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Report on a Detailed Soil Survey

of the

SUNGAI TANYIT AREA,

LAMBIR - SUBIS

4th Division

by

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Sarawak

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TOPOGRAPHY AND PARENT MATERIAL

The area under study is a series of low hills with a maximum height of 100 feet above the local base level. Hill slopes range from 20-25 degrees being most common. The small area of valley floor is poorly drained and the large alluvial areas along the river are subject to slight flood damage.

The parent material of the hill soils consists of uniform dark gray calcareous siltstone. Thin lenses of calcareous limestone are scattered throughout in thin beds in deep bedded in this general area but soil analysis indicates no strong reaction for calcareous material and the parent material under the hill soils are usually considered as non-calcareous.

SOIL MAPPING UNITS

The definitions of the soil mapping units were based on the present revised classification of soils in central and north Sarawak. A brief description of soils in Central and North Sarawak by J. S. Smith, 1953. The soils are mapped on a level level but some of the soil profiles were separated into series and sub-series. The depth limit of 25 cm to 50 cm is important for an 80 cent depth level level and for 100 cent depth level level and other soil profiles are defined as follows:

- Soils less than 10 cm (10 inches) Family A
- 25-50 cm (10-20 inches) Series
- 50-75 cm (20-30 inches) Moderately shallow
- 75-100 cm (30-40 inches) Moderately deep
- Soils less than 100 cm (40 inches) Series

Report on a Detailed Soil Survey of the
Sungai Tanyit Area

1. INTRODUCTION

In September 1972, the Sarawak Land Development Board expressed its interest to conduct an observation trial of cocoa growth on hill soils on an area near Ladang Dua, Mile 42 of the Miri-Bintulu Road. Members of the Soils Division who were attached to the Miri-Bintulu Feasibility Study were requested to investigate about 200 acres and to suggest a 20-acre plot for initial observation trial.

The area surveyed (see Soil Map) is bounded by the Miri-Bintulu Road to the west, the old timber road leading from this trunk road to Rumah Pakut to the north and Sungai Tanyit to the south and east.

2. FIELD WORK

The field work was carried out entirely by Agricultural Assistant Rosli bin Sahari, and the rentis cutting teams were provided by the field manager at Ladang Dua.

The rentises were cut at intervals of 150 meters. Along each rentis, the soils were described at every 25 meters intervals. In addition, 10 pit profiles were sampled and analysed. The locations of these rentis lines, soil augerings and profile sites are shown on the soil map. Altogether, 236 sites (including 10 soil pits) were examined, giving the density of soil examination as being 1.2 bores per acre.

3. TOPOGRAPHY AND PARENT MATERIAL

The area comprises mainly low hills with amplitude of less than 100 feet above the local base level, hill slopes ranging from 20-25 degrees being most common. The small area of valley floor is poorly drained but the levee alluvium along Sungai Tanyit is moderately well drained though subject to slight flash flooding.

The parent material of the hill soils consists of uniform dark grey carbonaceous silty shale. Thin lenses of calcitic limestone have been observed in unweathered shale in deep road cutting in this general area but soil analyses indicate no strong reaction for calcareous material and the parent material upon which the hill soils are immediately derived from are considered as non-calcareous.

4. SOIL MAPPING UNITS

The definitions of the soil mapping units were based on the recent revised classification of soils in central and north Sarawak (A Draft Reclassification of Soils in Central and North Sarawak by I.M. Scott, 1973). The soils are mapped mainly at series level but family intergrades are included where separation into series was not possible. The depth limit of 25 cm (10 inches) is one important parameter at the family level while soils deeper than 25 cm for each family are further separated into depth phases which are defined as follows:

Less than 25cm (10 inches)	..	..	Family division
25-50cm (10-20 inches)	..	..	Shallow
50-75cm (20-30 inches)	..	..	Moderately shallow
75-100cm (30-40 inches)	..	..	Moderately deep
More than 100cm (40 inches)	..	..	Deep.

A soil may lie directly over relatively unweathered rock (lithic horizon), or it may merge into a deeply weathered horizon of parent material (paralithic horizon) in which fragments of the original parent material are still recognisable. Soil depth is measured from the surface to the upper surface of the lithic horizon or to that of the paralithic horizon. The paralithic horizon is arbitrarily defined as one in which more than 10% of the volume consists of weathering parent material. Stonelines which are greater than 25cm (10 inches) in thickness in the subsoils are considered a serious impedance to rooting and where these occur, these are treated as paralithic a lithic horizons and soil depth is measured from the soil surface to the upper surface of the stonelines.

The soils mapped are shown in the soil legend and are described in more details below.

4.1 Hill Soils

The hill soils formed from shale are characterised by uniform texture. Family and series differentiation are based on soil depth and colour respectively. All hill soils which are deeper than 50cm (20 inches) are mapped as series of MERIT family, soils which range from 25-50cm deep are mapped as MERIT-KAPIT family intergrade while soils shallower than 25cm (10 inches) were not mapped. The two series - Merit and Jakar - within the MERIT family were separated on the basis colour.

4.1.1 Merit Series (Mrt)

Clay from non-calcareous shale coloured yellowish brown (10YR) or yellower in the surface 50cm (20 inches), pH less than 6.0, base saturation less than 35 per cent and exchangeable calcium less than 5 milliequivalents in all horizons.

4.1.2 Jakar Series (Jkr)

This is similar to the Merit series except that the colour is redder than yellowish brown (10YR) below the first 10cm (4 inches); this means that the colour of the lower A-horizon is strong brown, reddish yellow or redder.

4.2 Lowland Soils

The lowland soils are formed from actively accreting alluvium of Sungai Tanyit and colluvium in valleys. The ratio of the augerings of lowland soils to ~~the~~ total number of augerings shows that the lowland area occupies about 21% of the surveyed area.

4.2.1 SEDUAU Family (SDU)

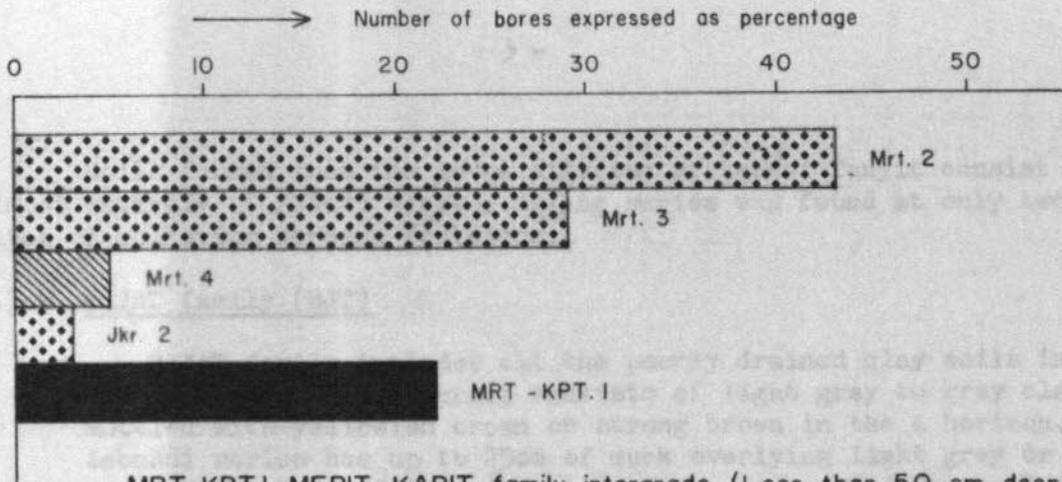
The well to moderately well drained soils from levee alluvium are mapped as SEDUAU family of which two series are separated:

4.2.2 Seduau series (Sdu)

Yellowish brown (10YR) or yellower clay in the upper 50cm (20 inches), cation exchange capacity less than 30 milliequivalents/100gm.

4.2.3 Malang series (Mlg)

As for Seduau series but colour redder than yellowish brown (10YR) in some part of the upper 50cm (20 inches), this means that colour in some part of the upper 50cm is strong brown, reddish yellow or redder.



MRT-KPT.1 MERIT KAPIT family intergrade (Less than 50 cm deep).
 Mrt. 2 - Merit series, moderately shallow (50 - 75 cm deep).
 Mrt. 3 - Merit series, moderately deep (75 - 100 cm deep).
 Mrt. 4 - Merit series, deep (more than 100 cm deep).
 Jkr. 2 - Jakar series, moderately shallow (50 - 75 cm deep).
 Deeper phases of Jakar series do not occur.

Fig. 1a. Bar graph showing the number of bores expressed as percentage for hill soils mapped. Total number of bores is 187.

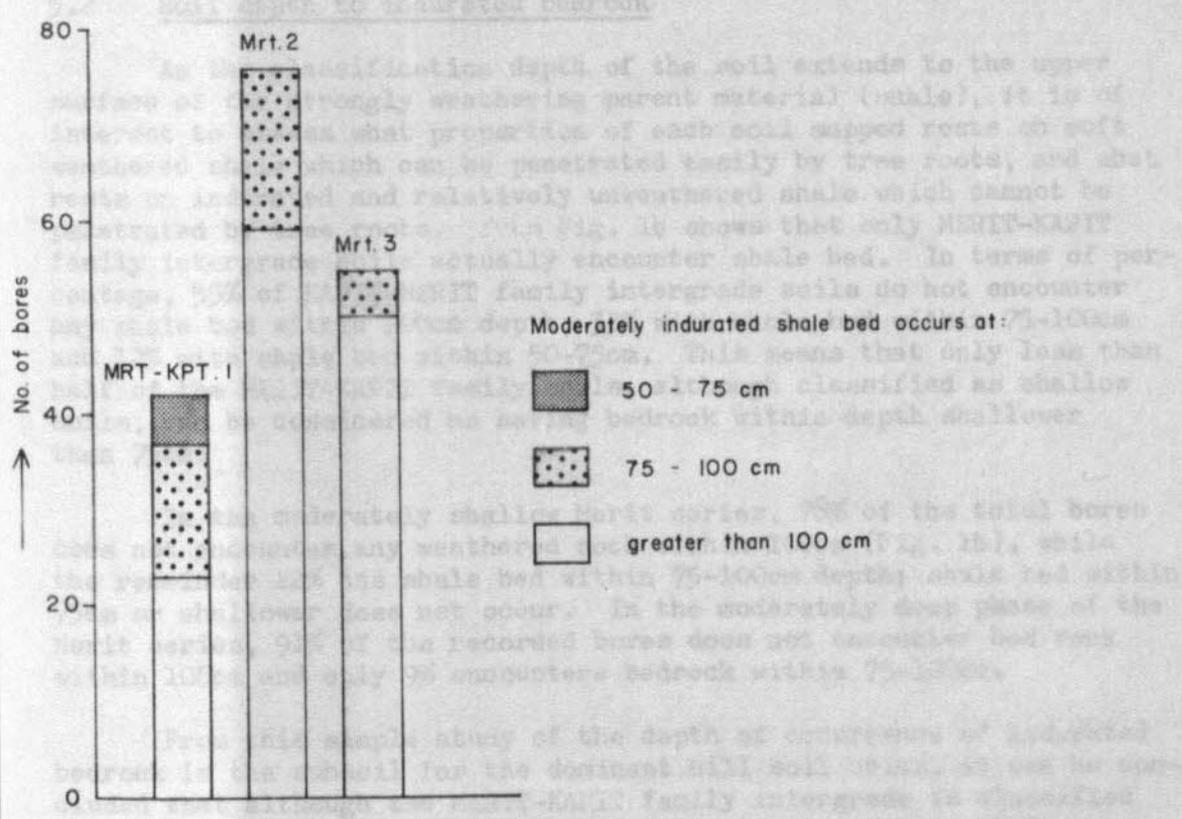


Fig. 1b. Number of bores for the three dominant hill soils mapped where moderately indurated shale bed occurs within the three depth intervals.

