss on ignition of between 35 and 65 percent. These soils occur as transition zones between peats and the surrounding mineral soils. The depth of the organic soils overlying material exceeds 15 cm (6 inches).

Organic Clay: Soils having an organic surface horizon exceeding 6 inches and with a loss on ignition between 20 and 35 percent. These soils are similar in appearance to muck, and also overly mineral alluvial material.

Muck and Organic Clay Soils have been mapped as an association. Depending whether the underlying material is sand or clay the crop group selection is the same as for Local Alluvium.

<u>Slope range</u>	<u>Crop Group Selection</u>
0 - 2°	(1), 5
After drainage:	
0 - 2°	2, 3, 4, 5, 6, 7, (8), 9, 10

Peat

Peat consists largely of decomposed plant material, with a loss on ignition of above 65 percent. The peat on the east coast of the Penggerang area is very acid and generally sand although areas with heavier textures occur. There are three depth phases: shallow (25 to 50 cm or 10 to 20 inches of peat), moderately deep (50 to 100 cm or 20 to 40 inches of peat) and deep (over 100 cm or 40 inches of peat).

Peat, shallow phase.

<u>Slope range</u>	<u>Crop Group Selection</u>
0 - 2°	forest reserve, 12

Peat, moderately deep phase.

<u>Slope range</u>	<u>Crop Group Selection</u>
0 - 2°	forest reserve, 12

Peat, deep phase.

<u>Slope range</u>	<u>Crop Group Selection</u>
0 - 2°	forest reserve, 12

The agricultural potential is very low due to sand, which underlies the peat over a majority of the project area, also the humification is very poor and acidity very high. In comparison with the peats on the West coast, the East coast peats are of a much poorer quality. (Chapter 6, Soils, Section 6.2.9). Whilst the peat on the east coast of the Tanjong Penggerang Region is definitely unsuitable for tree crops, it is nevertheless recommended that limited crop and drainage trials be established to examine whether this area can possibly be used for annual and semi-perennial crops.

8.4.3 Land use potential mapping.

The combined information provided by the Soils and Terrain Class Maps has formed the basis

for the construction of the Land Use Potential Maps. The accuracy of mapping is therefore largely dependent upon the accuracy of the Soils and Terrain Class Maps. The Land Use Potential Maps were compiled from the 1:63,360 Soils and Terrain Class Maps and no reduction of the Land Use Potential Maps has been carried out.

For ease of map reading Crop Groups have been combined to form six main units. These are:

- (1) Suitable for annual and semi-perennial crops.
- (2) Suitable for annual, semi-perennial and perennial crops.
- (3) Suitable for semi-perennial and perennial crops.
- (4) Suitable for perennial crops.
- (5) Suitable for forest under controlled exploitation with regeneration or for reserves.
- (6) Existing developed land, including disturbed mining land.

These six units are identified by different colours on the maps and can be regarded as simple mapping units. By definition Unit 6 is not a Land Use Potential unit. Crop groups within these main units have been identified by their crop group code (Table 8.1) and mapping units within the main units indicate where crop group changes occur.

Only the extent to which soil and terrain conditions will permit any of the crops mentioned in Table 8.1 to be grown is illustrated on the Land Use Potential maps. Which of them should be developed, the rate of development and the ultimate scale of any enterprise can only be decided after an analysis of other constraints, such as market prospects and the availability of technical knowledge.

A P P E N D I C E S

PART II

GEOLOGY AND MINERALISATION

APPENDIX A

TABULATION OF INFORMATION FROM PROSPECTING REPORTS

APPENDIX A

Prospecting permit & mining certificate records examined,
but for which no analyses are recorded.

TENGAH AREA

- AT
2/30, B17, MC177, MC178, 35.
- BT
7/69.
- IT
29/67, 1/69.
- JT
78/63.
- KT
60/63, 78/63, 28/68, 22/60, 4/34, 32/68, 18/38,
A449.
- PT
104/61, 135/61, 1/62, 81/62, 24/67, 31/67, 107/67,
135/67, 37/68, 109/68, 20/64, 139/61, B10, 39/68,
5/67, A459, A257.
- QT
157/67, 53/65, 28/65, 53/66, 168/67, 146/61, 138/60,
92/62, 22/60, 18/63, 90/63, 20/64, 91/63, 49/64,
37/66, 178/66, 195/66, 88/67, 89/67, 106/67, 127/67,
161/67, 12/68, 13/68, 43/68, 72/68, 99/68, 100/68,
101/68, 125/68, 147/68, 96/60, 97/60, 77/59, 73/60,
4/37, A182, A125, A113, 43/65.
- RT
8/61, 25/61, 13/62, 3/62, 57/62, 32/66, 71/66, 231/66,
14/62, 8/62, 25/67, 11/68, 125/68, 110/68, 111/61,
112/61, 170/63, A359, A142, A154.
- ST
76/60, B5.
- UT
179/68, 232/68, 7/39, 194/61.
- VT
79/63, 96/67, 129/67, 136/67, 121/68, 145/68, 17/61,
162/62, 192/61, 104/66, 7/51, 66/62, 20/66, 104/66,
147/66, 7/62, 19/67, 99/67, 123/68, A165.
- WT
183/55, 78/57, 3/60, 49/67, 12/36, 69/59, 131/60,
115/67, A86, A94, A109.
- BP
17/53, A69, A43, A366, A2, A12, A49, A53, A54, A55,
A8, A64, A65, A66, A71, A81, A22, A45, A77.

TENGAH AREA

Map blocks	AT	AT	BT	BT	BT	ET	HT	HT	IT	IT
Prospecting area no.	5/23	36/23	37/23	38/23	21/68	17/66	5/36	7/30	39/68	45/68
Geol. survey file no.	B251	B251	B251	B251	B15	B205	A445	A437	A459	A385
Mining cert. licence no.	MC172	MC166	MC167	MC168						
Size of area (acres)	67	43	48	48	237	735	1000		180	
Number of boreholes	72				27	37	76	45	41	
Average depth (Ft)					17	21		20	22	
Average value (KPCY)	1.05				0.06	Nil			0.23	0.03
Number of values .25 KPCY									22	
Bedrock type					WG					Schist
No pits or boreholes										
Average depth										
Grade of ore										
'Ore' tonnage volume										
Overburden depth										
Other constituents										
Mining application										
Principal mineral										
Remarks										

Map blocks	JT	KT	KT	LT	MT	MT	MT	MT	MT	MT
Prospecting area no.	40/68	142/68	1/2/36	29/28	50/61	53/62	80/63	17/63	22/60	12/68
Geol. survey file no.	A380	A380	A444	A406	A167	A179	A237	A218	A205	A376
Mining cert. licence no.					MC715	MC767				
Size of area (acres)	306	210	2680	1450	725	750	554	750	666	400
Number of boreholes		19	270	10	58	25	64	51	29	14
Average depth (Ft)		21				16	15	16	30	20
Average value (KPCY)		Nil	Nil			0.076	0.065	0.087	0.24	Nil
Number of values .25 KPCY					28	5	1	5	17	
Bedrock type		Clay/Sand		G	WG	Clay	WG	WG		
No pits or boreholes										
Average depth										
Grade or ore										
'Ore' tonnage volume										
Overburden depth										
Other constituents										
Mining application										
Principal mineral										
Remarks										

TENGAH AREA

Map blocks	PT	QT	QT	QT	QT							
Prospecting area no.	40/63	66/61	89/60	81/63	37/64	15/65	97/59	43/66	46/66	128/66		
Geol. survey file no.	A214	A140	A120	A234	A245	A270	A138	A308	A272	A282		
Mining cert. licence no.				MC698	MC801	MC802	MC803	MC804	MLO1516	MC786	MC468	MC797
Size of area (acres)	750	650	750	750	750	450	350	480	400	750		
Number of boreholes	40	40	18	71	139	61	30	76	44			
Average depth (Ft)	15	33.9	26	18	15	23	19	29	19			
Average value (KPCY)	Nil	0.033	Nil	0.116	0.303	0.32	0.1	0.24	Nil			
Number of values .25 KPCY		25		14	58	37	13	30				
Bedrock type	Clay	WG	G		Kong	Clay		Kong	Clay	WG		
No pits or boreholes												
Average depth												
Grade of ore												
'Ore' tonnage volume												
Overburden depth												
Other constituents												
Mining application												
Principal mineral												
Remarks												

Map blocks	QT	QT	QT	QT	QT	QT	QT	QT	QT	QT	QT
Prospecting area no.	37/67	146/61	17/69	42/63	143/60	13/63	19/63	17/64	54/64	18/64	
Geol. survey file no.	A341	A182	A464	A222	A132	A221	A247	A224	A240	A238	
Mining cert. licence no.				MC729	MC680					MC717	
Size of area (acres)	220	542	350	400	750	284	750	480	350	740	
Number of boreholes	57	89	133	37	59	39	26	53	114	96	
Average depth (Ft)	13	20	21	21	19	16	17	14	17	26	
Average value (KPCY)	0.005	0.118	0.26	0.81	0.36	0.19	0.016	0.09	0.21	0.26	
Number of values .25 KPCY		19	84	12	32	5	1	8	29	48	
Bedrock type	WG	Clay	Clay	Clay	WG	G	White sand	Clay	WG	Clay	
No pits or boreholes											
Average depth											
Grade of ore											
'Ore' tonnage volume											
Overburden depth											
Other constituents											
Mining application											
Principal mineral											
Remarks	4.6 M yds ³ 231 pikuls	Northern Southern part of part area selected selected for mining. for mining.									

TENGAH AREA

	QT	QT	QT	QT	QT	QT	QT	QT	QT	RT
Map blocks										
Prospecting area no.	16/66	146/66	150/68	216/68	218/68	3/41	18/60	77/60	3/33	141/59
Geol. survey file no.	A259	A287	A374	A388	A378	A38	A110	A111		A155
Mining cert. licence no.							MC655			MC603 MC635
Size of area (acres)	288	375		580	215		609	750		
Number of boreholes	23	87	16	64	24	170	67	17		
Average depth (Ft)	9	21	17	14	37	15	25	23		
Average value (KPCY)	0.015	0.24	0.14	0.27	0.477	Nil-Trace	0.23	0.086		
Number of values .25 KPCY		52	2	23	7		10			
Bedrock type	Kong	Kong	Kong	WG	WG		WG	WG	Clay	
No pits or boreholes									32	
Average depth									8	
Grade of ore									38.5%	Fe
'Ore' tonnage volume										
Overburden depth										
Other constituents									Sn O ₂	
									0.08%	
Mining application										
Principal mineral									Fe	
Remarks									Below com- mercial grade.	

	RT	RT	RT	RT	RT	RT	RT	RT	RT	RT	RT
Map blocks											
Prospecting area no.	41/63	12/65	8/62	45/64	18/66	60/65	1/66	59/68	57/68	36/68	
Geol. survey file no.	A216	A249	A213	A230	B192	A290	A265	A375	A361	A358	
Mining cert. licence no.	MC719	MC760	MC784 MC783	MC700							
Size or area (acres)	500	380	650	85 750 140	200	600	151	700	220	622	
Number of boreholes	90	85	75	44 41	42	214	48	24	21	27	
Average depth (Ft)	24	14	23	15, 15	24	19	19	16, 13	19	17	
Average value (KPCY)	0.31	0.30	0.26	0.27 0.29	0.3	0.07	0.19	0.21 0.104	Nil Trace	0.03	
Number of values .25 KPCY	56	25	41	25, 32	27	16	11	3			
Bedrock type	Clay	WG	Clay		White clay	WG	Kong	WG	WG	WG	
No pits or boreholes											
Average depth											
Grade of ore											
'Ore' tonnage volume											
Overburden depth											
Other constituents											
Mining application											
Principal mineral											
Remarks											

TENGAH ARRA

Map blocks	RT	RT	RT	RT	RT	RT	RT	ST	TT	TT
Prospecting area no.	143/68	12/40	148/51	35/64	61/68	73/66	71/62	30/61	67/61	89/61
Geol. survey file no.	A381	A31	A80	A226	A354 A366	A289	A195	B5	A171	A170
Mining cert. licence no.				MC718			MC662	MC614		
Size of area (acres)	658		152		180 50	178	730		740	750
Number of boreholes	31, 14, 69	137	14		32, 40	220	94		43	42
Average depth (Ft)	19, 20, 19	12	19		12, 16	23	14		22	12
Average value (KPCY)	0.28, 0.34 0.22	0.055	0.05		0.13 0.18	0.08	0.116		0.12	Nil
Number of values .25 KPCY	16, 11, -	2			2, 10	18	21		5	
Bedrock type	WG	W. Kong	WG		Kong		Clay		G	G
No pits or boreholes										
Average depth										
Grade of ore										
'Ore' tonnage volume										
Overburden depth										
Other constituents										
Mining application										
Principal mineral										
Remarks										Many good values.

Map blocks	TT	UT	UT	UT	UT	UT	UT	UT	UT	UT
Prospecting area no.	90/61	91/61	195/61	125/61	137/60	142/60	32/61	36/61	121/61	147/61
Geol. survey file no.	A172	A174	A166	A156	A130	A128	A187	A139	A145	A146
Mining cert. licence no.										
Size of area (acres)	694	400	600	750	750	750	450	620	350	750
Number of boreholes	50	31	9	22	56	39			15	14
Average depth (Ft)	13	14	8	17	23	20			33	26
Average value (KPCY)		0.08	Nil	Trace	Traces	Nil			0.08	Nil
Number of values .25 KPCY	3	2								
Bedrock type	Clay	G	Schist		Clay					WG
No pits or boreholes										
Average depth										
Grade of ore										
'Ore' tonnage volume										
Overburden depth										
Other constituents										
Mining application										
Principal mineral										
Remarks										

TENGAH AREA

Map blocks	VT	VT	VT	VT	VT	VT	VT	VT	WT	WT
Prospecting area no.	75/63	238/66	86/66	9/66	211/66	35/64	14/67	155/68	4/69	6/69
Geol. survey file no.	A130	A306	A278	A268	A309	A226	A344	A368	A389	A393
Mining cert. licence no.						MC718				
Size of area (acres)	750	740	750	645	350	450	680	750	680	150
Number of boreholes	56	44	29	94	35	79	50	58	40	22
Average depth (Pt)	23	14	19	20	18	15	24	19	20	22
Average value (KPCY)	Nil	Nil	Nil	0.26	0.0003	0.132	Nil	0.02	0.03	0.25
Number of values .25 KPCY	0.01			25		9				9
Bedrock type	WG		WG	Kong	WG	Clay	Kong	Clay	Clay	Clay
No pits or boreholes										
Average depth										
Grade of ore										
'Ore' tonnage volume										
Overburden depth										
Other constituents										
Mining application										
Principal mineral										
Remarks										

Map blocks	WT	WT	WT	WT	WT	WT	Dp	Dp	Dp	Dp
Prospecting area no.	29/60	29/62	23/64	1/64	79/61	30/60	5/60	32/61	1/67	158/67
Geol. survey file no.	A115	A184	A231	A219	A153	A136	A129	A187	A318	A329
Mining cert. licence no.										
Size of area (acres)	550	300		350	520	550	485	450	500	280
Number of boreholes	58	77	18	107	31	40	41	127	19	18
Average depth (Pt)	20	23	19	13	18	25	37	24	19	38
Average value (KPCY)	Traces	0.362	0.03	0.37	Nil	0.04	Trace	0.145	0.06	0.03
Number of values .25 KPCY		42		82				23		
Bedrock type	WG	Clay	Kong	Clay	Laterite	WG	W.Schist	W.Schist	Clay	Kong
No pits or boreholes										
Average depth										
Grade of ore										
'Ore' tonnage volume										
Overburden depth										
Other constituents										
Mining application										
Principal mineral										
Remarks										

TENGAH AREA

Map blocks	Dp	Dp	XT	XT	XT	WT	WT	RT
Prospecting area no.	164/68	173/66	6/55	37/55	74/60	183/55	78/57	114/61
Geol. survey file no.	A369	A312	A79	A87	A135	A86	A94	A162
Mining cert. licence no.				MC615	MC821			
					MC822			
Size of area (acres)	80	280	820	250	335			
Number of boreholes	24	60	23	30	29			10
Average depth (Ft)	35	14	28	40	38			11
					37			
Average value (KPCY)	0.06	0.06	N11	0.56	0.308			0.1
					0.204			
Number of values .25 KPCY								
					11			3
Bedrock type	Kong	Clay			WG		Clay	WG
No pits or boreholes						16	21	
Average depth						15	20	
Grade of ore							60% Fe ₂ O ₃	
'Ore' tonnage volume							<u>1.5 M tons</u>	
							8.2	
Overburden depth							4'	
							<u>722K yds³</u>	
Other constituents								
Mining application								
Principal material							Fe	
Remarks								3 High Values recorded.

Prospecting permit & mining certificate records examined,
but for which no analyses are recorded.

PENGGERANG REGION

A'P

61/65, 46/60, 60/60, 72/60, 136/60, 102/66, 5/61,
126/66, 140/66, 172/66, 3/67, 7/67, 118/67, 156/67,
103/56.

AP

10/59, 207/60, 5/63, 59/65, 22/67, 24/67, 67/69,
67/68, 10/29, 60/65, 45/66, A174, A201, A362.

B'P

193/66, 39/67, 159/68, 59/58.

BP

61/58, 60/58, 62/58, 66/58, 160/61, 161/61, 131/66,
187/66, 239/66, 41/67, 18/67, 67/67, 95/67, 148/67,
55/68, 73/68, 119/68, 99/59, A173.

C2P

116/60, 193/61.

CP

210/66, 3/34, 3/39, 40/55, 35/55, 48/65.

DP

72/62, 235/66, 18/39, 403/49, 1/51, 3/51, 1/52, 7/51,
7/53, 5/52, 2/53, 7/53, 43/62, 68/62, A214, A23, A53,
A52, A56, A60, A61, A64, A65, A73, A68, A116.

EP

122/66, 145/66, 208/66, 113/67, 132/67, 133/67, 34/68, V
41/68, 74/68, 86/68, 200/66, A296.

FP

246/66, 66/67, 183/61, 10/62, 33/62, 10/67.

GP

214/67, 10/56, 4/57, A92.

HP

141/62, 139/67, 6/39, 13/39, 3/49, 8/54, 7/54, 47/60,
48/60, 87/60, 76/63, A21, A22, A45, A76, A77, A121,
A122.

IP

55/66, 125/66, 127/66, 204/66, 206/66, 217/66, 85/67,
98/68, 124/68, 122/68, 149/68, 42/61, 98/59, 21/40,
77/62.

JP

21/64, 57/66, 206/66, 60/67, 195/67, 178/61, 152/68,
208/68.

KP

211/68, 217/68, 226/68, 29/54, 201/66, 3/68, 56/66,
247/66, A78, A298.

LP

25/67, 34/67, 58/67, 405/68, 2/52, 3/52, 4/45, 29/54,
5/58, 405/68, 109/60, 115/60, 119/60, 75/60, 18/62,
6/38

MP

7/63, 66/64, 57/66, 78/66, 25/67, 98/67, 141/67, 22/68,
38/68, 215/68, 218/68, 33/61, 126/61, 186/61, 201/61,
202/61, 112/67, A209, A256, A378.

NP

159/67, 10/68, 167/68, 194/68.

OP

3/63, 21/67, 5/29, 3/30, 1/35, 2/33, 82/62, 44/63, 77/66,
C11, A428, ML358, ML319, ML381, ML322, ML323, ML324.

PP

197/66, 189/68, 194/68, 157/68, 117/61, 138/67, 21/67,
140/67, 58/68, 2/33, 70/59, 86/60, 93/60, 60/63, 20/63,
73/63, 229/66, 234/66, A113.

QP

6/67, 17/67, 33/67, 68/67, 166/67, 225/66, A310.

SP

154/67, 59/60, 6/60, 30/62, 120/66.

TP

171/66, 109/67, 160/67, 33/68, 35/68, 40/68, 120/68,
20/60, 40/60, 139/60.

UP

45/68, 20/68, 8/30, A384, A438.

V

139/60, 2/61, 212/66, 9/67, 63/67, 151/67, 163/67, 165/67,
A150, 56/68, 146/68, 163/68, 209/68, 14/66, 125/62, A260.

W

161/68, 7/52, 91/62, 117/62, 132/62, 7/30, 6/49, 9/53,
12/58, 62/60, 51/61, 7/63, A67, A6, A57, A66.

Y

28/67, 32/67, 60/68, 62/68, 233/68, 80/62, 48/64, 13/58,
A320, A376.

Z

A72.

PENGGERANG REGION

Map blocks	A'P	A'P	A'P	A'P	A'P	A'P	A'P	A'P	A'P	A'P	A'P
Prospecting area no.	33/63	9/65	20/66	71/59	55/62	11/58	5/63	6/63	104/56	92/50	
Geol. survey file no.	A206	A263	A271	A148	A183	A359	A201	A202	A93	A107	
Mining cert. licence no.	423		798	327						766	
Size of area (acres)	750	747	620	950	740	250	750	750		200	
Number of boreholes	88	55	34	84	31	40				82	
Average depth (Ft)	14	23	22	21	28	31				31	
Average value (KPCY)	0.23	Nil	0.14	0.405	Nil	Nil				Trace	
Number of values .25 KPCY	38	-	9	55	-	Nil				Nil	
Bedrock type	WG	-	WG	WG	WG	Clay				G	
No pits or boreholes											
Average depth							83	107			
Grade of ore							15	15			
'Ore' tonnage volume											65%
Overburden depth											
Other constituents											
Mining application											
Principal mineral							Fe	Fe		Fe	
Remarks				High tin values per- mit area extended.			Low grade Fe deposit	Low grade Fe deposit			

p-0.115
s-0.025
sn-0.015

Map blocks	AP	AP	AP	AP	AP	AP	B'P	BP	BP	BP
Prospecting area no.	33/67	36/67	37/67	5/63	5/30	11/30	19/62	64/58	94/60	35/67
Geol. survey file no.	A330	A353	A356	A212	A435	A432	A185	A104	A144	A323
Mining cert. licence no.										
Size of area (acres)	300	332	367	650		115	750		735	725
Number of boreholes	25	30	25	7	116		176	6		18
Average depth (Ft)	36	27	28	30			11	8		21
Average value (KPCY)	0.03	0.003	0.01				0.04	Nil		Traces
Number of values .25 Kpcy	-	-	-				13			
Bedrock type	Clay			Clay	WG		WS			WG
No pits or boreholes										
Average depth						41				
Grade of ore						41				
'Ore' tonnage volume										
Overburden depth										
Other constituents										
Mining application										
Principal mineral									Fe	Fe
Remarks										No analyses

PENGGERANG REGION

Map blocks	C2P	CP	DP	DP	DP	DP	DP	EP	EP	EP
Prospecting area no.	61/60	3/39	5/60	26/67	2/29	121/62	81/66	100/66	179/66	23/67
Geol. survey file no.	D159	A450	A129	A327	A4	A196	A277	A279	A302	A314
Mining cert. licence no.										
Size of area (acres)	350		485	340	1000	750	700	750	750	750
Number of boreholes		29	41	39	65	27	55	-	21	23
Average depth (Ft)		14	36.8	42	21	19	17	16	19	13
Average value (KPCY)			Trace				Nil	0.01	0.03	Nil & Trace
Number of values .25 KPCY						Nil				
Bedrock type		WG		Kong			WG	WG		WG
No pits or boreholes	182									
Average depth	7'									
Grade of ore	60K Tons									
'Ore' tonnage volume	212,960 yds ³									
	24									
	178K yds ³									
Overburden depth										
Other constituents										
Mining application										
Principal mineral		Fe								
Remarks		Dauvi Iron Mine								
		workable deposit								
		of low grade material								

Map blocks	EP	EP	EP	EP	EP	FP	HP	HP	HP	HP
Prospecting area no.	110/67	192/66	174/66	199/66	203/66	214/66	29/65	2/68	182/68	2/38
Geol. survey file no.	A335	A300	A313	A373	A301	A304	A251	A370	A456	A455
Mining cert. licence no.										
Size of area (acres)	640	750	748	750	610	750	300	117	550	
Number of boreholes	17	34	42	17	34	16	22	74	53	69
Average depth (Ft)	23	18	16	13	14	16	30	15	37	35
Average value (KPCY)	Nil & Trace	0.03	0.05	Traces	0.069	Nil & Trace	Nil	0.32	0.24	Traces
Number of values .25 KPCY					3			19	12	
Bedrock type		Red Block Weathered Later-Clay Sand	Schist	ite	WG	WG	WG	WG	Kong	WG
No pits or boreholes										
Average depth										
Grade of ore										
'Ore' tonnage volume										
Overburden depth										
Other constituents										
Mining application										
Principal mineral										
Remarks										

PENGGERANG REGION

Map blocks	HP	HP	HP	HP	HP	HP	HP	HP	HP	HP
Prospecting area no.	17/53	32/55	5/56	28/40	71/60	177/61	34/62	105/62	142/62	63/63
Geol. survey file no.	A69	A84	A89	A35	A116	A180	A169	A181	A336	A232
Mining cert. licence no.			ML466							
Size of area (acres)		230		1250	899	500	200	750	63	650
Number of boreholes	40	21	29	112		36	27	38	48	15
Average depth (Ft)	11	19	18	23		16	14	14	16	14
Average value (KPCY)	0.5	Trace		0.03		0.02	0.18	0.01	Nil	0.05
Number of values .25 KPCY	18			1		1	4			1
Bedrock type			G	Clay	P & S ore	WG	Clay	WG		Clay
No pits or boreholes					26					
Average depth					61					
Grade of ore										
'Ore' tonnage volume										
Overburden depth										
Other constituents										
Mining application										
Principal mineral					Fe					
Remarks						High sn value re- corded in area.				

Map blocks	HP	HP	HP	IP	IP	IP	IP	IP	IP	IP
Prospecting area no.	24/65	17/66	41/66	132/66	98/66	175/66	152/67	75/68	54/69	12/30
Geol. survey file no.	A266	A267	D242	A340	A281	A322	A333	A351	A463	A414
Mining cert. licence no.		MC824 MC825			MC826 MC827 MC828 MC829				MC292	
Size of area (acres)	480	642	150	370	750	720	680	692	25, 19 & 7	
Number of boreholes	34	53	21	32	92	23	13	35	23, 20 & 6	247
Average depth (Ft)	16	15	8	14	12	16	19	13	11, 18 & 14	
Average value (KPCY)	0.004	0.21	0.08	0.23	0.27	Traces	0.38	0.175	0.08 0.148 0.15	
Number of values .25 KPCY		16	2	7	54			12	2	
Bedrock type	Yellow-grey	Clay	G	Kong	Clay	WG	WG	Kong	WG	
No pits or boreholes										
Average depth										
Grade of ore										
'Ore' tonnage volume										
Overburden depth										
Other constituents										
Mining application										
Principal mineral										
Remarks					Only small prospected			58 acres contains selected 0.17 Kpcy 6467 pikuls.		

FENGGERANG REGION

Map blocks	IP	IP	IP	IP	IP	JP	JP	JP	JP	JP
Prospecting area no.	13/29	118/68	47/67	13/40	142/62	2/65	23/65	123/66	3/39	4/39
Geol. survey file no.		A386	A357	A454	A294	A250	A256	A293	A19	A20
Mining cert. licence no.							ML415 ML416			
Size of area (acres)		610	730		750	620	700	720	150	150
Number of boreholes	30	50	25	70	24	56	77	17		43
Average depth (Ft)	15	20	13	17	25	19	12	38		14
Average value (KPCY)		Nil	0.08	Traces	Traces	0.023	0.22	Traces		0.25
Number of values .25 KPCY							34			10
Bedrock type		Sandy-Clay	Sandy-Clay		WG	WG	Kong	WG		WG
No pits or boreholes										
Average depth										
Grade of ore										
'Ore' tonnage volume										
Overburden depth										
Other constituents										
Mining application										
Principal mineral										
Remarks										

Map blocks	JP	JP	JP	JP	LP	LP	LP	LP	LP	LP
Prospecting area no.	7/40	47/61	38/63	44/68	32/67	8/55	3/63	244/66	245/66	9/29
Geol. survey file no.	A29	A141	A199	A352	A320	A83	C11	C13	C14	A411 ML 46
Mining cert. licence no.										
Size of area (acres)	320	150	243	400	600	300	55	750	340	
Number of boreholes	23	14	51	45	24		5	41	49	
Average depth (Ft)	19	23	16	22	14	40	64	22	31	
Average value (KPCY)	0.04	0.408	0.13	0.23	Nil	Nil		0.21	0.03	
Number of values .25 KPCY	1	12	11	12		Nil		14		
Bedrock type	WG	WG	WG	Laterite			W.Shale	Clay	Clay	
No pits or boreholes										
Average depth										
Grade of ore										
'Ore' tonnage volume										
Overburden depth										
Other constituents										
Mining application										
Principal mineral										
Remarks										

PENGGERANG REGION

Map blocks	MP	MP	MP	MP	OP	OP	PP	PP	PP	PP
Prospecting area no.	230/68	165/68	219/68	3/70	245/66	244/66	225/66	65/67	127/67	199/68
Geol. survey file no.	A392	A363	A379	A466	C14	C13	A310	A328	A332	A364
Mining cert. licence no.		MC845								MC844
Size of area (acres)	360	722	600	680	340	750	727	460	350	443
Number of boreholes					34	90	30	66	21	
Average depth (Ft)					31	20	19	24	15	
Average value (KPCY)					0.03		0.03	Nil	Nil-Trace	
Number of values .25 KPCY						14				
Bedrock type					Clay	Clay	Kong	Sand-Clay		
No pits or boreholes	23		66	171						
Average depth				9						
Grade or ore	49.4		55.05	53.86						
	Al ₂ O ₃		Al ₂ O ₃	Al ₂ O ₃						
'Ore' tonnage volume	463Kft ³			142,535						
Overburden depth										
Other constituents			S ₁ O ₂ -8%	S ₁ O ₂ -4.70%						
			Fe ₂ O ₃ 8%	Fe ₂ O ₃ -12.14%						
Mining application										
Principal mineral	A1		A1							
Remarks	Ramunia Bauxite		Ramunia Bauxite							

Map blocks	QP	QP	QP	QP	SP	SP	SP	SP	TP	TP
Prospecting area no.	2/67	131/67	65/68	36/69	143/67	1/57	2/57	43/60	55/67	2/68
Geol. survey file no.	A346	A337	A362	A467	A348		A102	A114	A317	A350
Mining cert. licence no.						MC628	MC629			
Size of area (acres)	700	650		750	720	150	200	3000	750	540
Number of boreholes	15	54		85	62			67	26	36
Average depth (Ft)	14	17		24	32			18	17	17
Average value (KPCY)	Nil	Nil		Nil	Nil			Nil	Nil	Nil
Number of values .25 KPCY								Nil		
Bedrock type	Clay	Sand + Clay		Clay	Sand + Clay			W.Shale		
No pits or boreholes	32					4	6	7		
	21									
Average depth	A12O ₃ -30%									
Grade of ore						55	53			
'Ore' tonnage volume										
Overburden depth										
Other constituents										
Mining application										
Principal mineral	A1					Fe	Fe A1 - sn			
Remarks						Bukit Penawar	Bukit Twatow	Bauxite trace-tin-nil		

FENGGERANG REGION

	TP	TP	TP	UP	UP	UP	UP	UP	UP	UP
Map blocks										
Prospecting area no.	36/67	36/65	4/60	77/59	2/63	20/61	22/68	25/68	15/68	151/60
Geol. survey file no.	A319	A91	A106	A125	A198	A149	A387	A390	A383	A126
Mining cert. licence no.										MC624
Size of area (acres)	700		980	750	2447	60	390	278	600	800
Number of boreholes	23		16				65	42	72	
Average depth (Ft)	18		34	15			33	29	31	
Average value (KPCY)	N11		N11	0.06			0.06	0.04	0.01	
Number of values .25 KPCY			N11	1			1			
Bedrock type			Rhyolitic Volcanic	Clay	Clay		Kong		Kong	
No pits or boreholes					221	50				58
Average depth						12				
Grade of ore					55.34% A1203					53% A1203
'Ore' tonnage volume		6.03Myds^3 3.01M tons				124Ktons 181.7K yds ³				
Overburden depth										S102-5%
Other constituents										Fe2O3-9%
Mining application										A1
Principal mineral			Fe		A1	A1				Ramunia
Remarks					Mined & workout					

	UP	UP	UP	UP	V	V	V	V	V	V
Map blocks										
Prospecting area no.	33/23	21/29	23/48	47/59	88/59	3/60	28/60	49/60	3/61	3/60
Geol. survey file no.	A160	A418	A44	A101	A105	A109	A112	A119	A124	A108
Mining cert. licence no.	MC163	ML480	ML248	MC591		MC609				
Size of area (acres)	500	200	499	750	1970	32	1429	500	750	1200
Number of boreholes	50	34	72		15	108				
Average depth (Ft)	11	15	33		67	17				
Average value (KPCY)		0.26	0.49		N11	0.33				
Number of values .25 KPCY		10	40			211				
Bedrock type				Clay	WG	WG				
No pits or boreholes				254				11	79	36
Average depth				7				13	6	
Grade of ore				56-25% A1203				38% A1203	54% A1203	35% A1203
'Ore' tonnage volume				800K ton 61				680K tons 41		
Overburden depth										
Other constituents				S102-7.45				Fe2O3 35%		S102-13% Fe2O3-70%
Mining application								A1	A1	A1
Principal mineral					A1					No Bauxite of ore grade
Remarks										

PENGGERANG REGION

Map blocks	V	V	V	V	V	V	V	V	V	V
Prospecting area no.	29/62	39/62	131/62	11/63	3/64	32/65	14/66	30/66	82/66	20/67
Geol. survey file no.	A176	A158	A204	A211	A223	A345	A260	A283	A274	A339
Mining cert. licence no.		MC635								
Size of area (acres)	80	80	260	118	100	196	40	500	210	250
Number of boreholes	12			32	16	33		104	38	33
Average depth (Ft)	19			15	29	19		12	23	27
Average value (KPCY)	Nil			0.37	0.126	0.104		0.12	Trace	0.22
Number of values .25 KPCY	W. Tuff			11	2	1		17	Nil	15
Bedrock type				Limoni- tised shale	WG				Kong	Sand- Clay
No pits or boreholes		34	26							
Average depth		7	9							
Grade of ore		54%	54%							
'Ore' tonnage volume		A1203	A1203							
		<u>168K tons</u>								
		9'								
Overburden depth										
Other constituents				S:0.29%						
				Fe2O35%						
Mining application										
Principal mineral		A1	A1							
Remarks				Ramunia	Some High Values shown Anglo-Malayan Development Ltd.					

Map blocks	V	V	V	V	V	V	V	W	X	X
Prospecting area no.	54/67	20/68	244/68	34/69	34/65	28/67	145/67	49/61	157/61	33/70
Geol. survey file no.	A305	A384	A462	A394	A326	A349	A355	A297	A164	A434
Mining cert. licence no.										MA479
Size of area (acres)	132	323	67, 235	40	270	106	600	240	38	
Number of boreholes		46	48, 53	25		17	81	35		55
Average depth (Ft)		36	19, 19	13		33	22	37		35
Average value (KPCY)		0.06	0.29 0.27	0.25		Nil	Nil - Trace	Nil		Nil
Number of values .25 KPCY		1	35	15						
Bedrock type		Kong	Kong			Clay	Kong		Clay	
No pits or boreholes										3
Average depth										8
Grade of ore										55% - A1203
'Ore' tonnage volume										5
Overburden depth										
Other constituents										
Mining application										
Principal mineral										A1
Remarks						A1				
						No results or analyses				

PENGGERANG REGION

Map blocks	X	X	X	X	X	X	X	X	X	X
Prospecting area no.	5/49	12/49	13/58	86/59	93/59	63/61	95/61	7/62	60/62	133/62
Geol. survey file no.	A51	A50	A96		A103	A161	A137	A165	A189	A203
Mining cert. licence no.		ML511					MC619	MC476		
Size of area (acres)			231	273	650	750	150	90	470	37
Number of boreholes								32	18	
Average depth (Ft)								28	39	
Average value (KPCY)								N11	0.006	
Number of values	.25 KPCY									
Bedrock type				Clay				Clay	WG Bauxite	Alluvial
No pits or boreholes			5	82	82	13	99			25
Average depth			5	5	5	8	43			11
Grade of ore			40%	57%	Selected	55%	56%			58.6%
			A12O3	A12O3m	area	A12O3	A12O3			A12O3
'Ore' tonnage volume	<u>188K tons 18K tons</u>			5'	5'	5'	4'			<u>17.9K tons</u>
Overburden depth										9'
Other constituents							S1O2-11%			
							Fe2O3-3%			
Mining application										A1
Principal mineral	A1		A1	A1	AL	A1	A1			
Remarks			No com-			High				
			mercial value			silica				

Map blocks	X	Y	Y	Y	Y	Y	Y	Y	Y	Y
Prospecting area no.	6/63	23/63	62/63	83/63	6/64	203/64	25/65	6/65	1/66	22/66
Geol. survey file no.	A202	A197	A220	B151	A241	A163	A254	A246	A252	A275
Mining cert. licence no.			ML478							
Size of area (acres)	750	134	296		94	110	272	67	22	191
Number of boreholes		57	24	64		18				127
Average depth (Ft)		37	22	8		60				47
Average value (KPCY)		0.185	N11	0.03		0.004				0.31
Number values		.25 KPCY	15	16						94
Bedrock type	WG	Clay	Clay	W.Clay	W.Clay		Clay			Schist
No pits or boreholes	107						77	32	53	
Average depth							13		6	
Grade of ore					44%		55%	44.31%	56%	
					A12O3		A12O3	A12O3	A12O3	
'Ore' tonnage volume	<u>4</u>						<u>29K tons</u>	<u>36K yds</u>	<u>3'</u>	
Overburden depth										
Other constituents					S1O2-13%		S1O2-14.2%			
					Fe2O3-18%		Fe2O3-18.37%			
Mining application										
Principal mineral	Fe				A1		A1	A1	A1	
Remarks	Insufficient Ore & unmarketable grade				S.E.AB.Ltd.					Some very high values

PENGGERANG REGION

1950-1951

Map blocks	Y	Y	Y	Y	Y
Prospecting area no.	104/67	23/48	47/64	2/63	12/58
Geol. survey file no.	A338	A44	B170	A198	A96
Mining cert. licence no.		ML248			
Size or area (acres)	270		630	2447	131
Number of boreholes	49	72	17, 15		
Average depth (Ft)	15	32	15		
Average value (KPCY)	0.22	0.51	0.237		
Number of values .25 KPCY	14	38	13		
Bedrock type					
No pits or boreholes					51
Average depth					4'
Grade of ore				55% Al ₂ O ₃	38% Al ₂ O ₃
'Ore' tonnage volume					
Overburden depth					
Other constituents				SiO ₂ - 9% Fe ₂ O ₃ - 9%	SiO ₂ - 36% Fe ₂ O ₃ - 4%
Mining application					
Principal mineral				AL	
Remarks					Some high value

TABLE III - MINING

PRODUCTION OF INDIVIDUAL MINES AND AVERAGE LABOUR FORCE

No.	Name	1965		1966		1967		1968		Remarks
		Output (Tons)	Average Labour							
10	...	550	31	577	31	597	31	621	31	
11	...	714	107	673	7	674	108	621	108	
12	...	628	27	660	26	657	26	650	27	Others
13	...	1079	34	126	33	791	33	662	34	
14	...	495	31	495	31	495	31	495	31	
15	...	103	25	617	25	657	25	717	25	Others
16	...	74	-	-	-	-	-	-	-	
17	...	685	35	-	-	-	-	-	-	
18	...	667	25	724	25	797	25	760	25	
19	...	675	27	674	27	725	27	682	27	
20	...	330	19	418	-	-	-	-	-	
21	...	100	-	-	-	-	-	-	-	
22	...	-	-	677	25	625	25	1020	25	Others
23	...	502	17	460	-	-	-	-	-	
24	...	567	25	541	25	605	25	651	25	Others

PART II

APPENDIX B

PRODUCTION OF INDIVIDUAL MINES AND AVERAGE LABOUR FORCE

1966 - 69

25	...	1498	41	1448	32	1462	32	1479	32	Others
26	...	1470	38	1448	32	1462	32	1479	32	
27	...	408	24	827	24	799	24	1081	24	
28	...	1803	25	711	25	647	25	1843	25	Others
29	...	912	24	505	24	885	24	1089	24	
30	...	254	29	752	31	1027	31	943	31	
31	...	627	25	627	25	627	25	627	25	
32	...	526	-	717	21	82	-	-	-	
33	...	671	-	-	-	-	-	-	-	
34	...	85	-	-	-	-	-	-	-	
35	...	190	25	627	24	675	24	745	24	
36	...	1025	26	1282	26	1407	26	1704	26	Others
37	...	627	25	627	25	627	25	627	25	
38	...	290	29	661	29	720	29	1117	29	Others
39	...	307	-	374	19	426	19	747	19	
40	...	474	23	1775	28	52	-	673	28	
41	...	107	31	1217	31	104	31	617	31	Others
42	...	173	24	508	24	472	24	562	24	
43	...	577	24	675	24	675	24	675	24	
44	...	627	25	627	25	627	25	627	25	Others

PART II APPENDIX B

PRODUCTION OF INDIVIDUAL MINES AND AVERAGE LABOUR FORCE 1966-69

TC No.	Name	1965		1966		1967		1968		1969		Remarks
		Output	Staff									
148	Poh Nyen Tin Mine	860	32	677	32	197	?					
152	Pelepah Kanan Mining Co.	3141	165	6741	-	6074	186	6421	182	6627	-	
159	Loong Cheong Kongsai No.2 Mine No.1	860	27	580	26	474	29	540	21	508	-	Closed
161	Wai Fong Kongsai Mine No.2	1019	24	754	28	701	26	403	-			
166	Sim Teek Hing Tin Mg. Co. Ltd. No.1			893	35	708	-					
167	Eng Kwai Tin Mine No.1	503	25	617	25	377	25	517	29	238	-	Closed
170	Sin Hoa Realty Co. Ltd. Mine No.1	76	-									
185	Chee Nam Kongsai No.1	686	35	124	-							
187	Chye Heng Loong Mine Co. No.1	986	25	556	25	598	26	363	-	489	-	
190	Loong Cheong Kongsai No.2 Mine No.2	979	27	804	25	578	29	525	11	249	-	
191	Chong Khoon Lai Tin Mine	330	19	216	-							
192	Pelepah Kanan Mining Ltd. No.2	1134	-									
193	Toong Hing Loong Tin Mining Co. Ltd.			873	45	805	35	1448	43	1666	-	
195	Yik Kee Tin Mine	562	17	445	-							
196	Eng Kwai Tin Mine No.2	583	28	541	28	405	28	421	27			Closed
201	Chye Heng Loong Mining Co. No.2	614	20	800	20	508	24	347	-	386	-	
202	Yap Chee Nan Kongsai No.2	18	8	346	33	69	-					
203	Tengkil Mining Sydn. Ltd. No.1	1638	45	1807	45	1297	45	1720	41	1273	-	
206	Tengkil Mining Sydn. Ltd. No.2	1470	32	2442	32	1182	40	1568	35	1273	-	
208	Seng Mining Co. Mine No.1	406	24	665	24	799	24	1184	30	238	-	
220	Seng Mining Co. Mine No.2	1203	25	711	25	846	25	1249	32	1172	-	
224	Seng Mining Co. Mine No.3	917	24	368	24	865	24	1249	32	317	-	
209	Wai Fong Kongsai Mine No.1	264	28	725	32	267	18	643	39			
228	Wai Fong Kongsai Mine No.3	627	30	1022	41	1504	30					
230	Sin Hoa Realty Co. Ltd. Mine No.2	338	-	311	25	62	-					
235	Meng Wah Tin Mine	221	-									
236	Pelepah Kiri Mining Co.	98	-									
240	Eng Kwai Tin Mine No.3	490	34	657	34	324	24	246	-			
241	Tengkil Mining Sdn. No.3	2373	28	1552	28	1681	37	1394	30	864	-	
242	Yuen Wan Loong Tin Mine Ltd.			621	31	63	-					
252	Foh Woh Tin Mine	258	29	861	30	775	26	1117	26	803	-	
253	Chye Heng Loong Mine No.3	269	-	374	15	466	18	708	30	21	-	Closed
255	Sin Kian Huat Mining Co. Ltd.	434	22	1376	26	32	-	251	-			
257	Seng Mining Co. Mine No.4	592	24	1311	31	984	33	842	34	991	-	
258	Ngee Seng Tin Mining Co.	373	26	388	24	492	24	362	18	302	-	
260	Ting Soon Tin Mine			570	28	628	28	331	-			
262	Loong Cheong Kongsai No.2 Mine No.3	12	21	600	26	633	29	248	-	75	-	Closed

TC No.	Name	1965		1966		1967		1968		1969		Remarks
		Output	Staff									
263	Berjaya Sharikat Lombong			258	-							
270	Eng Kwai Tin Mine No.4	354	31	656	28	319	22	21	-			
271	Johore Tin Mining Co.	33	25	395	39	32	-					
274	Hoe Peng Tin Mining Co.	7	24	482	30	742	-	516	22	34	-	Closed
277	Tengkil Mining Sdn. No.4	289	21	1913	22	1657	33	1530	28	1089	-	
284	Hong Loong Mining Co. Ltd. No.2			620	32	693	-	706	29			Closed
288	Sharikat Lombong Bersatu					147	22	207	-			
290	Yik Kee Tin Mine No.3			51	-							
291	Wong Teng Heng Tin Mine			302	-							
292	Kim Say Tin Mining Co. Ltd.			416	38	904	36	1267	38	1002	-	
297	Fow Seng Tin Mines			172	32	624	23	1060	23	497	-	
298	Wai Fong Kongsı Mine No.4			177	-							
300	Lombong Tin Mining Co. Ltd.			100	28	226	29	720	-	870	-	
304	Seng Mining Co. No.5							99	22	879	-	
305	Thien Foong Mining Co.			142	28	61	-					
306	Yuen Choy Tin Mine Co.			349	16	287	-					
307	Eng Kwai Tin Mine No.5			140	20	627	20	173	-			
309	Sim Kian Huat Mining Co. Ltd. No.2			11	24	486	31	609	24	325	-	Closed
312	Hock Hin Tin Mining Co. Ltd.			108	20	286	20	552	20	268	-	
313	Sin Yek Kee Tin Mine No.1			293	17	447	20	831	26	614	-	Closed
314	Sin Yik Kee Tin Mine No.3			29	26	30	-					
317	Tung Soon Mining Co. No.2					444	28	645	30	172	-	
318	Heng Lee Sisek Tin Mine			16	17	181	-	714	31	747	-	
320	Yee Poh Tin Mining Kongsı					475	29	208	-			
321	Yang Tinggi Mining Co.				23	181	-					
324	Poh Nyen Tin Mine No.2					284	-					
325	Poh Thian Mining Sdn. Bhd.					520	25	98	-			
327	Johore Bahru Mining Sdn. Bhd.					507	37	1230	35	707	-	
329	Chye Hing Ling Hak Kee Mg. Co. No.4					376	22	250	-			
332	Chye Seng Tin Mining Co.					276	28	453	42	340	-	
333	Soon Brothers Tin Mining Co.					295	16	362	23	4	-	
338	Johore Tin Mining Sdn. Bhd.					173	45	220	33	606	-	Closed
340	Hup Seng Kung Mining Sdn. Bhd.							296	26	275	-	Closed
342	Ngee Seng Tin Mining Sdn. Bhd.						20	1097	28	932	-	
343	Tengkil Mining Sdn. Ltd. Mine No.5							821	26	1517	-	
350	Hup Seng Mining							48	-			
353	Sin Kian Huat Mining Co. Ltd. No.3							269	22	327	-	Closed
356	Poh Nyen Mining Dev. Co.							208	32	381	-	Closed
357	Ngee Seng Tin Mining Sdn. Bhd. No.2									87	-	
360	Loong Cheong Kongsı No.2 Mine No.4							93	17	19	-	Closed
362	Ka Chong Tin Mining Sdn. Bhd.									652	-	
368	Wofong Mining Sdn. Bhd. No.2									58	-	Closed
371	Thian Pow Tin Mining									81	-	

No. No.	Name	1965		1966		1967		1968		1969		Remarks
		Output	Staff	Output	Staff	Output	Staff	Output	Staff	Output	Staff	
377	Seng Hin Tin Mine									27	-	
502	Kota Tinggi Mining Sdn. Bhd.					700	-	10550	12			Iron
674	Sin Kian Huat Mining Co. Ltd. No.1											
727	Eng Kwai Tin Mine Sdn. Bhd.											
766	Sharikat Metal Mining Co.					2800	-	4995	13			Iron
642	Sharikat Lombong Sedili Sdn. Bhd.					30181	63	84086	67			Iron
579	Tai Oon Kian Bauxite Mine			53304	-							Bauxite
	Ramunia Bauxite Ltd.	190957	165	88886	129	276737	128	387257	128	412680	-	Bauxite
467	S.E.A. Bauxite Ltd.	488287	175	667863	201	505906	209	391789	226	643388	-	Bauxite
	Heah Foo Seang R.E.Ltd. Penabok Mine	144397	-	110138	84	102746	-	6996	-			Bauxite
661	Sungei Rengit Mining	19531	11	20,256	10							Bauxite
603	Slow Wong Fatt Mine	12278	41	35569	-	22357	-	3638	-			Iron Closed
		42	36									
	Total (Tin-Piculs)	25026	945	37958	1274	85965	1339	39400	1237	30011	-	
	Total (Iron-Tons)	12278	41	35569		56038		103269	92			
	Total (Bauxite-Tons)	843172	392	976016	424	885389	337	786042	354	1056068		

Note: Bauxite and Iron quantities are in tons, tin is in piculs.

PART II

TIME TABLE FOR PROSPECTING AND CLEARANCE

AREA THREE

No. Ref. Number	Location	Future Land Use	Desirable Reclamation For Development	Desirable Reclamation If None	Effect on surrounding land use
1	S. 1200	Agriculture	Yes		
2	Section 34, RAYNES & SAGE and 34, CHARLES	Agriculture	Yes	Is suitable for farming after removal of structures	Will affect area with the old structures, now vacant, being removed, however it will not be affected with possible future use as there are no structures.
3	Part of S. 1200	Agriculture	Within 5 years		
4	Upper reaches of S. 1200	Agriculture	Within 5 years		
5	Lower reaches of S. 1200	Agriculture	Yes		
6	Upper reaches of S. 1200	Recreation area & reservoir	Yes	Should be cleared out by 1977	Will affect existing structure with possible removal of remaining structure.

PART II

APPENDIX C

AREA THREE

No. Ref. Number	Location	Future Land Use	Desirable Reclamation For Development	Desirable Reclamation If None	Effect on surrounding land use
TIME TABLE FOR PROSPECTING AND CLEARANCE					
1	S. CHARLES and Upper S. LENOX	Recreation area Reservoir & Water Works	Yes	Should be cleared out by 1977	Will affect area with the old structure, now vacant, being removed, however it will not be affected with possible future use as there are no structures.
2	Upper reaches of S. RAYNE & S. SAGE RAYNES	Agriculture & possible alternative source for water supplies	Yes	Should be cleared out by 1977	Will affect area with the old structure, now vacant, being removed, however it will not be affected with possible future use as there are no structures.
3	Upper reaches of S. SAGE RAYNES	Agriculture & possible alternative source for water supplies	Within 5 years	Should be cleared out by 1977	Will affect area with the old structure, now vacant, being removed, however it will not be affected with possible future use as there are no structures.
4	Reaches of S. SAGE	Agriculture	Within 5 years	Should be cleared out by 1977	Will affect area with the old structure, now vacant, being removed, however it will not be affected with possible future use as there are no structures.

PART II APPENDIX C

TIME TABLE FOR PROSPECTING AND CLEARANCE

JOHOR TENGAH

Map Ref. Number	Location	Future Land Use	Desirable Priorities For Prospecting	Desirable Priorities If Mined	Effect on Recommended Land Use
1	S. SEBOL	Agriculture	Now		
2	Section of S.SAYONG & some small tributaries	Agriculture	Now	As soon as possible after results of prospects	Land mined over will, for all practical purposes, become sterile. Quality of water will be affected with possible escalation of treatment costs.
3	Part of S.CHENAS system	Agriculture	Within 3 years		
4	Upper reaches of S.JENGELI	Agriculture	Within 5 years		
5	Lower reaches of S.JENGELI	Agriculture	Now		
6	Upper reaches of S.LINGGIU	Catchment area & Reservoir	Now	Should be mined out by 1977	Will affect quality of water with possible escalation of treatment costs

TANJONG PENGGERANG

Map Ref. Number	Location	Future Land Use	Desirable Priorities For Prospecting	Desirable Priorities If Mined	Effect on Recommended Land Use
1	S. CHEMANGAR and Upper S. LEBAM	Catchment Area Reservoir & Water Works	Now	Should be mined out by 1977	As for (6) above
2	Upper reaches of S. PAPAN & S. PAPAN KECHIL	Agriculture & Possible alternative source for water supplies	Now	Should be mined out by 1977	Land mined over will, for all practical purposes, become sterile. Quality of water will be affected with possible escalation of treatment costs.
3	Upper reaches of S. SEDILI KECHIL	Agriculture & possible alternative source for water supplies	Within 3 years	Small area - should be mined out by 1975	
4	Headwaters of S. PANTI	Agriculture	Within 5 years	Small area - should be mined out by 1977	Land mined over will, for all practical purposes become sterile.

PART II
AN INVESTIGATION OF THE GUNONG SUMALAYANG LIME

1. INTRODUCTION

The work was carried out in the period July 1934 to August 1935. The aim of the project was to investigate a rock limestone occurrence on Gunung Sumalayang, situated some 17 miles north-west of Ipoh (Fig. 1), to establish whether it was a commercially viable deposit located in the area.

The limestone was discovered by officers of the West Malayan Geological Survey in the course of their routine geological reconnaissance. Its presence was first noted in a report on Malaya, but probably first noted at Gunong Sumalayang, the name investigated in the last two years.

The importance of a cheap source of carbonate for increasing the use of Portland cement, which is largely made from imported raw materials, has been the subject of numerous discussions, have been the subject of numerous papers and conferences with representatives of the various governmental departments concerned.

From the point of view of regarding the well-being of the country, the limestone is of great importance. However, the cheapest source of carbonate is always imported (essentially foreign) limestone. The positive result of using domestic limestone is not only the saving of foreign exchange, but also the development of the local limestone industry, which is a source of employment and income to the country.

The limestone is of a type which is suitable for the manufacture of Portland cement. It is a hard, crystalline rock, which is a source of employment and income to the country. It is a hard, crystalline rock, which is a source of employment and income to the country.

AN INVESTIGATION OF THE GUNONG SUMALAYANG LIMESTONE

The limestone is of a type which is suitable for the manufacture of Portland cement. It is a hard, crystalline rock, which is a source of employment and income to the country. It is a hard, crystalline rock, which is a source of employment and income to the country.

A preliminary study was made by the committee, consisting of the Director of the Geological Survey, the Director of the Mining Department, and the Director of the Public Works Department. The committee was formed in 1934.

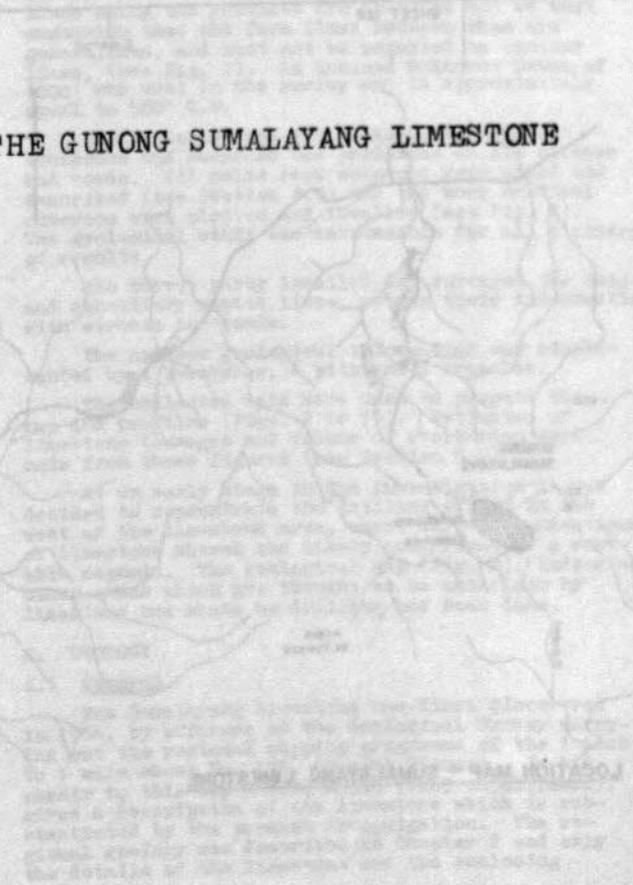
The committee was formed in 1934. The committee was formed in 1934. The committee was formed in 1934. The committee was formed in 1934. The committee was formed in 1934.

The investigation was led by the committee, with the Geological Survey and the Mining Department.

The limestone is of a type which is suitable for the manufacture of Portland cement. It is a hard, crystalline rock, which is a source of employment and income to the country. It is a hard, crystalline rock, which is a source of employment and income to the country.

PART II

APPENDIX D



KEY TO ILLUSTRATIONS



OVERBURDEN sandstone boulders, soil, clay, etc...



DOHOL METASEDIMENTS OVERLYING LIMESTONE siltstones, sandy mudstones etc...



UPPER SUMALAYANG LIMESTONE medium grey, pale grey to almost white, massive limestones.



LOWER SUMALAYANG LIMESTONE black to medium grey, bedded limestones with argillaceous partings



DOHOL METASEDIMENTS BELOW LIMESTONE dark grey to black indurated shales and mudstones often with calcareous bands and lenses.



Calculated tonnage of limestone shown on profiles.



Rock outcrop, shown on profiles.

BH

Borehole

S

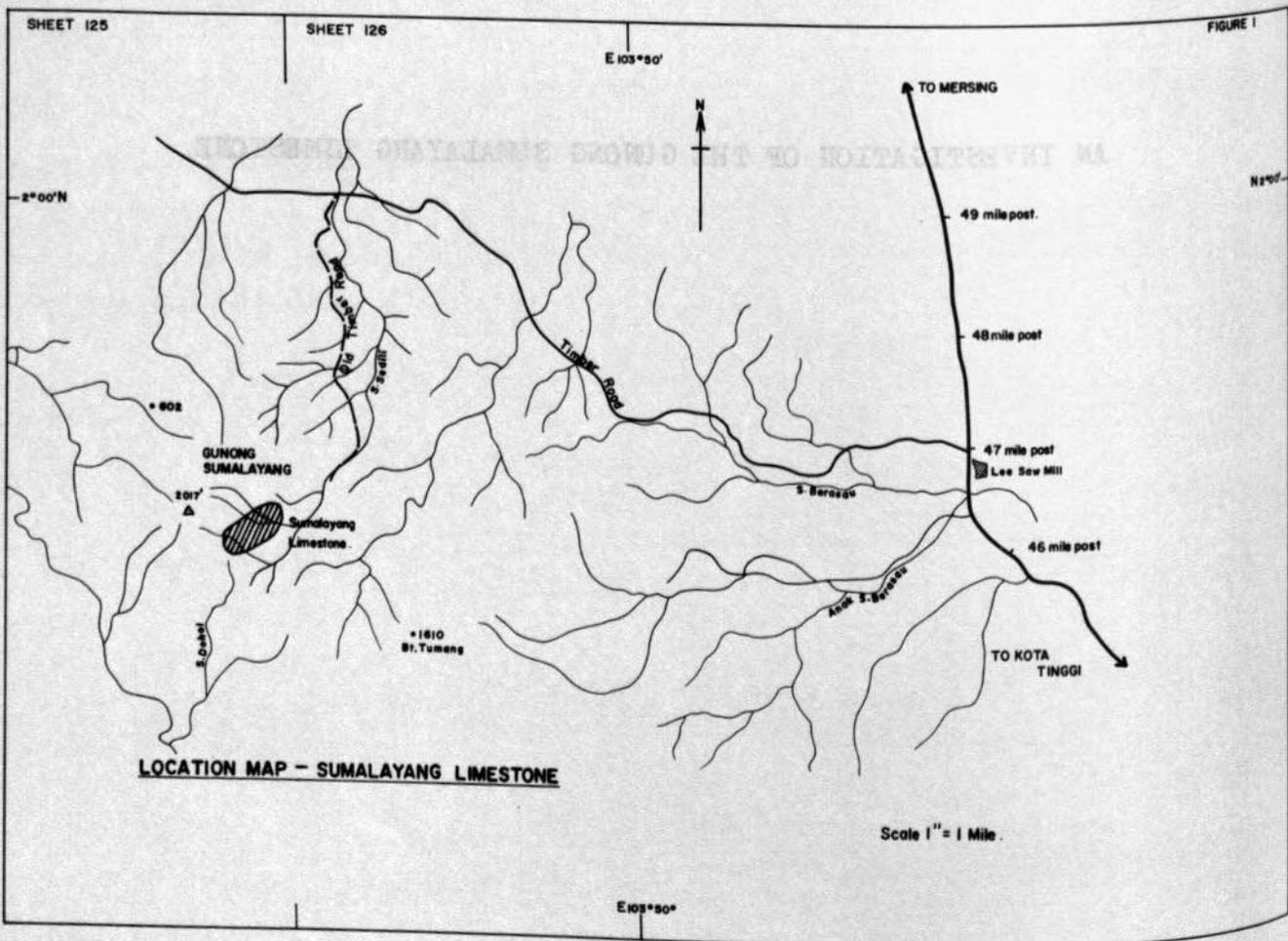
Stream

(R)

Timber road

Loc. (R)

Refers to geological observation (see text section 4.1)



AN INVESTIGATION OF THE GUNONG SUMALAYANG LIMESTONE

1. INTRODUCTION

The work was carried out in the period July 18th to August 22nd, 1970. The aim of the project was to investigate a known limestone occurrence on Gunung Sumalayang, situated some 17 miles north-west of Kota Tinggi (Fig. 1), to establish whether a commercially exploitable deposit occurred in the area.

The limestone was discovered by officers of the West Malaysian Geological Survey in the course of their routine regional mapping programme. Its economic viability as a cement raw material, has probably been tested by Pan Malaysian Cement, who have investigated the area in the last two years.

The importance of a cheap source of carbonate for increasing the pH of certain soils, particularly those under study in the South East Johor Project area and the implications for crop diversification, have been the subject of previous papers and discussions with representatives of the various government departments concerned.

Purely from the point of view of reducing the soil acidity the type of carbonate used is immaterial. However, the cheapest source of carbonate is ground limestone (essentially calcium carbonate). The relative merit of using dolomite (calcium/magnesium carbonate), which in addition provides the nutrient element magnesium, has been the source of some controversy. Strictly speaking dolomite contains a 1 : 1 ratio of calcium to magnesium. Treatment with this material is likely to provide more magnesium than is required by plants as a nutrient, and could result in a build up of the element in the soil with undesirable results. In most areas of the world the acceptable ratio of Ca/Mg is 8 or 10 : 1.

The Sumalayang Limestone is not a dolomite, but work done by the West Malaysian Geological Survey has shown that the rock contains small amounts of magnesium. Thin sections show small crystals of dolomite and chemical analysis of two samples has shown MgO contents of 0.24 and 0.53 percent respectively. Analyses of samples taken during the present study give a better picture of overall magnesium content of the deposit (Table in Section 9). If the rock is quarried for agricultural lime, quality control analysis will determine the amount of magnesium which is being added to soils, and make it possible to calculate how much is required from other sources to maintain the optimum nutrient level of this element.

A preliminary study of the area was made by the consultants' geologist assisted by Geological Survey Staff on the 4th and 5th of June, 1970. A report on this study was made to the Project Steering Committee (No. 5 July 1970) and the present investigation results from the follow up recommendations made in that report.

We would like to thank the Director of the Geological Survey for providing staff to help with all stages of this investigation. In particular for providing the services of Enche Hew Kiang Tho, Geological Assistant, whose work in all aspects of the study was excellent. We would also like to thank the drillers, Drilling and Minerals Sdn. Bhd. and the labour force from Sedili Kechil, who remained cheerful in some difficult terrain and weather conditions.

2. LABOUR FORCE

The investigation was led by the consultants' geologist, with the Geological Survey assistant as

second in command. The survey party consisted of a surveyor with two assistants. The drilling crew was made up of 1 clerk, 1 foreman driller, 1 fitter, 3 drillers and 6 drilling assistants. The drilling companies' supervisors paid periodic visits to the site. The general camp labour force consisted of 10 to 14 men made up of 1 cook, 1 man responsible for drill site and route preparation and 8 to 10 labourers. The latter were concerned with movement of supplies, test pitting, rentis cutting etc. A contract team of 7 men was used in the early stages to renovate old timber roads, build bridges and to cut part of the main pattern of rentis lines, prior to the commencement of drilling. An extra crew of 12 labourers was used in the first few days, to carry supplies, erect camp and cut rentis.

3. METHOD OF INVESTIGATION

The immediate aim of the investigation was to prepare a detailed geological map and profiles of the limestone area to a scale of 1" = 200', with a view to estimating the amount of limestone in the area, its structure and the amount of overburden present.

To produce a detailed topographic map of the area at this scale would be an extremely lengthy and costly operation. Therefore survey work was restricted to compass traversing of streams and old timber tracks tied to a pattern of accurately surveyed and levelled rentis lines. The profile lines along the rentises are accurate but we must emphasize that the form lines between them are generalised, and must not be regarded as contour lines, (see Fig. 2). An Assumed Ordnance Datum of 1000' was used in the survey and is approximately equal to 500' O.D.

The geologist and the geological assistant traversed and recorded the positions of all streams and roads. All solid rock outcrops were noted and described (see Section 4.2) and the more critical outcrops were plotted and levelled (see Fig. 2). The geological staff was responsible for all plotting of results.

The survey party levelled and surveyed the main and subsidiary rentis lines, noting their intersection with streams and roads.

The surface geological information was supplemented by 4 boreholes, 6 pits and 2 trenches.

The collected data were used to prepare the map and profiles (Figs. 2 to 15). Estimates of limestone tonnages and volume of overburden were made from these figures (see Section 5.2).

At an early stage in the investigation it was decided to concentrate the drilling effort in the west of the limestone area, where surface indications of limestone showed the likely occurrence of a workable deposit. The geological map (Fig. 2), indicates other areas which are thought to be underlain by limestone but where no drilling has been done.

4. GEOLOGY

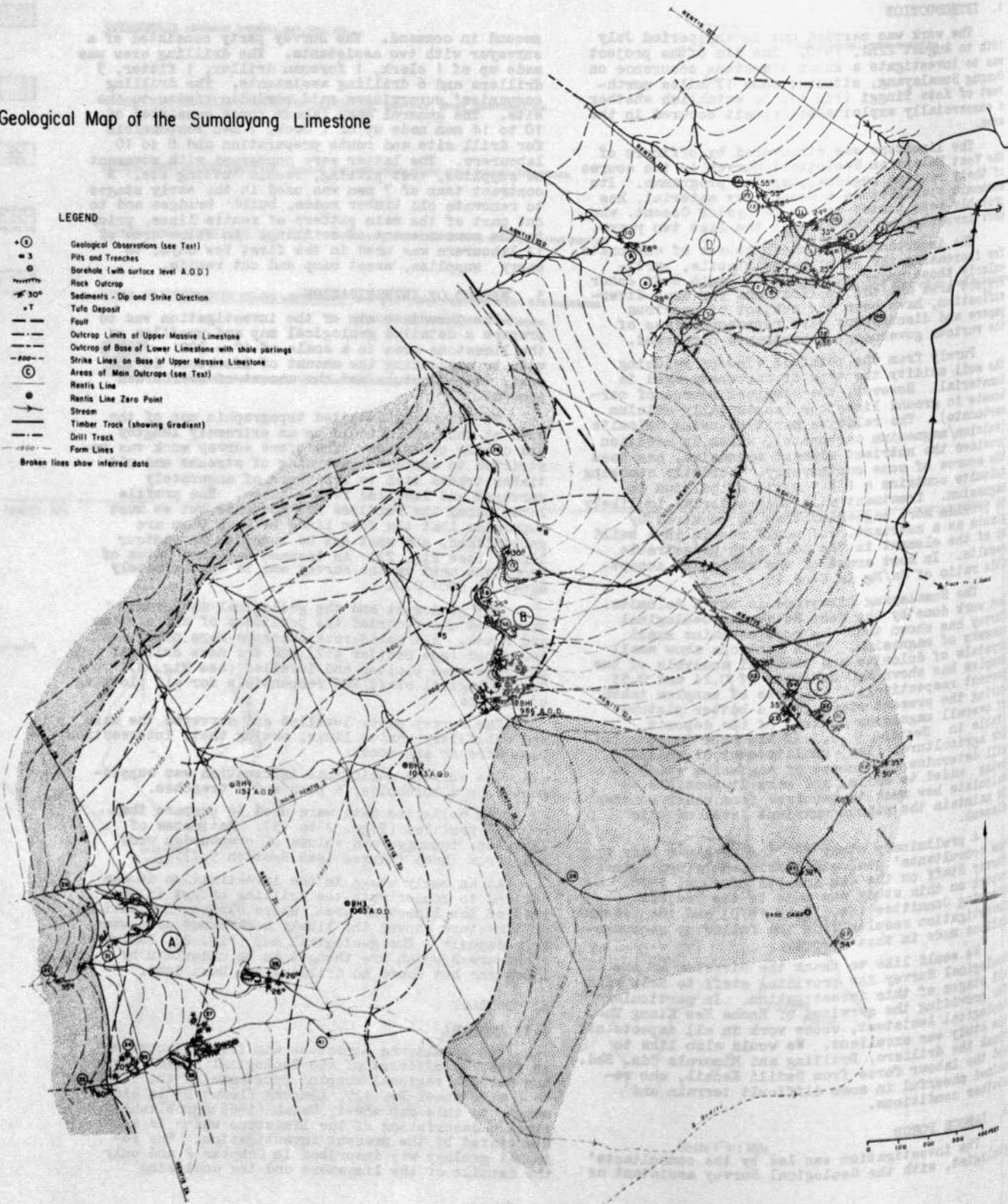
4.1 General

The Sumalayang Limestone was first discovered in 1966, by officers of the Geological Survey carrying out the regional mapping programme of the 1 inch to 1 mile sheet No. 125, (Gunong Blumut). In his memoir to this map sheet, Rajah (1969 unpublished), gives a description of the limestone which is substantiated by the present investigation. The regional geology was described in Chapter 2 and only the details of the limestone and the enclosing

Geological Map of the Sumalayang Limestone

LEGEND

- (1) Geological Observations (see Text)
 - 3 Pits and Trenches
 - Borehole (with surface level A.O.D.)
 - Rock Outcrop
 - 30° Sediments - Dip and Strike Direction
 - T Tufa Deposit
 - Fault
 - Outcrop Limits of Upper Massive Limestone
 - Outcrop of Base of Lower Limestone with shale partings
 - Strike Lines on Base of Upper Massive Limestone
 - Areas of Main Outcrops (see Text)
 - Rents Line
 - Rents Line Zero Point
 - Stream
 - Timber Track (showing Gradient)
 - Drill Track
 - Farm Lines
- Broken lines show inferred data



metasediments will be given in this report.

4.2 Geological Observations

Observation numbers refer to localities shown in Figs. 2-15.