Soils formed from the levee alluvium of Sungai Tanyit consist almost entirely of Seduai series; Malang series was found at only two sites on colluvium bordering footslopes.

4.3.4 BIJAT family (BJT)

BIJAT family includes all the poorly drained clay soils in valley floor. Bijat series consists of light grey to grey clay mottled with yellowish brown or strong brown in the A horizon. Sebandi series has up to 25cm of muck overlying light grey or grey clay. No profiles of both series were sampled for analysis. Soils associated with SEDUAU family but strongly gleyed in the subsoil (deeper than 50cm) are mapped as SEDUAU-BIJAT family intergrade. As the main interest of the survey in the area lies in the hill soils, the lowland soils will not be discussed further.

5. PHYSICAL and CHEMICAL CHARACTERISTICS OF HILL SOILS

5.1 Distribution of soils units from soil bores

The number of sites examined for the hill soils total 187 (includes 10 soil pits). Fig. 1a shows that 43% of these bores belongs to Merit series moderately deep phase (75-100cm) and 22% to Merit-Kapit family intergrade (25-50cm). It can be seen that soils with depth greater than 75cm account for less than 30% of all the hill soils mapped. From this, it would appear that the majority of the hill soils are probably of insufficient depth for deep-rooting tree crops like cocoa.

5.2 Soil depth to indurated bedrock

As the classification depth of the soil extends to the upper surface of the strongly weathering parent material (shale), it is of interest to assess what proportion of each soil mapped rests on soft weathered shale which can be penetrated easily by tree roots, and what rests on indurated and relatively unweathered shale which cannot be penetrated by tree roots. From Fig. 1b shows that only MERIT-KAPIT family intergrade soils actually encounter shale bed. In terms of percentage, 55% of KAPIT-MERIT family intergrade soils do not encounter any shale bed within 100cm depth, 33% with shale bed within 75-100cm and 12% with shale bed within 50-75cm. This means that only less than half of the MERIT-KAPIT family soils, although classified as shallow soils, can be considered as having bedrock within depth shallower than 75cm.

In the moderately shallow Merit series, 78% of the total bores does not encounter any weathered rock within 100cm (Fig. 1b), while the remainder 22% has shale bed within 75-100cm depth; shale bed within 75cm or shallower does not occur. In the moderately deep phase of the Merit series, 91% of the recorded bores does not encounter bed rock within 100cm and only 9% encounters bedrock within 75-100cm.

From this simple study of the depth of occurrence of indurated bedrock in the subsoil for the dominant hill soil units, it can be concluded that although the MERIT-KAPIT family intergrade is classified as a soil with weathered parent material occurring within 25-50cm depth, more than 50% of this soil in the Sungai Tanyit Area probably has sufficient rooting depth for deep-rooting crops if we accept the weathered shale horizon (BC horizon) as adequate and presents no severe limitation to rooting. Similarly in the moderately shallow phase of the Merit series, although the classification depth is defined as 50-75cm over weathered parent material, only 22% have shale bed within 75-100cm.

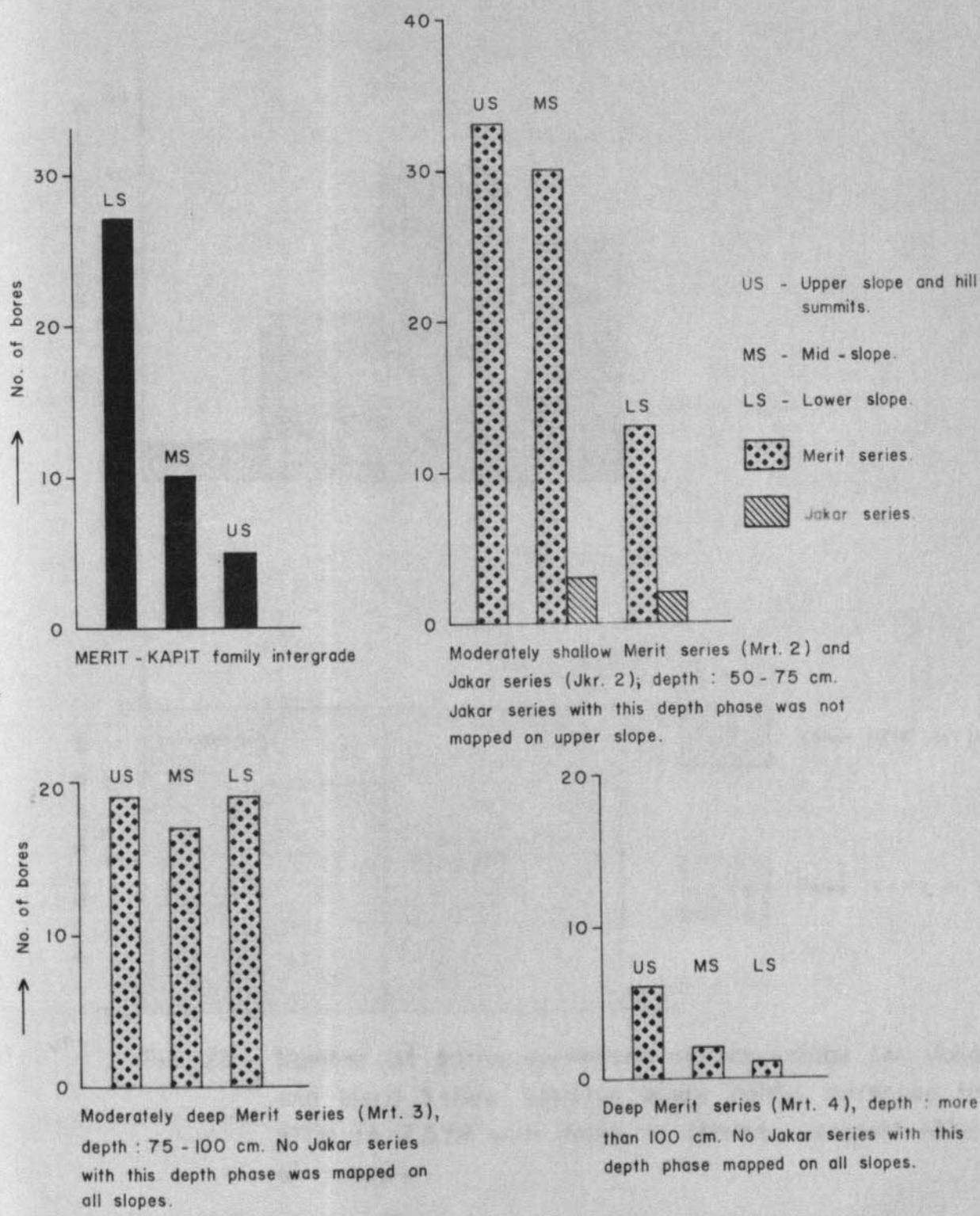


Fig. 2a. Bar graphs showing the number of bores occurring at lower, middle and upper slopes for Merit - Kapit family intergrade, and the three depth phases of Merit and Jakar series.

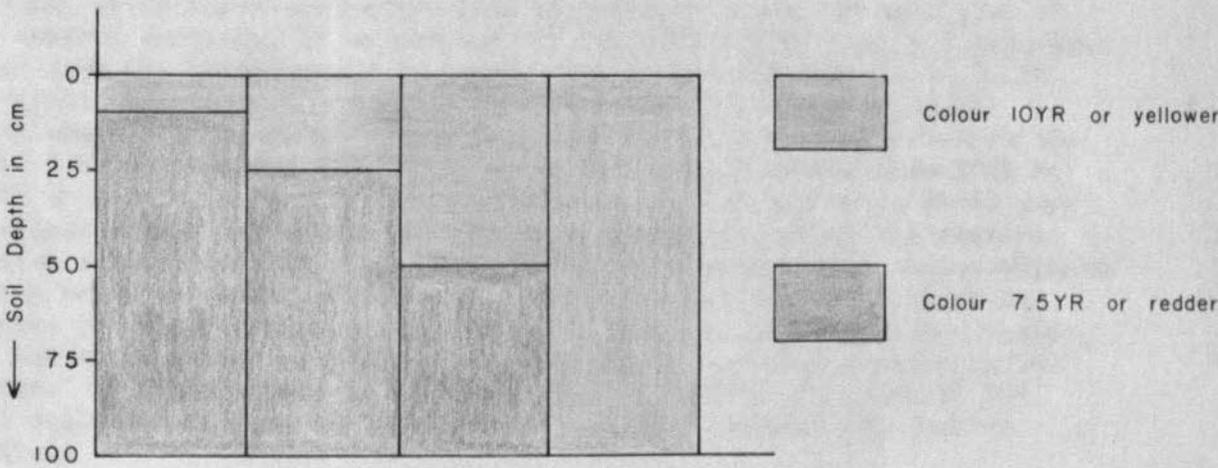
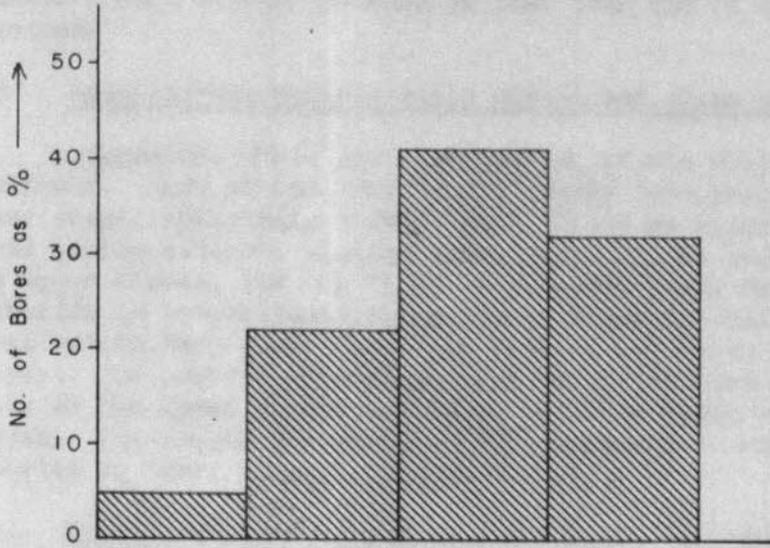


Fig. 2b Number of bores expressed as percentage for Jakar and Merit Series, showing where colour increases from 10YR to 7.5YR with depth or remains constant 10YR or yellower.