1. Argillaceous metasediments in stream bed, brown weathered, bedding strike and dip indeterminate.
2. Cliff of argillaceous metasediments, shaley mudstone B/S 280° dip 46° N.N.E. Top 909', base 888' A.O.D.
3. Dark grey argillaceous metasediments B/S 260° dip 44° N.
4. Brownish argillaceous metasediments B/S 350° dip 25° W.
5. Brownish weathered argillaceous metasediments right bank of stream next to large tufa deposit top 972' A.O.D. B/S 350° dip 35° W.
6. Very dark grey argillaceous metasediments with black limestone ribs, 4' exposed at small waterfall B/S 010°45°W. 984' A.O.D.
7. Brown weathered shaley mudstones in stream bed B/S 280° dip 70° N.
8. Limestone cliff 12' high in dry stream bed right bank of main stream. Dark grey limestone fine grained with some argillaceous partings B/S 240° dip 28° NW. Top 1057' base 1045' A.O.D.
9. Fine dark limestone with chert bands and nodules. This outcrop forms small waterfall and may be faulted (220°) B/S 260° dip 28° N. Top 1095' A.O.D.
10. Small outcrop in stream bed above (9), dark fine grained limestone with fusulinids B/S 260° dip 34° N. 1108' A.O.D.
11. Dark grey argillaceous metasediments with black limestone lenses B/S 360° dip 55° W.
12. Dark grey to black indurated shales and mudstones with black limestone bands and lenses. Forms series of waterfalls in main stream.
13. Dark grey limestone B/S 260° dip 24° NW. Overlying argillaceous metasediments. Contact here may be faulted.
14. Small outcrops of pale grey limestone in stream bed. Appears to be massive upper limestone. B/S indeterminate.
15. Cliff of massive medium grey limestone. B/S 260° dip 30° NW. Top 1172' base 1118' A.O.D.
16. Cliff of massive grey limestone B/S 240° 33° NW. Top 1119' base 1076' A.O.D.
17. Cliff of massive grey limestone B/S 240° 24° NW. Top 1086' base 1041' A.O.D.
18. Numerous outcrops of mainly massive grey limestone, lower outcrops with shale partings. B/S 220° dip 28° W; 220° 36° W; 230° 30° NW.
19. Dark grey shaley mudstone with limestone ribs at small waterfall. B/S 220° dip 36° NW. Limestone boulders in stream nearby.
20. Dark grey shaley mudstone B/S 210° dip 35° NW.
21. Massive grey limestone forms cliff, 16' visible thickness, overlain by bedded limestone and shales 5'. B/S 200° dip 26° NW; 350° dip 35° E. Evidence from pitting and trenching shows this outcrop is faulted (fault bearing 010°?).
22. Chocolate brown shaley mudstone, weathered, forms waterfall B/S 240 - 245° dip 38° NW.
23. As (24) B/S 330° dip 35° NE.
24. Black indurated shaley mudstones with limestone lenses B/S 250° dip 32° NW.
25. As (26) B/S 240° 54° NW.

26. Dark grey mudstone in stream bed. B/S indeterminate.
27. Tuff in stream bed.
28. Large outcrop of medium to pale grey massive limestone B/S 010° dip 30° W? Top 1179' Base 1123' A.O.D.
29. Small outcrops of massive grey limestone. Top 1173' A.O.D.
30. Brown and grey mudstone forming waterfall B/S 260° dip 35° NW.
31. Brown mudstone B/S 350° dip 60° W.
32. Outcrops of massive grey limestone B/S indeterminate. Top 1191' base 1166' A.O.D.
33. Large outcrop of massive grey limestone, with chert nodules. B/S 360° dip 20° W. Top 1201', base 1168' A.O.D.
34. Numerous outcrops of grey massive limestone B/S indeterminate. Top 1138' base 1069' A.O.D.
35. As (36) Top of highest outcrop 1092', base of lowest outcrop 1075' A.O.D.
36. Numerous outcrops of grey massive limestone B/S difficult to determine. Figures of 200° dip 26° NW and 190° dip 26° W were recorded. Highest outcrop 881', lowest outcrop 859'.
37. Argillaceous metasediments, brown weathered in stream bed. B/S 200° 36° W.
38. Same as (39) B/S indeterminate.
39. Grey fine grained limestone B/S indeterminate.
40. Dark grey to black shaley mudstone B/S 010° dip 50° W.

4.3 Lithology and Stratigraphy

The rock succession is illustrated in the Key to illustrations following page 20.

Rajah has described the Dohol Formation of which the Sumalayang Limestone Member is a component part. The formation is made up of a wide variety of rock types in addition to limestone. However, in general, and certainly in the area under discussion, it consists essentially of argillaceous (clay) sediments. The entire rock succession shows varying degrees of low grade regional metamorphism (a process under which rocks are subjected to heat and/or pressure). Exposures of the Dohol argillites at a considerable depth below the limestone are not common. It is considered, that locality 24 (see Fig. 2) is probably the lowest horizon exposed. Here the sediments show small scale block jointing and consist of deeply weathered chocolate coloured shaley mudstones: the unweathered rock is probably dark grey. Higher in the succession these rocks become progressively harder, tougher, darker and more calcareous. The rocks in the bed of the Sungai Sedili (localities 26, 27 and 42), near the base camp are of this type, as are those forming the series of waterfalls further north, at localities 12, 13 and 14. They consist of grey to black indurated shaley mudstones, which are often quite calcareous and may contain small bands and lenses of black limestone. The latter are particularly in evidence in localities 12, 13 and 14.

Higher in the succession still, in rocks only adequately seen in the boreholes, the amount of argillaceous matter continues to decrease. The general colour of the rocks becomes lighter, limestone beds are thicker and the argillaceous component is largely confined to streaks and partings.

Within the limestone succession itself the change continues. The colour gradually decreases to light grey and almost white in places. The higher limestones are massive, recrystallized and uniform in hand specimen. There are no shale

PROFILE ALONG MAIN RENTIS I.

FIGURE 3

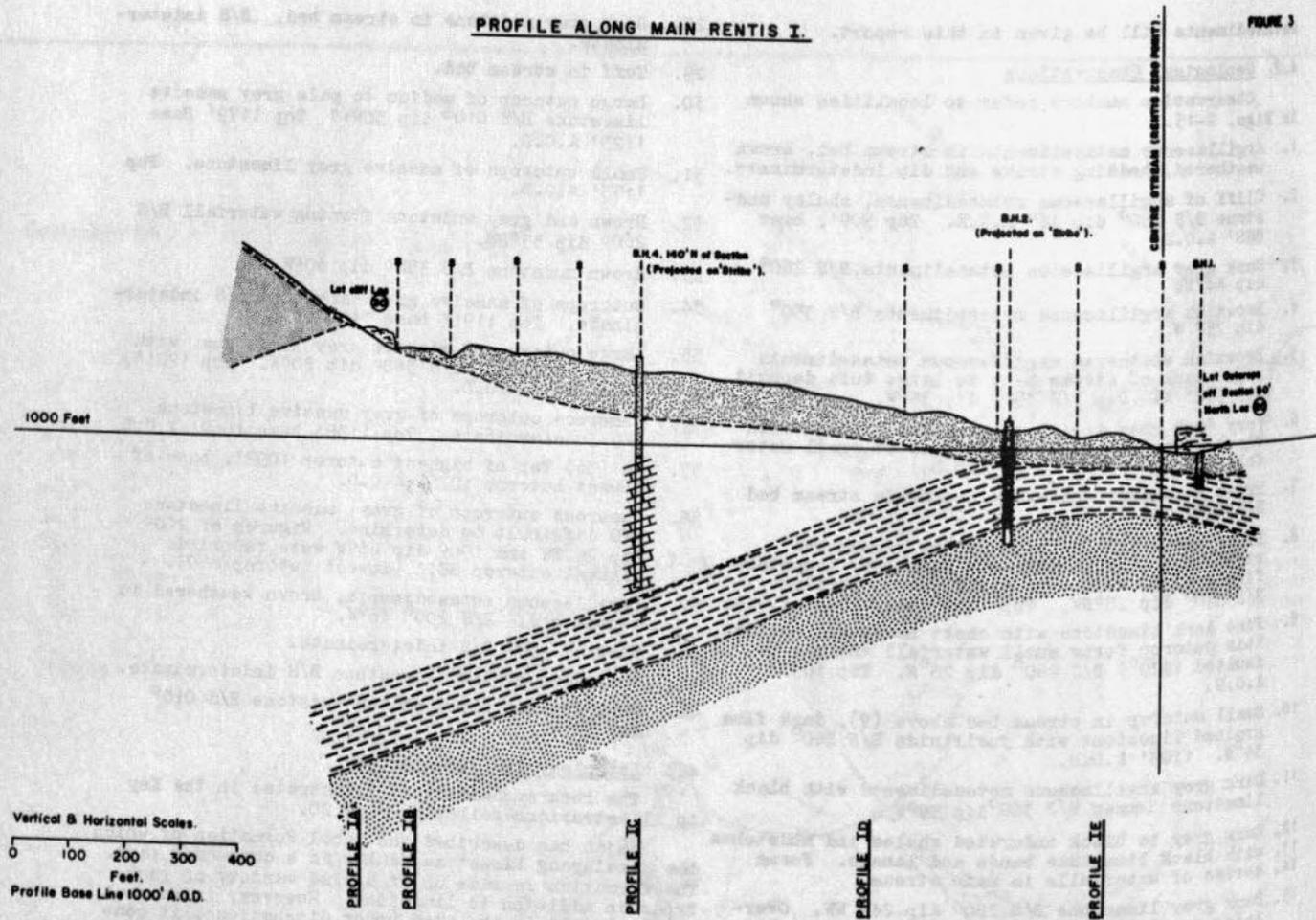
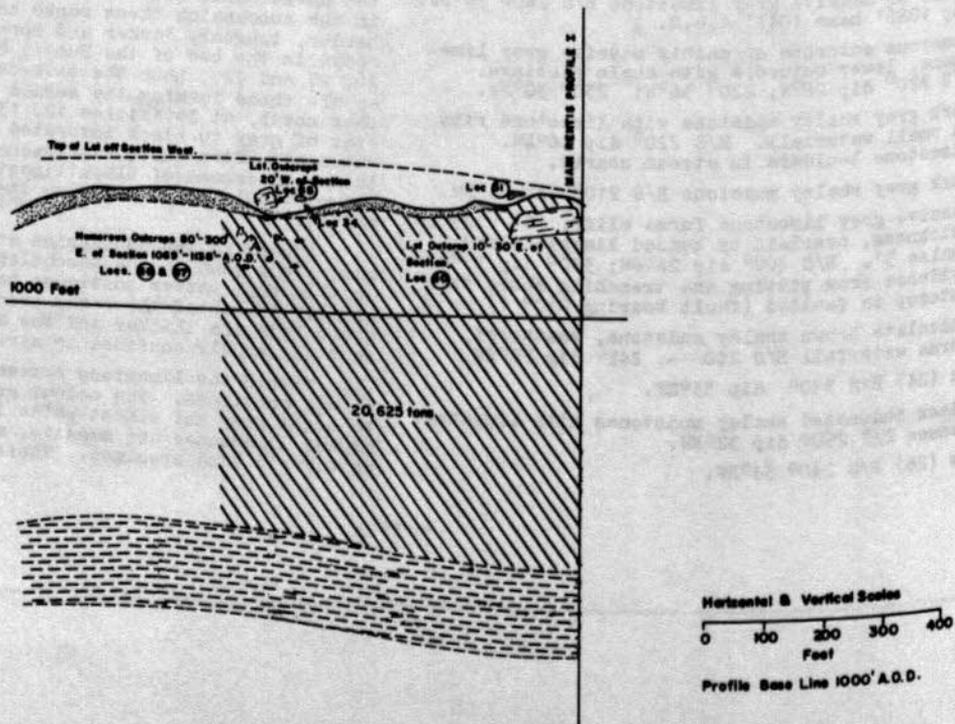


FIGURE 4

PROFILE ALONG RENTIS IA



partings and conclusive dip and strike measurements are difficult to record, either from surface exposures or from boreholes.

In general all the limestones are fine grained with rare beds of medium grain size. The colour varies between black and almost white.

Unlike the gradual transition seen at the base of the limestone, the upper boundary with the higher horizons of the Dohol Formation is quite distinct. The rocks immediately overlying the limestone are different in character to those seen below it. In general they are usually pale grey to golden brown streaked, highly weathered sandy mudstones. In one locality the overlying rock is probably a sandstone, though no actual contact is visible. In another tuff is thought to overlie the limestone. All the overlying sediments seen are highly weathered and quite soft. In the vicinity of area A (see Fig. 2) the top of the limestone can be defined from stream exposures to within 15 or 20 feet. The occurrence of solid rock overburden, as opposed to unconsolidated material, coincides with the development of a pronounced steep slope feature which trends north near area A then swings north-east near the large limestone outcrop at locality 30. From here the feature is traceable running north-east still it dies out in the flatter high ground to the north of area B. The latter is known to be underlain by limestone (outcrops at locality 16). It is considered that the slope feature mentioned above, defines the top of the limestone with reasonable precision, in an area where there are no rock outcrops whatever.

Most of the area underlain by limestone is covered by colluvial overburden. This material consists of large boulders of the Panti Sandstone Formation with more rarely boulders of the Sedili Volcanic Formation which overlies the Dohol Formation. The soils in the area are dominantly yellow brown sandy clays derived from these boulders. Typical dark red limestone soils were found only in the flatter high ground north of area B (see Fig. 2). In this area and also in the high ground near area A, limestone vegetation, typically of one storey, is thought to occur.

The limestone area as a whole has slightly lower vegetation than the surrounding country. This is readily visible on the air photographs and may be due to the drier soil conditions created by limestone, even when it occurs at some depth beneath the overburden.

4.4 Structure

Apart from one major element, a fault shown in figure 2 trending north-west, the structure is essentially that which was described in our preliminary report. In general the main area of limestone indicated in figure 2 forms an asymmetrical pitching anticline, with its axis bearing approximately west-north-west. The rocks forming the eastern limb of the anticline dip at approximately 30° N.W. (strike 230°), while those in the west show a gentler dip, 20° W (strike 010°). Detailed individual observations have been given in Section 4.2 of this report.

The major fault mentioned above affects the eastern limb of the anticline, with the limestone further west showing a lateral displacement towards the north. The fault has only been observed in pits (6 and 7 locality 23), where it is trending northwards with hade and downthrow to the west. At locality 23, the argillites which are in lateral juxtaposition with the limestones, are quite different in character to those which normally underlie the limestone/localities 6, 7 and B.H. 2. They are chocolate coloured (probably due to block jointing (locality 24)). They closely resemble the rocks seen in localities 2, 3 and 5 to the north, which are thought to be some 80 ft.

below the limestone. The black argillite and limestone banded sequence seen in localities 21 and 22 is more typical of the succession below the limestone and it is possible that a further small fault occurs between here and locality 24.

The alignment of the fault shown in figure 2 is inferred, and is partly based on the occurrence of a steep ground slope feature running north-east on profile IIC (Fig. 12). Because of its possible effect on the quantity of limestone available, we have made no estimates north-east of rentis IIB (see Section 5.2).

Small faults have been observed at localities 9 and 15; it is not considered that these will affect the economics of the deposit in this area.

The differential movement of the softer argillites, which show a greater degree of folding (steeper dips etc.) relative to the harder limestone, was mentioned in our earlier report. Evidence of interbed movement within the limestone sequence is common. All argillite partings are slickensided, with graphitic partings (presumably due to the high carbon content of the original argillites) being fairly common.

That most of the accommodation movement resulting from folding was taken up along the more argillaceous horizons, is shown by the greater amount of fracturing found at these levels. Limestone fragments "wrapped" in argillaceous material are common, and suggest that this is due to movement of the limestone beds lubricated by the argillaceous partings, fragments of limestone being ground off and mixed with the "lubricant". The greater degree of fracturing and recementation of limestones near argillaceous partings is very striking in B.H. 2. The higher more massive limestones show less evidence of small scale fracturing and recementation, possibly due to the absence of shale partings.

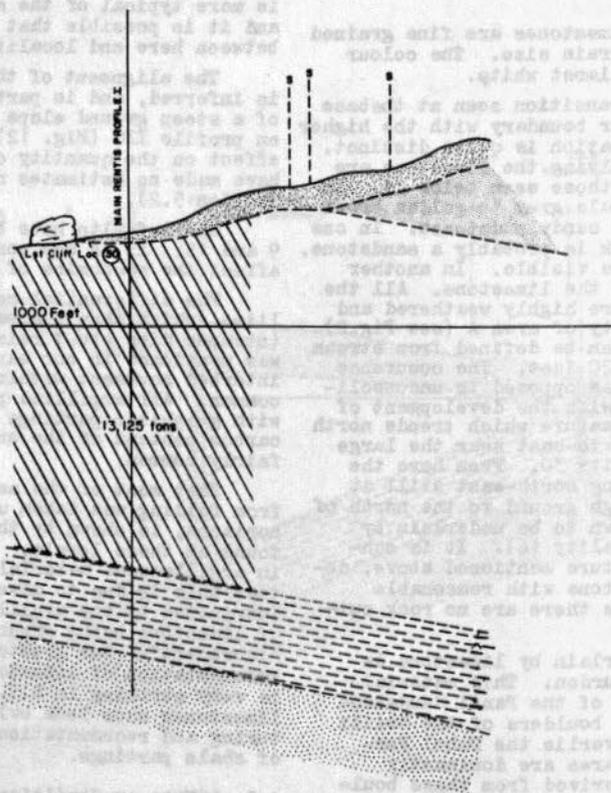
4.5 A Note on Conditions of Sedimentation

Rajah mentioned the possibility that the Sumalayang Limestone Member was a "reef knoll". This cannot be confirmed however, as throughout the succession, the study revealed no trace of any reef building organisms. While the mode of formation of the limestone is largely irrelevant to this investigation, it does affect the type and quality of limestone which occurs in the area, and it is therefore interesting to speculate about the condition of sedimentation. The rocks could provide material for a very interesting academic study of conditions of sedimentation if more exposures become available as a result of quarrying.

The rock sequence reflects gradually changing conditions of sedimentation, from fairly deep water in the case of the argillaceous sediments to shallower water, particularly for the upper limestones. The original basin of deposition was probably landlocked (back reef or lagoonal facies), against a low lying hinterland with sluggish rivers providing mainly clay sediment. The dark colour of the shales is almost certainly due, at least in part, to finely divided carbonaceous matter, probably land plant derived. Aggregations of iron pyrites show a foetid sea bottom with high reducing conditions and although the macroscopic pyrite, seen in some of the darker limestones, has probably been "sweated" out during metamorphism, micro (framboidal) pyrite almost certainly occurs in the darker argillites and limestones. Sporadic brachiopod and gasteropod shells show no original broken shells; this would suggest little or no current action at the time of deposition. These conditions are quite unacceptable to any reef building organisms.

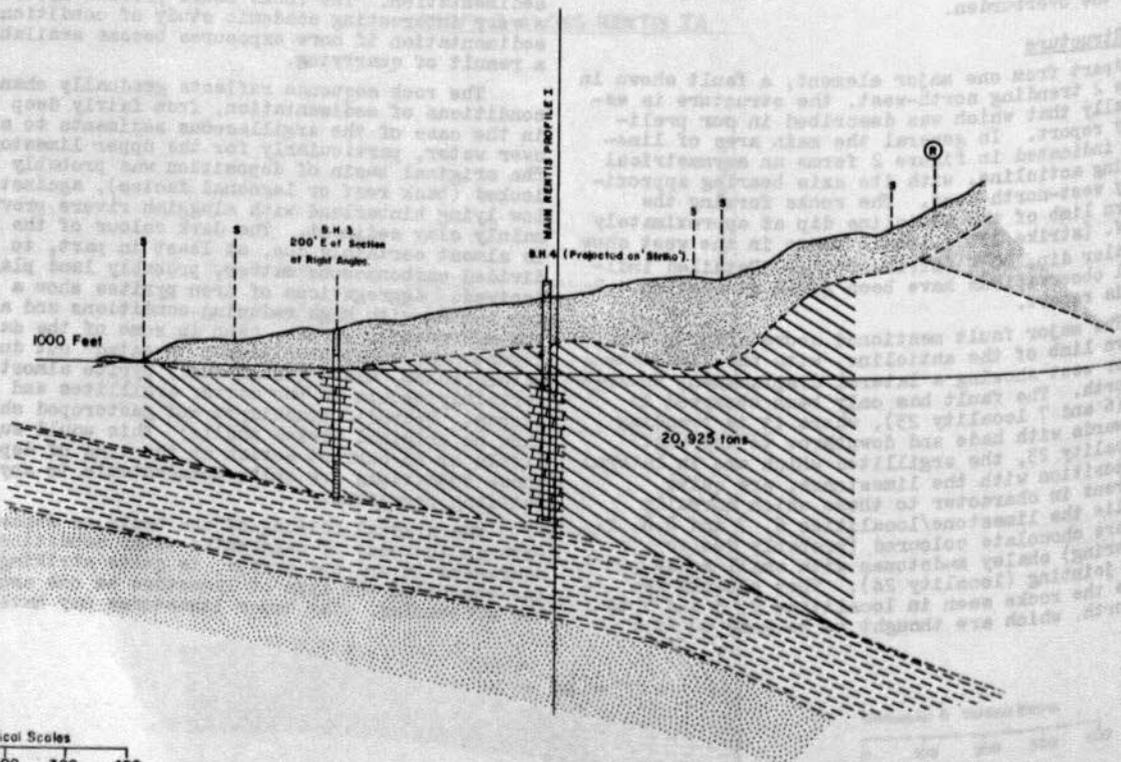
The gradual filling of the basin of deposition, with an increase of oxygenated water conditions, decreases in mud and pyrite, is quite striking from the change in the type of limestone as one ascends the succession. The upper limestones may have been

PROFILE ALONG RENTIS IB



Horizontal & Vertical Scales
 0 100 200 300 400
 Feet
 Profile Base Line 1000' A.O.D.

PROFILE ALONG RENTIS IC



Horizontal & Vertical Scales
 0 100 200 300 400
 Feet
 Profile Base Line 1000' A.O.D.

PROFILE ALONG RENTIS I D

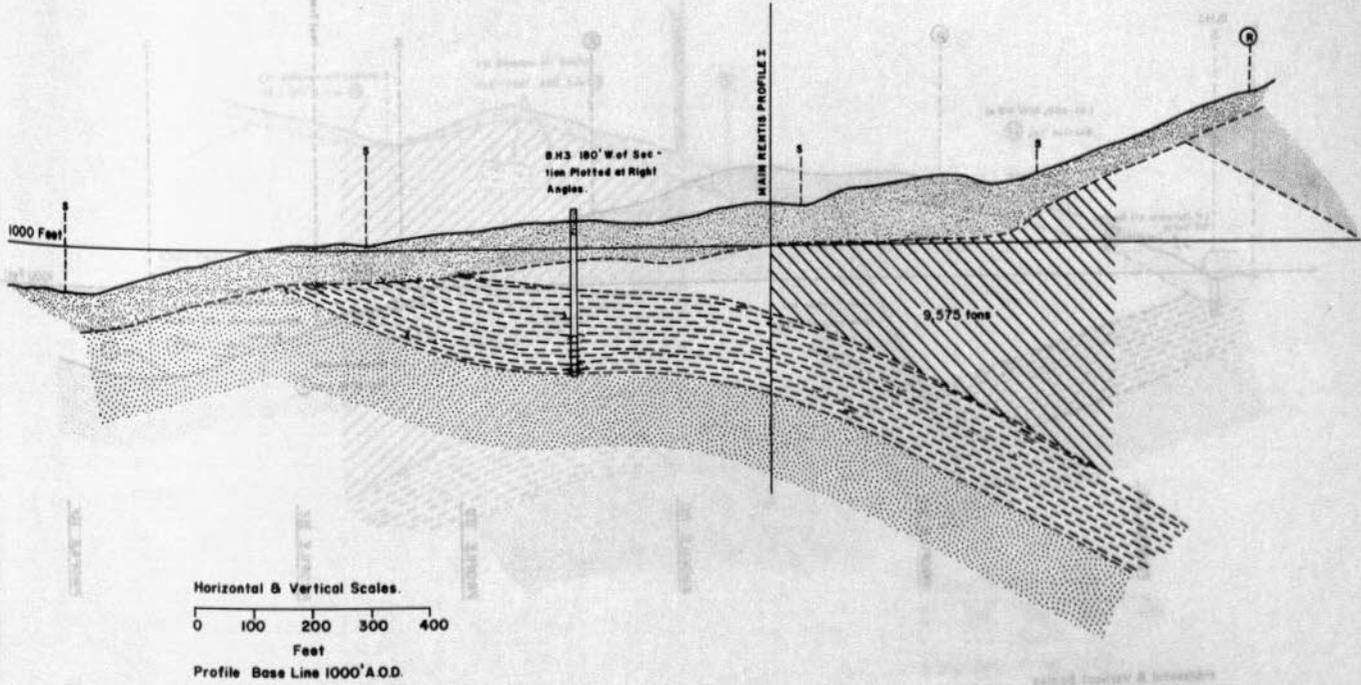
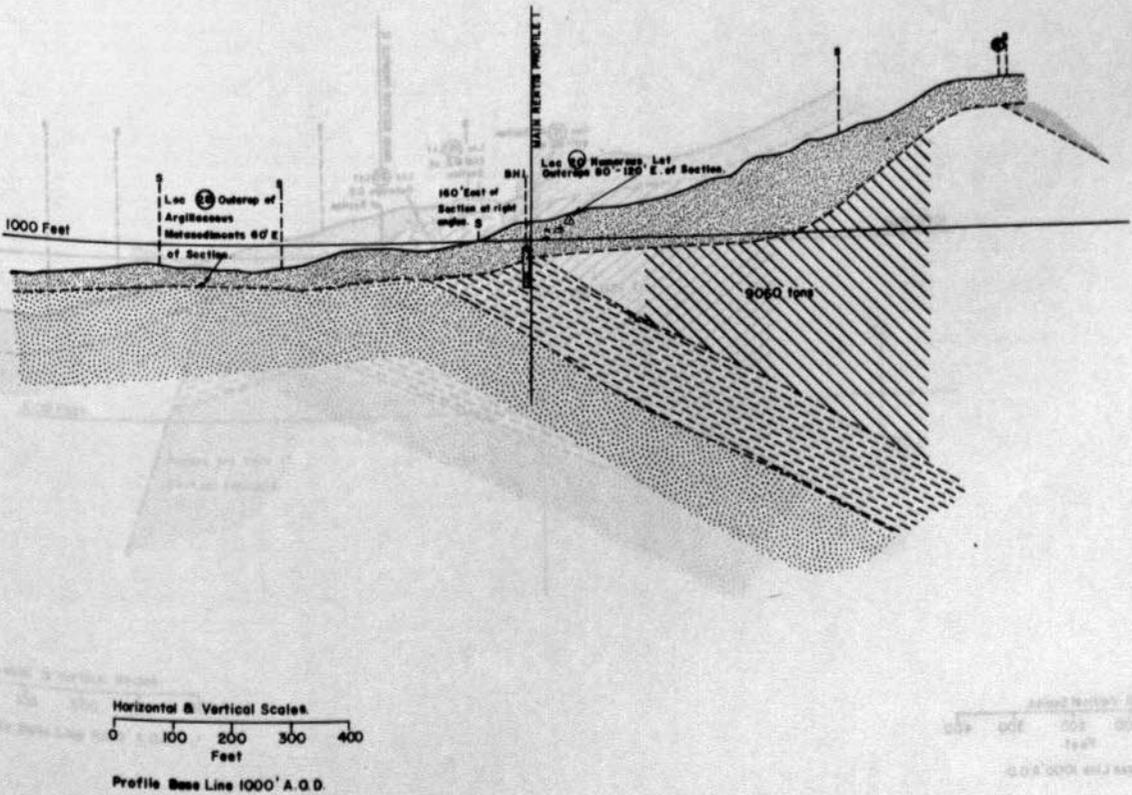
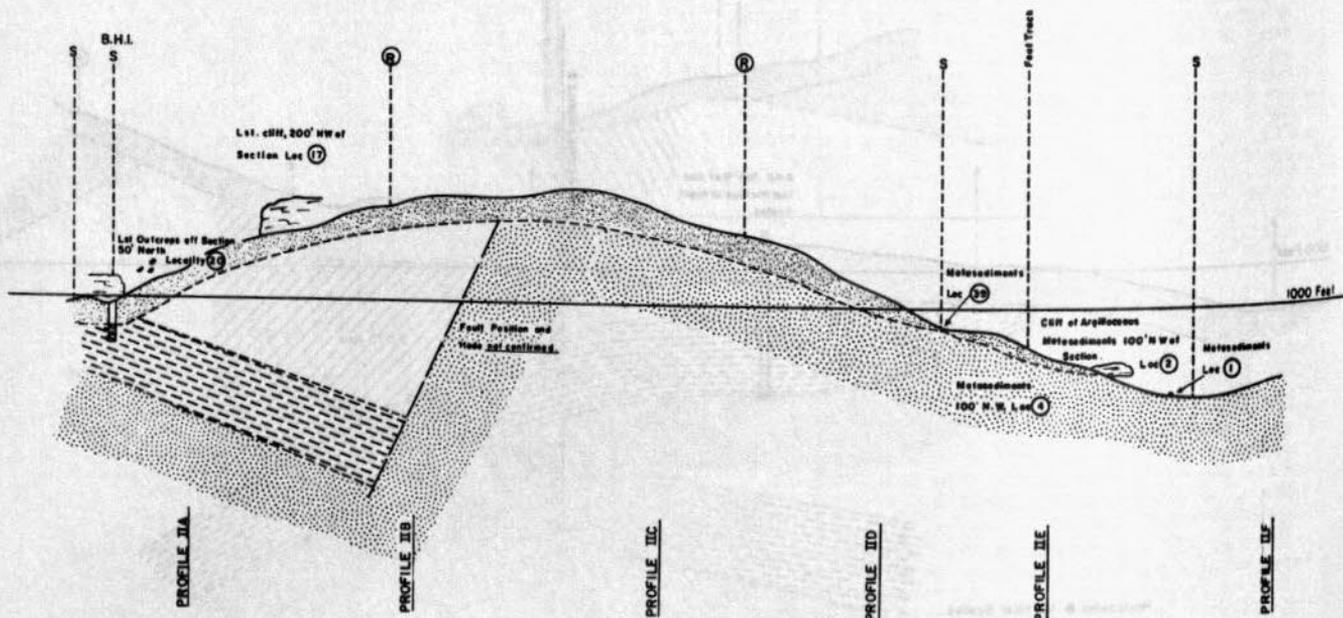


FIGURE 8

PROFILE ALONG RENTIS I E

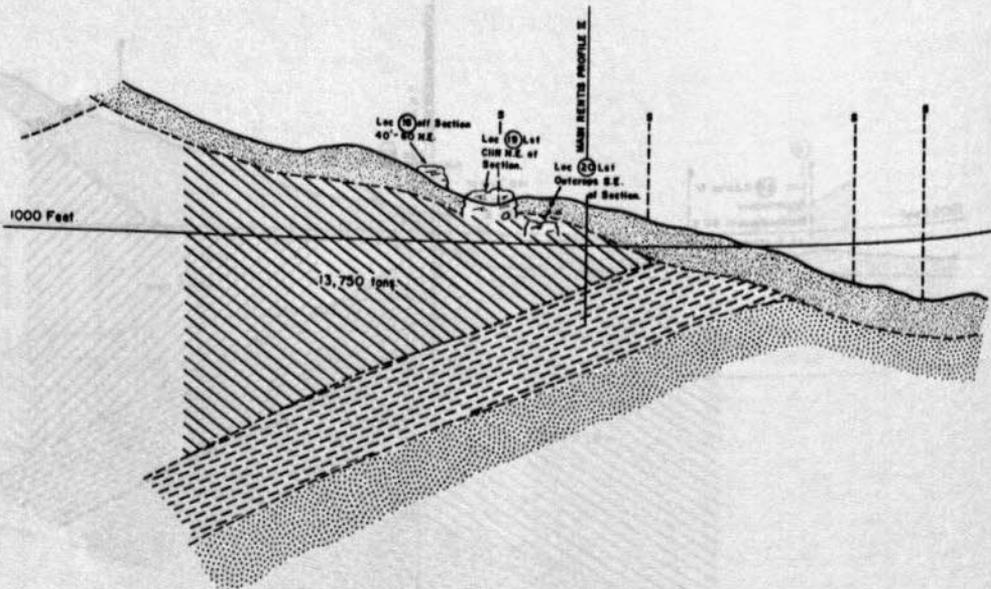


PROFILE ALONG MAIN RENTIS II



Horizontal & Vertical Scales
 0 100 200 300 400 Feet.
 Profile Base Line 1000' A.O.D.

PROFILE ALONG RENTIS II A



Horizon & Vertical Scales
 0 100 200 300 400 Feet.
 Profile Base Line 1000' A.O.D.

PROFILE ALONG RENTIS IIB

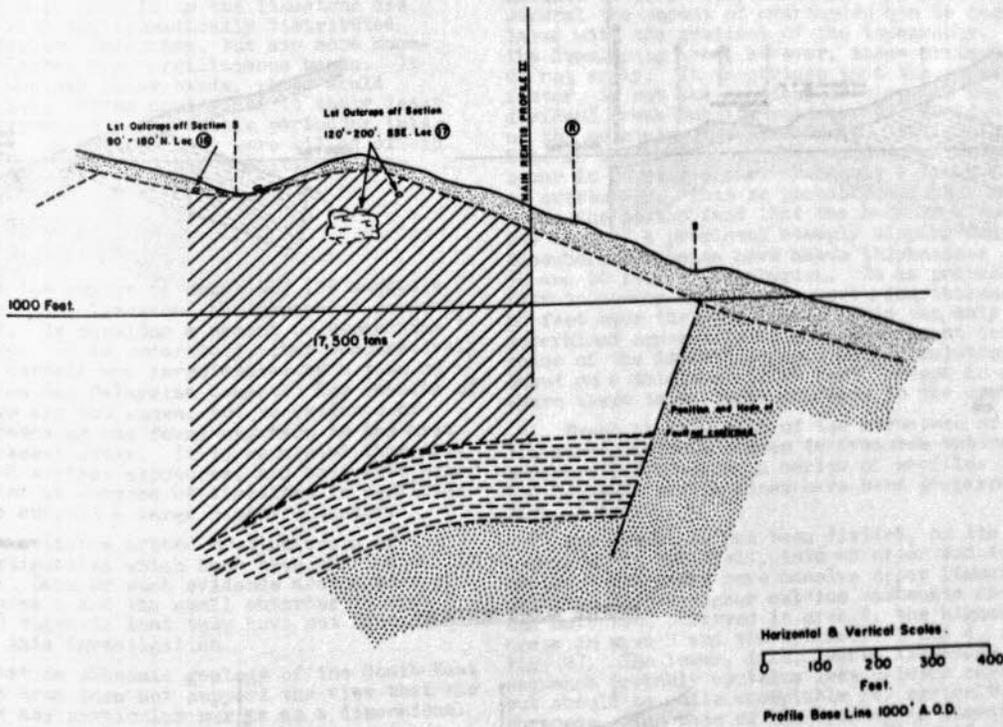
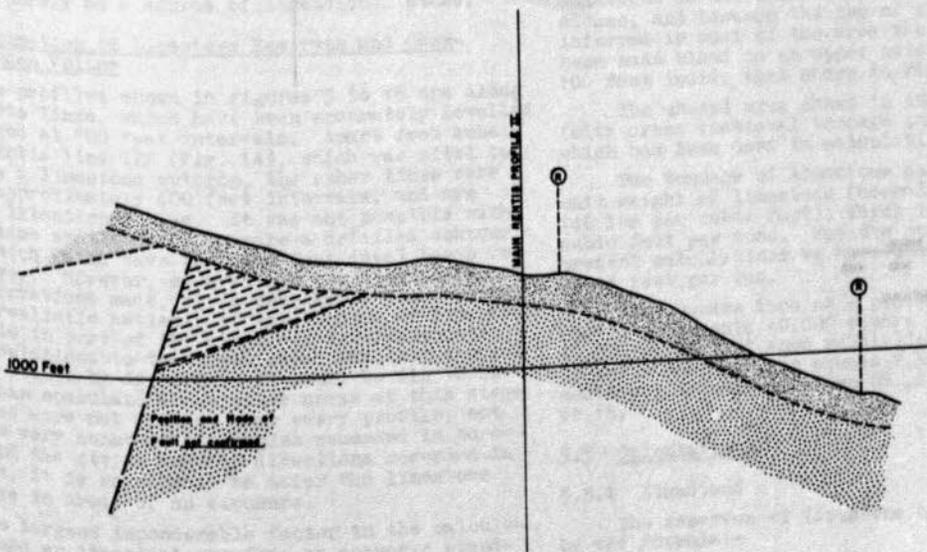


FIGURE 12

PROFILE ALONG RENTIS IIC

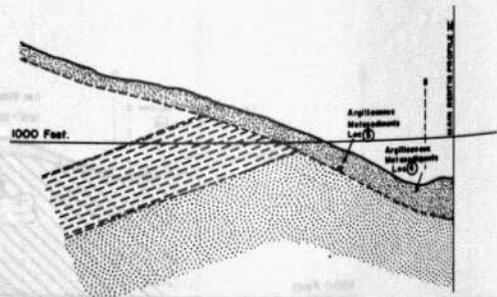
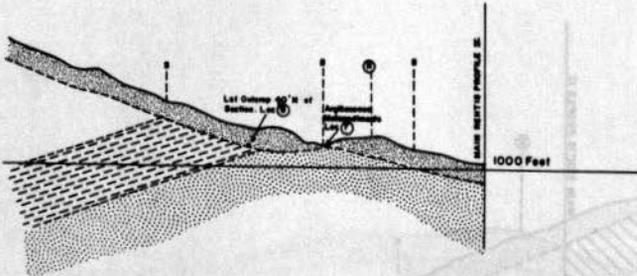


Horizontal & Vertical Scales.
0 100 200 300 400 Feet
Profile Base Line 1000' A.O.D.