In considering the depth to bed rock of all the soils mapped in relation to cocoa rooting depth requirement most of the MERIT-KAPIT soils may have marginal depth for cocoa, while the moderately shallow and moderately deep phases of the Merit series should be regarded as moderately suitable and suitable respectively for cocoa, since indurated bedrock occurs within 75-100cm in less than 25% of the total bores examined.

5.3 Relationship between soils mapped and slope position

Figure 2a. shows the distribution of the hill soils and slope positions. Most of the MERIT-KAPIT family intergrade soils occur at lower slope, while only a small part occurs on upper slope. For the Merit series moderate shallow phase, most of the bores occur at middle and upper slopes; for the Merit series moderately deep phase, the distribution is proportionally spread out along the hill slope and for the Merit series deep phase more than half of the bores occurs on the upper slopes. The general conclusion that can be derived from this is that soils at the lower slopes are shallower than soils at middle and upper slopes. The reason for this can be attributed to rapid removal of material on lower slope by Sungai Tanyit.

5.4. Significance of colour as a parameter for series differentiation in the Merit family.

The Merit series is differentiated from the Jakar series by the colour change from yellowish brown or yellower (10YR) to strong brown (7.5YR) or redder in the top 50cm of the control section. Jakar series has colour redder than 10YR throughout the control section below the base of 10cm, while Merit series has 10YR or yellower colour in some part of the control section. If we exclude all the MERIT-KAPIT family intergrade soils from the total number of bores, then soils with colours of 7.5YR or redder throughout the control section account for only 5%, soils which show an increase in colour from 10YR to 7.5YR or redder within the first 50cm account for 22%, soils which increase in colour from 10YR to 7.5YR or redder at depth below 50cm account for 41% and soils which have no colour change but remain as 10YR or yellower throughout the control section account for 32% (Fig. 2b). From this simple study, soils coloured strong brown or redder occupy a very small proportion; soils which increases in colour either within the first 50cm or deeper are more common, but the total number of soils which show colour increase amounts to two thirds. Of significance in this area is that nearly one third of the hill soils do not show any increase in colour throughout the control section.

Reddish colour or increase in colour is caused mainly by increase in unhydrated iron oxides. It will be shown in the following section that this increase, as reflected in the increase in total Group III elements, bears a strong relation to reserve or total calcium in particular.

The present limiting depth allowed for colour change between the two important series of the Merit family is not considered the most appropriate parameter for field classification in this area. Based on colour change alone, three soil series may be separated:

1. Soils coloured 7.5YR or redder throughout the control section and are at present mapped as Jakar Series.
2. Soils coloured 10YR or yellower in the A horizon but colour increases to 7.5YR or redder in the B Horizon; these soils are now mapped as a Merit Series and are by far the most common hill soils in the area. Merit series can be retained or a new series name created for these soils, depending on (3) below.

3. Soils coloured 10YR or yellower and show no increase in colour with depth and occupy a third of all hill soils mapped. These soils are now mapped as Merit series, but if Merit series is to be retained for (2) above, then a new series would have to be created for these soils.

However, the above suggested changes and addition of a new series to the definitions given for Merit and Jakar series as given in the "Draft Classification of Soils in Central and North Sarawak" would require more statistical and detailed studies of Merit family soils in other parts of Sarawak.

6. SOIL CHEMISTRY

The analytical data and descriptions of 10 profiles are given in the Appendix.

The table below provides a guide for rating of nutrient levels as used in Sarawak soils.

Table 1. Ratings for nutrient levels used in Sarawak Soils

Determination \ Rating	Low	Medium	High
pH	Less than 4.5	4.5 - 5.5	Over 5.5
%C	0.25	0.25 - 0.5	0.5
%N	0.3	0.3 - 0.6	0.6
C/N	10	10 - 15	15
CEC	10	10 - 25	25
TEB	7	7 - 15	15
"Available" P (ppm)	10	10 - 30	30
"Reserve/Total" P (ppm)	400	400 - 800	800
"Exchangeable" Ca (me/100gm.)	1.0	1.0 - 2.0	2.0
"Reserve" Ca (ppm)	500	500 - 2000	2000
"Exchangeable" Mg (me/100gm.)	0.6	0.6 - 1.0	1.0
"Reserve" Mg (ppm)	1000	1000 - 2000	2000
"Exchangeable" K (me/100gm.)	0.2	0.2 - 0.4	0.4
"Reserve" K (ppm)	1000	1000 - 5000	5000

6.1. Mechanical analysis:

Only three profiles were determined for mechanical analysis, two of these are Merit series moderately shallow phase (S8177/82 and S8183/88) and one is a MERIT-KAPIT family intergrade. The analyses show that the textures range from clay loam to clay. Clay percentage increases from 30 to 55%; silt percentage ranges from 31% to 41% with a slight decrease in the B horizon due probably to its breakdown in the parent

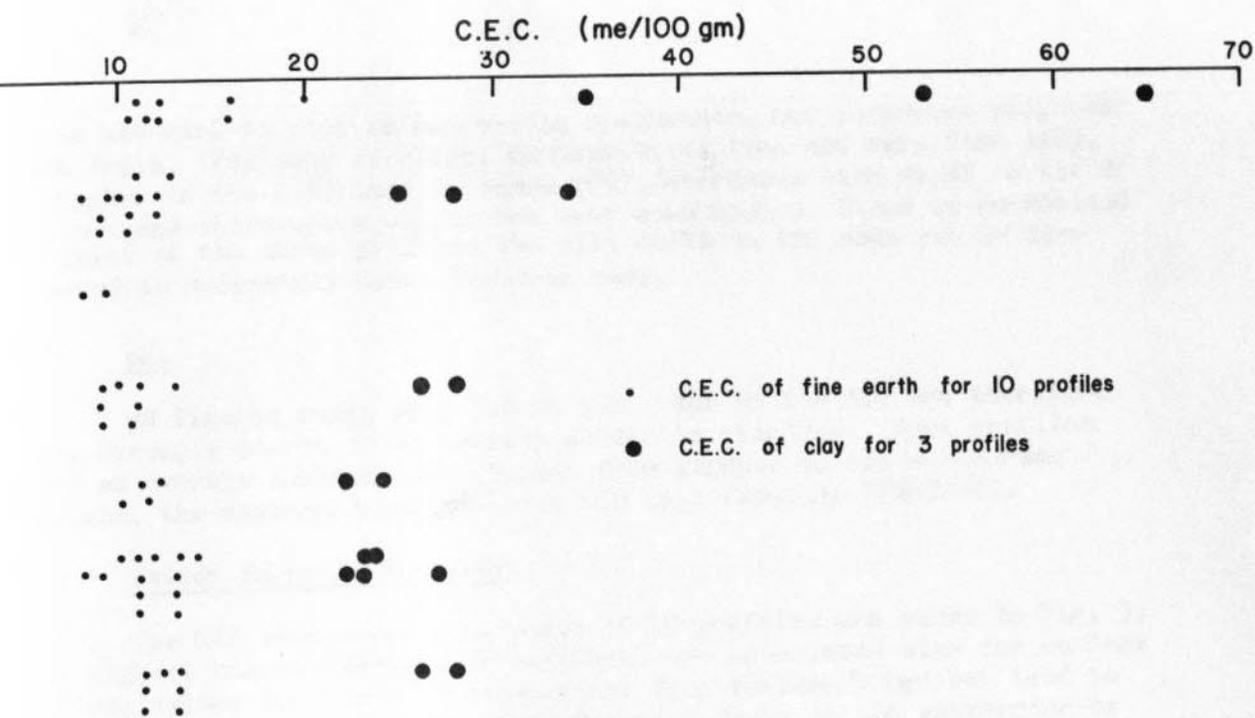


Fig. 3 Scatter graph for C.E.C. in soil horizons.

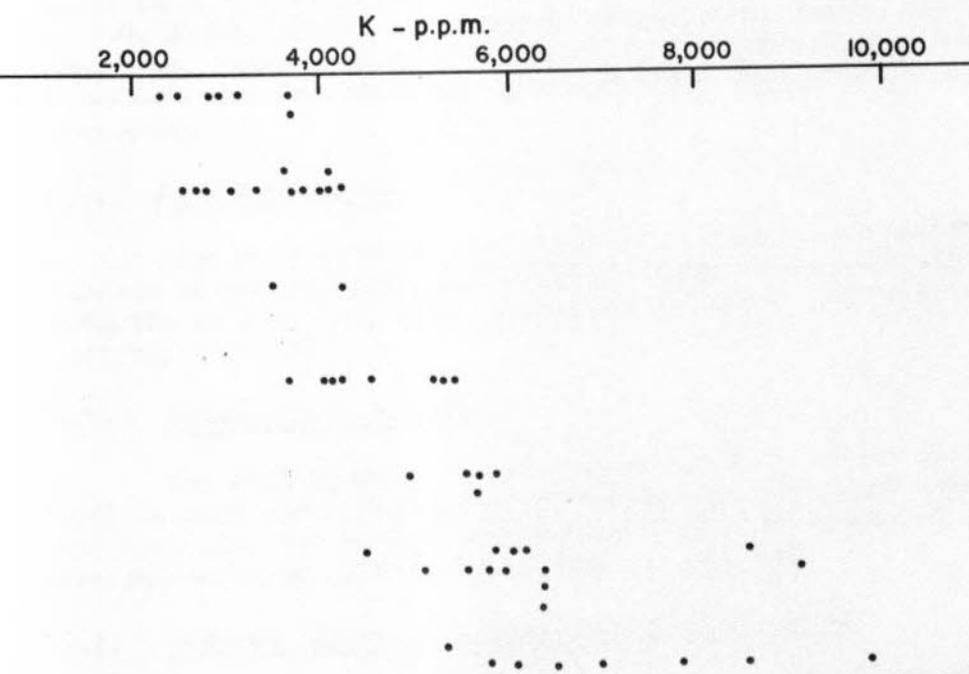


Fig. 4a. Scatter graph for reserve potassium in soil horizons for 10 profiles.

shale material to clay as weathering progresses, and increases slightly with depth. The sand fraction, dominantly as fine and very fine sand, is higher in the A horizon (maximum 28%), decreases with depth in the B Horizon and increases again in the weathered shale. Based on mechanical analyses of the three profiles the hill soils in the area can be considered as moderately heavy textured clay.