PROFILE ALONG RENTIS II D

FIGURE 13

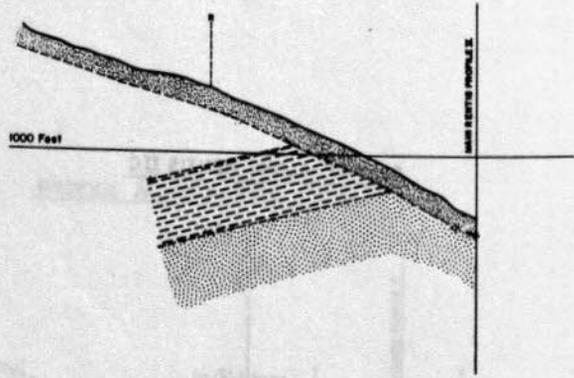
PROFILE ALONG RENTIS II E



Horizontal & Vertical Scales.
 0 100 200 300 400
 Feet
 Profile Base Line 1000' A.D.

FIGURE 14

PROFILE ALONG RENTIS II F



Horizontal & Vertical Scales.
 0 100 200 300 400
 Feet
 Profile Base Line 1000' A.D.

chemically precipitated in fairly shallow water. This could account for their pale colour and seemingly high purity. The coarser silty and sandy horizons in the Dohol Metasediments above the limestone appear to continue the trend towards shallow water conditions.

The commonest fossils in the limestone are fusulinids. They are sporadically distributed through the darker limestones, but are more numerous in the blacker more argillaceous bands. It is not known whether these bands, which would appear to reflect bottom conditions at their least favourable, represent a favourable period for this type of animal, or whether they were killed off in greater numbers due to the bad conditions. The latter seems the more likely.

5. ECONOMIC GEOLOGY

5.1 General

Rajah in the memoir to sheet No. 125 suggests that the Sumalayang limestone had important economic possibilities. He mentions a cement or ornamental stone industry. It is understood, that comparatively recently the deposit was investigated by a team of geologists from Pan Malaysian Cement. The results of their findings are not known, but no evidence of pitting or trenching was found anywhere in the area during the present study. It is concluded that they worked only on surface exposures, and that this evidence suggested an absence of limestone in sufficient quantities to support a large cement industry.

There is evidence around most outcrops of the various investigations which have been carried out in recent years. Lack of such evidence around most of outcrops in area A and the small outcrops in area B (Locality 16) suggests that they have not been examined prior to this investigation.

The report on economic geology of the South East Johor Project area does not support the view that the limestone has any particular merits as a dimensional (ornamental) stone. Certain of the lower horizons show quite attractive black limestones with contrasting white fossils and calcite veins. The upper limestones on the other hand are rather unstriking, being more uniform in colour. Obviously if a quarry is started for industrial lime, then those limestone horizons which have a beautiful appearance, should be considered as the raw material for an ornamental stone, particularly in an area of the world which is experiencing something of a building boom. However, it would not be feasible to consider opening the deposit purely as a source of dimensional stones.

5.2 Estimation of Limestone Reserves and Overburden Volume

The profiles shown in figures 3 to 15 are along out rentis lines, which have been accurately levelled and pegged at 100 feet intervals. Apart from subsidiary rentis line IIE (Fig. 14), which was sited to traverse a limestone outcrop, the other lines were set at approximately 400 feet intervals, and are without intentional bias. It was not possible within the time available to prepare a detailed contour plan, which would have been the most ideal basis for the survey. However, even within the limitations of the observations made, it is considered possible to make a realistic estimate of the tonnage of limestone available in part of the area. We have restricted our calculations to that area which has been studied in some detail by drilling. It would be idle to do other than speculate about other areas at this stage. Boreholes were not drilled near every profile, but from the very constant dip angles recorded in boreholes and the strike and dip directions recorded in outcrops, it is reasonable to infer the limestone structure in areas of no exposure.

The largest imponderable factor in the calculations, and an important one from an economic stand-

point, is the volume of unconsolidated overburden present in the area. It was hoped that the thickness of overburden could be assessed by pitting. Experience in the Tanjong Penggerang Region has shown overburden to 5 feet on tops of hills or ridges, 3 to 4 feet on shoulders, with greater amounts on lower slopes and in valleys. In general the amount of overburden can be correlated with the gradient of the topography. In the Sumalayang area, however, these criteria do not apply. It is obvious that the significant factor, is not the gradient of slope in small individual areas but the position of the limestone on the mountain side as a whole. Being near the base of the mountain, large amounts of colluvium occur in certain areas. Borehole 4 shows 173 feet of overburden. This is probably exceptional and maybe due to the fact that the hole is sited at the foot of a prominent steeply sloping feature. Elsewhere boreholes have shown thicknesses of 40, 50 and 60 feet of overburden. It is probably fair to assume an average overburden thickness of 80 feet over the whole area. This can only be determined accurately at the development drilling phase of the investigation. Our calculations are based on a thickness of 80 feet, except in areas, where there is definite evidence to the contrary.

Based on knowledge of the structure of the limestone, which has been derived from outcrop and borehole information, a series of profiles along the surveyed rentis lines have been prepared (see Figs. 3 to 15).

The limestone has been divided, on its appearance in the field, into an upper and lower series. The paler more massive upper limestones probably have a higher calcium carbonate content and have been observed in area A, the higher outcrops in area B and the boreholes 3 and 4. (see Fig. 2). The lower, dark, bedded limestone sequence probably contains less calcium carbonate but should be quite acceptable for agricultural purposes. The base of the Sumalayang limestone is shown at an inferred position in Figure 2 and was set at 850 feet A.O.D. in Borehole 2. As has been mentioned previously, the change from argillaceous Dohol metasediments to limestone above is gradational and therefore the mapped base of the limestone is rather arbitrary.

Our calculations of limestone tonnage are restricted to the area southwest of profile IIA, Figure 10. A more tentative estimate is given for the ground between profiles IIA and IIB. The calculations do not include the lower bedded limestones, and because the top of the limestone is inferred in most of the area the calculations have been made based on an upper outcrop limit set some 100 feet inside that shown in Figure 2.

The shaded area shown in individual profiles (with cross sectional tonnage indicated) is that which has been used in calculations.

The tonnage of limestone assumes an average unit weight of limestone (normally accepted as 146 lbs per cubic foot), which is equal to 15.3 cubic feet per tons. For the purposes of the present calculations we have used a figure of 16 cubic feet per ton.

Each square inch on a profile (scale 1" = 200'), represents 40,000 square feet, which equals 40,000 cubic feet when multiplied by unity and at 16 cubic feet per ton equals 2,500 tons. The cross sectional tonnage is shown on profiles Figures 3 to 15.

5.3 Calculations

5.3.1 Limestone

The reserves of limestone available are given by the formula:-

$$W = t \times \frac{d}{2}$$

where W is the tonnage, t is the cross sectional tonnage and d is the average distance between adjacent profiles.

- (i) Estimated tonnage east of Rentis Profile IA

$$W = 20,625 \times \frac{570}{2}$$

= 5,877,525 tons.

- (ii) Estimated tonnage east of Rentis Profile IB

$$W = 13,125 \times \frac{400}{2}$$

= 2,625,000 tons.

- (iii) Estimated tonnage west of Rentis Profile IC

$$W = 20,975 \times \frac{480}{2}$$

= 5,022,000 tons.

- (iv) Estimated tonnage east of Rentis Profile IC

$$W = 20,925 \times \frac{400}{2}$$

= 4,185,000 tons.

- (v) Estimated tonnage west of Rentis ID

$$W = 9,575 \times \frac{400}{2}$$

= 1,915,000 tons.

- (vi) Estimated tonnage east of Rentis Profile ID

$$W = 9,575 \times \frac{400}{2}$$

= 1,915,000 tons.

- (vii) Estimated tonnage west of Rentis Profile IE

$$W = 9,060 \times \frac{400}{2}$$

= 1,812,000 tons.

- (viii) Estimated tonnage east of Rentis IE west of Rentis IIA

$$W = 1,710,750 \text{ tons.}$$

Total estimated tonnage between Rentis Profiles IA and IIA = 25,000,000 tons

Between Rentis lines IIA and IIB a further tonnage of limestone can be calculated. No holes were drilled in this area, however, based on outcrop evidence, cross sectional tonnages have been indicated on Profiles IIA and IIB. From these figures the following calculation can be made for this area:

$$W = \frac{13,750 + 17,500}{2} \times 350$$

= 5,468,750 tons

5.3.2 Unconsolidated overburden

As has been mentioned above, a detailed estimate of the overburden is not possible from our investigations. Methods of determining the amount of overburden are discussed in Section 6 of this report. It is fair to assume an average overburden thickness of 80 feet except in those areas where there is direct evidence to the contrary. Overburden will be thickest at the base of steep slopes and thinner on shoulders of hills and ridges. The overburden shown on the profiles (Figs. 3 to 15) probably represents a fairly accurate picture of the amount of overburden present.

We estimate from these profiles, that the tonnage of limestone calculated above, will be covered by approximately 3,000,000 cubic yards of unconsolidated overburden.

6. CONCLUSIONS AND RECOMMENDATIONS

The investigation has revealed the presence of an estimated 25,000,000 tons of massive pure limestone in one part of the area investigated with a further 5,500,000 tons occurring further east. Extraction of this limestone will require the removal of 3,000,000 cubic yards of overburden. It is important to remember that this material will have to be moved over the lifetime of the deposit and not before operations begin. The tonnage of limestone under solid rock overburden of Dohol sediments has not been estimated but indications are that the limestone continues at depth below this material. The latter increases rapidly in thickness in some areas, due to the combined effect of steeply dipping limestone and a rapid increase in ground slope. However, the material is quite soft and should be easily ripplable if the limestone is required.

It is not feasible to estimate the tonnage of limestone east of the major fault shown in Figure 2, however, the vegetation and geological structure suggests that the high ground here is underlain by limestone. Time and financial restrictions did not permit the drilling of boreholes which would have been able to establish whether the limestone occurs at a workable thickness in this area. Present indications suggest that the outcrops in the vicinity of area D (Fig.2) are of the lower bedded limestones and that the massive upper limestones will occur on the high ground further to the north-west. The streams traversing this area were investigated but no solid rock outcrops were visible. However, the vegetation in this area is similar to that seen in areas known to be underlain by limestone.

We recommend further investigation of the ground between areas A and B (Fig.2), to establish methods of working, face alignment, depth of overburden etc. Traditionally further investigation would involve development drilling. Holes could be drilled at 100 feet centres over the entire area to determine overburden volume accurately. This approach would necessitate the removal of the vegetation from the area. A detailed topographic survey could be carried out at this time. An alternative method of determining overburden would be to use seismic reflection geophysical techniques. The seismic velocities of limestone and overburden should show a good contrast and make it possible to determine the depth to solid rock rapidly and cheaply without removing the vegetation. It is desirable to leave existing vegetation and drainage intact as long as possible if the area is to remain stable, with minimum erosion and possibility of landslip over the lifetime of the deposit. The geophysical results would have to be checked by drilling and we suggest the use of a crawler tractor mounted, air flush drill. We consider that the advice of an experienced quarry engineer should be sought prior to the working of the deposit. We make the following observations concerning this aspect of the work. It should be possible to establish a strike face in area A (Fig.2). In most of the area strike faces should be avoided if possible. The deposit is traversed by a series of parallel streams which should be left undisturbed as long as possible and therefore dip faces aligned roughly north-west may be better. It will be necessary to clear a strip on the uphill slope above any working faces; this will prevent landslip into the quarry and contamination of

the limestone. Stability of the slopes will be aided by the prevailing dip of the limestone which in most areas is contrary to the hill slope.

It is possible that detailed investigations to the north-east will reveal further extensions of the deposit. To the south of area A the limestone is probably bounded by a fault which is followed by the line of the S. Sedili. An investigation of this fault could reveal limestone further south. Rajah has recorded a small limestone outcrop on the southern side of the fault near the drainage divide between this river system and that of the S. Dohol. Unfortunately, time did not permit investigation of this occurrence in detail.

7. BOREHOLE RECORDS

Borehole 1 - Surface Level: - 986 Feet A.O.D.
 Base of Unconsolidated Material: - 948 Feet A.O.D.
 Borehole ends at: - 928 Feet A.O.D.

Depth	Core Recovery	Description	Remarks
0-8'	25%	Coarse Yellow/Brown Sandstone	0-38'6" overburden and stream debris
-10'	45%	Yellow clay with Tuff and Sandstone pebbles	Top of limestone 38'
-16'	30%	Broken core shale fragments	
-18'	20%	Broken core shale fragments	
-22'	20%	Broken core shale fragments with rounded sandstone pebbles	
-25'	18%	Broken core shale fragments	
-34'6"	5%	Broken core shale fragments	
-37'	30%	Broken core shale fragments	
-38'	40%	Broken core shale fragments	
-38'6"	90%	Dark grey, fine grained limestones	
-40'8"	100%	Dark grey limestone with black argillaceous partings	Dip 36°
-45'8"	100%	Similar limestone with white calcite joints and stylolites	
-50'2"	100%	Limestone similar, broken and cemented with calcite Pyrite in limestone and shale	Shale partings dips 38° Shale partings are slickensided
-52'10"	100%	Limestone similar, Core contains black calc. mudstone partings. Large calcite joints	Dip 20°
-58'	100%	Black calc. mudstone. Dark fine grained limestone Some medium grey limestone with calcite joints	Dip 34° Dip 32°

Borehole 2 - Surface Level: - 1,043 feet A.O.D.
 Base of Overburden: - 983 feet A.O.D.
 Base of Limestone: - 868 feet A.O.D.
 Borehole ends at: - 838 feet A.O.D.

Depth	Core Recovery	Description	Remarks
0-2'	0%		
-4'	40%	Brown clay with sandstones, gritstone pebbles	
-6'	0%		0-60' Superficial deposits
-7'	100%	Yellow/red clay	
-9'	0%		
-13'	100%	Yellow/red clay	
-17'	0%		
-21'	93%	Yellow/red clay	
-24'	0%		
-28'	100%	Yellow/red clay 2' Stiff brown clay 2'	
-30'	0%		
-33'	100%	Stiff brown clay	
-34'	50%	Broken pebbles of quartzite and vein quartz	
-35'6"	60%	Stiff brown clay	
-40'	0%		
-45'	80%	Stiff brown clay. Broken vein quartz.	
-50'	0%		
-52'6"	40%	Stiff brown clay and gravel	
-57'	0%		
-60'	83%	Stiff brown clay	
-64'	98%	Medium grey fine grained limestone becoming finer darker to 62'. Calcite joints. Some broken core of fine dark grey limestone.	Rare fusulinids and crinoid ossicles 62'10"-63'2" fusulinids
-65'3"	97%	Fine fine dark grey to black limestone. Numerous calcite filled joints.	Core broken Fusulinids common.
0-70'3"	98%	Medium to dark grey limestone. Rare argillaceous partings (Dip 32°).	Limonic & calcite joints common.
-72'6"	90%	Broken core large calcite filled joints (70°).	Numerous fusulinids.
-77'6"	100%	Fine dark limestone. Calcite veins to 78'2" contorted black mudstone at 73'6". Numerous argillaceous streaks and partings (Dip 34°). Thin calcite veins show small scale faulting	
-80'10"	98%	Medium grey fine grained limestone. 4" broken mudstones at 80'3". Numerous calcite veins and joints.	Dip 33°

Borehole 2 cont'd.

<u>Depth</u>	<u>Core Recovery</u>	<u>Description</u>	<u>Remarks</u>
-85'10"	100%	Mainly very dark grey fine grained limestone	Large calcite veins & joints. 2" fusulinid band 85'
-95'10"	98%	Medium grey fine grained limestone with argillaceous partings, becoming finer dark limestone with argillaceous streaks and partings common.	Fusulinid bands at 89' Dips on argillaceous 30°-32°
-100'10"	100%	Dark grey fine grained limestone black argillaceous bands (often slickensided) common. 97'4" limestone fragments in argillaceous matrix	Dip 30° Scattered Brachiopod shells. Gasteropod at 99'4". Fusulinids scattered
-109'10"	98%	Very dark grey to black limestone. Contorted argillaceous partings often slickensided. Calcite veins and joints	Fusulinids common to 105'4". Dip 33° at 104'10"
-118'4"	95%	As above. Fusulinids mainly in black limestone and argillaceous bands	110'5" - Fusulinid band. 112'10" - Fusulinid band 111'7" - Slickenside. 117'10" - Slickenside Dip 34°
-120'	90%	Dark fine grey limestone. Calcite veins	Numerous slickensides Dip 32° Fusulinids rare.
0-127'6"	98%	Limestone similar, broken & recemented. Broken shale partings calcite joints and veins.	
-137'	100%	Limestone similar argillaceous streaks and partings (almost vertical)	Dip 36° ? Fault Scattered Fusulinids.
-146'9"	100%	Medium grey fine limestone fine argillaceous streaks. 143'6"-12" Pale greenish grey siliceous mudstone.	
-149'6"	100%	Limestone similar	
-159'		Limestone similar becoming fine dark with argillaceous bands & Fusulinids	Fusulinid bands 153'6", 154'7", 155'8". Dips 28°
-167'	95%	Similar.	162'2" Small faults
-177'	100%	Similar to 175' with argillaceous bands becoming dominant Calcite joints.	173'8" Gasteropod Brachiopods Dip 32°
-187'	100%	Mainly grey, green & black mudstones and shales, often mottled, contorted or showing slump structures.	Dip 34°
-196'	100%		
-205'	100%		

Borehole 3 - Surface Level: - 1,065 feet A.O.D.
Base of Overburden: 1,023 feet A.O.D.
Base of Massive Limestone: - 846 feet A.O.D.
Borehole ends at: - 779 feet A.O.D.

<u>Depth</u>	<u>Core Recovery</u>	<u>Description</u>	<u>Remarks</u>
0-10'	50%	Stiff yellow brown clay.	
-12'	90%	Grey to buff coarse grained sandstone.	
-18'	0%		
-42'6"	10%	Clay and Sandstone.	
-53'	100%	Very pale grey fine grained recrystallized limestone.	
-61'6"	100%	" " " " " "	
-71'6"	100%	" " " " " "	
-76'3"	100%	" " " " " "	Occasional calcite
-86'7"	100%	" " " " " "	veinings, stylolites
-91'8"	100%	" " " " " "	
-96'10"	100%	" " " " " "	
-102'	100%	" " " " " "	102' limestone becoming darker
-107'1"	100%	108'-112' limestone darker	
-112'2"	100%	with fusulinids	
-117'2"	100%	Limestone becomes lighter to 113'7"	Fusulinids rare.
-		Then pale grey limestone.	
-122'2"	100%	Pale grey limestone	Dark Calcite vein
-126'	98%	Grey limestone	
-131'	100%	Grey limestone	
-137'	100%	Grey limestone	Large calcite veins
-143'	100%	Grey limestone	
-148'	100%	Grey limestone	
-153'	97%	Grey limestone	Fusulinids 152'-153'4"
-157'	100%	Grey limestone	Scattered fusulinids
-162'8"	86%	Similar limestone broken	Scattered fusulinids.
0-167'10"	98%	Grey limestone	
-173'	100%	Grey limestone	
-178'	100%	Grey limestone	175'6" Darker limestone with fusulinids
-183'3"	100%	Grey limestone becoming pale grey	Fusulinids 181'3"
-193'7"	100%	Very pale grey limestone	
-198'10"	100%	" " " "	
-204'	100%	" " " "	
-208'2"	100%	" " " "	

Borehole 3 cont'd

<u>Depth</u>	<u>Core Recovery</u>	<u>Description</u>	<u>Remarks</u>
-213'2"	100%	Very pale grey limestone	
-218'2"	100%	" " " "	
-223'2"	95%	" " " "	
		219' dark grey to black limestone shale partings & calcite joints and veins	? Plant remains in shales. Pyrite common. Slickensides common. Graphitic partings
-228'2"	100%	Similar	Dip 28°
-233'8"	100%	Similar more argillaceous	Brachiopod - 233'6"
-239'	100%	Similar calcite vein	238'6" Argillaceous parting dip 27°
-244'2"	100%	Similar	
-249'4"	100%	Similar	
-254'6"	100%	Similar	
-259'6"	100%	Similar	
-264'6"	100%	Similar	
-270'	100%	Similar	269' - ? Dip 38°
-275'6"	95%	Similar	
-281'	95%	Similar	
-286'	100%	Similar	

Borehole 4 - Surface level: - 1,152 feet A.O.D.
 - Base of Overburden: - 980 feet A.O.D.
 - End of borehole: - 762 feet A.O.D.

<u>Depth</u>	<u>Core Recovery</u>	<u>Description</u>	<u>Remarks</u>
0-172'6"	20%	Overburden, clay & boulders of sandstone. 15'-18' coarse angular conglomerate boulder	Poor core recovery
-173'10"	95%	Pale grey massive recrystallised limestone	
-175'10"	80%	" " " "	Reduced to BX core
-181'6"	100%	" " " "	
-195'9"	100%	" " " "	Calcite vein 4'
-198'9"	95%	" " " "	
-200'	95%	" " " "	
-201'6"	98%	" " " "	
-207'	0%		Core bored away
-214'	86%	Fine grey limestone calcite joints and veins	
-219'	90%	Fine grey limestone	
-222'	96%	" " " "	
-232'	100%	" " " "	Massive calcite veins
-237'	100%	" " " "	" " "
-246'3"	100%	" " " "	237-242' slightly darker with fusulinids
-256'3"	100%	" " " "	Fusulinids 248'3", 252'
-390'			

Individual "draws" not seen by geologist. Core reported by geological assistants as

Description cont'd

similar, massive grey limestones. Occasional darker bands, no shale partings. Limestone becoming darker to 390'.

8. DRILLING AND EQUIPMENT USED

1. General

The drilling crew from Drilling and Minerals Sdn. Bhd., Kuala Lumpur, arrived at the access timber road, approximately 3 1/4 miles from the first drill site at midday of July 22nd.

After arriving at the first site all work was smoothly and efficiently carried out. The projected figure of 90 feet per three shift drilling day was achieved on most days. Core recovery in the limestone was excellent and fully up to expectations.

The drilling team working in three shifts, consisted of 1 clerk, 1 foreman driller, 1 fitter, 3 drillers and 6 drilling assistants.

All holes were drilled vertically, total of 940 feet being drilled.

2. Drilling Equipment

One Boyles Brothers BBS10 drilling machine - fitted with hydraulic swivel head and driven by a Perkins P3 diesel engine.

One Mono Water Supply Pump driven by a Lister diesel engine.

One Bean Royal Control Pump with Deutz diesel engine.

20 feet of H casing for collaring.

100 feet of NX (i.d.3.1/16") casing for hole lining.

250 feet of BX (i.d.2.15/32") casing for hole lining.

400 feet of BW (o.d.2.1/18") drill rods.

One NWF 10 feet Double tube core barrel with swivel head.

One NMLC 5 feet Triple tube core barrel.

One BMLC 5 feet Triple tube core barrel.

NX casing bits and shoes.

BX casing bits and shoes.

NMLC core bits (Step and Flat face) - core size 2.5/64".

NMLC Reamer Shells.

NXF Core bits and Reamer Shells - core size 2.1/8".

BMLC Core bits and Reamer Shells - core size 1.25/64".

NW, BW Reducer/Adaptors.

NX, BX Casing Caps.

Rod Bells and Taps.

Water and Lifting Swivels.

Sheave Block.

1700 feet Plastic water supply hose.

2000 p.s.i. pressure hose.

Mud Tank.

Mud Mixer.

'Macobar' Bentonite drilling mud.

Jarring hammers.

Ground casing clamps.

Miscellaneous small hand tools.

Core boxes.

9. ANALYTICAL RESULTS

The chemical analysis of samples from two cores was carried by the Geological Survey, Ipoh, the results are reproduced here with acknowledgement to the Director of the Geological Survey.

Limestone samples from Gunung Sumalavang, Johore

<u>Sample Marking</u>	<u>Percent CaO</u>	<u>Percent MgO</u>
S 1	55.0	0.04
S 2	54.5	0.56
S 3	54.6	0.54
S 4	55.1	0.27
S 5	55.1	0.21
S 6	55.0	0.32
S 7	53.4	0.92
S 8	53.4	0.92
S 9	49.1	3.14
S 10	52.9	0.74
S 11	53.8	0.05
S 12	54.3	0.27
S 13	52.3	1.07
S 14	52.8	0.45
S 15	55.2	0.61
S 16	52.0	0.39
S 17	54.2	0.64
S 18	50.8	0.58
S 19	40.9	0.54
S 20	42.9	0.78
S 21	47.9	2.48
S 22	48.6	0.94
S 23	47.8	1.07
S 24	44.7	1.28
S 25	44.3	0.77

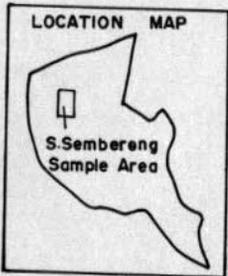
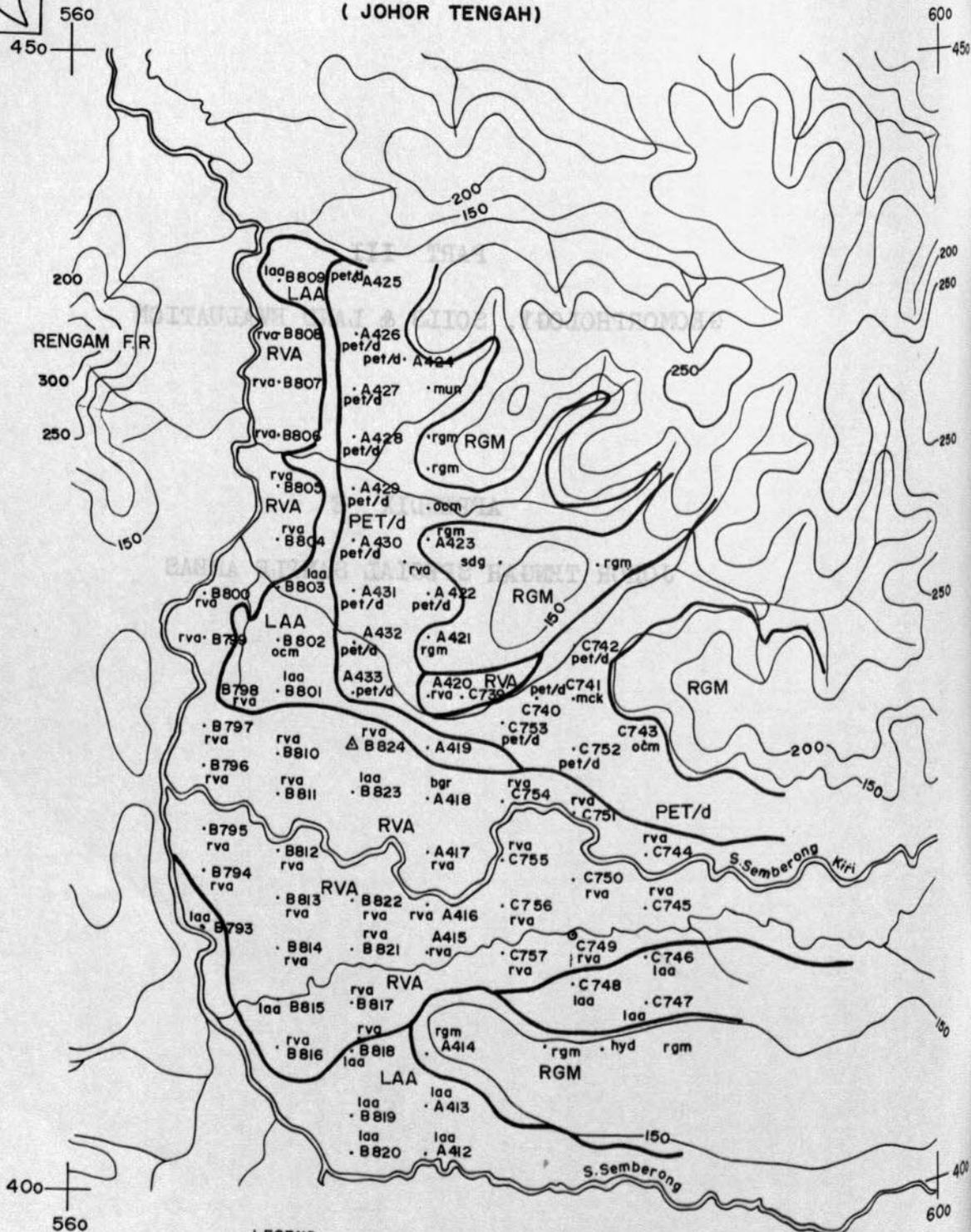


FIGURE 1
SUNGEI SEMBERONG SAMPLE AREA

Scale: 1:25,000

Topographic Sheet No.124b
(JOHOR TENGAH)



LEGEND

Rengam Series	RGM or rgm	Organic Clay and Muck	OCM or ocm
Munchong Series	MUN mun	Muck	MCK mck
Bungor Series	BGR bgr	Peat, deep	PET/d pet/d
Halyrood Series	HYD hyd	Bore site and number	. B823
Riverine Alluvium	RVA rva	Bore site sampled	⊙
Local Alluvium	LAA laa	Pit site	△
coarse phase	LAA/co laa/co	Soil boundary	—
Map reference	400 + 560	Contour line	-250-

JOHOR TENGAH SPECIAL SAMPLE AREAS.

1. INTRODUCTION

River valley alluvium occupies rather large areas of the Johor Tengah Region. Such alluvial deposits are usually very variable in composition, and it is almost impossible to give much indication of this variability in a semi-detailed soil survey. To check the degree of variability within an area of river valley alluvium, two small areas were surveyed in detail. The first, situated at the junction of the S. Semberong and S. Semberong Kiri, was chosen to represent an area within which the semi-detailed study has indicated alluvia with a wide range of drainage characteristics. The second area, in the valley of the S. Dengar, about three-quarters of a mile south of that river's confluence with the S. Kahang, covered an area which the semi-detailed survey indicated was uniform, at least in terms of drainage.

It must be pointed out, that Fig. 1, 2 and 3 of this Appendix have been drawn at field mapping scale, i.e. 1:25,000. This is due to the fact that no larger scale maps (e.g. 1:10,000) were available for the field work. The above maps must therefore not be regarded as claiming an accuracy appropriate to 1:25,000 after reduction from a larger scale.

2. S. SEMBERONG SAMPLE AREA

This sample area covers some 2 square miles of alluvium and foothills (Figure 1). Some 11 miles of rents were surveyed, auger inspections being made at 10 chain intervals. A total of 72 sites were examined and described. The survey revealed that the area is a complex pattern of levees and backswamps associated with the S. Semberong and S. Semberong Kiri, and with two tributaries. Riverine Alluvium soils are formed on the higher level levees; these are heavy textured, varying from fine sandy clay to silty clay and clay. Drainage is imperfectly to well drained, the better drained soils occurring on the highest parts of the levees. In most cases, the soils are rather compact, with a well developed angular blocky structure which appears to have a low porosity. The imperfectly drained members have a permanent water-table at 60 cm (24 inches) or greater. The soils above this level are strongly mottled indicating considerable fluctuation of the water-table. The well drained soils on the highest part of the levee are fine sandy clays rather than silty clays or clays. They are more friable and more weakly structured with higher porosity than the finer members.

Within the backswamp areas behind the levees are soils of the Local Alluvium group and deep peat, the latter occurring towards the base of the low hills surrounding the alluvium. Below the confluence of the S. Semberong and S. Semberong Kiri, the S. Semberong has no well defined levees, and soils of the Local Alluvium extend as far as the river bank. The Local Alluvium soils are fine textured gleys with an organic surface horizon of less than 15 cm (6 inches). The sub-soil has a very high water content and very little cohesion, indicating permanent saturation. No settling and compaction of the material has occurred. A coarse phase member of this soil has tentatively been organised. Soils of the Local Alluvium grade very rapidly into the deep peat soils. These are at least 100cm (40 inches) deep, very poorly humified and rather woody. The water content is extremely high.

3. S. DENGAR SAMPLE AREA

In the valley of the S. Dengar, an area of one square mile was examined at the same level of detail (Figure 2). The soil pattern is very simple, with

three groups of soils in bands parallel to the river. The Riverine Alluvium and Local Alluvium are similar to those of the Semberong valley, described above. The third group is the Organic Clay and Muck soils. These are organic soils containing between 25 and 65 percent organic matter measured by loss on ignition. They are unconsolidated soils with very high water contents.

4. S. PENGELI SAMPLE AREA

In any semi-detailed survey, the detailed variations within a series which can be mapped are rather limited. These differences can be important for agricultural development, especially if annual cropping on a small-holder system is envisaged. To give some indication of the variability within a series unit as mapped during the semi-detailed survey, an area of low gently undulating soils of the Harimau Series was examined. This area of approximately 2½ square miles is located at the confluence of the S. Pengeli and S. Sayong (Figure 3). The level of detail was the same as for the other areas described above i.e. auger inspection at 10 chain intervals along rents 15 chains apart. The survey revealed that there are three distinct phases with the Harimau Series in this area.

It appears that the older alluvium overlies an older surface of shale derived material, the junction being marked by a band of rather close packed laterite. The underlying material is very compact. Over a large part of the area examined, this laterite band and shale material occur within 100 cm (40 inches) of the surface. These soils have been called a moderately deep phase of the Harimau Series. The deeper Harimau Series soils have been divided into the normal series soil and a friable phase. The latter phase of the Harimau Series has not been established by the Soil Science Division of the Division of Agriculture, Kuala Lumpur and should therefore be regarded as tentative. The normal series has moderately structured, friable surface horizon(s) of sandy clay loam to sand clay texture, overlying at about 40 cm (16 inches) rather firmer and more coarsely structured sandy clay sub-soil horizons. In the friable phase, the soil is weakly structured and friable to at least 80 cm (32 inches). No reason for this difference is known, other than the fact that the texture is more generally sandy clay loam than sandy clay, when soils are more friable.