6.2 pH.

pH figures range from 3.8 to 5.2. The hill soils are therefore very strongly acidic to moderately acidic in reaction. Most profiles show an average increase of 0.5 unit from surface to the weathering horizon, the maximum increase being 0.8 unit (Profile S8642/46).

6.3 Cation Exchange Capacity

The CEC values for fine earth of 10 profiles are shown in Fig. 3. The highest values (maximum 46 me/100gm) are associated with the surface 0-10cm; values for the B horizons range from 10-12me/100gm but tend to increase by not greater than 2me/100gm with depth in the weathering or unweathered shale.

The CEC values computed on the clay basis for three profiles with mechanical data were also plotted on Fig. 3. On the clay basis, the CEC of the Ao horizon reaches 65 me/100 but CEC values of all subsoil horizons are characteristically constant within the limits of 20-30 me/100gm. These values are generally higher than Merit soils mapped in Central Sarawak and they underline the difficulty of using CEC as a parameter to differentiate the Pintasah series (CEC/clay greater than 16 me throughout the control section) from the Merit and Jakar series (CEC/clay less than 16 me in some part of the control section) as proposed in "A Draft Reclassification of Soils in Central and North Sarawak by I.M. Scott, 1973". As a result of the above study, the Pintasah series has since been deleted from this classification and no CEC limit is not adopted for defining Merit and Jakar series until more data are available.

6.4. Base Saturation

Base saturation in the topsoils (0-10cm) as expected, is high because of the influence of organic matter. Base saturation in the subsoils is very low, being less than 10% except for profile S8183/88, with value of 22%.

6.5. Exchangeable Cations

The exchangeable cations Ca, Mg and K in the Ao horizons are high in most profiles because of the organic complexes associated with the topsoils, but beneath the surface 10cm, the levels of exchangeable cations immediately decrease to low or very low.

6.6. Reserve Cations and Total Group III Elements

The results of reserve Ca and total Group III elements against soil horizons are plotted in Fig. 4c. The range of values and the ratings by soil horizons are given below.

Fig. 4c. Scatter graph for reserve calcium and total group III elements in soil horizons for 10 profiles.

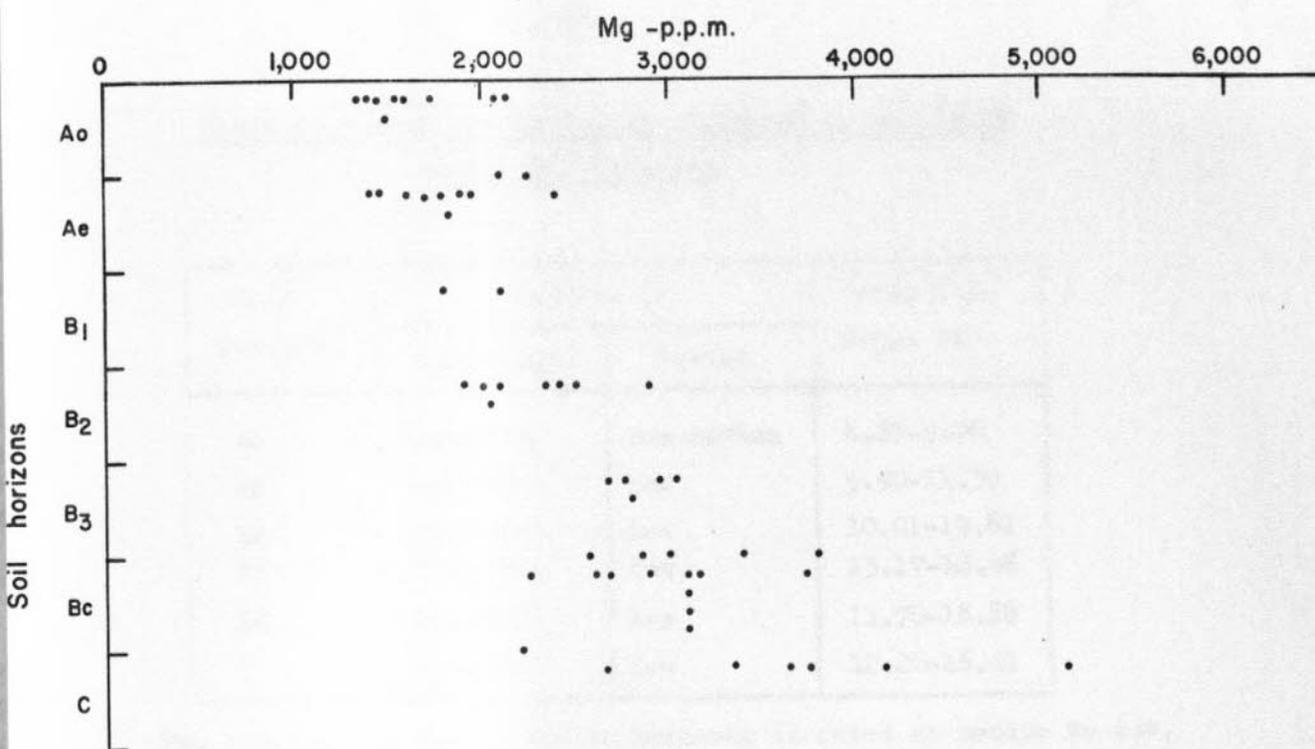


Fig. 4b. Scatter graph for reserve magnesium in soil horizons for 10 profiles.

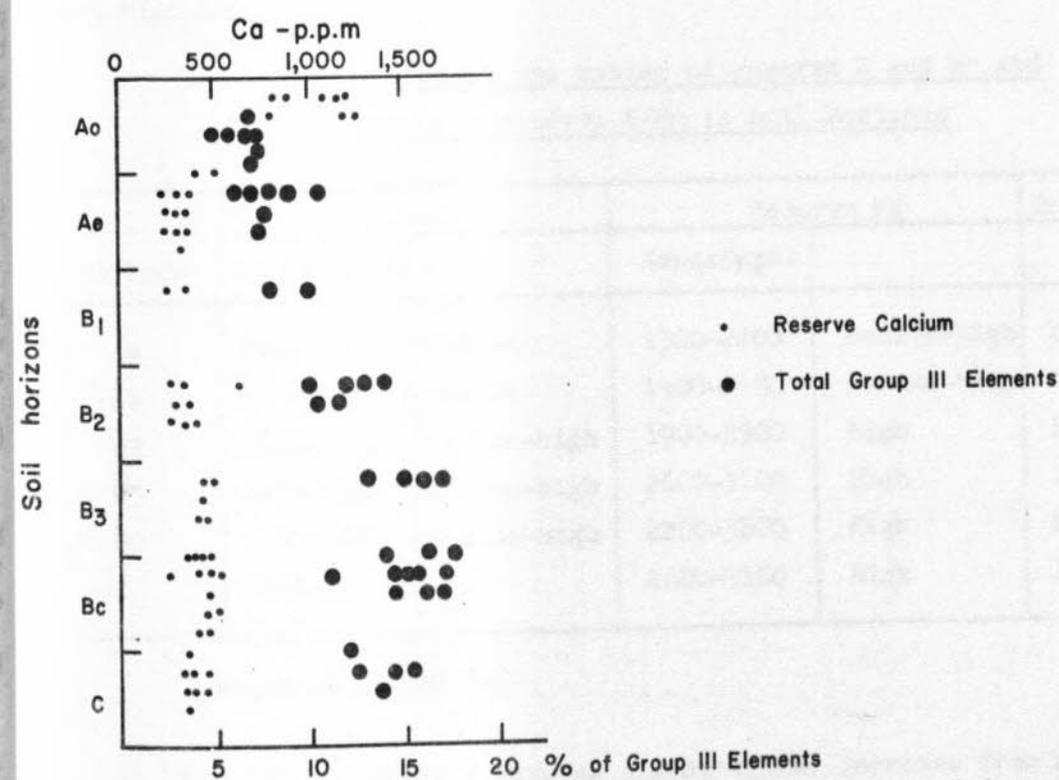


Fig. 4c. Scatter graph for reserve calcium and total group III elements in soil horizons for 10 profiles.

Table 2. Range and rating of "reserve" Ca and Total Group III Elements

Soil Horizon	Reserve Ca		Group III Range (%)
	Range (ppm)	Rating	
Ao	392-1249	Low-medium	4.81-9.76
Ae	233-363	Low	5.90-11.39
B2	260-450	Low	10.01-19.82
B3	342-500	Low	13.17-18.46
BC	259-512	Low	11.76-18.88
C	375-448	Low	12.26-16.01

The reserve calcium in the Ao horizons is rated as medium to low, but in all subsoils, including the weathering shale, the reserve calcium is low, with a slight increase in the B3 and BC horizons. Levels of total Group III elements increase with depth, the highest being in the B3 and BC horizons where variable volumes of soft iron-coated shale fragments are found. There is a strong relationship between reserve calcium and total Group III elements in all soil horizons below the Ao; any increase or decrease in reserve calcium is accompanied by a corresponding increase or decrease in total Group III elements.

The range of reserve potassium and magnesium values and their ratings for soil horizons are shown in Table 3 below and also in Fig. 4a and Fig. 4b.

Table 3. Range and rating of reserve K and Mg and ratio of reserve K/Mg in soil horizons

Soil Horizon	Reserve K		Reserve Mg		Reserve K/Mg
	Range (ppm)	Rating	Range(ppm)	Rating	Ratio
Ao	2300-3800	Medium	1300-2200	Medium-high	1.7-2.0
Ae	2500-4200	Medium	1400-2400	Medium-high	1.7-2.2
B2	3600-5400	Medium-high	1900-2900	High	1.7-2.2
B3	4900-5900	Medium-high	2600-3100	High	1.8-2.1
BC	4400-6400	Medium-high	2200-3800	High	1.6-2.5(2.0) ¹
C	5200-9800	High	2600-5100	High	1.5-2.7

¹ weighted around 2.0

Levels of reserve K show an almost linear increase from medium in the A horizons to medium-high in the B2 and high in the weathering shale -BC horizon, with weighted value of 6000 ppm. Levels of reserve Mg also show almost similar increase with depth. In the A horizon, reserve Mg values are rated as medium-high, increasing to high in the B and C horizons.

The relationship between the Reserve K/Mg Ratio and the Reserve K/Mg Ratio is shown in Fig. 4d by plotting Reserve K/Mg Ratio against Soil Horizons. It can be seen that from the 0 to 10 cm depth, the Reserve K/Mg Ratio is fairly constant within the range of 1.5 to 2.5. The Reserve K/Mg Ratio for the 10 to 20 cm horizon (Fig. 4d) is slightly around 2.0, but for the 20 to 30 cm horizon it is increased over a much wider range, from 1.5 to 3.5.

Soil horizons A and B have similar relationships between Reserve K and Mg for Meritt soils. However, the Reserve K/Mg Ratio is the lowest in the A horizon, and it is noted that the Reserve K/Mg Ratio in B horizons are slightly lower, thus raising the K/Mg ratio. The results of the analyses are shown below for comparison.

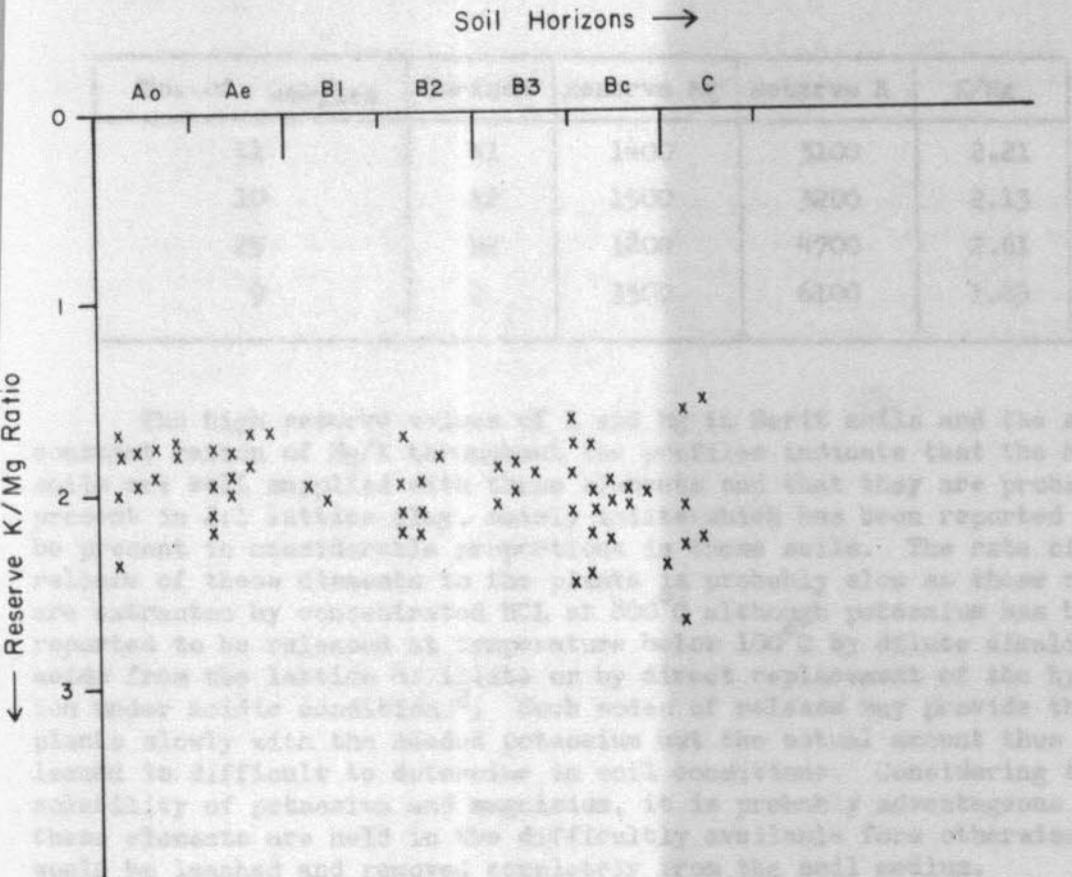


Fig. 4d: Plot of Reserve K/Mg Ratio and Soil Horizons for 10 Profiles.

The inference from the preceding discussion is that the hill soils are strongly leached but immature. The absence of well-developed gullies and the presence of a thin O horizon probably exceeds the rate of erosion. The Reserve K/Mg Ratio is a large part of the Reserve K/Mg Ratio.

4. CONCLUSIONS

4.1. Physical properties

1. Soils of Meritt series are the most common occurring nearly two-thirds of the whole study area. From the analysis of the depth of occurrence of individual horizons within the subsoils, over 70% of the Meritt series horizons (Fig. 2) is considered to have formed from the weathering of the parent material since within 100 cm depth of these soils. The most stable soil horizons within 100 cm depth are considered as original. The upper horizons only 50% of the soils retained at the surface directly under the soil surface depth.

1. J. H. Williams, *Soils of the Meritt Series*, 1960. The results of the investigation, a detailed description of the soils and an account of the physical and chemical properties of the Meritt series, are given in the report of the author.

The relationship between reserve K and Mg ratio is shown in Fig. 4d by plotting reserve K/Mg ratio against soil horizons. It can be seen that from the A₀ to B₃ horizons, this ratio remains fairly constant within the range of 1.7-2.2. The K/Mg ratio for the B₃ horizon is about 2.0, but for the relatively unweathered shale it is increased over a much wider range, from 1.5 to 2.5.

Wall¹ has also found similar relationship between reserve K and Mg for Merit soils formed from shale parent material in the Cumberland Plateau area except that the average reserve K value for the B₃ horizon is lower. This raises the K/Mg ratio. The results of his analysis are shown in the following comparison:

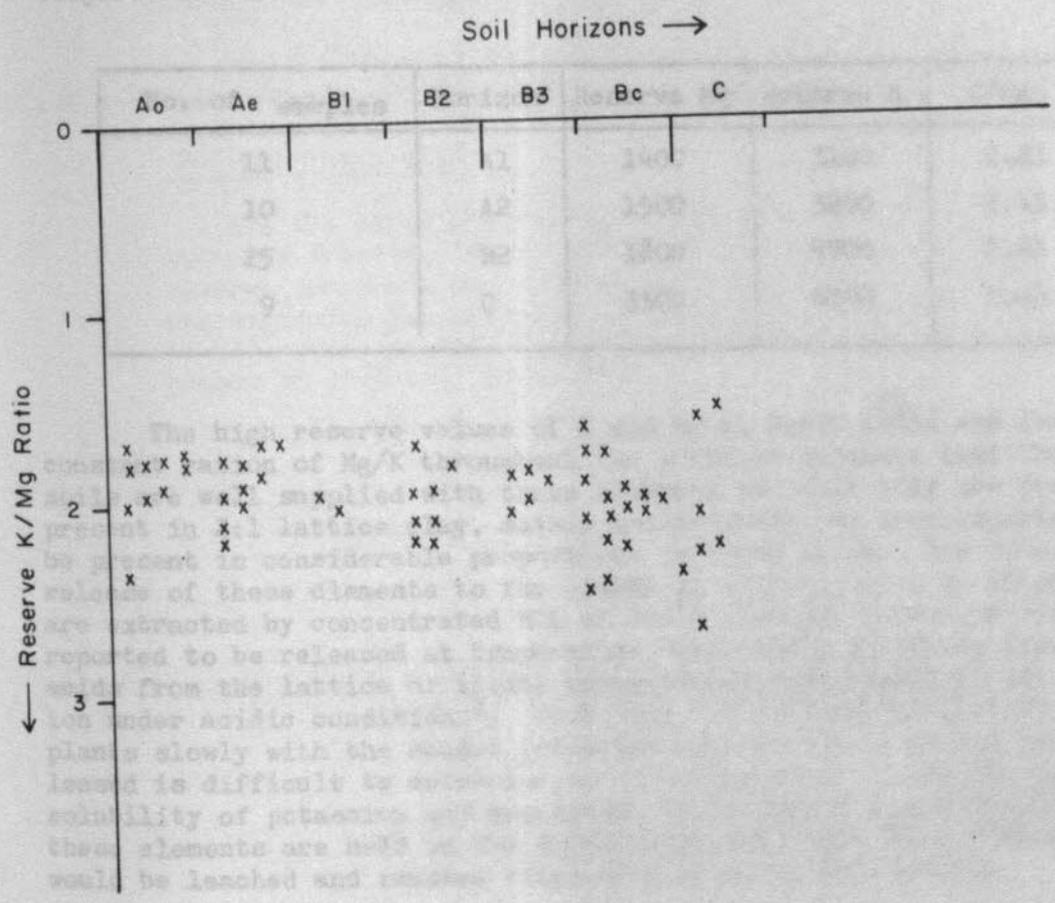


Fig. 4d: Plot of Reserve K/Mg Ratio and Soil Horizons for 10 Profiles.

7. CONCLUSIONS

A. Physical properties

1. Soils of Merit series are the most common soil type in the two-thirds of the whole study area. They are composed of the depth of occurrence of the parent material, which is about 100m, over 75% of the soil depth. The Merit soils are considered to have adequate rooting depth for crops to be introduced into the area within 100m depth of the soil. The soil texture of Merit soils is mainly silty clay loam. The soil texture is good for crops because only 5% of the soil material is too fine to be directly used as soil bed within 100m depth.

¹J.B. Wall, Ph. D. Thesis, 1964.

The analysis of the environment, a detailed appraisal of the soils and an assessment of the agricultural potential of Cumberland Plateau area.

The relationship between reserve K and Mg value is shown in Fig. 4d by plotting reserve K/Mg ratio against soil horizons. It can be seen that from the A₀ to B₃ horizons, this ratio remains fairly constant within the range of 1.7-2.2. The K/Mg ratio for the BC horizon (fig. 4d) is weighted around 2.0, but for the relatively unweathered shale it is dispersed over a much wider range, from 1.5 to 2.7.

Wall¹ has also found similar relationship between reserve K and Mg for Merit soils formed from shale parent material in the Bekenu-Niah-Suai area except that the average reserve Mg values are slightly lower, thus raises the K/Mg ratio. The results of his analyses are shown below for comparison:

No. of samples	Horizon	Reserve Mg	Reserve K	K/Mg
11	A1	1400	3100	2.21
10	A2	1500	3200	2.13
25	B2	1800	4700	2.61
9	C	3300	6100	1.85

The high reserve values of K and Mg in Merit soils and the almost constant ration of Mg/K throughout the profiles indicate that the Merit soils are well supplied with these elements and that they are probably present in 2:1 lattice clay, mainly illite, which has been reported to be present in considerable proportions in these soils. The rate of release of these elements to the plants is probably slow as these reserves are extracted by concentrated HCL at 800°C although potassium has been reported to be released at temperature below 100°C by dilute alkalis or acids from the lattice of illite or by direct replacement of the hydrogen ion under acidic conditions². Such modes of release may provide the plants slowly with the needed potassium but the actual amount thus released is difficult to determine in soil conditions. Considering the solubility of potassium and magnisium, it is probably advantageous that these elements are held in the difficultly available form otherwise they would be leached and removed completely from the soil medium.