Alluvial soils are generally not subdivided into phases, but sub-division has been done tentatively in this detailed study. Thus the coarse and compacted phases of the Riverine Alluvium should not be regarded as established in the West Malaysian soil classification. The Riverine Alluvium/coarse is a very sandy soil with textures lighter than sandy loam, merging into sand at a depth of about 90 cm (36 inches). The Riverine Alluvium/compacted is a soil which has a very firm consistency from a depth between 15 and 50 cm (5 and 20 inches).

Series belonging to upland soils have been discussed in detail early in this Report (Chapter 6, Soils).

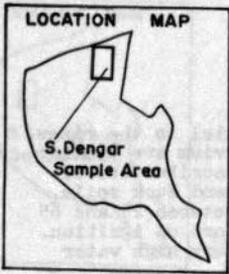


FIGURE 2
SUNGEI DENGAR SAMPLE AREA
 Scale: 1:25,000
 Topographic Sheet No.124b
 (JOHOR TENGAH)

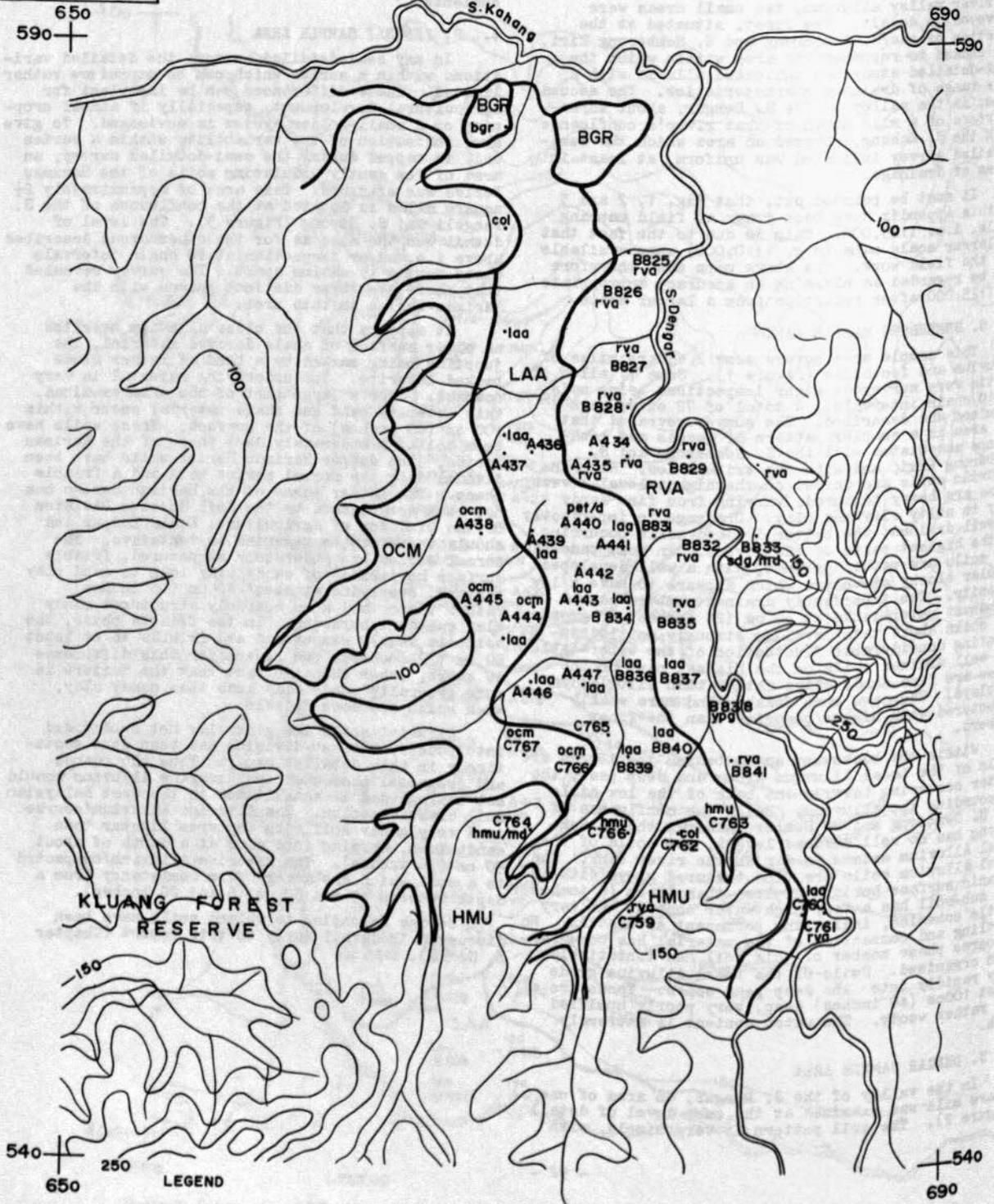




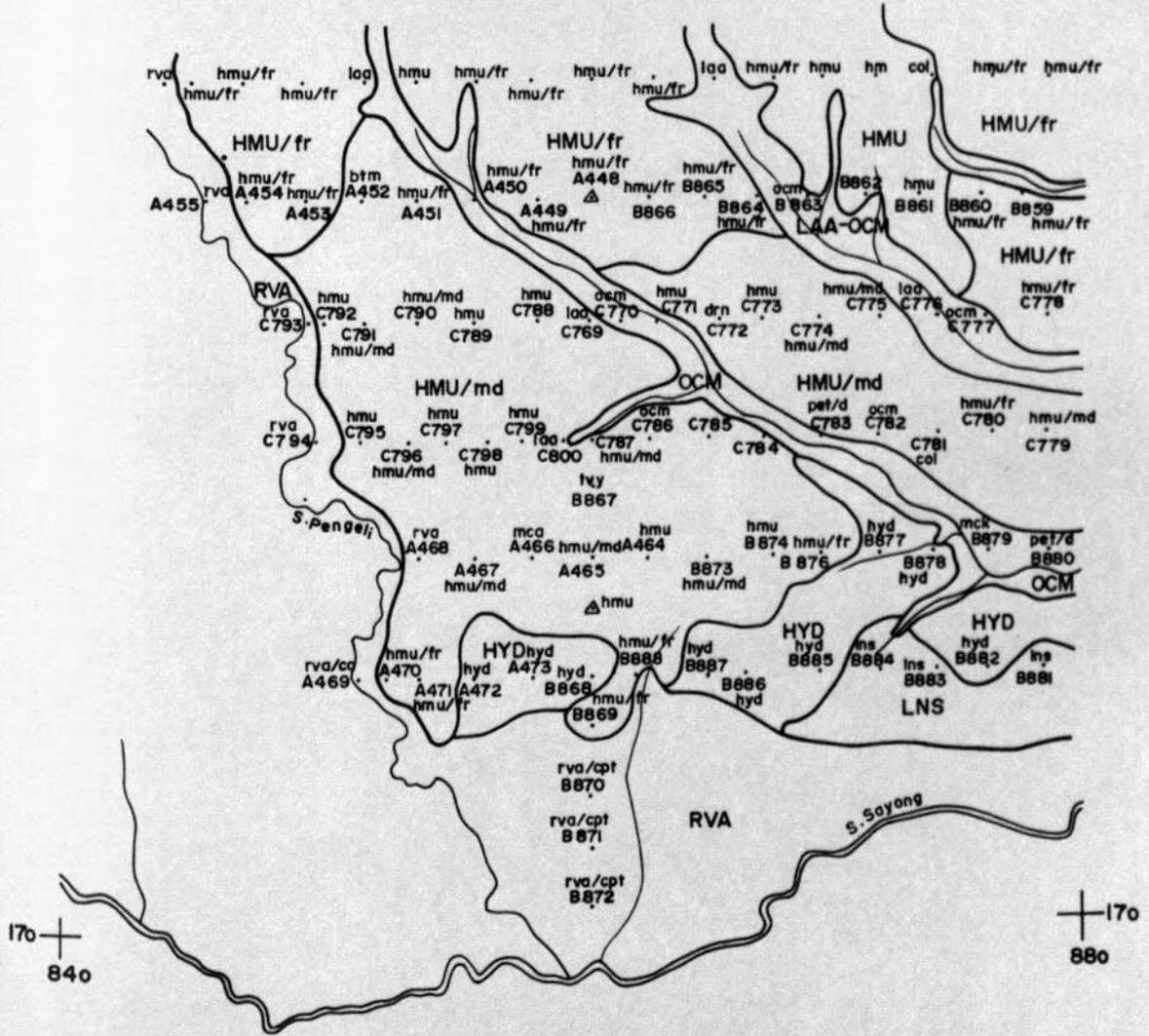
FIGURE 3
SUNGEI PENGELI SAMPLE AREA

Scale: 1:25,000

Topographic Sheet No. 125e & 130a
(JOHOR TENGAH)

840
210

880
210



LEGEND

Batu Anam Series	BTM	or	btm
Durian Series	DRN		drn
Tavy Series	TVY		tvy
Malacca Series	MCA		mca
Colluvium	COL		col
Harimau Series	HMU		hmu
friable phase	HMU/fr		hmu/fr
moderately deep phase	HMU/md		hmu/md
Holyrood Series	HYD		hyd
Lunas Series	LNS		lns
Riverine Alluvium	RVA		rva
coarse phase	RVA/co		rva/co
compacted phase	RVA/cpt		rva/cpt

Organic Clay and Muck	OCM	or	ocm
Muck	MCK		mck
Peat, deep	PET/d		pet/d
Bore site and number			• C 771
Pit site			△
Soil boundary			—
Contour line			— 250 —
Map reference			170 + 840

SOIL MOISTURE DETERMINATIONS

In order to determine the amount of water in soil, it is necessary to know the weight of the soil and the weight of the water in it. This is done by weighing a known amount of soil and then weighing it again after it has been dried in an oven at 105°C for 24 hours. The difference in weight is the weight of the water in the soil.

The following table shows the results of the soil moisture determinations for the various soil samples.

Soil Sample	Weight of Soil (g)	Weight of Soil + Water (g)	Weight of Water (g)	Moisture Content (%)
1	10.0	10.5	0.5	5.0
2	10.0	11.0	1.0	10.0
3	10.0	11.5	1.5	15.0
4	10.0	12.0	2.0	20.0
5	10.0	12.5	2.5	25.0
6	10.0	13.0	3.0	30.0
7	10.0	13.5	3.5	35.0
8	10.0	14.0	4.0	40.0
9	10.0	14.5	4.5	45.0
10	10.0	15.0	5.0	50.0

PART III

APPENDIX F

SOIL MOISTURE DETERMINATIONS

The following table shows the results of the soil moisture determinations for the various soil samples. The moisture content is expressed as a percentage of the dry weight of the soil.

It is recommended that further studies be carried out in regard to the relationship between soil moisture content and soil fertility.

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1	10.0	10.5	0.5	5.0
2	10.0	11.0	1.0	10.0
3	10.0	11.5	1.5	15.0
4	10.0	12.0	2.0	20.0
5	10.0	12.5	2.5	25.0
6	10.0	13.0	3.0	30.0
7	10.0	13.5	3.5	35.0
8	10.0	14.0	4.0	40.0
9	10.0	14.5	4.5	45.0
10	10.0	15.0	5.0	50.0

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It is recommended that further studies be carried out in regard to the relationship between soil moisture content and soil fertility.

SOIL MOISTURE DETERMINATIONS

The amount of moisture which soils retain and which is available for crop growth is related to soil texture, structure, the nature and amount of inorganic and organic colloidal material, the kind and quantity of exchangeable cations and the size and volume of the pores.

The plant must overcome certain forces in order to take up water from the soil; this is called soils moisture stress, which represents the combined forces of matric tension and osmotic tension. The latter is due to dissolved salts, but in wet humid climates dissolved salts are negligible therefore soil moisture stress is equal to soil matric tension.

High soil temperatures can deplete soil moisture reserves, and often do so on cultivated land especially when the crop is still in its early stages of growth and the soil surface is bare. These high soil temperatures can be reduced by mulching and green cropping.

The range of soil moisture which is important to crop growth is the "available water content" (also called available water capacity) or AWC. This range can be determined by several methods, in this study the following were employed:

- laboratory determination using the porous plate and pressure membrane apparatus.
- Calculations using Salter and Williams' method of estimating the available water capacity in the field (Salter and Williams, 1967).

The AWC is defined as the moisture held by the soil between field capacity (FC) and permanent wilting point (PWP).

The field capacity is the highest moisture content of the soil at which plants absorb moisture except transiently in the interval between saturation and the drainage of surplus water out of the pore zone and the wilting point is the lowest possible moisture content for plant survival.

Under practical conditions the field capacity of a soil is reached some two days after the soil has been completely saturated with water, either by rainfall or irrigation, and downward flow of water by gravitational pull has practically ceased.

In the laboratory the field capacity has been simulated by using tension of 1/10 or one-third of an atmosphere. (pF figures 2.0 and 2.5 respectively). In this project for coarse textured soils 1/10 of an atmosphere and for medium and fine textured soils the one-third of an atmosphere tension was used. The wilting point for all textures was measured at 15 atmosphere tension, pF 4.2.

The moisture content of the soil is measured on a dry weight basis. But for many purposes it is more useful to know the moisture content by volume of the soil; this can be calculated using the bulk density (B.D) or apparent specific gravity. The bulk density is a means of expressing the weight of dry soil per unit volume and thus includes the space occupied by soil solids and the pore space in a particular volume of soil. The bulk densities of soils studied range from 1.00 to 1.60, the higher figures being generally found in sands.

Not all the water held by a soil is equally available for plant growth and in the lower ranges the plant has to exert considerable force to obtain moisture. When the permanent wilting point is reached no water can be extracted. Between this moisture content and field capacity the ease of extraction increases rapidly. The remaining water at that wilting points varies in amount depending on soil

texture. In sandy soils the amount of water remaining at wilting point may be about 0.5 inch per foot of soil, in loamy soils approximately 1.5 inch per foot and in clay soils about 2.5 inches per foot. (Tamhane, Motiramani, Bali and Donahue, 1964). The moisture held at low tensions also increases with texture, so that the AWC varies less with texture than do the moisture content, a point illustrated in Table 3.

Table 1 illustrates the moisture holding characteristics of a number of selected profiles. In the table the following calculations have been used:

- AWC by weight percentage = moisture held at 1/10 or one-third of an atmosphere minus moisture held at 15 atm.
- AWC in volume percent = AWC in weight percent times B.D.
- AWC in inches per soil horizon = $\frac{\text{AWC Vol. percent} \times \text{depth}}{100}$

Table 2 gives the average AWC in inches per foot of soil. It must be pointed out that the average AWC has been calculated from the total profile. Therefore these figures are slightly lower than the AWC in inches per horizon (column 13, Table 1).

The above tables indicate that the Rengam, Bungor and Holyrood series have the highest available water, followed by Yong Peng and Harimau Series and Rengam Series, coarse sandy clay phase with the lowest figures. Surprisingly Holyrood Series has a similar AWC to the Rengam and Bungor Series. The reason is that this particular Holyrood Series profile has higher than usual fine sand and clay figures. The texture of the two analysed profiles is sandy clay loam. In other words this Holyrood Series profile appears to be heavier textured than its modal profile.

Table 3 illustrates wilting point, field capacity and available water capacity for a number of textural classes. The AWC figures in this table generally compare with those in Table 2.

Work done by Salter and Williams (1967, IV) has made it possible to estimate an approximation to the available water capacity on the basis of the soil texture. The West Malaysian textural classes have the silt fraction boundaries between 0.002 and 0.02 millimetres (Leamy and Panton, 1966). Therefore the equation used to work out the AWC in inches per foot is:

$$Y = 2.17 - 0.018a + 0.0072b.$$

In which Y = AWC (in/ft)

a = percent coarse sand

b = percent fine sand.

Table 4 illustrates the calculated values for available water expressed in inches per foot, for most of the sampled soil series. This table should be regarded as an approximation only since insufficient work has been done to correlate the calculated AWC values with the actually measured values. There is however general agreement between the figures in Tables 4 and 2.

Table 5 lists the percentage of moisture retained by a number of selected soil profiles at pressures of 0, 1/10, 1/3, 1 and 15 atmosphere.

It is recommended that further studies are carried out in respect of the agriculturally

TABLE 1

MEASURED AVAILABLE WATER CAPACITY FOR SELECTED PROFILES

1	2	3	4	Percentage moisture retention on dry weight basis at pressure:					10	11	12	13	Soil Separates Percentage on fine earth				On original Sample percent		20				
				5	6	7	8	9					B,D g/cc	AWC wt. %	AWC vol. %	AWC in. per horizon	14 Clay less than 0.002 mm.	15 Silt to 0.002 0.02 mm		16 Fine Sand to 0.2 mm	17 Coarse Sand to 2 mm	18 gravel	19 stones
YFG	A152	A0048	15-54	40.0	31.7	29.5	29.2	21.6	1.4	7.9	11.1	1.77	73	4	11	17	1	N11	C				
		A0049	54-94	52.8	36.5	34.0	33.7	25.0	1.2	9.0	10.8	1.73	71	2	11	20	29	1	C				
YFG	B029	B0022	11-32	49.7	44.9	42.7	42.4	30.8	1.3	11.9	15.5	1.32	77	8	10	11	N11	N11	C				
		B0023	32-67	53.5	44.9	42.6	42.3	31.7	1.2	10.9	13.1	1.79	23	57	10	11	N11	N11	SL				
		B0024	67-96	55.7	46.5	43.6	43.2	32.8	1.2	10.8	13.0	1.48	25	59	10	10	0.6	N11	SL				
YFG	C103	C0041	50-82	41.1	36.1	34.6	32.8	24.2	1.3	10.4	13.5	1.76	25	48	8	24	1.4	N11	SL				
		C0042	82-115	26.0	18.4	17.3	16.4	13.2	1.6	4.1	6.6	0.85	67	6	6	26	40.8	27	C				
RCM	B337	B0095	0-14	86.9	50.3	44.6	43.9	22.0	1.0	22.6	22.6	1.24	59	6	14	26	N11	N11	C				
		B0096	14-44	47.2	34.7	32.6	32.3	22.7	1.4	9.9	13.9	1.64	61	4	12	28	1.5	N11	C				
		B0097	44-70	45.6	35.5	33.2	32.7	23.7	1.3	9.5	12.4	1.26	30	37	10	28	4.5	0.6	CL				
		B0098	70-106	45.9	33.7	31.4	31.2	23.0	1.4	9.4	13.2	1.87	30	37	7	31	22.1	1.9	CL				
RCM	B405	B0109	12-34	40.7	32.6	30.3	30.0	20.2	1.3	10.1	13.1	1.13	61	2	12	30	4.2	N11	C				
		B0110	34-77	42.0	29.1	26.2	25.9	18.0	1.4	8.2	11.5	2.02	59	2	10	34	9.3	N11	C				
		B0111	77-120	38.5	22.3	20.8	20.5	15.2	1.3	5.6	7.3	1.18	63	2	10	30	31.7	N11	C				
RCM/ SFG	B482	B0138	22-42	29.7	17.1	15.7	14.6	10.8	1.3	4.9	6.4	0.51	44	9	8	32	23	N11	SC				
		B0139	42-80	29.2	16.4	15.5	14.8	9.1	1.3	6.4	8.3	1.24	44	25	5	43	42	N11	CL				
RCM	A291	A0060	15-42	43.6	34.3	33.3	32.5	22.5	1.3	10.8	14.0	1.48	61	4	13	25	N11	N11	C				
		A0061	42-75	44.7	37.2	36.1	34.3	24.1	1.3	12.0	15.6	2.08	65	4	11	24	1	N11	C				
		A0062	75-101	37.9	27.3	27.0	26.1	19.2	1.3	7.8	10.1	1.02	67	8	7	21	3	N11	C				
MSI	A199	A0037	15-48	38.7	28.1	25.9	25.6	17.6	1.4	8.3	11.6	1.51	48	3	10	42	1.7	N11	SC				
SFG/ SFG	B545	B0148	16-49	35.9	27.8	26.2	24.3	17.0	1.4	9.2	12.9	1.67	48	3	13	41	N11	N11	SC				
		B0149	49-100	36.4	28.2	27.1	26.4	17.7	1.4	9.5	13.3	2.67	45	3	17	40	N11	N11	SC				
		B0150	100-152	34.7	29.7	28.6	27.7	18.4	1.5	10.2	15.3	3.13	47	2	14	35	N11	N11	SC				
RCR	C039	C0025	0-10	49.9	36.5	33.6	30.6	16.5	1.1	17.1	18.8	0.73	45	7	34	16	N11	N11	SC				
		C0026	10-47	40.8	31.9	30.1	28.6	18.0	1.3	12.1	15.7	2.29	52	4	32	17	N11	N11	SC				
		C0027	47-109	32.9	28.3	26.8	25.5	18.0	1.5	8.8	13.2	3.22	51	8	30	16	N11	N11	C				
PHI	B211	B0075	11-38	35.5	27.9	25.9	24.2	16.3	1.5	9.6	14.4	1.52	53	6	15	31	N11	N11	SC				
		B0076	38-68	34.1	29.8	26.1	24.6	18.2	1.6	7.9	12.6	1.48	54	5	15	31	N11	N11	SC				
		B0077	68-138	31.9	27.6	26.1	24.7	18.5	1.6	7.6	12.2	3.36	57	6	15	25	N11	N11	C				
RMO	C018	C0002	6-21	40.5	32.4	30.2	28.3	14.8	1.4	15.4	21.6	1.27	45	4	22	33	2.4	N11	SC				
		C0003	21-36	31.0	25.7	24.3	22.2	15.7	1.6	8.6	13.8	0.81	49	2	20	32	3.4	N11	SC				
		C0004	36-67	31.0	26.3	25.1	23.6	18.3	1.5	6.8	10.2	1.24	49	3	14	36	18.8	N11	SC				
		C0005	67-139	30.3	27.4	26.2	25.1	21.2	1.5	5.0	7.5	2.13	53	6	13	33	7.5	N11	SC				
		B114	B0052	17-58	28.9	18.1	14.7	14.4	7.8	1.5	10.3	15.5	2.49	26	4	36	39	1.1	N11	SCL			
	B0053	58-121	22.9	14.8	12.6	11.5	6.4	1.6	8.4	13.4	3.32	24	4	35	41	5.0	N11	SCL					

TABLE 2
AVERAGE MEASURED AVAILABLE WATER CAPACITY (INCHES/FOOT)

Soil Series	Site No.	Total Depth of sampled horizons (inches)	Thickness of sampled profile	Total AWC (Inches) for sampled profile	AWC (Inches) per inch Soil Depth	Average AWC inches/foot of soil	Laboratory textures of examined profile
Yong Peng	A152	5.9 - 37.0	31.1	3.40	0.10	1.2	Sandy clay to silt loam
Yong Peng	B029	4.3 - 37.8	33.5	4.59	0.13	1.6	As above
Yong Peng	C103	19.7 - 45.3	25.6	2.61	0.10	1.2	Silt loam to clay
Rengam	B337	0 - 41.7	41.7	6.01	0.14	1.7	Clay to clay loam
Rengam	B405	4.7 - 47.2	42.5	4.33	0.10	1.2	Clay
Rengam coarse sandy clay phase	B482	8.7 - 31.5	22.8	1.75	0.07	0.8	Sandy clay to clay loam
Rengam	A291	5.9 - 39.8	33.9	4.58	0.13	1.6	Clay
Masai	A199	5.9 - 18.9	13.0	1.51	0.11	1.3	Sandy clay
Serdang, sandy clay phase	B545	6.3 - 59.8	53.5	7.47	0.13	1.6	Sandy clay
Bungor	C039	0 - 42.9	42.9	6.24	0.14	1.7	Sandy clay to clay
Pohoi	B211	4.3 - 54.3	50.0	6.36	0.12	1.4	As above
Harimau	C018	2.4 - 54.7	52.4	5.45	0.10	1.2	Sandy clay
Holyrood	B114	6.7 - 47.6	40.9	5.81	0.14	1.7	Sandy clay loam

TABLE 3
WILTING POINT, FIELD CAPACITY, AND AVAILABLE WATER CAPACITY OF VARIOUS SOIL TEXTURES+

Soil texture	Wilting Point		Field Capacity		Available Water Capacity	
	percent	Water per foot of soil depth (inches)	percent	Water per foot of soil depth (inches)	percent	Water per foot of soil depth (inches)
Medium sand	1.7	0.3	6.8	1.2	5.1	0.9
Fine sand	2.3	0.4	8.5	1.5	6.2	1.1
Sandy loam	3.4	0.6	11.3	2.0	7.9	1.4
Fine sandy loam	4.5	0.8	14.7	2.6	10.2	1.8
Loam	6.8	1.2	18.1	3.2	11.3	2.0
Silt loam	7.9	1.4	19.8	3.5	11.9	2.1
Clay loam	10.2	1.8	21.5	3.8	11.3	2.0
Clay	14.7	2.6	22.6	4.0	7.9	1.4

+ Source: Water. The Yearbook of Agriculture, 1955, page 120, U.S. Dept. of Agriculture

Note: It is obvious that since there is a variation in the amounts and kinds of sand, silt, and clay within any one textural group (such as within loam soils), there is also a variation in the water constants; however, for purposes of simplification an average value is given in this table.

available water in the various soil series not only in the southern part of West Malaysia but also in the north where climatic conditions are different.

TABLE 4

AVERAGE CALCULATED VALUES OF AVAILABLE WATER CAPACITY (inches/foot)
(after Salter & Williams)

Soil Series	No. profiles	0 - 12 inches Average	12 - 24 inches Range	12 - 24 inches Average	24 - 36 inches Range	24 - 36 inches Average	Total 0-36 inches	Remarks
Yong Peng	9	1.90	1.70-2.25	1.85	1.60-2.20	1.65	1.20-2.10	5.40
Jerangau	4	1.84	1.69-1.98	1.86	1.65-2.05	1.88	1.79-2.01	5.58
Rengam	11	1.70	1.50-1.80	1.60	1.35-1.75	1.50	1.30-1.70	4.80
Rengam, coarse sandy clay phase	3	1.40	1.15-1.60	1.10	1.05-1.20	1.00	1.10-1.00	3.50
Rengam, fine sandy clay phase	10	1.75	1.60-1.85	1.75	1.65-1.80	1.75	1.65-1.85	5.25
Masai	4	1.60	1.06-1.93	-	-	-	-	shallow soil incomplete profiles.
Serdang	4	1.56	1.50-1.70	1.63	1.60-1.75	1.56	1.20-1.80	4.75
Serdang, sandy clay phase	2	1.93	1.70-2.15	1.80	1.50-2.10	1.87	1.60-2.15	5.60
Bungor	6	2.05	1.65-2.40	2.00	1.70-2.35	1.95	1.70-2.35	6.00
Marang	5	2.18	2.04-2.30	2.09	1.89-2.26	1.65	1.19-2.17	5.92
Durian	5	2.25	2.15-2.35	2.25	2.20-2.40	2.20	2.10-2.35	6.70
Pohoi	3	2.03	1.75-2.21	2.01	1.75-2.15	1.90	1.65-2.20	5.94
Malacca	8	1.85	1.21-2.17	1.13	0.61-2.00	-	-	shallow soil incomplete profiles.
Tavy	4	2.00	1.75-2.20	1.57	0.88-2.00	1.28	0.75-1.80	4.85
Harimau	8	1.80	1.65-2.15	1.60	1.35-2.15	1.60	1.25-2.00	5.00
Holyrood	3	1.50	1.25-1.75	1.57	1.30-1.75	1.42	1.30-1.60	4.49

TABLE 5
SOIL MOISTURE ANALYSES

Sample No.	Depth (cm)	Bulk Density g/cc.	Percentage moisture retention on dry weight basis at pressures:					
			0 atm.	1/10 atm.	1/3 atm.	1 atm.	15 atm.	
A199	MASAI SERIES							
A0037	15-48	1.413	38.7	28.13	25.9	25.6	17.6	
A152	YONG PENG SERIES							
A0048	15-54	1.429	40.0	31.7	29.5	29.2	21.6	
A0049	54-94	1.211	52.8	36.5	34.0	33.7	25.0	
B029	YONG PENG SERIES							
B0022	11-32	1.301	49.7	44.9	42.7	42.4	30.8	
B0023	32-67	1.244	53.5	44.9	42.6	42.3	31.7	
B0024	67-96	1.220	55.7	46.5	43.6	43.2	32.0	
B114	HOLYROOD SERIES							
B0052	17-58	1.532	28.9	18.1	14.7	14.4	7.8	
B0053	58-121	1.61	22.9	14.8	12.6	11.5	6.4	
B337	RENGAM SERIES							
B0095	0-14	1.034	86.9	50.3	44.6	43.9	22.0	
B0096	14-44	1.356	47.2	34.7	32.6	32.3	22.7	
B0097	44-70	1.336	45.6	35.5	33.2	32.7	23.7	
B0098	70-106	1.381	45.9	33.7	31.4	31.2	23.0	
B405	RENGAM SERIES							
B0109	12-34	1.343	40.7	32.6	30.3	30.0	20.2	
B0110	34-77	1.381	42.0	29.1	26.2	25.9	18.0	
B0111	77-120	1.336	38.5	22.3	20.8	20.5	15.2	
A291	RENGAM SERIES							
A0060M	15-42	1.25	43.6	34.3	33.3	32.5	22.5	
61M	42-75	1.31	44.7	37.2	36.1	34.3	24.1	
62M	75-101	1.30	37.9	27.3	27.0	26.1	19.2	
B211	POHOI SERIES							
B0075M	11-38	1.47	35.5	27.9	25.9	24.2	16.3	
76M	38-68	1.55	34.1	29.8	26.1	24.6	18.2	
77M	68-138	1.62	31.9	27.6	26.1	24.7	18.5	
B482	RENGAM SERIES, coarse sandy clay phase							
B0138	22-42	1.30	29.7	17.1	15.7	14.6	10.8	
139	42-80	1.33	29.2	16.4	15.5	14.8	9.1	
B545	SERDANG SERIES, sandy clay phase							
B0148	16-49	1.36	35.9	27.8	26.2	24.3	17.0	
149	49-100	1.35	36.4	28.2	27.1	26.4	17.7	
150	100-152	1.50	34.7	29.7	28.6	27.7	18.4	
C018	HARIMAU SERIES							
C0002M	6-21	1.35	40.5	32.4	30.2	28.3	14.8	
3M	21-36	1.59	31.0	25.7	24.3	22.2	15.7	
4M	36-67	1.48	31.0	26.3	25.1	23.6	18.3	
5M	67-139	1.47	30.3	27.4	26.2	25.1	21.2	
C039	BUNGOR SERIES							
C0025M	0-10	1.12	49.9	36.5	33.6	30.6	16.5	
26M	10-47	1.32	40.8	31.9	30.1	28.6	18.0	
27M	47-109	1.50	32.9	28.3	26.8	25.5	18.0	
C103	YONG PENG SERIES							
C0041M	50-82	1.36	41.1	36.1	34.8	32.8	24.2	
42M	82-115	1.67	26.0	18.4	17.3	16.4	13.2	

APPENDIX G

TRACE ELEMENTS

1. INTRODUCTION

Most chemical elements have been shown to be present in animal and plant tissues, and in soils and rocks.

The term trace element was applied by early workers to those chemical elements which occur in small amounts relative to the amounts of the main constituents of the material. Among the many chemical elements detected in biological tissues, an essential physiological role has been established for a minority. These will be referred to as the micronutrient elements.

The elements copper, cobalt, manganese, iodine, zinc and selenium are considered essential for the proper nutrition of the higher forms of animal life and copper, manganese, zinc, boron and molybdenum for the life of higher plants.

Originally most trace elements were derived from the igneous rocks forming the earth's crust and during crystallisation of these rocks they entered into the crystal phases formed by the major constituents.

Chemical and physical weathering of the rocks eventually occurred and soil and plants established themselves.

Water movement through the soil tends to remove trace elements into lower horizons or into the drainage water.

Plants growing in the soil counteract this downward movement by absorption of elements from the soil-water and transference into the tissues. Later the plant is returned to the soil as debris, is broken down by microbiological activity and the chemical elements are incorporated into the organic horizon.

Plants and animals depend upon the soil for the supply of all micronutrient elements.

A plant obtains all its nutrients from a particular soil whereas animals, due to their mobility, may derive their nutritive requirements from a variety of plants growing on different soils. Furthermore appreciable amounts of some trace elements may be obtained from drinking water.

Many nutritional disorders in plants and animals result primarily from the inability of the soil to supply their essential micronutrient elements.

The processes of soil formation have a great effect upon the distribution of trace elements in the soil which, under appropriate conditions, may be:

- a) Leached down the profile if they are present as soluble ions;
- b) accumulated in the organic layer due to plant uptake and subsequent decay;
- c) moved in the course of podsolisation together with iron and aluminium;
- d) mobilised in the gley horizons of poorly drained soils.

2. DISCUSSION OF ELEMENTS

Table 1 shows, for a number of soil samples collected in the Tanjong Penggerang Region, the range in concentrations encountered for all trace elements, their mean

value, the limiting concentration required for detection and the normal range in soils.

A study of the data revealed that in general the soils are rather poorly supplied with trace elements and toxic concentrations of elements do not occur although some molybdenum values are much higher than normal. The most important finding is that the copper content and in some cases manganese is sufficiently low to bring about nutritional disorders in plants.

2.1 Copper

Soils derived from acidic rocks, sandstones and shales are normally low in copper and the values obtained in this survey confirm these observations.

Copper deficiency may be especially severe on peat soils where, even if the total copper content appears adequate, it is often unavailable for plant growth.

All soils are low in copper (content less than 5 ppm is deficient) but those derived from shales have slightly higher values. In Rengam Series (B0095-B0098) and the Serdang Series (B0109-B0111) the molybdenum content is higher than normal. The low copper values in these soils may be aggravated by the comparatively high molybdenum contents since molybdenum is known to induce copper deficiency in ruminants.

2.2 Cobalt

Cobalt is an essential element for all ruminants but has not yet been proved necessary for the growth of higher plants.

Soils with a total cobalt value less than 5 ppm are considered deficient. Cobalt values are low throughout all soil types.

Cobalt deficiency occurs on the all soils regardless of its parent material.

2.3 Manganese

Manganese deficiencies occur on very acid soils low in total manganese contents. Total manganese is not a good indication of the quantity available for plant growth but a lower limit has tentatively been placed at 20 ppm for general guidance for deficiency levels.

Leeper (1935) found that 10 ppm of easily reducible manganese was the critical value and Sherman et alia (1942) placed the limit at around 15 ppm of easily reducible manganese.

2.4 Zinc

Zinc deficiency is common on acid leached soils and some organic soils. The particular method used is rather insensitive for zinc determination and the values measurable are reported as less than 50 ppm.

Alben and Boggs (1936) demonstrated that soils containing 25 ppm of total zinc induced deficiency symptoms in crops.

2.5 Molybdenum

Strongly leached soils are usually low in molybdenum. Further more the molybdate anion is strongly absorbed by soil colloids at a pH below 6.0 (Jones, 1957) and consequently acid soils may have high total quantities of molybdenum, but the amount available for plant growth is often insufficient.

Molybdenum values are variable and it is possible that molybdenum deficiencies may occur on some soils. Some rather high values occur and should be considered in relation to the low copper content of the soils.

2.6 Other Trace Elements.

Values are generally low to average. The elements lead, nickel and chromium are agriculturally only of interest when the concentration in the soil is sufficiently high to produce toxic symptoms in growing crops. Tin values are higher than normal but this is to be expected since tin bearing alluvial deposits occur at various points within the Project area.

TABLE 1

RANGE OF TRACE ELEMENTS IN SOILS OF THE TANJONG PENGGERANG REGION

Element	Range in ppm.	Mean Value ppm	Limit of Detection ppm	Normal Range in soil ppm
Lead	5-130	21	2	2-200
Tin	5-160	34	5	5-10
Gallium	16-50	36	2	2-30
Bismuth	5	5	5	1
Vanadium	30-300	94	2	20-500
Molybdenum	2-13	5	2	2-5
Copper	2-30	5	2	2-100
Zinc	50-200	90	50	10-300
Titanium	1000-10,000	4,634	50	1000-10,000
Silver	0.2	0.2	2	1
Nickel	5-30	15	5	5-500
Cobalt	5-5	5	5	1-40
Manganese	13-50	24	5	200-3000
Chromium	8-130	41	2	5-1000

Notes to Table of Trace Element Contents

1. The following chemical symbols are used for the elements:

Pb	Lead
Ga	Gallium
V	Vanadium
Zn	Zinc
Cu	Copper
Ti	Titanium
Ni	Nickel
Co	Cobalt
Mn	Manganese
Cr	Chromium
Mo	Molybdenum
Sn	Tin

2. The sensitivity of each element is given and represents the lowest concentration detectable by the method used.

3. Elements present in concentrations less than the sensitivity have been omitted. These include: bismuth and silver.

4. Values for the normal range in soil are

taken from Swaine (1955).

5. Iron, which is regarded as a macronutrient element, occurs in most soils in the range 10,000 - 40,000 ppm. Other macronutrient elements such as potassium, calcium and magnesium also occur in comparatively high concentrations even in very impoverished mineral soils.

TABLE 2

TRACE ELEMENT ANALYSES OF SELECTED PROFILES

Pit. Sample No.	Pb	Sn	Ga	V	Mo	Cu	Zn	Tl	Ni	Co	Mn	Cr
SERDANG SERIES												
C439	10	20	20	40	5	5	50	2000	5	5	16	10
C0109	13	30	40	60	10	5	100	6000	5	5	16	10
C0110	13	40	40	60	8	16	100	4000	5	5	30	16
C0111	13	40	40	60	8	16	100	4000	5	5	30	16
C0112	13	40	50	50	5	2	100	6000	5	5	30	20
RENGAM SERIES												
C422	13	40	40	40	5	2	50	4000	5	5	20	20
C0113	10	30	40	40	5	2	50	3000	5	5	13	20
C0114	10	30	40	40	5	2	50	3000	5	5	13	20
C0115	10	30	40	50	6	2	50	2000	8	5	16	20
MASAI SERIES												
A199	13	16	40	40	5	2	50	4000	5	5	20	20
A0036	16	20	40	50	5	2	50	4000	6	5	16	20
A0037	16	20	50	40	5	2	50	4000	6	5	16	20
A0038	13	13	40	60	5	2	50	3000	8	5	40	20
A0039	13	16	50	100	5	2	50	5000	10	5	30	30
A0040	13	16	50	100	5	2	50	5000	10	5	30	30
MALACCA SERIES; deep phase												
A217	60	40	40	200	2	5	200	8500	30	5	50	100
A0041	50	40	40	200	2	10	100	8500	30	5	40	85
A0042	50	40	40	200	2	5	160	8500	30	5	40	85
A0043	40	40	40	200	2	5	160	8500	30	5	40	85
RENGAM SERIES												
B337	10	16	50	40	13	2	50	3000	6	5	30	10
BO095	8	13	40	30	10	2	50	2000	5	5	16	8
BO096	5	13	30	40	10	2	50	1600	5	5	16	8
BO097	5	13	30	40	10	2	50	1600	5	5	16	8
BO098	5	10	30	30	10	2	50	1300	5	5	16	8
RENGAM SERIES												
B405	16	30	50	85	10	2	200	3000	10	5	16	16
BO108	16	30	50	85	10	2	200	3000	10	5	16	16
BO109	16	30	50	85	10	2	200	3000	10	5	16	16
BO110	16	30	50	85	10	2	200	3000	10	5	16	16
BO111	16	20	50	60	8	2	100	3000	10	5	20	16
BUNGOR SERIES												
B419	16	5	16	60	2	2	100	4000	20	5	10	40
BO113	16	5	16	60	2	2	100	4000	20	5	13	50
BO114	16	5	16	60	2	2	100	4000	20	5	13	50
BO115	20	10	20	130	2	2	100	5000	30	5	20	100
BO116	20	10	20	100	2	2	100	4000	30	5	16	85
BO117	16	10	20	130	2	2	50	4000	40	5	13	100
BO118	10	40	30	40	5	20	100	5000	10	5	20	20
SERDANG SERIES; fine sandy clay phase												
B435	10	30	20	40	2	2	100	4000	10	5	16	13
BO119	13	40	30	40	5	2	100	4000	10	5	20	16
BO120	16	40	40	40	5	2	100	4000	10	5	20	16
BO121	16	40	40	40	5	2	100	5000	10	5	30	20
BO122	16	40	40	50	5	2	50	6000	10	5	20	20
DURIAN SERIES												
B445	130	160	40	300	5	20	200		20	5	30	130
BO123	40	160	40	300	5	10	200	8500	30		20	100
BO124	50	130	40	200	2	16	100	8500	20		20	100
BO125	130	160	50	300	5	30	200		30		20	130
MALACCA SERIES												
B468	16	20	40	130	2	5	100	8500	5		50	30
BO128	13	20	40	85	2	5	100	6000	5		40	20
BO129	16	16	40	100	5	5	100	8500	5		50	20
BO130	16	16	40	100	5	5	100	8500	5		50	20
SERDANG SERIES; fine sandy clay phase												
B481	16	5	20	50	2	5	50	4000	10		13	40
BO133	13	5	20	50	2	4	50	4000	20		10	40
BO134	20	5	30	200	5	5	50	8500	30		20	85
BO135	16	5	20	130	5	5	50	5000	30	5	13	40

AERIAL PHOTO-INTERPRETATION

1. INTRODUCTION

Stereoscopic examination of aerial photographs is a standard technique in soil and land use surveys. It can be used with high accuracy, and considerable knowledge concerning the physical characteristics of a survey area and accessibility. It can also provide the soil survey team with a tool with which the accuracy of the soil units can be considerably improved.

Under dense jungle conditions the value of aerial photo-interpretation could be reduced by the jungle cover, which tends to mask the another slope features (TAMM and HORTON 1967). With reference to the dense tropical survey it must however be emphasized that the value of the aerial photographs reduces considerably with the increase of the survey density. Further very important factors related to the success of an aerial photo-interpretation are the experience and local reference level of the interpreters.

It must be emphasized here again that aerial photo-interpretation is only a tool used in soil, land use and other surveys (VINK, 1968), and is therefore never the end result of such a survey; carefully planned field checks are always required.

As stated earlier in this report (part I) Introduction and Chapter 2 (geomorphology) the aerial photographs have been very useful in that considerable time could be saved in certain aspects of the survey.

The aerial photo-interpretation map was drawn on a scale of 1:25,000 and no reduction was carried out. These maps have not been reproduced to be included in this report. "Will be" handed to the Soil Science Division, Div. of Agriculture for future reference.

2. DISCUSSION OF THE AERIAL PHOTO-INTERPRETATION LEGEND

The following section discusses the legend devised for this study. The soil series were not correlated with the aerial photo-interpretation units. It was felt that in general adequate information to draw the soil boundaries was available on the 1:25,000 scale topographic maps. In certain parts of the landscape, however, the photographs gave better support to mapping than the topographic maps; this was especially the case in the area of the mountains, where in some parts of the post-war years the topographic maps gave insufficient or incorrect information.

The basic unit of the legend is the land type. Land types with similar terrain features and associated to be formed on the same parent rock have been combined to terrain units; drainage patterns are also important features of the terrain units. It was found however that the relationship between terrain units A, B and C mentioned below, is intermediate and types of soil would not vary greatly between terrain units.

3. THE LEGEND (Revised)

Terrain Unit A

Undulating terrain with rounded, sub-conical hills and a sub-rectangular drainage pattern. This terrain unit is assumed to be formed on granitic parent rock.

PART III

APPENDIX H

AERIAL PHOTO-INTERPRETATION

Terrain Unit B

Undulating terrain with conical hills forms and regular drainage patterns less clearly pronounced. This unit is assumed to be formed on sedimentary and metamorphosed parent rock.

Terrain Unit C

This unit is intermediate between A and B. During the preliminary interpretation it was thought that undulating terrain that could not be differentiated into units A or B would be classed as C.

Sub-divisions of Terrain Units A, B and C

Landtype A1 (B1): The elevation of the summit is over 200 feet. The hills in this land type have average slopes of over 12 degrees with summits of around 2 degrees. The valleys are filled with short steep slopes over 25 degrees. Higher, isolated steeper hills are denoted A1 (H) or A1 (X) as appropriate (see below).

Landtype A2 (B2): The elevation of the summit is between 150 and 200 feet. In this land type the average slope ranges between 8 and 12 degrees, with hills tops between 5 and 7 degrees. The isolated valleys have steeper hills over 20 degrees.

Landtype A3 (B3): The elevation of the summit is less than 150 feet. The average slopes in this land type range from 4 to 8 degrees. The short slopes of the isolated valleys are less than 12 degrees.

Landtype A4 (B4): Initially, the broad valley is generally in A1 (B1) and A1 (H) (B1) could include the lower hills, conical slopes and some alluvium. After the first field period this was modified to include footpaths only. The lower hills and alluvium seemed to fit more easily in land-type A2.

Terrain Unit B

Conical hills with straight to concave slopes. Generally isolated. Assumed to be formed on extrusive igneous rocks.

Landtype B1: High cones, peaks higher than 250 feet, steep topography.

Landtype B2: Lower cones, elevation between 150 and 250 feet; moderately steep topography.

Landtype B3: Very low cones, elevation less than 150 feet; gentle topography.

Landtype B4: Very low undulating areas, with elevation less than 50 feet between cones, and with negligible slopes.

Terrain Unit B

High ridged, rugged terrain on sedimentary rocks. Drainage is generally sub-parallel to sub-telluric, but could be variable.

Landtype B5: The elevation of the summit is generally above 200 feet, slopes are steep and rugged, but mostly steeper than 10 degrees. Drainage patterns are dense.

Landtype B6: This landtype is similar to B5, but with a less dense drainage pattern and it is also less dissected.

AERIAL PHOTO-INTERPRETATION.

1. INTRODUCTION

Stereoscopic examination of aerial photographs is a standard technique in most soil and land use surveys. It can, if used with discretion, add considerable knowledge concerning the physical characteristics of a survey area and accessibility: it can also provide the soil survey teams with a tool with which the accuracy of the soil units can be considerably improved.

Under dense jungle conditions the value of aerial photo-interpretation could be reduced by the jungle cover, which tends to mask the smoother slope features (TAMS and Hunting Technical Services Ltd., 1967). With reference to the Jengka Triangle Survey it must however be emphasised that the value of the aerial photographs reduces considerably with the increase of the survey density. Further very important factors related to the success of an aerial photo-interpretation are the experience and local reference level of the interpreters.

It must be emphasised here again that aerial photo-interpretation is only a tool used in soil, land use and other surveys (Vink, 1961), and is therefore never the end result of such a survey; carefully planned field checks are always required.

As stated earlier in this report (Part III, Introduction and Chapter 5 Geomorphology) the aerial photographs have been very useful in that considerable time could be saved in certain aspects of the survey.

The aerial photo-interpretation map was drawn on a scale of 1:25,000 and no reduction was carried out. These maps have not been reproduced to be included in this report, but "will be" handed to the Soil Science Division, Div. of Agriculture for future reference.

2. DISCUSSION OF THE AERIAL PHOTO-INTERPRETATION LEGEND

The following section discusses the legend devised for this study. The soil series were not correlated with the aerial photo-interpretation units. It was felt that in general adequate information to draw the soil boundaries was available on the 1:25,000 scale topographic maps. In certain parts of the Tanjong Penggarang Region the photographs gave better support to mapping than the topographic maps; this was especially the case in the east of the peninsula, where in some parts of the peat swamp area the topographic maps gave insufficient or incorrect information.

The basic unit of the legend is the land type. Land types with similar terrain features and suspected to be formed on the same parent rock have been combined to terrain units; drainage patterns are also important features of the terrain units. It was found however that the differentiation between Terrain units A, B and C, mentioned below, is indeterminate and types of slope would not vary greatly between terrain units.

3. THE LEGEND (Revised)

Terrain Unit A

Undulating terrain with rounded, sub-conical hill forms and a sub-rectangular drainage pattern. This terrain unit is assumed to be found on Granitic parent rock.

Terrain Unit B

Undulating terrain, with conical hill forms and regular drainage patterns less clearly expressed. This unit is assumed to be found on sedimentary and metamorphosed parent rock.

Terrain Unit C

This unit is intermediate between A and B. During the preliminary interpretation it was thought that undulating terrain that could not be differentiated into units A or B would be classed as C.

Sub-divisions of Terrain Units A, B and C

Landtype A1 (B1, C1): the elevation of the summits is over 200 feet. The hills in this land type have average slopes of over 12 degrees with summits of around 5 degrees. The valleys are incised with short steep slopes over 25 degrees. Higher, isolated steeper hills are denoted A1 (H) or A1(x) as appropriate (see below).

Landtype A2 (B2, C2): The elevation of the summits is between 130 and 200 feet. In this land type the average slopes range between 6 and 15 degrees, with hill tops between 3 and 5 degrees. The incised valleys have short steep slopes over 20 degrees.

Landtype A3 (B3, C3): The elevation of the summits is less than 130 feet. The average slopes in this land type range from 4 to 8 degrees. The short slopes of the incised valleys are less than 12 degrees.

Landtype A4 (B4, C4): Initially, the broad valley areas, found principally in A1 (B1 and C1) landtype, which could include the lower hills, colluvial slopes and some alluvium. After the first field period this was modified to include footslopes only, the lower hills and colluvium seemed to fit more easily in landtype A3.

Terrain Unit H

Conical hills with straight to concave slopes, generally isolated. Assumed to be formed on extrusive igneous rocks.

Landtype H1: High cones, peaks higher than 250 feet, steep topography.

Landtype H2: Lower cones, elevation between 130 and 250 feet; moderately steep topography.

Landtype H3: Very low cones, elevation less than 130 feet; gentle topography.

Landtype H4: Very low undulating areas, with elevation less than 50 feet between cones, and with negligible slope.

Terrain Unit R

High ridged, rugged terrain on sedimentary rocks. Drainage is generally sub-parallel to sub-trellis, but could be variable.

Landtype R1: The elevation of the summits is generally above 300 feet, slopes are steeper than 12 degrees, but mostly steeper than 18 degrees. Drainage patterns are dense.

Landtype R2: This landtype is similar to R1, but with a less dense drainage pattern and it is also less dissected.

Landtype R3: Lower ridges, with elevations between 130 and 300 feet. Slopes probably range between 6 and 15 degrees. The terrain is rugged and dissected.

Landtype R4: The footslope areas within the Terrain Unit R, including broad valley areas, these may include colluvial slopes and alluvial valleys, as well as some low convex areas.

Terrain Unit T

This unit includes all alluvial terraces and has been identified with the aid of the reconnaissance soil map (Null, Acton and Wong, 1965).

Landtype T1: High terraces, elevation over 130 feet, land surface strongly dissected by gully erosion, which was the main distinguishing characteristic on the aerial photographs, slopes over 12 degrees.

Landtype T2: Medium high terraces, elevation 50 to 150 feet. Land forms are similar to that of A2, from which it is difficult to distinguish. The terrain is less dissected and generally less steep than T1. This type has a parallel drainage pattern.

Landtype T3: Low terraces, elevation less than 50 feet. Identified in flood plains (e.g. around Kota Tinggi) by being slightly raised above these plains, with lighter colour tones. Such areas cannot be distinguished under forest.

Terrain Unit F

This unit consists of freshwater alluvium and would generally be poorly to imperfectly drained.

Landtype F1: Narrow valleys, width up to about 15 mm on 1:25,000 scale maps. Generally non-peaty.

Landtype F2: Broader valleys; which may be peaty.

Landtype F3: Main river valleys; levees etc. Generally non peaty.

Landtype F4: Main river valleys; back swamps, Generally peaty.

Landtype F5: Transitional to Terrain unit M, this landtype is brackish.

Terrain Unit M

This unit consists of mangrove swamps; saline alluvium. Terrain unit M has not been sub-divided into landtypes.

Terrain Unit S

This unit includes all beaches and sub-recent beaches.

Landtype S1: The present day beach.

Landtype S2: Recent beach, adjacent to present beach; light colour tone except in the shales, which are peaty.

Landtype S3: The sub-recent beach is either adjacent to Landtype S2 or separated from S2 by areas of permanent swamp (Terrain unit W). In the latter case S3 can be recognised by crescentic forms roughly parallel to the present coastline; it also has a different canopy from the adjacent swamps (or light colour tone if cleared).

Terrain unit W

This unit includes the freshwater (as opposed to saline) permanent swamps. The landtypes are not readily distinguishable when the forest cover is of a secondary nature. They are expected to be deep peat.

Landtype W1: The canopy is uneven and colour texture is moderately coarse.

Landtype W2: The canopy is lower than in W1 and uniform in appearance. Colour tones are dark and moderately fine textured.

Landtype W3: The canopy is lower than W1 and W2 and uniform in appearance. Colour tones are light grey and fine textured.

Note: the Suffix "X" denotes particularly steep hills e.g. A1(X). and the suffix "Z" disturbed land e.g. mining, and mine tailings.

It should be noted that the above legend has been revised after the preliminary field period was completed. So some local terrain knowledge has been included.

PART III

APPENDIX I

SOIL PROFILE DESCRIPTIONS

APPENDIX I

SOIL PROFILE DESCRIPTIONS.

TANJONG PENGGERANG REGION

The following profile descriptions of a number of soil series and phases of soil have in many cases been selected because these profiles had been sampled for certain special reasons such as soil moisture determinations.

It should be noted that the profiles listed are not claimed to be representative for the soil series and phases found in the Project Area. Also certain minor soil series occurring in the Region have been omitted.

Textural classes mentioned in the soil descriptions are those recorded in the field; so no corrections to field textures have been applied on the basis of laboratory analyses.

Site No: B029

Map Reference: 131b; 204093

Topography: Gently sloping 15°

Parent Material: Volcanic

Soil Series: Yong Peng

Vegetation: Mature rubber

Drainage: Well drained

Description for Specified Depths

0-11 cm

Brown to dark yellowish brown (10YR 5/3-5/4); heavy silt loam; moderate medium subangular blocky structure; moist and friable; few pores; abundant roots; few fine mica. Clear irregular boundary to:

11-32 cm

Reddish yellow (7.5YR 6/6-6/8); clay loam; moderate coarse angular blocky structure; moist very firm; few pores, and many fine cracks; few roots; few fine quartz grit; few patchy clay skins. Smooth diffuse boundary to:

32-67 cm

Reddish yellow (7.5YR 6/6-6/8); heavy clay loam; moderate coarse angular blocky structure; moist very firm; few pores and many fine cracks; few roots; few fine quartz grit; discontinuous weak clay skins; smooth diffuse boundary to:

67-96 cm

Reddish yellow (7.5YR 6/7-6/8); clay; moderate to strong medium angular blocky structure; moist firm; many pores; few roots; few fine quartz grit; discontinuous moderate clay skins; abrupt smooth boundary to:

96-140 cm

Reddish yellow (7.5YR 6/8); silty clay; structureless; moist extremely firm; few pores; few roots; abundant indurated laterite stones; few fine mica. Clear smooth boundary to:

140-160 cm

Red (5YR 5/8); silty clay; weak fine subangular blocky structure; moist firm; few pores; few roots; abundant laterite gravel and stones; few very hard, fresh quartz gravel up to 7 cm in diameter; few fine mica.

Note: soil moisture analysis carried out on three horizons between 0 and 67 cm., also sampled for trace element analyses.

Site No: B667

Map Reference: 132C; 526813

Topography: Gently sloping 3°

Parent Material: Granite

Soil Series: Jerangau

Vegetation: Logged primary jungle

Drainage: Well drained

Description for Specified Depths

0-12 cm

Dark brown (10YR 3/3); heavy fine sandy loam; moderate, medium and fine subangular blocky structure; moist very friable, abundant pores and roots. Clear and smooth boundary to:

12-52 cm

Strong brown (7.5YR 5/8); fine sandy clay loam; moderate, medium and fine subangular blocky structure; moist very friable, abundant pores and roots. Clear and smooth boundary to:

52-96 cm

Reddish yellow to strong brown (7.5YR 6/8-5/8); clay loam to fine sandy clay; moderate medium subangular blocky structure; moist friable; abundant pores and roots; discontinuous weak clay skins, few fine quartz grit. Smooth diffuse boundary to:

96-150 cm

Reddish yellow to strong brown (7.5YR 6/8-5/8); clay to clay loam; moderate medium subangular blocky structure; moist firm to friable; many pores and roots; discontinuous weak clay skins; few fine quartz grit.

Site No: B337

Map Reference: 131d; 322008

Topography: Gently sloping even midslope 10°

Parent Material: Granite

Soil Series: Rengam

Vegetation: Cleared and burned for FLDA scheme
Cover crop Callopoponium

Drainage: Well drained

Description for Specified Depths

0-14 cm

Yellowish brown (10YR 5/4); heavy fine sandy loam; moderate medium subangular blocky structure; moist firm; few pores and many fine cracks; many roots; few fine quartz grit; many pieces of charcoal. Clear and smooth boundary to:

14-44 cm

Yellowish brown (10YR 6/7); heavy fine sandy clay loam; moderate medium subangular blocky structure; moist very firm; few pores and cracks, many roots; many fine quartz grit; discontinuous weak clay skins; organic staining on pedfaces; Smooth, diffuse boundary to:

44-70 cm

Yellowish brown (10YR 6/7); sandy clay; strong coarse prismatic structure; moist firm; few pores; many roots; continuous strong clay skins; many medium quartz grit. Clear wavy boundary to:

70-106 cm

Yellowish brown (10YR 6/7); gritty clay; strong coarse prismatic structure; moist firm to very

firm; few pores, few roots; continuous moderate clay skins; abundant coarse quartz; few laterite gravel and boulders.

Note: Sampled for soil moisture and trace element analyses.

Site No: B482

Map Reference: 131d; 339999

Topography: Hilly, steep upper slope 26°

Parent Material: Granite

Soil Series: Rengam, coarse sandy clay phase

Vegetation: Cleared and burned jungle (FLDA scheme)

Drainage: Well drained

Description for Specified Depths

0-22 cm
Yellowish brown (10YR 5/8); sandy clay loam; moderate medium and coarse subangular blocky structure; moist friable; many pores and roots. Smooth diffuse boundary to:

22-42 cm
Reddish yellow (7.5YR 6/8); coarse sandy clay; moderate coarse subangular blocky structure; moist friable; abundant pores, many roots; discontinuous weak clay skins; abundant medium and coarse quartz grit. Smooth and clear boundary to:

42-80 cm
Strong brown (7.5YR 5/8); gravelly clay, weak coarse angular blocky structure; moist firm; few pores and roots; discontinuous moderate clay skins; abundant coarse quartz grit. Smooth diffuse boundary to:

80-130 cm
Yellowish red (5YR 5/8); other features as 42 - 80 cm horizon.

130-180 cm
Yellowish red (5YR 5/6); gravelly clay loam; very weak coarse angular blocky structure; moist very friable, many coarse distinct yellow mottles; few pores and roots; abundant coarse quartz grit; many granite stones.

Site No: C665

Map Reference: 132; 496840

Topography: Gently sloping, lower slope above steep incision 5°

Parent Material: Granite, probably colluviated

Soil Series: Rengam, fine sandy clay phase

Vegetation: Old open secondary jungle

Drainage: Well drained

Description for Specified Depths

0-16 cm
Dark yellowish brown (10YR 4/4 and 5/4); fine sandy loam; moderate medium crumb structure; moist friable; abundant pores and roots. Smooth clear boundary to:

16-63 cm
Reddish yellow to brownish yellow (7.5 - 10YR 6/8); heavy sandy clay loam; weak coarse subangular blocky structure; moist firm; many pores and roots; continuous moderate clay skins; many fine quartz grit. Smooth diffuse boundary to:

63-115 cm
Reddish yellow (7.5YR 6/8); heavy sandy clay

loam; weak coarse subangular blocky structure; moist firm; many pores, few roots; continuous strong clay skins; many medium quartz grit. Smooth diffuse boundary to:

115-152 cm

Reddish yellow (7.5YR 6/8); sandy clay; weak fine subangular blocky structure; moist firm; few pores and roots; continuous strong clay skins; many medium quartz grit, few laterite gravel.

Site No: A199

Map Reference: 132C; 460008

Topography: Gently sloping 5° mid-slope

Parent material: Igneous rock

Soil Series: Masai

Vegetation: Logged primary jungle

Drainage: Well drained

Description for Specified Depths

0-15 cm

Dark yellowish brown (10YR 4/4); sandy loam; weak medium subangular blocky structure; moist very friable; many pores, abundant roots; many fine quartz grit. Smooth diffuse boundary to:

15-48 cm
Brownish yellow (10YR 6/8); sandy clay loam; moderate medium subangular blocky structure; moist firm; abundant pores, many roots; discontinuous weak clay skins; many fine quartz grit. Smooth diffuse boundary to:

48-68 cm

Reddish yellow (7.5YR 6/8); light clay; moderate medium subangular blocky structure; moist firm; many pores, few roots; discontinuous moderate clay skins; abundant medium quartz grit. Smooth abrupt boundary to:

68-90 cm

Reddish yellow (7.5YR 7/8); sandy clay; weak medium subangular blocky structure; moist very firm; many pores; few roots; discontinuous weak clay skins; many, medium quartz grit; abundant laterite stones and boulders (up to 25 cm diam). Smooth abrupt boundary to:

90-150 cm

Reddish yellow (7.5YR 6/8); coarse sandy clay; very weak subangular blocky structure; moist very firm; few pores; discontinuous weak clay skins; many medium quartz grit; abundant laterite stones.

Note: Sampled for trace element analyses.

Site No: A207

Map Reference: 132, 435988

Topography: Hilly, 15° lower slope

Parent Material: Shale and vein quartz

Soil Series: Batang Merbau

Vegetation: Open, older secondary jungle

Drainage: Moderately well drained

Description for Specified Depths

0-5 cm

Dark yellowish brown (10YR 4/4); very fine sandy loam; weak to moderate fine subangular blocky structure; moist very friable; many pores, abundant roots; many fine mica. Smooth diffuse boundary to:

5-52 cm

Yellowish brown (10YR 5/4-5/6); fine sandy clay loam; strong coarse subangular blocky structure; moist friable; many pores, abundant roots; discontinuous, weak clay skins; many fine mica. Abrupt, smooth boundary to:

52-110 cm

Brownish yellow (10YR 6/6); silty clay; weak to moderate medium subangular blocky structure; moist firm; many medium distinct red brown mottles; few pores and roots; abundant fine mica; abundant coarse quartz; many laterite quartz gravel and some laterite boulders at bottom of pit.

Site No: C050

Map Reference: 131d; 247105

Topography: Steep 22° near crest of spur

Parent Material: Sandstone

Soil Series: Serdang

Vegetation: Young, immature rubber, dense cover crop

Drainage: Well drained

Description for Specified Depths

0-10 cm

Yellowish brown (10YR 5/6); light sandy loam; weak medium subangular blocky structure; moist very friable; abundant pores and roots. Smooth diffuse boundary to:

10-28 cm

Strong brown (7.5YR 5/6); sandy loam; moderate medium subangular blocky; moist very friable; abundant pores and roots. Smooth diffuse boundary to:

28-68 cm

Yellowish red (5YR 5/6); sandy loam; moderate medium subangular blocky structure; moist friable; abundant pores and roots; discontinuous weak clay skins; few micaceous laterite grit. Clear smooth boundary to:

68-100 cm

Yellowish red (5YR 5/8); heavy sandy loam; moderate medium subangular blocky structure; moist friable; abundant pores, many roots; discontinuous clay skins; few micaceous laterite grit. Smooth abrupt boundary to:

100-136 cm

Yellowish red (5YR 5/8); stony sandy clay loam; structureless; moist friable to firm; abundant pores many roots; weak discontinuous clay skins; abundant micaceous laterite stones; few laterized parent rock, quartz stones.

Site No: B545

Map Reference: 132; 484938

Topography: Gently sloping 2°, near top of low hill

Parent Material: Sandstone

Soil Series: Serdang, sandy clay phase

Vegetation: Logged primary jungle

Drainage: Well drained

Description for Specified Depths

0-16 cm

Brown (10YR 5/3); loam to fine sandy clay loam; moderate, medium and fine subangular blocky structure; moist very friable; abundant pores and roots; few fine quartz grit. Clear irregular boundary to:

16-49 cm

Brownish yellow (10YR 6/6-6/8); fine sandy clay loam; moderate coarse subangular blocky structure; moist friable; abundant pores, many roots; very weak discontinuous clay skins; few fine quartz grit and mica. Smooth diffuse boundary to:

49-100 cm

Brownish yellow (10YR 6/7-6/8); fine sandy clay; moderate coarse angular blocky structure; moist firm to friable; many pores and roots; discontinuous moderate clay skins; few fine quartz grit and mica. Smooth diffuse boundary to:

100-152 cm

Brownish yellow (10YR 6/8); sandy clay; weak to moderate angular blocky structure; moist firm; abundant pores, few roots; discontinuous clay skins; many fine quartz grit and few fine mica.

Note: Sampled for soil moisture analysis.

Site No: C022

Map Reference: 131b; 238088

Topography: Undulating sloping 20-25°

Parent Material: Conglomerates

Soil Series: Kedah

Vegetation: Young, immature rubber, cover crop mecania

Drainage: Well drained

Description for Specified Depths

0-7 cm

Very dark greyish brown (10YR 3/2); very fine sandy loam (heavy); moderate medium crumb structure; moist very friable; abundant pores and roots; clear smooth boundary to:

7-40 cm

Yellowish brown (10YR 5/6); heavy sandy loam; weak coarse subangular blocky structure; moist friable; abundant pores, many roots; few fine quartz grit. Diffuse wavy boundary to:

40-65 cm

Light brownish grey (10YR 6/2); sandy loam to sandy clay loam; weak coarse subangular blocky structure; abundant pores, few roots; weak discontinuous clay skins; many small quartz grit. Smooth diffuse boundary to:

65-92 cm

Strong brown (7.5YR 5/8); gritty clay loam; weak coarse subangular blocky structure; moist friable; many pores; few roots; many coarse prominent red mottles; weak discontinuous clay skins; many quartz stones.

92-247 cm

Reddish yellow (5YR 6/8); gritty clay loam; other features of this horizon same as 65-92 cm.

Site No: C039

Map Reference: 131b; 252096

Topography: Gently sloping 10°

Parent Material: Fine grained sandstone

Soil Series: Bungor

Vegetation: Young, immature rubber, cover crop mecania.

Drainage: Well drained

Description for Specified Depths

0-10 cm

Brown to dark brown (10YR 4/3); very fine sandy loam to heavy loam; moderate to strong medium crumb; moist very friable; abundant pores and roots. Clear wavy boundary to:

10-47 cm

Yellowish brown (10YR 5/8); fine sandy clay loam; moderate medium angular blocky structure; moist firm; many pores, few roots. Smooth diffuse boundary to:

47-109 cm

Yellowish brown (10YR 5/8); sandy clay loam to clay loam; strong coarse prismatic structure; moist firm; many pores, few roots; discontinuous clay skins; many fine quartz grit. Smooth diffuse boundary to:

109-129 cm

Strong brown (7.5YR 5/8); clay loam; strong coarse prismatic structure; moist firm to very firm; moderate discontinuous clay skins.

Note: Sampled for soil moisture analyses.

Site No: B230

Map Reference: 126f; 353238

Topography: Gently sloping 10°

Parent Material: Sandstone with quartzite and some hard grey shale

Soil Series: Kuala Brang

Vegetation: Old Secondary jungle

Drainage: Well drained

Description for Specified Depths

0-12 cm

Dark yellowish brown (10YR 4/4); fine sandy loam; moderate to strong medium subangular blocky structure; moist friable; many pores; abundant roots; Clear smooth boundary to:

12-46 cm

Yellowish brown (10YR 5/4); fine sandy clay loam; weak to moderate coarse angular blocky structure; many pores and roots; weak discontinuous clay skins; many shale grit; few medium quartz grit. Irregular abrupt boundary to:

46-80 cm

Yellowish brown (10YR 5/5); stony silty clay; structureless; moist very firm; few pores and roots; moderate discontinuous clay skins; many shale grit; abundant medium quartz grit; few laterized quartzite and shale. Smooth diffuse boundary to:

80-102 cm

Yellowish brown (10YR 5/4 and 5/8); loamy sand and clay; structureless; moist very firm; few pores, rare roots; moderate discontinuous clay skins. A mixed horizon of brown clay with brighter weathered sandstone/quartzite, some of it iron coated. Some of the quartz may be vein quartz.

Site No: B676

Map Reference: 132; 597849

Topography: Gently sloping 5°, upper slope

Parent Material: Sandstone and carbonaceous shale

Soil Series: Marang

Vegetation: Logged primary jungle

Drainage: Moderately well drained

Description for Specified Depths

0-5 cm

Dark greyish brown (10YR 4/2); heavy fine sandy loam; moderate medium and fine subangular blocky structure; moist very friable; abundant pores and roots. Clear irregular boundary to:

5-25 cm

Light grey to very pale brown (10YR 7/2-7/3); fine sandy clay loam; weak to moderate subangular blocky structure; moist friable; abundant pores, few roots; many coarse distinct grey mottles; few fine quartz grit. Smooth diffuse boundary to:

25-58 cm

Light grey to very pale brown (10YR 7/2-7/3); heavy fine sandy clay loam; weak coarse angular blocky structure; moist firm; many pores, few roots; weak discontinuous clay skins; few fine distinct brown and many coarse distinct grey mottles; few fine quartz grit. Smooth diffuse boundary to:

58-87 cm

Very pale brown (10YR 7/3); fine sandy clay; weak coarse angular blocky structure; moist very firm; few pores and roots; many mottles; weak to moderate discontinuous clay skins; few fine and coarse quartz grit. Smooth diffuse boundary to:

87-115 cm

Light grey (10YR 7/2); sandy clay; weak coarse angular blocky structure; moist very firm; few pores rare roots; weak discontinuous clay skins; many fine distinct red and many medium distinct grey mottles; many coarse quartz grit.

Site No: C598

Map Reference: 132; 551905

Topography: Gently sloping 4°, midslope

Parent Material: Sandstone

Soil Series: Marang, deep phase

Vegetation: Old secondary jungle on edge of old clearing

Drainage: Moderately well drained, water-table at 100cm, after heavy rain.

Description for Specified Depths

0-5 cm

Brown to dark brown (7.5YR 4/2); loamy fine sand; weak fine crumb; moist loose; abundant pores and roots; clear wavy boundary to:

5-26 cm

Light brownish grey to light yellowish brown (2.5YR 6/3); heavy fine sandy loam; weak fine subangular blocky structure; moist very friable; abundant pores and roots. Clear wavy boundary to:

26-60 cm

Light yellowish brown (2.5YR 6/4); heavy fine sandy loam; weak medium subangular blocky structure; moist very friable; many pores and roots. Smooth diffuse boundary to:

60-100 cm

Light yellowish brown to brownish yellow (10YR 6/5); light fine sandy clay loam; weak medium subangular blocky structure; moist friable; many pores and roots; very weak discontinuous clay skins. Smooth diffuse boundary to:

100-120 cm

Light yellowish brown to brownish yellow (10YR 6/5); fine sandy clay loam; weak medium subangular blocky structure; moist friable to firm; weak discontinuous clay skins.