The inference from the preceding discussion is that the hill soils are strongly leached but immature. The absence of well-developed genetic horizons and the high percentage of shallow soils resting on weathering shale parent material indicate that soil wastage probably exceeds the rate of replendishment by weathering in large part of the area.

7. CONCLUSIONS

A. Physical properties

1. Soils of Merit series are the most common comprising nearly two-thirds of the whole study area. From the analysis of the depth of occurrence of indurated bedrock within the subhorizons, over 75% of the most shallow Merit series (Mrt. 2) is considered to have adequate rooting depth for cocoa as no indurated shale occurs within 100cm (40 inches) of these soils. The most shallow hill soils - MERIT-KAPIT family intergrade are considered as marginal for cocoa because only 50% of the soils recorded do not rest directly within shale bed within 100cm depth.

¹J.R. Wall, Ph. D. Thesis, 1966.

"The analysis of the environment, a detailed appraisal of the soils and an assessment of the agricultural potential of Bekenu-Niah-Suai Area.

²Marshall, C.E. 1964

"The Physical Chemistry and Mineralogy of the Soils."

2. Shallow soils appear to be found more commonly at lower slopes than middle and upper slopes; the reason suggested for this is the rapid removal of material at lower slopes by Sungai Tanyit.

3. Excluding the shallow soils of MERIT-KAPIT family intergrade, nearly two thirds of the deeper hill soils show increase in colour with depth; only one third shows no change in colour throughout the control section. The present series classification based on colour change limited to the upper part of the control section is unsatisfactory for this area.

4. Mechanical analyses show the hill soils are moderately heavy-textured clay, being clay loam in the A horizon and clay in the B.

B. Chemical Properties

All the soils are strongly to moderately acidic in reaction, strongly leached, low in exchangeable cations, available and reserve phosphate and reserve calcium. However, reserve potassium and magnesium (extracted by concentrated HCL at 800°C) are high in all subsoils, but how readily these cations are available to plants is difficult to assess.

Profile: S.8172/76

Family : ~~MERET~~-KAPIT.1

Series : Merit-Kapit.1

Phase : Shallow

Location : Rentis 4, tape22, near Mile 4 $\frac{1}{2}$ Miri-Bintul Road

Parent Material : Dark grey shale

Topography : On upper ridge, slope 16 $^{\circ}$

Vegetation/Land Use : Young regrowth, about 1 year old

Drainage : Moderately well drained.

- | | | |
|---------|--------|--|
| 0 - 2 | inches | Yellowish brown (10YR 5/6) clay loam, mottled common fine distinct strong brown and grey; moist; friable; crumbly; many fine roots, clear smooth change, |
| 2 - 8 | " | Light yellowish brown (2.5Y 6/4) silty clay, mottled many medium to prominent dark brown (7.5YR 4/4); moist, slightly firm; weak subangular blocky; few fine roots, organic leaching from above; few earthworm activities, clear wavy change, |
| 8 - 19 | " | Reddish yellow (7.5YR 6/6) clay, mottled common fine distinct pale yellow (2.5Y 7/4); moist, slightly firm; weak subangular blocky; few fine roots, many soft iron shale concretions with dusky red, dark red and weak red colours; thin clay skin develops along cracks, gradual wavy change; |
| 19 - 37 | " | Reddish yellow (7.5YR 7/8) clay, mottled common fine distinct pale yellow; moist, very firm; moderately strong angular blocky; no roots, common soft iron concretions, increasing soft weathering shale with multi-red colours, clay skins extent along cracks, clear wavy change, |
| 37 - 60 | " | Grey (10YR 6/1) shale bed with soft iron concretions embedded between weathering shale. |

APPENDIX II

Profile: S.8172/76

Lab. No.	S.8172	S.8173	S.8174	S.8175	S.8176
Depth - inches	0-2	2-8	8-19	19-37	37-60
Sand	27.54	15.08	11.12	11.33	14.45
Silt	31.80	39.86	29.97	31.38	37.41
Clay	30.39	41.36	54.47	54.86	45.95
Texture Class	Clay Loam	Silty Clay	Clay	Clay	Clay
Fine Sand	26.89	14.35	7.75	7.47	7.45
Coarse Sand	0.34	0.40	2.11	2.18	3.92
Medium Sand	0.31	0.33	1.26	1.68	3.08
Carbon %	3.87	0.76	0.43	0.22	0.07
Nitrogen %	0.340	0.120	0.098	0.086	0.092
C/N	11.4	6.3	4.4	2.6	0.7
<u>pH</u>					
H2O	4.4.	4.1	4.3	4.3	4.4
KCL	3.9	3.5	3.6	3.6	3.6
<u>Exchangeable</u>					
Ca.	4.71	.78	.26	.26	.32
Mg.	1.46	.32	.10	.04	.16
K	.43	.13	.08	.06	.08
Na.	.29	.29	.21	.36	.18
CEC	16.11	10.36	12.77	12.67	12.16
BS%	42	1.14	5	5	6
<u>Reserve</u>					
Ca.	903	363	471	459	367
Mg.	1464	1943	2853	3141	3354
K.	2615	4209	5988	6282	6943
P.	291	184	194	168	199
Group III %	7.37	10.83	17.64	17.07	14.41
<u>Phosphate</u>					
Total	262	140	119	144	205
Available	19	<1	<1	<1	<1

Profile: S.8642/46

Family : MERIT-Kapit.1

Series : Jakar-Kapit

Phase : Shallow

Location : Rentis 7, tape 6, near mile 42½ Miri-Bintulu Road

Parent Material : Dark grey shale

Topography : 13° slope lower slope

Vegetation : Young regrowth, about 1 year old

Drainage : Moderately well drained.

- 0 - 5 inches Yellowish brown (10YR 5/8) clay loam, mottled common fine to medium pale yellow and strong brown, moist, slightly friable and crumbly; many fine roots, few earthworm activities, contain organic matter, abrupt irregular change to,
- 5 - 11 " Reddish yellow (7.5YR 6/6) clay, mottled common fine distinct pale yellow and strong brown, moist, slightly firm, crumbly; few fine roots, clear irregular change to,
- 11 - 25 " Reddish yellow (5YR 6/8) clay, mottled common fine to medium pale yellow and weak red; moist, very firm; strong angular blocky; few fine dead roots, accumulations of soft iron shale concretions, few grey shale bits at lower depth, thin clayskin coated along cracks, clear irregular change to,
- 25 - 41 " Reddish yellow (5YR 6/8) clay, coloured common prominent multi-red, moist, very firm, increasing grey shale bits, common platy soft iron shale concretions, angular blocky, clear wavy change,
- 41 - 66 " Grey (10YR 6/1) soft weathering shale with soft black particles (manganese?) moist, very firm to hard.

Profile: S.8642/46

Lab. No.	S.8642	S.8643	S.8644	S.8645	S.8646
Depth - inches	0-5	5-11	11-25	25-41	41-66
Sand					
Silt					
Clay					
Texture Class					
Fine Sand					
Coarse Sand					
Medium Sand					
Carbon %	1.22	0.67	0.36	0.19	0.11
Nitrogen %	0.171	0.114	0.103	0.089	0.077
C/N	7	6	4	2	1
pH					
H2O	4.1	4.1	4.6	4.7	4.9
KCL	3.8	3.6	3.8	3.8	3.8
<u>Exchangeable</u>					
Ca.	0.32	0.32	0.20	0.20	0.14
Mg.	0.02	0.18	0.09	0.05	0.31
K.	0.01	0.20	0.19	0.19	0.13
Na.	0.27	0.28	0.30	0.30	0.30
CEC	10.96	11.80	13.75	12.81	13.08
BS%	6	8	6	6	39
<u>Reserve</u>					
Ca.	392	353	450	473	448
Mg.	2166	2245	3412	3728	3745
K.	4078	4078	8531	9056	8506
P.	209	165	172	152	130
Group III %	9.74	10.16	18.46	18.30	16.01
<u>Phosphate</u>					
Total	175	175	180	137	132
Available	5	1	1	1	<1

Profile: S.8647/52

Family : MERIT-KAPIT.1

Series : Jakar-Kapit.1

Phase : Shallow

Location : Rentis 1 tape 10, near Mile 42, Miri-Bintulu Road

Parent Material : Dark grey shale

Topography : on slope of 16°

Vegetation/Land Use : young regrowth about 1 year old

Drainage : Moderately well drained

- 0 - 5 inches Yellowish brown (10YR 5/6) clay loam; moist, friable, crumbly, common, fine to medium roots; few charcoal pieces, clear wavy change to,
- 5 - 14 " Reddish yellow (7.5YR 6/6) clay loam to clay, moist, slightly friable; weak subangular blocky; few medium to fine roots, clear organic leaching from above, mainly along cracks and root channels, diffuse wavy change,
- 14 - 24 " Reddish yellow (7.5YR 6/6) clay, few faint pale yellow (2.5Y 7/4) mottles; moist, firm, weak subangular blocky; few fine roots; soft iron shale concretion at 20-24 inches, coloured prominent weak red (10YR 4/4) and dark red (10YR 3/6), clear wavy change,
- 24 - 33 " Reddish yellow (7.5YR 6/6) clay, moist, firm, weak angular blocky; no roots, common soft platy iron shale concretions few light grey (2.5Y 7/1) shale pieces coloured prominent weak and dark red; diffuse irregular change,
- 33 - 40 " Reddish yellow (7.5YR 7/6) clay, moist, weak crumbly when broken up; no roots, increasing soft weathering shale coloured light grey (5Y 7/1) with prominent multi-red (mainly dark red, weak red, pale red), gradual irregular change,
- 40 - 55 " Light grey (5Y 7/1) weathering shale bed with multi-red colours; moist, very firm.