Site No: B308

Map Reference: 131b; 307086

Topography: Gently sloping 5°, upper slope

Parent Material: Shale

Soil Series: Durian

Vegetation: Logged primary jungle

Drainage: Moderately well drained

Description for Specified Depths

0-11 cm

Yellowish brown (10YR 5/4); very fine sandy clay loam; moderate medium subangular blocky structure; moist friable; many pores; abundant roots; few fine mica. Smooth diffuse boundary to:

11-36 cm

Light yellowish brown (10YR 6/4); heavy silty clay loam; moderate coarse subangular blocky structure; moist firm; few pores, abundant roots; discontinuous clay skins; few medium fine grey mottles; few fine mica. rare medium quartz. Smooth diffuse boundary to:

36-63 cm

Pale yellow (2.5Y 7/4); silty clay; strong coarse angular blocky structure; moist very firm; few pores, many roots; moderate nearly continuous clay skins; many medium distinct grey and reddish yellow mottles; few fine shale grit and mica. rare medium quartz grit. Smooth diffuse boundary to:

63-108 cm

Light yellowish brown (2.5Y 6/4); clay; strong coarse prismatic structure; moist extremely firm; few pores, and roots; strong nearly continuous clay skin; few medium distinct grey and many fine prominent red mottles; many fine shale grit and few fine mica; few medium quartz. Smooth diffuse boundary to:

108-143 cm

Light yellowish brown (2.5Y 6/4); clay; moderate to strong coarse angular blocky structure; moist very firm; few pores and roots; strong nearly continuous clay skins; many medium prominent red mottles; many fine and medium shale grit; few fine mica. few medium quartz.

Site No: B211

Map Reference: 126f; 333250

Topography: Undulating sloping 13°

Parent Material: Shale

Soil Series: Pohoi

Vegetation: Mature rubber

Drainage: Well drained

Description for Specified Depths

0-11

Brown to dark brown (10YR 4/3); heavy fine sandy

loam; weak medium subangular blocky structure; moist friable; abundant pores and roots. Clear smooth boundary to:

11-38 cm

Yellowish brown (10YR 5/4); fine sandy clay loam; weak medium subangular blocky structure; moist friable to firm; many pores and roots; weak discontinuous clay skins. Smooth diffuse boundary to:

38-100 cm

Yellowish brown (10YR 5/4); sandy clay; moderate medium subangular blocky structure; moist firm; many pores, few roots; moderate discontinuous clay skins; smooth diffuse boundary to:

100-190 cm

Yellowish brown (10YR 5/6); sandy clay; weak coarse angular blocky structure; moist firm; many pores, few roots; weak discontinuous clay skins; few fine and medium quartz; rounded laterite grit.

Note: Sampled for soil moisture analyses.

Site No: B231

Map Reference: 126f; 355241

Topography: Gently sloping 5°, ridge top

Parent Material: Shale

Soil Series: Malacca

Vegetation: Logged primary jungle

Drainage: Well drained

Description for Specified Depths

0-6 cm

Dark yellowish brown (10YR 4/4); fine sandy loam; weak moderate subangular blocky structure; moist very friable; abundant pores and roots. Clear smooth boundary to:

6-25 cm

Yellowish brown (10YR 5/6); fine sandy clay loam; moderate medium subangular blocky structure; moist firm; many pores, abundant roots; very weak discontinuous clay skins; few fine quartz grit. Abrupt wavy boundary to:

25-44 cm

Yellowish brown (10YR 5/8); fine sandy clay; structureless; moist friable; many pores and roots; few laterite stones and abundant laterite gravel. Clear smooth boundary to:

44-72 cm

Yellowish brown (10YR 5/8); silty clay; structureless; moist firm; few pores and roots; moderate to strong discontinuous clay skins; abundant laterite stones and gravel. Clear wavy boundary to:

72-96 cm

Strong brown (7.5YR 5/8); silty clay; structureless; moist very firm; moderate discontinuous clay skins; abundant laterite stones and boulders.

Site No: C035

Map Reference: 131b; 256093

Topography: Gently sloping 13°, midslope

Parent Material: Phyllite with vein quartz, carbonaceous shale and sandstone

Soil Series: Tavy

Vegetation: Young rubber, mecania

Drainage: Well drained

Description for Specified Depths

0-6 cm

Brown to dark brown (10YR 4/4); heavy very fine

sandy loam; moderate to strong medium crumb; moist very friable; many pores, abundant roots. Clear irregular boundary to:

6-28 cm

Reddish yellow to strong brown (7.5YR 6/8-5/8); very fine sandy clay loam; moderate coarse angular blocky structure; moist firm; many pores, abundant roots; very weak discontinuous clay skins; few medium quartz grit. Smooth diffuse boundary to:

28-54 cm

Reddish yellow (7.5YR-5YR 6/8); heavy clay loam; weak to moderate coarse subangular blocky structure; moist firm; many pores and roots; few medium quartz grit. Clear irregular boundary to:

54-155 cm

Yellowish red (5YR 5/8); clay; moderate medium subangular blocky structure; moist firm, few pores and roots; many laterite grit; many medium quartz grit.

Site No: C018

Map Reference: 131b; 232087

Topography: Very gently sloping 6°

Parent Material: Old Alluvium

Soil Series: Harimau

Vegetation: Young, immature rubber, mecana

Drainage: Well drained

Description for Specified Depths

0-6 cm

Brown to yellowish brown (10YR 5/3-5/4); loam; moderate medium crumb; moist friable; many pores and roots. Smooth diffuse boundary to:

6-21 cm

Yellowish brown (10YR 5/4-5/6); fine sandy loam; moderate medium subangular blocky structure; moist friable; few pores, many roots. Clear irregular boundary to:

21-36 cm

Brownish yellow (10YR 6/6); fine sandy clay loam; moderate coarse angular blocky structure; moist firm; many pores, few roots; many fine quartz. Clear irregular boundary to:

36-67 cm

Reddish yellow (7.5YR 6/8); clay loam; moderate coarse subangular blocky structure; moist firm; few pores and roots; moderate discontinuous clay skins; abundant medium quartz grit.

67-139 cm

Reddish yellow (5YR 6/6); clay; weak medium angular blocky structure; moist firm; few pores, no roots; moderate discontinuous clay skins; abundant coarse quartz grit; soft laterite pieces. Smooth diffuse boundary to:

139-160 cm

Pink and reddish yellow (7.5YR 7/4 and 5YR 6/6); gritty clay to clay loam; weak coarse angular blocky structure; moist firm; no pores, no roots; soft laterite pieces; many fine to coarse quartz grit.

Note: Sampled for soil moisture analyses.

Site No: B114

Map Reference: 131b; 208141

Topography: Nearly flat ridge top

Parent Material: Sub-recent Alluvium

Soil Series: Holyrood

Vegetation: Mature rubber

Drainage: Very well drained

Description for Specified Depths

0-17 cm

Dark greyish brown (10YR 4/2); loamy sand; moderate medium subangular blocky structure; moist very friable; few pores, abundant roots. Smooth diffuse boundary to:

17-58 cm

Pale brown (10YR 6/3); light sandy loam; weak to moderate medium subangular blocky structure; moist very friable; few pores, few roots; few pieces of laterized parent material. Smooth diffuse boundary to:

58-121 cm

Very pale brown (10YR 7/4); sandy loam; moderate coarse subangular blocky structure; moist very friable; few medium distinct white mottles; few pores and roots; very weak discontinuous clay skins; few fine quartz grit. Clear smooth boundary to:

121-140 cm

Very pale brown (10YR 8/4); gritty loam, moderate coarse subangular blocky structure; moist very friable; few roots; very weak discontinuous clay skins; many fine quartz grit.

TABLE 1

CHEMICAL AND MECHANICAL ANALYSES

YONG PENG SERIES
Pasak Sample Area
Site No: B029
Run/Photo No: 107N/71

Agric. Dept. Laboratory No.	Depth (cm)	SE/P Sample Reference	Percentage				On Original Sample		pH on Air-dry Soil		Percentages				Easily Sol.		6N HCl Soluble					
			Clay	Silt	Fine Sand	Coarse Sand	Gravel	Stones	Distilled Water	0.01N KCl	Loss on Ignition	Organic Matter	Carbon	Nitrogen	C/N Ratio	0.5N CH ₃ COOH Soluble Potassium p.p.m.	0.1N NaOH Soluble Phosphorus p.p.m.	Phosphorus p.p.m.	Iron Fe ₂ O ₃ %	Potassium m.eq./100g.	Calcium m.eq./100g.	Magnesium m.eq./100g.
RW 26 T	0-11	B0021	70	7	13	13	Nil	Nil	4.4	3.7	13.6	3.69	2.14	0.18	12	24	n.a	119	6.00	3.95	1.29	2.24
sa	11-32	B0022	77	8	10	11	"	"	4.6	3.8	12.0	1.58	0.92	0.10	9	12	"	69	6.57	4.15	1.21	2.41
sb	32-67	B0023	23	57	10	11	"	"	4.8	3.8	11.5	1.10	0.64	0.06	11	10	"	58	6.69	6.60	1.12	2.41
sc	67-96	B0024	25	59	10	10	0.6	"	4.6	3.7	11.5	0.95	0.55	0.06	9	11	"	58	6.86	3.50	1.03	2.95
sd	96-140	B0025	23	57	10	14	22.7	20.8	4.7	3.8	12.2	0.97	0.50	0.05	10	10	"	72	10.48	4.40	1.12	2.24
se	140-160	B0026	57	12	12	24	Nil	Nil	5.1	4.4	11.9	0.31	0.18	0.02	9	8	"	74	16.12	3.90	1.03	2.50

milliequivalents per 100 g soil

Depth (cm).	C.E.C.	Calcium	Magnesium	Sodium	Potassium	Total Ca+Mg+Na+K	Percentage Saturation
0-11	13.00	0.14	0.16	0.03	0.04	0.37	3
11-32	9.55	0.19	0.03	0.07	0.06	0.35	4
32-67	8.39	0.08	0.03	0.03	0.02	0.16	2
67-96	8.72	0.05	0.05	0.01	0.02	0.13	1
96-140	9.55	0.08	0.03	0.01	0.02	0.14	1
140-160	11.03	0.11	0.05	0.05	0.06	0.27	2

n.a = not analysed.

TABLE 2

CHEMICAL AND MECHANICAL ANALYSES

JERANGAU SERIES
 Tanjong Penggerang Region
 Site No: B667

Agric. Dept. Laboratory No.	Depth (cm)	SEJP Sample Reference	Percentage			On pH on		Percentages			6N HCl Soluble						
			Clay	Silt	Fine Sand	Original Sample	Air-dry Soil	Carbon	Nitrogen	Phosphorus P.P.M.	Iron Fe ₂ O ₃ %	Potassium m.eq./100g.	Calcium m.eq./100g.	Magnesium m.eq./100g.			
RW 351 T	0-12	B0183	65	2	15	20	Nil	Nil	3.8	3.5	not analysed	not analysed	264	5.58	0.45	1.47	1.30
sa	12-52	B0184	67	2	15	21	"	"	4.4	4.0	not analysed	not analysed	158	6.86	0.58	1.30	1.21
sb	52-96	B0185	67	2	15	21	"	"	4.6	4.1	not analysed	not analysed	147	7.04	0.45	1.65	0.95
sc	96-150	B0186	69	4	13	19	"	"	4.9	4.3	not analysed	not analysed	140	7.70	0.45	1.91	1.21

milliequivalents per 100 g soil

Depth (cm).	C.E.C.	Calcium	Magnesium	Sodium	Potassium	Total Ca+Mg+Na+K	Percentage Saturation
0-12	23.70	0.16	0.19	0.21	0.16	0.72	3
12-52	6.58	0.16	Nil	0.81	0.05	0.39	6
52-96	6.42	0.11	Nil	0.06	0.02	0.19	3
96-150	6.42	0.08	Nil	0.09	0.02	0.19	3

TABLE 3

CHEMICAL AND MECHANICAL ANALYSES

RENGAM SERIES
Tanjong Penggerang Region
Site No: B337
Run/Photo No: 109N/183

Agric. Dept. Laboratory No.	Depth (cm)	SEJP Sample Reference	Percentage			On		pH on		Percentages				Easily Sol.	6N HCl Soluble		
			Clay	Silt	Fine Sand	Original Sample	Air-dry Soil.	Loss on Ignition	Organic Matter	Carbon	Nitrogen	0.5N CH ₃ COOH Soluble Potassium p.p.m.	0.1N NaOH Soluble Phosphorus p.p.m.		Phosphorus p.p.m.	Iron Fe ₂ O ₃ %	Potassium m.eq./100g.
RW 97 T	0-14	B0095	59	6	14	26	Nil	Nil	4.6	4.0	not analysed	not analysed	55.2	3.37	1.11	0.87	2.46
Sa	14-44	B0096	61	4	12	28	1.5	"	4.3	3.9	not analysed	not analysed	36.8	3.74	1.30	0.87	2.38
Sb	44-70	B0097	30	37	10	28	4.5	0.6	4.3	3.9	not analysed	not analysed	36.4	4.34	1.70	1.03	2.46
Sc	70-106	B0098	30	37	7	31	22.1	1.9	4.3	4.0	not analysed	not analysed	41.6	6.90	2.04	0.95	2.86
Sd	106-153	B0099	59	6	6	34	22.1	Nil	4.5	4.0	not analysed	not analysed	36.8	6.44	2.04	1.03	2.46

milliequivalents per 100 g soil

Depth (cm)	milliequivalents per 100 g soil						Percentage Saturation
	C.E.C.	Calcium	Magnesium	Sodium	Potassium	Total Ca+Mg+Na+K	
0-14	11.44	0.16	0.11	0.06	0.29	0.62	5
14-44	7.74	0.16	0.03	0.09	0.19	0.47	6
44-70	6.75	0.14	0.03	0.08	0.14	0.39	6
70-106	6.42	0.11	Nil	0.03	0.07	0.21	3
106-153	4.28	0.08	"	0.08	0.07	0.23	5

TABLE 4

CHEMICAL AND MECHANICAL ANALYSES

RENGAM SERIES, coarse sandy clay phase
Tanjong Penggerang Region
Site No: B482
Run/Photo No: 110S/26

Agric. Dept. Laboratory No.	Depth (cm)	SEJF Sample Reference	Percentage					On Original Sample	pH on Air-dry Soil	Percentages					6N HCl Soluble		
			Clay	Silt	Fine Sand	Coarse Sand	Gravel			Stones	Distilled Water	0.01N KCl	Loss on Ignition	Organic Matter	Carbon	Nitrogen	Phosphorus p.p.m.
RW 338 T	0-22	B0137	40	7	31	25	14	Nil	4.5	4.0	not analysed	not analysed	28	3.07	3.07	1.91	2.25
Sa	22-42	B0138	44	9	8	41	23	"	4.6	4.0	not analysed	not analysed	22	3.14	3.60	1.73	1.91
Sb	42-80	B0139	28	25	5	43	42	"	4.8	4.3	not analysed	not analysed	14	3.71	3.75	1.73	2.77
Sc	80-130	B0140	36	21	7	42	45	"	4.6	4.0	not analysed	not analysed	14	4.11	3.70	1.56	2.77
Sd	130-180	B0141	34	17	7	39	40	"	4.4	4.0	not analysed	not analysed	9	3.67	4.00	1.73	1.13

milliequivalents per 100 g soil

Depth (cm).	C.E.C.	Calcium	Magnesium	Sodium	Potassium	Total Ca+Mg+Na+K	Percentage Saturation
0-22	9.22	0.38	0.24	0.09	0.07	0.78	8
22-42	6.42	0.19	0.27	0.15	0.06	0.67	10
42-80	4.61	0.11	0.27	0.11	0.04	0.53	11
80-130	4.12	0.11	0.16	0.09	0.04	0.40	10
130-180	4.94	0.11	Nil	0.06	0.02	0.19	4

TABLE 5

CHEMICAL AND MECHANICAL ANALYSES

RENGAM SERIES, fine sandy clay phase
Tanjong Penggerang Region
Site No: C665
Run/Photo No: 113S/111

Agric. Dept. Laboratory No.	Depth (cm)	SEJP Sample Reference	Percentage			On pH on		Percentages							Easily Sol.		6N HCl Soluble		
			Clay	Silt	Fine Sand	Original Sample	Air-dry Soil	Distilled Water	0.01N KCl	Loss on Ignition	Organic Matter	Carbon	Nitrogen	0.5N CH ₃ COOH Soluble Potassium p.p.m.	0.1N NaOH Soluble Phosphorus p.p.m.	Phosphorus p.p.m.	Iron Fe ₂ O ₃ %	Potassium m.eq./100g.	Calcium m.eq./100g.
RW 358 T	0-16	00157	53	4	15	33	Nil	Nil	4.6	4.1	not analysed	not analysed	119	3.90	0.58	0.95	1.13		
Sa	16-63	00158	53	6	13	33	"	"	4.9	4.2	not analysed	not analysed	83	5.01	0.45	1.04	1.56		
Sb	63-115	00159	63	2	14	26	3	"	4.9	4.4	not analysed	not analysed	86	5.35	0.68	1.04	1.56		
Sc	115-152	00160	67	2	9	27	15	"	5.1	4.6	not analysed	not analysed	82	4.23	0.68	1.13	1.21		

milliequivalents per 100 g soil

Depth (cm).	C.E.C.	Calcium	Magnesium	Sodium	Potassium	Total Ca+Mg+Na+K	Percentage Saturation
0-16	11.03	0.08	0.05	0.16	0.08	0.37	4
16-63	5.27	0.05	0.24	0.09	0.02	0.40	8
63-115	4.77	0.13	Nil	0.11	0.04	0.28	6
115-152	3.95	0.05	0.03	0.09	0.01	0.18	5

TABLE 6

CHEMICAL AND MECHANICAL ANALYSES

MASAI SERIES
Tanjong Penggerang Region
Site No: A199
Run/Photo No: 112S/28

Agric. Dept. Laboratory No.	Depth (cm)	SERP Sample Reference	Percentage		On Original Sample		pH on Air-dry Soil		Percentages				Easily Sol.	6N HCl Soluble				
			Clay	Silt	Fine Sand	Coarse Sand	Gravel	Stones	Distilled Water	0.01N KCl	Loss on Ignition	Organic Matter	Carbon	Nitrogen	0.5N CH ₃ COOH Soluble Potassium p.p.m.	0.1N NaOH Soluble Phosphorus p.p.m.	Phosphorus p.p.m.	Iron Fe ₂ O ₃ %
RW 218 T	0-15	A0036	44	3	15	43	0.7	Nil	4.5	3.8	not analysed	not analysed	134.0	4.29	2.91	0.89	2.33	
Sa	15-48	A0037	48	3	10	42	1.7	"	4.75	4.05	"	"	100.0	5.54	3.27	0.76	1.93	
Sb	48-68	A0038	59	2	9	35	27.4	"	4.85	4.1	"	"	92.0	6.20	4.05	0.60	2.33	
Sc	68-90	A0039	61	2	7	31	10.7	63.1	5.0	4.2	"	"	108.0	10.65	3.19	0.64	1.53	
Sd	90-150	A0040	53	1	10	36	17.5	12.2	5.15	4.3	"	"	48.0	6.65	2.12	0.72	1.13	

milliequivalents per 100 g soil

Depth (cm).	C.E.C.	Calcium	Magnesium	Sodium	Potassium	Total Ca+Mg+Na+K	Percentage Saturation
0-15	9.71	0.14	0.19	0.14	0.13	0.60	6
15-48	5.76	0.05	0.49	0.32	0.11	0.97	16
48-68	4.61	0.24	0.24	0.26	0.10	0.84	18
68-90	5.10	0.16	Nil	0.12	0.09	0.37	7
90-150	3.79	0.08	Nil	0.12	0.07	0.27	7

TABLE 7

CHEMICAL AND MECHANICAL ANALYSES

BATANG MERBAU SERIES
 Tanjung Penggerang Region
 Site No: A207
 Run/Photo No: 1128/30

Agric. Dept. Laboratory No.	Depth (cm)	SEJP Sample Reference	Percentage		pH on Air-dry Soil	Percentages				Easily Sol.	6N HCl Soluble			
			On Original Sample			Loss on Ignition	Organic Matter	Carbon	Nitrogen		Potassium m.eq./100g	Calcium m.eq./100g	Magnesium m.eq./100g	
			Clay		Distilled Water	0.5N CH ₃ COOH Soluble	Potassium p.p.m.	0.1N NaOH Soluble	Phosphorus p.p.m.	Phosphorus p.p.m.	Iron Fe ₂ O ₃ %	Potassium m.eq./100g	Calcium m.eq./100g	Magnesium m.eq./100g
			Silt		0.01N KCl	not analysed	not analysed	not analysed	not analysed	not analysed	not analysed	not analysed	not analysed	not analysed
			Fine Sand		Loss on Ignition	44.8	2.09	9.81	0.97	1.93				
			Coarse Sand		Organic Matter	48.8	4.40	12.03	0.68	3.30				
			Gravel		Carbon									
			Stones		Nitrogen									

milliequivalents per 100 g soil

Depth (cm).	C.E.C.	Calcium	Magnesium	Sodium	Potassium	Total Ca+Mg+Na+K	Percentage Saturation
5-52	6.42	0.11	Nil	0.21	0.13	0.45	7
52-110	4.30	0.08	"	0.04	0.09	0.21	5

TABLE 8

CHEMICAL AND MECHANICAL ANALYSES

SERDANG SERIES
Pasak Sample Area
Site No: C050
Run/Photo No: 108S/142

Agric. Dept. Laboratory No.	Depth (cm)	SEJP Sample Reference	Percentage			On Original Sample		pH on Air-dry Soil		Percentages			Easily Sol.	6N HCl Soluble				
			Clay	Silt	Fine Sand	Coarse Sand	Gravel	Stones	Distilled Water	0.01N KCl	Loss on Ignition	Organic Matter	Carbon	Nitrogen	0.5N CH ₃ COOH Soluble Potassium p.p.m.	0.1N NaOH Soluble Phosphorus p.p.m.	Phosphorus p.p.m.	Iron Fe ₂ O ₃ %
RW 58 T	10-28	C0059	32	4	25	44	Nil	Nil	4.4	4.0	not analysed	not analysed	91	3.49	11.20	2.84	4.57	
Sa	28-68	C0060	32	4	26	43	1.0	"	4.7	4.1	not analysed	not analysed	82	4.57	12.60	1.55	5.95	
Sb	68-100	C0061	30	6	28	41	1.0	"	4.8	4.1	not analysed	not analysed	78	4.69	12.60	1.21	7.50	
Sc	100-136	C0062	34	4	25	42	14.0	18.0	4.8	4.1	not analysed	not analysed	89	7.66	12.60	1.64	6.29	

milliequivalents per 100 g soil

Depth (cm)	C.E.C.	Calcium	Magnesium	Sodium	Potassium	Total Ca+Mg+Na+K	Percentage Saturation
10-28	7.41	0.10	0.08	0.03	0.04	0.25	3
28-68	5.27	0.11	0.08	0.06	0.04	0.29	6
68-100	4.12	0.11	Nil	0.01	0.03	0.15	4
100-136	4.61	0.08	"	0.01	0.04	0.13	3

TABLE 9

CHEMICAL AND MECHANICAL ANALYSES

SERDANG SERIES, sandy clay phase
 Tanjong Penggerang Region
 Site No: B545
 Run/Photo No: 112S/32

Agric. Dept. Laboratory No.	Depth (cm)	SEJP Sample Reference	Percentage			On Original Sample		pH on Air-dry Soil		Percentages			6N HCl Soluble				
			Clay	Silt	Fine Sand	Coarse Sand	Gravel	Stones	Distilled Water	0.01N HCl	Loss on Ignition	Organic Matter	Carbon	Nitrogen	Phosphorus p.p.m.	Iron Fe ₂ O ₃ %	Potassium m.eq./100g.
RW 340 T	0-16	B0147	53	1	13	28	Nil	Nil	5.2	4.2	not analysed	not analysed	63	3.52	0.45	1.04	2.25
Sa	16-49	B0148	48	3	13	41	"	"	4.8	4.2	not analysed	not analysed	62	3.38	0.58	0.87	1.39
Sb	49-100	B0149	22	26	17	40	"	"	4.7	4.2	not analysed	not analysed	66	3.01	0.45	1.04	1.30
Sc	100-152	B0150	47	2	14	35	"	"	4.3	3.9	not analysed	not analysed	83	2.38	0.68	1.13	1.30

milliequivalents per 100 g soil

Depth (cm)	C.E.C.	Calcium	Magnesium	Sodium	Potassium	Total Ca+Mg+Na+K	Percentage Saturation
0-16	4.77	0.11	Nil	0.15	0.04	0.30	6
16-49	6.09	0.08	"	0.11	0.02	0.21	3
49-100	5.60	0.05	0.03	0.06	0.02	0.16	3
100-152	8.56	0.08	0.11	0.06	0.05	0.30	4

TABLE 10

CHEMICAL AND MECHANICAL ANALYSES

KEDAI SERIES
Pasak sample Area
Site No: C022
Run/Photo No: 1078/70

Agric. Dept. Laboratory No.	Depth (cm)	SEJP Sample Reference	Percentage			On Original Sample	pH on Air-dry Soil	Percentages					Easily Sol.	6N HCl Soluble					
			Clay	Silt	Fine Sand			Coarse Sand	Gravel	Stones	Distilled Water	0.01N KCl		Loss on Ignition	Organic Matter	Carbon	Nitrogen	C/N Ratio	0.5N CH ₃ COOH Soluble Potassium p.p.m.
HW 30 T	0-7	C0007	37	4	26	36	Nil	Nil	4.2	3.8	9.9	6.82	3.96	0.26	15	30	n.a	not analysed	n.a.
Sa	7-40	C0008	41	4	24	36	1.2	"	4.3	3.8	5.8	1.57	0.91	0.08	11	14	"	not analysed	n.a.
Sb	40-65	C0009	43	4	22	36	13.3	"	4.3	3.9	5.2	0.88	0.51	0.05	11	15	"	not analysed	n.a.
Sc	65-92	C0010	26	14	19	45	25.4	"	4.4	3.8	4.4	0.42	0.25	0.03	8	11	"	not analysed	n.a.
Sd	92-147	C0011	36	6	21	42	19.6	"	4.5	3.8	4.0	0.18	0.11	0.02	6	12	"	not analysed	n.a.

milliequivalents per 100 g soil

Depth (cm)	C.E.C.	Calcium	Magnesium	Sodium	Potassium	Total Ca+Mg+Na+K	Percentage Saturation
0-7	14.81	1.22	0.41	0.14	0.12	1.89	13
7-40	10.53	0.16	0.05	0.11	0.03	0.35	3
40-65	9.05	0.14	Nil	0.09	0.03	0.26	3
65-92	6.91	0.08	0.08	0.11	0.03	0.30	4
92-147	5.76	0.14	0.03	0.11	0.03	0.31	5

N.a. = not analysed

TABLE 11

CHEMICAL AND MECHANICAL ANALYSES

BUNGOR SERIES
Pasak Sample Area
Site No: C039
Run/Photo No: 108S/142

Agric. Dept. Laboratory No.	Depth (cm)	SEJP Sample Reference	Percentage				On Original Sample		pH on Air-dry Soil		Percentage				Easily Sol.		6N HCl Soluble		
			Clay	Silt	Fine Sand	Coarse Sand	Gravel	Stones	Distilled Water	0.01N HCl	Loss on Ignition	Organic Matter	Carbon	Nitrogen	C/N Ratio	0.5N CH ₃ COOH Soluble Potassium p.p.m.	0.1N NaOH Soluble Phosphorus p.p.m.	Phosphorus p.p.m.	Iron Fe ₂ O ₃ %
RW 32 T	0-10	00025	45	7	34	16	N11	N11	4.1	3.7	10.1	4.42	2.56	0.18	14	65	n.a	not analysed	not analysed
Sa	10-47	00026	52	4	32	17	"	"	4.4	3.8	6.3	0.90	0.52	0.05	10	21	"	not analysed	not analysed
Sb	47-109	00027	51	8	30	16	"	"	4.5	3.8	6.2	0.53	0.31	0.03	10	21	"	not analysed	not analysed
Sc	109-129	00028	56	8	26	15	"	"	4.3	3.8	7.0	0.53	0.31	0.03	10	15	"	not analysed	not analysed

milliequivalents per 100 g soil

Depth (cm)	C.E.C.	Calcium	Magnesium	Sodium	Potassium	Total Ca+Mg+Na+K	Percentage Saturation
0-10	17.28	0.62	0.46	0.16	0.22	1.46	9
10-47	10.21	0.14	0.03	0.09	0.08	0.34	3
47-109	7.74	0.08	N11	0.05	0.06	0.19	2
109-129	7.74	0.08	0.05	0.09	0.06	0.28	4

n.a. = not analysed

TABLE 12

CHEMICAL AND MECHANICAL ANALYSES

KUALA BRANG SERIES
Tanjung Penggerang Region
Site No: B230
Run/Photo No: 110S/16

Agric. Dept. Laboratory No.	Depth (cm)	SEJP Sample Reference	Percentage			On Original Sample		pH on Air-dry Soil		Percentages			Basily Sol.	6N HCl Soluble				
			Clay	Silt	Fine Sand	Coarse Sand	Gravel	Stones	Distilled Water	0.01N HCl	Loss on Ignition	Organic Matter	Carbon	Nitrogen	0.5N CH ₃ COOH Soluble Potassium p.p.m.	0.1N NaOH Soluble Phosphorus p.p.m.	Phosphorus p.p.m.	Iron Fe ₂ O ₃ %
RW 6B T	0-12	B0070	42	6	23	34	Nil	Nil	4.6	4.0	not analysed	not analysed	94	1.94	6.90	1.12	3.02	
Sa	12-46	B0071	44	7	17	37	1.0	2.9	4.8	4.1	not analysed	not analysed	80	2.40	12.10	0.86	3.79	
Sb	46-80	B0072	44	7	16	38	27.0	23.0	4.9	4.2	not analysed	not analysed	77	3.06	12.75	1.21	4.40	
Sc	80-102	B0073	44	6	13	42	27.0	11.5	5.0	4.1	not analysed	not analysed	90	3.37	13.25	1.29	3.53	

milliequivalents per 100 g soil

Depth (cm)	milliequivalents per 100 g soil					Total Ca+Mg+Na+K	Percentage Saturation
	C.E.C.	Calcium	Magnesium	Sodium	Potassium		
0-12	10.04	0.16	Nil	0.23	0.14	0.53	5
12-46	7.74	0.11	"	0.10	0.04	0.25	3
46-80	5.93	0.11	"	0.09	0.04	0.24	4
80-102	5.27	0.11	"	0.06	0.03	0.20	4

TABLE 13

CHEMICAL AND MECHANICAL ANALYSES

MARANG SERIES
Tanjong Penggerang Region
Site No: B676

Agric. Dept. Laboratory No.	Depth (cm)	SEJP Sample Reference	Percentage		on Original Sample		pH on Air-dry Soil		Percentages			6N HCl Soluble					
			Clay	Silt	Fine Sand	Coarse Sand	Gravel	Stones	Distilled Water	0.01N KCl	Loss on Ignition	Organic Matter	Carbon	Nitrogen	Phosphorus p.p.m.	Iron Fe ₂ O ₃ %	Potassium m.eq./100g.
RW 348 T	5-25	B0170	32	12	48	12	Nil	Nil	4.6	3.7	not analysed	not analysed	43	0.42	4.90	1.21	1.90
Sa	25-58	B0171	34	14	44	13	"	"	4.7	3.8	not analysed	not analysed	46	0.54	6.10	1.13	2.25
Sb	58-87	B0171	38	15	40	12	1	"	4.7	3.8	not analysed	not analysed	47	0.64	7.55	1.30	4.16
Sc	87-115	B0172	40	14	34	12	4	"	4.8	3.9	not analysed	not analysed	46	0.51	8.20	1.13	2.68

Milliequivalents per 100 g soil

Depth (cm)	C.E.C.	Calcium	Sodium	Potassium	Magnesium	Total Ca+Mg+Na+K	Percentage Saturation
5-25	5.76	0.16	0.13	0.05	0.05	0.39	7
25-58	5.93	0.13	0.06	0.02	Nil	0.21	4
58-87	5.43	0.08	0.06	0.02	Nil	0.16	3
87-115	5.60	0.08	0.09	0.06	Nil	0.23	4

TABLE 14

CHEMICAL AND MECHANICAL ANALYSES

MARANG, deep phase
 Tanjung Penggerang Region
 Site No: C598
 Run/Photo No: 115S/118

Agric. Dept. Laboratory No.	Depth (cm)	SEJP Sample Reference	Percentage				On Original Sample		pH on Air-dry Soil		Percentages				Easily Sol.	6N HCl Soluble			
			Clay	Silt	Fine Sand	Coarse Sand	Gravel	Stones	Distilled Water	0.01N KCl	Loss on Ignition	Organic Matter	Carbon	Nitrogen	0.5N CH ₃ COOH Soluble Potassium p.p.m.	0.1N NaOH Soluble Phosphorus p.p.m.	Phosphorus p.p.m.	Iron Fe ₂ O ₃ %	Potassium m.eq./100g.
RW 361 T	0-26	CO144	36	6	34	24	Nil	Nil	4.6	4.1	not analysed	not analysed	not analysed	93	1.04	4.25	1.13	1.30	
Sa	26-60	CO145	47	1	33	24	"	"	5.1	4.1	not analysed	not analysed	115	1.39	4.65	1.30	4.69		
Sb	60-100	CO146	42	6	34	23	"	"	4.9	4.0	not analysed	not analysed	77	1.45	4.55	1.04	3.38		
Sc	100-140	CO147	42	6	33	24	"	"	4.9	4.0	not analysed	not analysed	82	1.51	4.70	1.30	2.68		

milliequivalents per 100 g soil

Depth (cm)	C.E.C.	Calcium	Magnesium	Sodium	Potassium	Total Ca+Mg+Na+K	Percentage Saturation
0-26	12.02	0.13	0.08	0.18	0.12	0.51	4
26-60	7.24	0.05	0.13	0.16	0.05	0.39	5
60-100	5.76	0.05	Nil	0.13	0.05	0.23	4
100-140	6.25	0.05	Nil	0.11	0.04	0.20	3

TABLE 15

CHEMICAL AND MECHANICAL ANALYSES

DURIAN SERIES,
Tanjong Penggerang Region
Site No: B308
Run/Photo No: 109N/187

Agric. Dept. Laboratory No.	Depth (cm)	SEJP Sample Reference	Percentage		On pH on		Percentages		Easily Sol.	6N HCl Soluble						
			Clay	Silt	Original Sample	Air-dry Soil.	Loss on Ignition	Organic Matter		Carbon	Nitrogen	0.5N CH ₃ COOH Soluble Potassium p.p.m.	0.1N NaOH Soluble Phosphorus p.p.m.	Phosphorus p.p.m.	Iron Fe ₂ O ₃ %	Potassium m.eq./100g.
RW 73 T	0-11	B0085	48	19	22	8 Nil	Nil	4.45	3.8	not analysed	not analysed	64	1.23	15.75	1.29	4.14
Sa	11-36	B0086	48	19	23	8 "	"	4.65	3.95	not analysed	not analysed	44	1.33	17.60	1.12	5.43
Sb	36-63	B0087	54	19	20	6 "	"	4.7	3.9	not analysed	not analysed	38	1.49	18.75	1.03	5.43
Sc	63-108	B0088	59	18	15	6 "	"	4.85	3.95	not analysed	not analysed	35	1.81	20.50	1.03	5.17
Sd	108-143	B0089	54	27	16	4 "	"	4.9	3.95	not analysed	not analysed	40	1.78	22.75	1.03	6.12

milliequivalents per 100 g soil

Depth (cm)	C.E.C.	Calcium	Magnesium	Sodium	Potassium	Total Ca+Mg+Na+K	Percentage Saturation
0-11	9.05	0.27	0.03	0.06	0.16	0.52	6
11-36	6.42	0.11	0.03	0.07	0.12	0.33	5
36-63	6.58	0.11	0.03	0.06	0.06	0.26	4
63-108	5.27	0.11	Nil	0.04	0.08	0.23	4
108-143	5.76	0.11	Nil	0.07	0.10	0.28	5

TABLE 16

CHEMICAL AND MECHANICAL ANALYSES

POHOI SERIES
 Tanjong Penggerang Region
 Site No: B211
 Run/Photo No: 109N/193

Agric. Dept. Laboratory No.	Depth (cm)	SEJP Sample Reference	Percentage				On Original Sample		pH on Air-dry Soil		Percentages			Easily Sol.	6N HCl Soluble			
			Clay	Silt	Fine Sand	Coarse Sand	Gravel	Stones	Distilled Water	0.01N KCl	Loss on Ignition	Organic Matter	Carbon	Nitrogen	0.5N CH ₃ COOH Soluble Potassium p.p.m.	0.1N NaOH Soluble Phosphorus p.p.m.	Phosphorus p.p.m.	Iron Fe ₂ O ₃ %
RW 69 T	0-11	B0074	44	7	15	31	Nil	Nil	4.8	4.3	not analysed	not analysed	not analysed	240	4.46	10.35	24.82	4.40
Sa	11-38	B0075	53	6	15	31	"	"	4.4	3.9	not analysed	not analysed	not analysed	152	5.32	12.25	1.12	5.08
Sb	38-68	B0076	54	5	15	31	"	"	4.5	3.95	not analysed	not analysed	not analysed	148	5.89	10.85	1.12	5.17
Sc	68-100	B0077	57	6	15	25	"	"	4.8	4.1	not analysed	not analysed	not analysed	157	6.17	11.00	1.03	5.51
Sd	100-138	B0078	57	6	15	25	"	"	4.6	4.1	not analysed	not analysed	not analysed	152	6.34	10.85	1.03	5.60

milliequivalents per 100 g soil

Depth (cm)	C.E.C.	Calcium	Magnesium	Sodium	Potassium	Total Ca+Mg+Na+K	Percentage Saturation
0-11	11.19	1.16	0.11	0.17	0.08	1.52	14
11-38	7.41	0.16	Nil	0.15	0.08	0.39	5
38-68	7.24	0.14	"	0.07	0.04	0.25	3
68-100	6.42	0.08	0.03	0.07	0.04	0.22	3
100-138	5.93	0.11	Nil	0.14	0.08	0.33	6

TABLE 17

CHEMICAL AND MECHANICAL ANALYSES

MALACCA SERIES
Tanjong Penggerang Region
Bore No: B231
Run/Photo No: 110S/16

Agric. Dept. Laboratory No.	Depth (cm)	SEJP Sample Reference	Percentage			On	pH on	Percentages			Easily	6N HCl Soluble					
			Clay	Silt	Fine Sand	Original Sample	Air-dry Soil	Loss on Ignition	Organic Matter	Carbon	Nitrogen	Sol.	Iron Fe ₂ O ₃ %	Potassium m.eq./100g.	Calcium m.eq./100g.	Magnesium m.eq./100g.	
RW 75 T	6-25	B0091	57	8	18	21	2.0 Nil	4.6	3.85	not analysed	not analysed	206	7.03	9.44	1.21	3.71	
Sa	25-44	B0092	61	6	14	24	11.0	31.7	4.8	4.0	not analysed	not analysed	224	8.28	9.54	1.55	3.45
Sb	44-72	B0093	67	6	8	20	24.0	48.8	4.9	4.05	not analysed	not analysed	246	9.54	10.85	1.12	3.19
Sc	72-96	B0094	65	4	9	24	38.0	26.2	5.2	4.4	not analysed	not analysed	328	16.51	9.10	1.03	3.10

milliequivalents per 100 g soil

Depth (cm)	C.E.C.	Calcium	Magnesium	Sodium	Potassium	Total Ca+Mg+Na+K	Percentage Saturation
6-25	8.56	0.11	Nil	0.06	0.06	0.23	3
25-44	7.57	0.11	Nil	0.09	0.06	0.26	3
44-72	7.24	0.11	Nil	0.09	0.08	0.28	4
72-96	5.93	0.11	0.03	0.09	0.03	0.26	4

TABLE 18

CHEMICAL AND MECHANICAL ANALYSES

TAVY SERIES
Pasak Sample Area
Bore No: C035
Run/Photo No: 108S/142

Agric. Dept. Laboratory No.	Depth (cm)	SEJP Sample Reference	Percentage		On Original Sample		pH on Air-dry Soil		Percentages				Easily Sol.	6N HCl Soluble												
			Clay	Silt	Fine Sand	Coarse Sand	Gravel	Stones	Distilled Water	0.01N HCl	Loss on Ignition	Organic Matter	Carbon	Nitrogen	C/N Ratio	0.5N CH ₃ COOH Soluble Potassium p.p.m.	0.1N NaOH Soluble Phosphorus p.p.m.	Phosphorus p.p.m.	Iron Fe ₂ O ₃ %	Potassium m.eq./100g.	Calcium m.eq./100g.	Magnesium m.eq./100g.				
RW 31 T	0-6	C0018	39	12	40	14	Nil	Nil	4.1	3.7	7.3	3.24	1.88	0.17	11	49	n.a.							not analysed	not analysed	
Sa	6-28	C0019	47	8	36	14	"	"	4.4	3.5	4.9	0.82	0.48	0.06	8	18	n.a.								not analysed	not analysed
Sb	28-54	C0020	49	10	30	16	1.4	"	4.6	3.7	5.3	0.53	0.31	0.05	6	19	n.a.								not analysed	not analysed
Sc	54-155	C0021	43	12	25	25	7.7	1.1	4.7	3.9	5.3	0.24	0.14	0.03	5	10	n.a.								not analysed	not analysed

milliequivalents per 100 g Soil

Depth (cm)	C.E.C.	Calcium	Magnesium	Sodium	Potassium	Total Ca+Mg+Na+K	Percentage Saturation
0-6	13.83	0.70	0.30	0.14	0.14	1.28	9
6-28	8.39	0.30	Nil	0.11	0.06	0.47	6
28-54	7.74	0.16	"	0.14	0.06	0.36	5
54-155	6.58	0.08	0.03	0.06	0.03	0.20	3

n.a. = not analysed

TABLE 20

CHEMICAL AND MECHANICAL ANALYSES

HOLYROOD SERIES
 Sipt Sample Area
 Bore No: B114
 Run/Photo No. 106S/33

Agric. Dept. Laboratory No.	Depth (cm)	SEJP Sample Reference	Percentage				On Original Sample		pH on Air-dry Soil		Percentages				Easily Sol.		6N HCl Soluble					
			Clay	Silt	Fine Sand	Coarse Sand	Gravel	Stones	Distilled Water	0.01N HCl	Loss on Ignition	Organic Matter	Carbon	Nitrogen	C/N Ratio	0.5N CH ₃ COOH Soluble Potassium p.p.m.	0.1N NaOH Soluble Phosphorus p.p.m.	Phosphorus p.p.m.	Iron Fe ₂ O ₃ %	Potassium m.eq./100g.	Calcium m.eq./100g.	Magnesium m.eq./100g.
RW 10 T	0-17	B0051	22	6	37	40	Nil	Nil	4.8	4.1	4.0	1.59	0.92	0.08	12	n.a.	n.a.	108.8	0.34	0.80	1.29	1.98
Sa	17-58	B0052	26	4	36	39	1.1	"	4.6	4.1	4.0	0.92	0.52	0.03	17	n.a.	n.a.	41.6	0.43	1.25	1.29	2.16
Sb	58-121	B0053	24	4	35	41	5.0	"	5.0	4.2	2.7	0.29	0.17	0.02	9	n.a.	n.a.	35.2	0.43	1.40	1.38	2.16
Sc	121-146	B0054	26	4	29	46	22.6	"	4.7	4.1	3.1	0.21	0.12	0.02	6	n.a.	n.a.	41.6	0.45	7.57	1.63	2.84

milliequivalents per 100 g soil

Depth (cm)	C.E.C.	Calcium	Magnesium	Sodium	Potassium	Total Ca+Mg+Na+K	Percentage Saturation
0-17	8.56	0.30	0.08	0.01	0.06	0.45	5
17-58	5.10	0.11	0.03	0.01	0.02	0.18	4
58-121	4.77	0.16	Nil	0.01	0.02	0.19	4
121-146	4.12	0.14	0.05	0.06	0.02	0.27	7

JOHOR TENGAH REGION

Full descriptions of modal profiles of the soil series mapped and the analytical data where available are given below. The horizon nomenclature follows that of Leamy & Panton (1966). The methods of analysis include:-

Mechanical Analysis - Bouyoucos Hydrometer Method using "Tetron" as a dispersing agent.

pH - Pye pH Meter using glass electrode, 10g. soil in 25 ml. distilled water or 0.01N KCl.

Carbon - Walkley & Black Method.

Nitrogen - Micro-Kjeldahl Method with a mixture of selenium, copper sulphate and potassium sulphate as catalyst.

Potassium (Easily Soluble) - extraction in N/2 acetic acid (10g sample in 100 ml acid) and estimation with flame photometer.

Phosphorus (Easily Soluble) - leaching with a solution of 2N NaCl and 0.2N HDL, and extraction with 0.01N NaOH.

Cation Exchange Capacity - leaching with 0.01N barium chloride and titrating the N ammonium acetate with N/50 versenate.

Exchangeable Calcium & Magnesium - titrate with N/50 versenate after separation of barium in 0.1N barium leachate.

Exchangeable Sodium & Potassium - determine on extract by flame photometer.

Percentage Base Saturation - calculated as a function of the total cations present in the leachate.

RENGAM SERIES

Location: Rengam Forest Reserve.
 Grid Reference: Map Sheet 124 - 665501.
 Elevation: Between 50 to 100 feet, a.s.l.
 Topography: 7° slope on undulating terrain.
 Vegetation: Primary forest.
 Parent Material: Acid Granite derived.

Soil Profile:-

Ah 0 to 3 in. (0 to 7.6 cm)

Brown (10YR 4/3) friable coarse sandy clay; strongly developed fine subangular blocky structures; many roots and pores; boundary distinct.

AB 3 to 25 in. (7.6 to 63.5 cm)

Brownish yellow (10YR 6/6) friable coarse sandy clay; moderately developed medium subangular blocky structures; many roots and pores; patchy clayskins; boundary diffuse.

Btj 25 to 45 in. (63.5 to 114.3 cm)

Brownish yellow (10YR 6/8) friable coarse sandy clay; moderately developed medium subangular blocky structures; discontinuous clayskins; boundary distinct.

BC 45 to 60+ in. (114.3 to 152.4 cm)

Yellowish brown (10YR 5/6) firm coarse sandy clay to clay; moderately developed angular blocky structures; continuous clay skins.

Depth (in.)	Percentage				%		pH		Percentage			
	Clay	Silt	Fine Sand	Coarse Sand	Gravel	Stone	Original Sample	Air-dry	Organic Matter	Carbon	Nitrogen	C/N Ratio
0-3	43	4	15	41	Nil	Nil	4.2	3.8	2.18	1.27	.12	10
3-25	49	4	14	37	"	"	4.3	3.9	0.71	0.41	.04	10
25-45	51	6	10	36	"	"	4.5	3.9	0.46	0.27	.04	7
45-60	55	4	13	32	"	"	4.6	3.9	0.36	0.21	.03	7

Depth (in.)	Easily Soluble		Exchangeable Cations					Percent Base Saturation
	K ppm	P ppm	C.E.C. m.eq./100g Soil	Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺	
0-3	N.D.	28	13.17	0.21	0.45	0.15	0.24	7
3-25	"	19	7.43	0.03	0.05	0.04	0.12	3
25-45	"	14	6.25	0.03	0.10	0.04	0.09	4
45-60	"	17	6.75	0.08	0.10	0.08	0.11	5

Horizon	Texture	Particle Size Range (mm)
N.3.	Clay	0.002 mm.
	Silt	0.002 - 0.02 mm.
	Fine Sand	0.02 - 0.2 mm.
	Coarse Sand	0.2 - 2.0 mm.
	Gravel	2 - 10 mm.
	Stone	10 mm.
	tr	= trace
	N.D.	= not done.

RENGAM SERIES COARSE SANDY CLAY PHASE

Location: Rengam Forest Reserve.
 Grid Reference: Map Sheet 124 - 648406.
 Elevation: 200 to 250 feet a.s.l.
 Topography: 8° slope on rolling terrain.
 Vegetation: Primary Forest.
 Parent Material: Acid granite derived.

Soil profile:-

Ah 0 to 3 in. (0 to 7.6 cm)
 Dark greyish brown (10YR 4/2) friable coarse sandy clay; moderate to strong fine & medium subangular blocky structures; many roots and pores; boundary distinct.
 AB 3 to 11 in. (7.6 to 27.9 cm)
 Brownish yellow (10YR 6/8) friable coarse sandy clya; moderate fine & medium subangular blocky structures; many roots and pores; patchy clayskins; boundary diffuse.
 Btj 11 to 26 in. (27.9 to 66.0 cm)
 Brownish yellow (10YR 6/8) friable coarse sandy clay with gravels; many pores; few roots; discontinuous clayskins; boundary distinct.
 Cm 26 to 55+ in. (66.0 to 139.7 cm)
 Yellowish red (5YR 5/8) firm coarse sandy to gravelly clay; weak coarse angular blocky structures; discontinuous clayskins.

YONG PENG SERIES

Location: Map Sheet 125.
 Grid Reference: 724619.
 Elevation: 100 feet a.s.l.
 Topography: On undulating terrain.
 Vegetation: Primary forest.
 Parent Material: Dacite and rhyodacite derived.

Soil profile:-

Ah 0 - 1 in. (0 to 2.5 cm)
 Brown (10YR 4/3) friable sandy clay loam; weak fine subangular blocky structures; boundary distinct.
 Ae 1 - 7 in. (2.5 to 17.8 cm)
 Yellowish brown (10YR 5/6) friable sandy clay; moderate medium subangular blocky structures; few pores; patchy clayskins; boundary indistinct.
 Bt 7 to 42 in. (17.8 to 106.7 cm)
 Yellowish brown to reddish yellow (10YR 5/6 to 7.5YR 6/6) friable to firm gritty clay; moderate medium subangular blocky structures; few pores; discontinuous to continuous clayskins; boundary indistinct.
 Cm 42+ in. (106.7+ cm)
 Brownish yellow (10YR 6/8) very firm gritty clay; moderate coarse angular blocky structures; few pores, patchy clayskins.

DURIAN SERIES

Location: Map Sheet 125.
 Grid Reference: 953348.
 Elevation: 150 feet a.s.l.
 Topography: Undulating terrain.
 Vegetation: Primary forest.
 Parent Material: Shale.

Soil profile:-

Ah 0 to 2 in. (0 to 5.1 cm)
 Brown (10YR 5/3) friable sandy clay loam; weak fine subangular blocky structures; boundary distinct.
 Ae 2 to 9 in. (5.1 to 22.9 cm)
 Yellowish brown (10YR 5/6) friable to firm gritty clay; moderate medium subangular blocky structures; few pores; patchy clayskins; boundary indistinct.
 Bt 9 to 31 in. (22.9 to 78.7 cm)
 Brownish yellow (10YR 6/6) firm clay; strong medium and coarse subangular blocky structures; many pores; continuous clayskins; boundary distinct.
 Bcm 31 to 40 in. (78.7 to 101.6 cm)
 Compacted nodular laterite and angular quartzite fragments in clay matrix; boundary distinct.
 Cm 40+ in. (101.6+ cm)
 Strong brown (7.5YR 5/8) very firm clay; profuse coarse distinct yellow and yellowish red (10YR 7/6 & 5YR 5/8) mottles; moderate medium and coarse blocky structures.

Depth (in.)	Percentage		Percent		pH		Percentage		Nitrogen	C/N Ratio		
	Clay	Silt	Original Sample	Air-dry	Air-dry	Air-dry	Organic Matter	Carbon				
0-3	49	5	12	35	Nil	Nil	4.6	4.0	3.54	2.06	.18	11
3-11	51	6	9	38	1.0	"	5.0	4.2	0.58	0.34	.05	7
11-26	55	6	10	32	6.0	"	5.0	4.2	0.29	0.17	.04	4
26-56	51	6	6	40	9.0	"	5.0	4.3	0.26	0.15	.02	7

K ppm	Easily Soluble		Exchangeable Cations m.eq./100g Soil				Percent Base Saturation
	P ppm	C.E.C. m.eq./100g Soil	Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺	
N.D.	29	12.66	0.13	0.42	0.05	0.17	6
"	13	5.57	0.10	0.13	Nil	0.02	4
"	20	6.75	0.10	0.21	"	0.05	5
"	11	3.54	0.10	0.21	"	0.01	9

BUNGOR SERIES

Location: Panti Forest Reserve.
 Grid Reference: Map Sheet 131 - 091164
 Elevation: 150 - 200 feet a.s.l.
 Topography: 9° on rolling terrain.
 Vegetation: Primary Forest.
 Parent Material: Low-grade metamorphosed schist, and sandstones.

Soil profile:

Ah 0 - 1 in. (0 to 2.5 cm)
 Dark yellowish brown (10YR 4/4) very friable fine sandy clay; weak fine subangular blocky structures; abundant roots and many pores; boundary distinct.

Ae 1 - 6 in. (0 to 15.2 cm)
 Yellowish brown (10YR 5/6) friable fine sandy clay; moderate fine to medium sunangular blocky structures; many pores; patchy clay-skins; boundary indistinct.

Bt 6 - 17 in. (15.2 to 43.1 cm)
 Brownish yellow (10YR 6/6) friable to firm clay; moderate to strong coarse and medium sunangular blocky structures; many pores; discontinuous clayskins; boundary indistinct.

Btv 17 - 56+ in. (43.1 to 142.2+ cm)
 Brownish yellow (10YR 6/8) firm clay; strong medium and coarse subangular blocky structures; many pores; continuous clayskins; few faint fine yellowish mottles.

SERDANG SERIES

Location: Panti Forest Reserve.
 Grid Reference: Map Sheet 131 - 053152.
 Elevation: 50 feet a.s.l.
 Topography: 4° slope on undulating terrain.
 Vegetation: Primary forest.
 Parent Material: Sandstone and quartzite.

Soil profile:

Ah 0 - 1 in. (0 to 2.5 cm)
 Dark yellowish brown (10YR 4/4) very friable loamy sand; weak fine and medium subangular blocky structures; abundant roots and pores; boundary distinct.

Ae 1 - 11 in. (2.5 to 27.9 cm)
 Yellow (2.5Y 7/6) very friable sandy clay loam; weak fine subangular blocky structures; many roots and pores; boundary diffuse.

Btj 11 - 35 in. (27.9 to 88.9 cm)
 Olive yellow (2.5Y 6/8) friable sandy clay loam; weak fine subangular blocky structures; many roots and pores; patchy clayskins; few fine faint red mottles; boundary distinct.

Con 35 - 45 in. (88.9 to 114.3 cm)
 Pieces of sandstone, schist and quartzite (1/2 to 2 in. in diameter) in a sandy clay matrix.

Ccu 45+ in. (114.3+ cm)
 Unconsolidated weathered fragments and sandstone and quartzite pieces.

Depth (in.)	Percentage				Percent Original Sample		pH Air-dry Soil	Percentage							
	Clay	Silt	Fine Sand	Coarse Sand	Gravel	Stone		Distilled Water	0.01N KCl	Moisture Air-dry/Oven dry	Loss on Ignition	Organic Matter	Carbon	Nitrogen	C/N Ratio
0-1	49	14	37	5	N11	N11	5.6	4.4	2.2	6.2	0.58	0.34	0.07	4.9	
1-6	53	10	33	8	"	"	4.8	3.8	1.8	5.3	0.84	0.49	0.07	7.0	
6-17	61	10	27	8	"	"	4.8	3.8	2.1	5.7	0.55	0.32	0.05	6.4	
17-56	67	10	22	5	"	"	5.0	3.9	2.4	6.4	0.41	0.24	0.04	6.0	

Easily Soluble			Exchangeable Cations m.eq./100g soil				6N HCl Soluble				
K ppm	P ppm	C.E.C m.eq./100g soil	Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺	Percent Base Saturation	Fe ₂ O ₃ %	K m.eq./100g	Ca m.eq./100g	Mg m.eq./100g
35	28	6.91	1.38	0.89	0.09	0.10	36	4.34	3.27	1.72	7.84
15	18	7.90	0.27	0.08	0.08	0.04	5	3.20	8.20	1.03	2.93
6	16	7.08	0.19	N11	0.05	0.02	4	4.40	10.80	1.03	2.84
5	17	3.13	0.19	"	N11	0.02	7	5.20	12.20	1.03	3.96

FRANG SERIES LATERITIC PHASE

Location: Kluang Forest Reserve
 Grid Reference: Map Sheet 124 - 603557.
 Elevation: 150 - 200 feet a.s.l.
 Topography: 12 - 18° on rolling terrain
 Vegetation: Secondary forest.
 Parent Material: Schist.

Soil profile:

Ah 0 - 5 in. (0 - 12.7 cm)

Yellowish red (5YR 5/6) friable silty clay loam; weak to moderate fine and medium sub-angular blocky structures; many roots, few pores; boundary distinct.

Bcn 5 - 29 in. (12.7 to 73.7 cm)

Yellowish red (5YR 5/6) friable silty clay matrix containing nodular laterite, which increase in abundance and size with depth; patchy clayskins; boundary distinct.

Btj 29 - 40+ in. (73.7 - 101.6 cm)

Yellowish red (5YR 5/6) friable silty clay; weak fine and medium subangular blocky and angular blocky structures, breaking into granular structures; patchy clayskins; faint mottles.

HARIMAU SERIES

Location: Endau-Kota Tinggi Wild Life Reserve
 Grid Reference: Map Sheet 125 - 870219
 Elevation: 100 to 150 feet a.s.l.
 Topography: 6° slope on undulating terrain.
 Vegetation: Secondary forest.
 Parent Material: Older Alluvium.

Soil profile:

Ah 0 to 2 in. (0 to 5.1 cm)

Dark yellowish brown (10YR 4/4) very friable coarse sandy clay loam; weak fine subangular blocky structures; abundant roots, many pores; boundary distinct.

Aej 2 to 24 in. (5.1 to 61.0 cm)

Yellowish brown (10YR 5/6) very friable coarse sandy clay loam; weak fine subangular blocky structures; many pores, few roots; boundary indistinct.

Btj 24 to 42 in. (61.0 to 106.7 cm)

Yellow (10YR 7/8 - 8/8) friable slightly gravelly clay loam; weak fine to medium subangular blocky structures; many pores; patchy clayskins; boundary indistinct.

BC 42 to 60+ in. (106.7 to 154.2 cm)

Reddish yellow (7.5YR 6/8 - 7/8) firm gravelly clay loam; moderate medium to coarse subangular blocky structures; few pores; patchy clayskins associated with quartz grains of 1/4 in. in diameter and somewhat rounded.

Depth (in.)	Percentage				Percent Original Sample		pH Air-dry Soil		Percentage					
	Clay	Silt	Fine Sand	Coarse Sand	Gravel	Stone	Distilled Water	0.01N KCl	Moisture Air-dry/Oven dry	Loss on Ignition	Organic Matter	Carbon	Nitrogen	C/N Ratio
0-2	24	2	21	58	2.2	Nil	3.9	3.6	0.7	5.1	5.39	3.13	0.21	15
2-24	28	2	18	56	4.6	"	4.6	4.1	0.7	3.9	1.32	0.76	0.07	11
24-40	30	4	16	55	8.0	"	4.6	4.0	0.6	3.5	0.86	0.50	0.05	10

Easily Soluble			Exchangeable Cations m.eq./100g Soil				Percent Base Saturation
K ppm	P ppm	C.E.C. m.eq./100g Soil	Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺	
38	57	7.90	0.13	0.35	0.11	0.11	9
18	56	5.10	0.08	Nil	0.08	0.07	5
11	44	4.12	0.08	"	0.09	0.03	5

HARIMAU SERIES MODERATELY DEEP PHASE

IIBt 27+ in. (68.6 cm)

Location: Endau-Kota Tinggi Wild Life Reserve
Grid Reference: Map Sheet 125 - 802219
Elevation: 100 to 150 feet a.s.l.
Topography: 3° on undulating terrain
Vegetation: Secondary forest.
Parent Material: Older Alluvium.

Reddish yellow (7.5YR 7/6) firm gravelly clay; moderate to strong medium and coarse subangular blocky structures; many pores; continuous clay-skins; abundant coarse distinct red (2.5YR 4/8) and white (2.5Y 8/1) and many medium faint yellow (2.5Y 8/8) mottles.

N.B.

Soil profile:
 Ah 0 to 2 in. (0 to 5.1 cm)

Horizon IIBt represents an old eroded surface, closely resembling the Bt of the Durian Series. The Harimau Series has developed on the older alluvium deposited over the old surface.

Dark yellowish brown (10YR 4/4) very friable coarse sandy clay; weak fine subangular blocky and granular structures; abundant roots and pores; boundary distinct.

Ae 2 to 12 in. (5.1 to 30.5 cm)

Brownish yellow (10YR 6/8) friable coarse sandy clay; weak to moderate fine and medium subangular blocky structures; many roots and pores; patchy clayskins; boundary indistinct.

Bt 12 to 27 in. (30.5 to 68.6 cm)

Strong brown (7.5YR 5/6) to reddish yellow (7.5YR 6/6) firm coarse sandy clay; weak to moderate coarse subangular blocky structures; patchy to discontinuous clayskins; gravels consist of somewhat rounded quartz grains and weathered clay pebbles; boundary distinct.

Depth (in.)	Percentage				Percent Original Sample		pH Air-dry Soil		Percentage					
	Clay	Silt	Fine Sand	Coarse Sand	Gravel	Stone	Distilled water	0.01N KCl	Moisture Air-dry/Oven dry	Loss on Ignition	Organic Matter	Carbon	Nitrogen	C/N Ratio
0-2	41	6	14	40	Nil	Nil	3.7	3.6	1.7	10.9	8.13	4.72	0.31	15
2-12	40	8	12	40	"	"	4.2	3.9	1.0	5.2	1.37	0.79	0.08	10
12-27	47	6	14	34	1.5	"	5.0	3.9	1.0	4.9	0.51	0.30	0.04	8
27+	69	11	12	10	19.9	"	4.8	4.8	1.5	7.5	0.32	0.19	0.02	10

Easily Soluble			Exchangeable Cations m.eq./100g Soil					Percent Base Saturation
K ppm	P ppm	C.B.C. m.eq./100g Soil	Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺		
63	41	17.94	0.27	0.29	0.11	0.19	5	
16	37	6.75	0.16	Nil	0.01	0.03	3	
12	40	5.10	0.11	"	0.03	0.03	3	
12	34	7.08	0.08	0.03	0.04	0.02	2	

ULU TIRAM SERIES

Location: Kluang Forest Reserve.
 Grid Reference: Map Sheet 124 - 636542.
 Elevation: 50 to 100 feet a.s.l.
 Topography: 4° slope on undulating terrain.
 Vegetation: Secodnary forest.
 Parent Material: Older alluvium.

Soil profile;

Ah 0 - 7 in. (0 to 17.8 cm)

Yellowish brown (10YR 5/4) loose sandy loam to sandy clay loam; moderate medium crumbs; abundant roots; boundary distinct.

Ae 7 - 11 in. (17.8 to 27.9 cm)

Yellowish brown (10YR 5/6) friable sandy clay loam; weak medium subangular blocky structures; many roots and pores; boundary indistinct.

Btj 11 - 22 in. (27.9 to 55.8 cm)

Strong brown (7.5YR 5/8) friable to firm sandy clay loam with gravels; weak medium and coarse subangular blocky structures; many roots and pores; patchy clayskins; faint mottles; boundary indistinct.

BC 22+ in. (55.8+ cm)

Strong brown (7.5YR 5/8) firm stony clay loam; massive to weak coarse angular blocky structures; patchy to discontinuous clayskins.

Depth (in.)	Percentage		Percent Original Sample		pH Air-dry		Percentage			C/N Ratio		
	Clay	Silt	Fine Sand	Coarse Sand	Gravel	Stone	Distilled Water	0.01N KCl	Organic Matter		Carbon	Nitrogen
0-7									1.08	0.63	0.06	10
7-11	24	16	29	34	1	Nil	4.5	3.8	0.88	0.51	0.04	13
11-22	28	10	28	34	6	"	4.4	3.8	0.46	0.27	0.02	13
22+	38	13	20	34	7	17	4.5	3.7				

Easily Soluble			Exchangeable Cations m.eq./100g Soil				Percent Base Saturation
K ppm	P ppm	C.E.C. m.eq./100g Soil	Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺	
60	6.75	0.08	0.08	0.23	0.12	0.07	7
47	6.07	0.08	0.08	0.41	0.08	0.07	11
52	5.40	0.08	0.08	0.44	0.09	0.08	12

PART III

APPENDIX J

REFERENCES

APPENDIX J

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APPENDIX

INDEX

Point of high land jutting out into the river...

Point of high land jutting out into the river...

Point of high land jutting out into the river...

The line separating the waters flowing into different basins...

The horizontal course of a stream.

The surface slope of ground when approximately parallel to the dip of the strata over which it lies.

The upper side of a hill.

Low ground.

A body of water.

A body of water, particularly in a river.

A natural upthrust, or rounded hill or plain bounded by heights.

Old trace line.

Members of the same of lakes and streams.

The elevated upland portions of a low mountain range...

The distinctive appearance of a mountain range...

Places where fragments of rock are scattered together.

Low in height...

Low in height...

Low in height...

Point of high land jutting out into the river...

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PART III

APPENDIX K

GLOSSARY

APPENDIX K

GLOSSARY

GEOMORPHOLOGY

Promontory

Point of high land jutting out into the sea or other expanse of water beyond the line of coast, a headland.

Swale

Swampy, linear depression.

Watershed

The line separating the waters flowing into different rivers or river basins.

Strike

The horizontal course of a stratum.

Dip slope

The surface slope of ground when approximately parallel to the dip of the strata over which it lies.

Scarp

The steep face of a hill.

Hummock

Low mounts.

Arcuate

Arched; bent like a bow.

Nickpoint

A break of slope, particularly in a river profile.

Cirque

A natural amphitheatre, or rounded hollow or plain encircled by heights.

Rentis

Cut trace line.

Littoral

Seashore or the shore of lakes and rivers.

Warping

The surface undulations produced by slow movements which cause one part of the land surface to be higher yet continuous with another.

SOILS

Katamorphism

The destructive processes of metamorphism, as opposed to the constructive processes, or anamorphism.

Breccia

Coarse angular fragments of rock cemented together.

Loss on ignition

Loss in weight caused by heating to redness of soil previously dried at 105°C.

pF

Common logarithm (to the base 10) of the height in cms. of a column of water corresponding to the free-energy difference between

free water and that held by soil excluding the effects of salts, expressed on a gravitational scale.

Argillaceous

Clayey (in contrast to arenaceous - sandy).

Colluvium

Heterogenous sediments deposited at the foot of slopes by gravitational processes such as soil slips, slope wash etc.

Alluvium

Deposit of water-borne sediment in valleys and on river floodplains, deltas, beaches etc.

Lattice structure

The orderly arrangement of atoms in a crystalline material (as in a clay lattice).

pH, soil

The negative logarithm of the hydrogen-ion activity of a soil. The degree of acidity (or alkalinity) of a soil as determined by means of a glass electrode (quinhydrone) or other suitable electrode or indicator at a specific moisture content or soil/water ratio and expressed in terms of pH scale.

Soil reaction

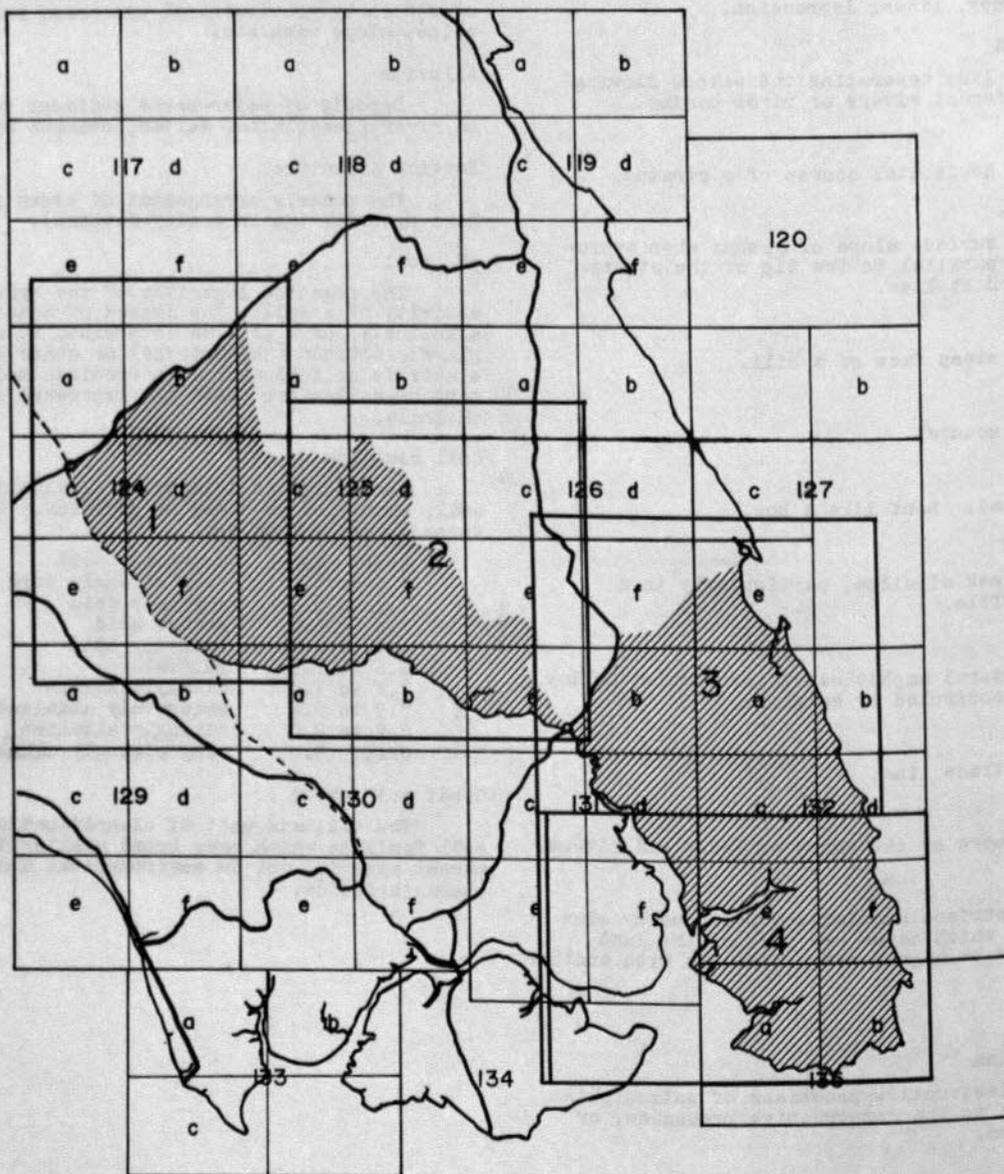
The degree of acidity or alkalinity of a soil, expressed in terms of pH value. Descriptive terms commonly used are:

below 4.5	extremely acid
4.5 to 5.0	very strongly acid
5.1 to 5.5	strongly acid
5.6 to 6.0	medium acid
6.1 to 6.5	slightly acid
6.6 to 7.3	neutral
7.4 to 7.8	mildly alkaline
7.9 to 8.4	moderately alkaline
8.5 to 9.0	strongly alkaline
over 9.0	very strongly alkaline.

Great soil group

The ultimate unit of classification comprising soil families which have broad similarities in parent material and in environmental and horizon characteristics.

MAP SHEET LAYOUT



1: 63,360 Series....132
 1: 25,000 Series.... a,b,c, etc.
 1: 63,360 Maps prepared for the project