Profile: S.8647/52

Lab. No.	S.8647	S.8648	S.8649	S.8650	S.8651	S.8652
Depth - inches	0-5	5-14	14-24	24-33	33-40	40-55
Sand						
Silt						
Clay						
Texture Class						
Fine Sand						
Coarse Sand						
Medium Sand						
Carbon %	1.36	0.44	0.29	0.18	0.17	0.08
Nitrogen %	0.185	0.089	0.077	0.070	0.084	0.083
C/N	8	6	4	3	2	1
<u>pH</u>						
H2O	4.2	4.5	4.7	4.7	4.7	4.8
KCL	3.9	3.7	3.8	3.8	3.8	3.7
<u>Exchangeable</u>						
Ca.	0.79	0.14	0.33	0.26	0.27	0.20
Mg.	0.89	0.37	0.14	0.06	0.20	0.06
K.	0.32	0.13	0.09	0.09	0.09	0.13
Na.	0.29	0.27	0.28	0.29	0.30	0.27
CEC	12.52	11.86	12.90	11.36	12.85	12.98
BS%	18	7	6	6	6	5
<u>Reserve</u>						
Ca.	500	329	623	421	504	330
Mg.	2104	2415	2907	2788	3106	3640
K.	3583	4036	5252	5589	6339	9791
P.	205	145	137	114	154	172
Group III %	9.08	11.39	19.82	15.41	16.60	13.80
<u>Phosphate</u>						
Total	197	121	122	121	178	177
Available	5	1	1	1	1	1

Profile: S.8177/82

Family : MERIT

Series : Merit

Phase : Moderately shallow

Location : Rentis 5, tape 13, near Mile 42½ Miri-Bintulu Road

Parent Material : Dark grey shale

Topography : On upper ridge, slope 16°

Vegetation : Young regrowth, about 1 year old

Drainage : Moderately well drained

- | | | |
|---------|--------|---|
| 0 - 3 | inches | Dark brown (10YR 3/3) clay loam; moist, friable and crumbly; abundant fine to medium roots, contains organic matter, many earthworms, clear smooth change, |
| 3 - 9 | " | Brownish yellow (10YR 6/6) clay loam to clay; mottled common fine distinct pale yellow (2.5Y 7/4) moist, slightly firm, crumbly, few fine roots, many earthworm activities, organic leaching from above; diffuse wavy change, |
| 9 - 23 | " | Brownish yellow (as above) clay, common fine distinct pale yellow and strong brown, moist, slightly firm, strong angular blocky; few fine roots, clear wavy change, |
| 23 - 38 | " | Reddish yellow (7.5YR 6/1) clay, mottled many fine to medium, distinct to prominent pale yellow and weak red; moist, very firm; strong angular blocky; no roots, accumulation of soft iron concretions, abrupt wavy change, |
| 38 - 54 | " | Reddish yellow (7.5YR 6/6) and pale yellow (2.5Y 7/4) variegated clay, mottled many light grey and strong brown, moist, firm, increasing soft iron shale concretion and soft weathering shale pieces thin clayskin develops along cracks; strong angular blocky, no roots, gradual wavy change, |
| 54 - 62 | " | Reddish yellow (7.5YR 6/6) and pale yellow clay, prominent red colours, moist, very firm, strong blocky, increasing soft weathering shale piece. |

Profile: S.8177/8182

Lab. No.	S.8177	S.8178	S.8179	S.8180	S.8181	S.8182
Depth - inches	0-3	3-9	9-23	23-38	38-54	54-62
Sand	13.29	24.60	14.94	13.42	11.44	14.93
Silt	34.47	40.74	37.43	31.02	35.52	37.94
Clay	34.15	32.54	42.31	51.03	51.66	41.43
Texture Class	Clay Loam	Clay Loam	Clay	Clay	Clay	Clay
Fine Sand	12.40	13.83	14.69	7.16	7.20	9.68
Coarse Sand	0.51	0.41	0.40	4.54	2.91	3.32
Medium Sand	0.38	0.36	0.25	1.70	1.33	1.93
Carbon %	5.71	1.65	0.51	0.29	0.22	0.15
Nitrogen %	0.427	0.182	0.094	0.886	0.085	0.174
C/N	13	9	5	0	3	1
<u>pH</u>						
H2O	3.9	3.8	3.9	4.0	4.2	4.3
KCL	3.6	3.5	3.6	3.7	3.6	3.7
<u>Exchangeable</u>						
Ca.	0.37	0.91	0.52	0.33	0.32	0.26
Mg.	1.43	0.42	0.16	0.01	0.02	0.02
K	0.34	0.15	0.10	0.08	0.06	0.09
Na.	0.25	0.26	0.23	0.24	0.18	0.23
CEC	12.28	11.00	11.12	12.06	11.64	11.36
BS%	19	1 15	9	5	4	5
<u>Reserve</u>						
Ca.	834	299	260	498	404	390
Mg.	1589	1713	1870	2937	3022	2576
K.	3111	3309	4092	5507	5797	5726
P.	326	192	1771	1160	1159	1146
Group III %	7.52	7.99	10.03	17.15	16.30	15.09
<u>Phosphate</u>						
Total	1247	177	107	95	90	72
Available	23	6	3	<1	<1	<1

Profile: S.8183/88

Family : MERIT

Series : Merit

Phase : Moderately shallow

Location : Rentis 6, tape 16 near Mile 42½ Miri-Bintulu Road

Parent Material : Dark Grey shale

Topography : Mid slope 14°

Vegetation : young regrowth about 1 year old

Drainage : Moderately well drained

0 - 1	inches	Brown (10Y 5/3) clay loam to silty clay loam, moist, friable and crumbly; many fine roots, contains organic matter, clear smooth change,
1 - 8	"	Brownish yellow (10YR 6/6) clay loam, mottled few fine distinct pale yellow and strong brown, moist, slightly friable and crumbly; many fine to medium roots, organic leaching from above, few earthworms activities; abrupt wavy change,
8 - 16	"	Reddish yellow (7.5YR 6/6) clay, mottled few fine distinct pale yellow and strong brown; moist, slightly firm, weak subangular blocky, few fine to medium roots, thin clayskin coated along crack, clear wavy change,
16 - 26	"	Reddish yellow (7.5YR 6/8) clay, mottled common fine to medium distinct pale yellow and strong brown; moist; firm; slightly strong angular blocky, few dead roots, accumulation of soft iron concretions, coloured prominent weak red and dusky red, clayskin penetrates along cracks and old root channels, abrupt wavy change,
26 - 43	"	Reddish yellow (as above) clay, coloured many medium to coarse light red, weak red, pinkish red and grey; moist, very firm strong angular blocky, increasing weathering soft, platy iron concretionary shale, clear smooth change,
43 - 53	"	Grey (10Y 7/1) shale bed with black layer of iron in between moist firm to hard.

Profile: S.8183/88

Lab. No.	S.8183	S.8184	S.8185	S.8186	S.8187	S.8188
Depth - inches	0-1	1-8	8-16	16-26	26-43	43-53
Sand	17.31	24.75	17.49	13.01	14.79	21.48
Silt	33.20	35.72	34.11	31.21	32.31	38.68
Clay	30.34	34.02	43.33	51.53	49.13	37.87
Texture Class	Clay - Silty Clay	Clay Loam	Clay	Clay	Clay	Clay Loam
Fine Sand	16.72	24.29	16.07	9.40	9.60	16.39
Coarse Sand	0.24	0.18	0.99	2.47	3.63	2.71
Medium Sand	0.35	0.28	0.43	1.14	1.56	2.38
Carbon %	4.42	1.27	0.55	0.38	0.24	0.09
Nitrogen %	0.389	0.149	0.088	0.088	0.083	0.073
C/N	11	9	6	4	3	1
<u>pH</u>						
H2O	4.8	4.0	4.0	4.3	4.4	4.3
KCL	4.4	3.5	3.6	3.6	3.7	3.7
<u>Exchangeable</u>						
Ca.	5.91	0.65	0.32	0.32	0.26	0.39
Mg.	0.99	0.50	0.24	0.22	0.89	1.69
K.	0.40	0.22	0.12	0.13	0.09	0.11
Na.	0.21	0.26	0.25	0.28	0.25	0.25
CEC	19.67	9.55	11.06	11.19	10.63	10.78
BS%	38	17	8	8	14	22
<u>Reserve</u>						
Ca.	1194	233	324	456	417	325
Mg.	1731	1603	2020	2761	2660	4156
K.	2852	2811	4209	5666	5476	6429
P.	297	184	159	146	160	159
Group III %	6.77	7.84	12.17	16.05	15.57	12.26
<u>Phosphate</u>						
Total	236	127	113	107	128	155
Available	15	3	<1	<1	<1	<1

Profile: S.8620/25

Family : MERIT

Series : Merit

Phase : Moderately shallow

Location : Rentis 2, tape 12, near mile 42, Miri-Bintulu Road

Parent Material : Dark grey shale

Topography : on low hill, slope 16°

Vegetation : young regrowth about 1 year old

Drainage : Moderately well drained.

- | | | |
|---------|--------|---|
| 0 - 2 | inches | Brown (10YR 5/3) clay loam, mottled fine pale yellow (2.5Y 7/4) and strong brown (7.5YR 6/8), moist, friable, fine crumbly, many fine to medium roots, clear smooth change, |
| 2 - 8 | " | Brownish yellow (10YR 6/6) clay loam, to clay , mottled few fine pale yellow (2.5Y 7/4); moist, slightly firm, weak subangular blocky, few fine roots, gradual change, |
| 8 - 21 | " | Brownish yellow (10YR 6/6) clay, mottled few fine pale yellow; moist, slightly firm, strong angular blocky, very few fine roots, few soft platy iron shale concretions, prominent weak red and strong brown colours, diffuse wavy change, |
| 21 - 34 | " | Brownish yellow (10YR 6/6) clay, moist, firm, strong subangular blocky, no roots, common accumulations of soft iron concretion, increasing soft weathering grey shale pieces, distinct wavy change, |
| 34 - 49 | " | Brownish yellow (10YR 6/6) clay, moist, compact and firm no roots, few iron concretions, increasing soft weathering grey shale with depth, strong brown, dark red and grey colours, clear change, |
| 49 - 63 | " | Soft grey (10YR 6/1) shale bed, with platy structure. |

Profile: S.8620/25

Lab. No.	S.8620	S.8621	S.8622	S.8623	S.8624	S.8625
Depth - inches	0-2	2-8	8-21	21-34	34-49	49-63
Sand						
Silt						
Clay						
Texture Class						
Fine Sand						
Coarse Sand						
Medium Sand						
Carbon %	2.16	0.48	0.36	0.21	0.15	0.11
Nitrogen %	0.255	0.088	0.083	0.083	0.070	0.071
C/N	9	6	4	3	2	2
<u>pH</u>						
H2O	5.1	4.3	4.7	4.7	5.1	5.2
KCL	5.2	4.1	4.0	4.2	4.2	4.1
<u>Exchangeable</u>						
Ca.	3.59	0.32	0.26	0.26	0.26	0.20
Mg.	0.22	0.24	0.24	0.22	0.24	0.37
K.	0.53	0.16	0.17	0.09	0.11	0.13
Na.	0.35	0.30	0.34	0.28	0.31	0.29
CEC	11.10	10.70	8.80	9.70	9.10	11.40
BS%	42	9	11	8	10	8
<u>Reserve</u>						
Ca.	1209	285	341	342	445	343
Mg.	1554	1811	2515	3787	3586	5138
K.	3653	3817	5306	6148	6217	7773
P.	226	129	131	150	155	179
Group III %	5.71	7.53	11.66	13.92	15.68	15.53
<u>Phosphate</u>						
Total	202	140	105	166	126	206
Available	10	2	1	1	1	1

Profile: S.8626/30

Family : MERIT

Series : Merit

Phase : Moderately shallow

Location: Rentis 2, tape 23, near Mile 42, Miri-Bintulu Road

Parent Material: Dark grey shale

Topography : On ridge slope 6°

Vegetation : Young regrowth about 1 year old

Drainage : Well drained

0 - 2	inches	Yellowish brown (10YR 5/6) clay loam, moist, friable, fine crumbly, many fine roots, clear smooth change,
2 - 12	"	Brownish yellow (10YR 6/6) very fine sandy clay loam to clay loam, moist, slightly firm, crumbly, few fine roots, earthworm activities, organic leaching from above, irregular change,
12 - 28	"	Reddish yellow (7.5YR 7/6) clay, moist, firm, strong angular blocky, no roots, iron concretions, distinct common weak red and dark red and strong brown colours, diffuse irregular change,
28 - 44	"	Reddish yellow (7.5YR 6/6) clay, moist, very firm, strong angular blocky, no roots, accumulation of grey weathering shale with common prominent red (2.5YR 4/6) and reddish brown (2.5YR 5/4), soft iron stonelines at 33-35", clear wavy change,
44 - 64	"	Reddish yellow (7.5YR 6/6) clay, moist, slightly friable; weak angular blocky, increasing soft weathering grey shale with prominent multi-red colours.

Profile: S.8626/30

Lab. No.	S.8626	S.8627	S.8628	S.8629	S.8630
Depth - inches	0-2	2-12	12-28	28-44	44-64
Sand					
Silt					
Clay					
Texture Class					
Fine Sand					
Coarse Sand					
Medium Sand					
Carbon %	2.91	0.70	0.26	0.10	0.07
Nitrogen %	0.283	0.087	0.070	0.057	0.044
C/N	10	8	4	2	2
<u>pH</u>					
H2O	4.6	4.7	4.9	5.1	5.1
KCL	4.4	3.8	3.9	4.0	3.9
<u>Exchangeable</u>					
Ca.	5.58	0.32	0.32	0.26	0.26
Mg.	0.65	0.09	0.02	0.02	0.02
K.	0.33	0.08	0.06	0.06	0.08
Na.	0.34	0.28	0.33	0.27	0.33
CEC	11.50	8.77	8.7	8.1	7.9
BS%	60	8	8	7	8
<u>Reserve</u>					
Ca.	1064	309	390	259	336
Mg.	1349	1466	2342	2253	2221
K.	2336	2573	4522	5051	5326
P.	195	93	104	98	75
Group III %	7.04	6.95	14.11	11.34	11.76
<u>Phosphate</u>					
Total	197	111	115	106	72
Available	10	2	1	1	1

Profile: S.8613/19

Family : MERIT

Series : Merit

Phase : Moderately deep

Location : Rentis 1 tape 4 near Mile 42, Miri-Bintulu Road

Parent Material : Dark grey shale

Topography : On 12° slope, low hill

Vegetation : Young regrowth, about 1 year old

Drainage : Moderately well drained

- | | | |
|---------|--------|---|
| 0 - 1 | inches | Brown (10YR 5/3) loam, moist, friable, abundant medium to fine roots, few earthworms activities, clear smooth change, |
| 1 - 7 | " | Brownish yellow (10YR 6/6) very fine sandy clay loam; few distinct pale yellow (2.5Y 7/4) mottles, organic leaching from above; moist, slightly friable, crumbly; few fine roots, diffuse wavy change, |
| 7 - 22 | " | Reddish yellow (2.5YR 6/8) clay loam with common distinct pale yellow mottles, moist, crumbly, few fine roots, diffuse wavy change to, |
| 22 - 33 | " | Reddish yellow (7.5YR 6/6) clay, mottled common medium to fine distinct pale yellow; moist, firm, moderately strong blocky; no roots, common clayskins, gradual wavy change to, |
| 33 - 47 | " | Reddish yellow (7.5YR 6/6) clay, abundant fine to medium dark red, weak red, yellow and pinkish red mottles, moist, slightly firm, weak subangular blocky; increasing soft weathering grey shale with depth; clear irregular change to, |
| 56 - 64 | " | Grey (5Y 7/1) shale bed, abundant fine to medium dark red, and pinkish red colours, moist, slightly firm. |

Profile: S.8613/19

Lab. No.	S.8613	S.8614	S.8615	S.8616	S.8617	S.8618	S.8619
Depth - inches	0-1	1-7	7-22	22-33	33-47	47-56	56-64
Sand							
Silt							
Clay							
Texture Class							
Fine Sand							
Coarse Sand							
Medium Sand							
Carbon %	3.38	0.86	0.31	0.23	0.23	0.20	0.13
Nitrogen %	0.303	0.112	0.063	0.057	0.070	0.064	0.064
C/N	11	8	5	4	3	3	2
pH							
H2O	4.2	3.8	4.4	4.6	4.7	4.5	4.7
KCL	4.2	3.7	3.9	4.0	4.1	4.1	4.2
<u>Exchangeable</u>							
Ca.							
Mg.							
K.							
Na.							
CEC	16.20	7.80	8.10	9.20	10.00	9.10	12.80
BS%	55	14	11	8	8	10	5
<u>Reserve</u>							
Ca.	1168	257	257	283	442	443	375
Mg.	1401	1424	1801	2032	2655	2894	2637
K.	2465	2693	3538	3924	4880	5737	6043
P.	231	116	93	93	123	118	117
Group III %	4.81	5.90	7.90	10.29	13.17	14.48	13.91
<u>Phosphate</u>							
Total	218	90	111	111	141	136	106
Available	17	4	1	1	1	1	1

Profile: S.8637/41

Family : MERIT

Series : Merit

Phase : Moderately deep

Location : Rentis 3, tape 9, near Mile 4 1/2 Miri-Bintulu Road

Parent Material : Dark grey shale

Topography : Upper slope 12°

Vegetation : Young regrowth about 1 year old

Drainage : Moderately well drained.

0 - 2	inches	Dark brown (10YR 4/3) clay loam, moist, very friable; fine crumbly; many fine to medium roots, many earthworm activities, contain organic matter, clear smooth change,
2 - 11	"	Brownish yellow (10YR 6/6) very fine sandy clay loam to clay loam; mottled few faint pale yellow (2.5Y 7/4); moist, slightly firm, weak subangular blocky; few fine roots, few earthworm activities, diffuse wavy change,
11 - 29	"	Reddish yellow (7.5YR 6/6) clay, mottled common fine distinct pale yellow and weak red; moist, firm to very firm; strong angular blocky; few fine roots, thin clayskin develops along cracks and root channels; abrupt wavy change,
29 - 45	"	Reddish yellow (7.5YR 5/6) clay, mottled many fine to medium prominent pale yellow and yellowish red (5YR 5/8), moist, very firm, strong angular blocky; no roots, accumulations of soft iron shale concretions, few grey shale bits, abrupt wavy change,
45 - 61	"	Reddish yellow (7.5YR 6/6) pale yellow (2.5Y 7/4), variegated clay; moist, firm to very firm; weak subangular blocky, no roots, increasing soft weathering grey shale and many soft iron shale concretions, multi-red colours.

Profile: S.8637/41

Lab. No.	S.8637	S.8638	S.8639	S.8640	S.8641
Depth - inches	0-2	2-11	11-29	29-45	45-61
Sand					
Silt					
Clay					
Texture Class					
Fine Sand					
Coarse Sand					
Medium Sand					
Carbon %	2.43	0.91	0.29	0.25	0.20
Nitrogen %	0.254	0.112	0.069	0.069	0.077
C/N	10	8	4	4	3
pH					
H2O	4.2	4.4	4.7	4.3	4.6
KCL	3.8	4.3	3.9	3.6	3.8
<u>Exchangeable</u>					
Ca.	0.32	2.92	0.39	0.39	0.40
Mg.	0.14	0.63	0.02	0.02	0.02
K.	0.15	0.28	0.07	0.08	0.09
Na.	0.34	0.39	0.33	0.38	0.27
CEC	10.75	10.39	9.92	10.98	10.82
BS%	8	40	8	7	7
<u>Reserve</u>					
Ca.	783	265	272	350	512
Mg.	2088	1829	2143	2564	3071
K.	3752	3048	3048	4403	5972
P.	228	148	122	127	142
Group III %	8.98	9.01	10.01	13.93	18.88
<u>Phosphate</u>					
Total	248	154	127	135	142
Available	6	3	1	1	1

Profile: S.8631/36

Family : MERIT

Series : Merit

Phase : Deep

Location : Rentis 4, tape 4 near Mile 42 Miri-Bintulu Road

Parent Material : Dark grey shale

Topography : Slope 13⁰, mid-slope

Vegetation : young regrowth

Drainage : Moderately well drained

- | | | |
|---------|--------|--|
| 0 - 3 | inches | Brown (10YR 5/3) clay loam, moist, friable, fine crumbly, many fine to medium roots, earthworm activities, contain organic matter, clear smooth change, |
| 3 - 11 | " | Brownish yellow (10YR 6/6) clay loam to clay, distinct few fine pale yellow and strong brown, moist, slightly firm, weak subangular blocky, few fine roots, earthworms activities, diffuse wavy change, |
| 11 - 22 | " | Yellow (10YR 7/6) clay, mottled common distinct fine to medium pale yellow (2.5Y 7/4) and yellowish red (5YR 5/6); moist, slightly firm; weak subangular to angular blocky; few fine roots, clear clayskin coating along cracks, clear irregular change, |
| 22 - 30 | " | Reddish yellow (5YR 6/6) clay with prominent common fine pale yellow (2.5Y 7/4); moist, firm; very strong angular blocky, no roots, clayskin coating along cracks, clear wavy change, |
| 30 - 44 | " | Yellow (10YR 8/6) clay with prominent reddish yellow (5YR 6/6); moist, firm, strong angular blocky, no roots, accumulation of few soft platy iron concretions; clear wavy change, |
| 44 - 64 | " | Reddish yellow (5YR 6/6) and yellow (10YR 7/6) variegated clay with prominent multi dark red, weak red colours, moist, slightly firm to compact, strong angular blocky; many soft iron shale concretions and grey shale pieces increasing with depth. |

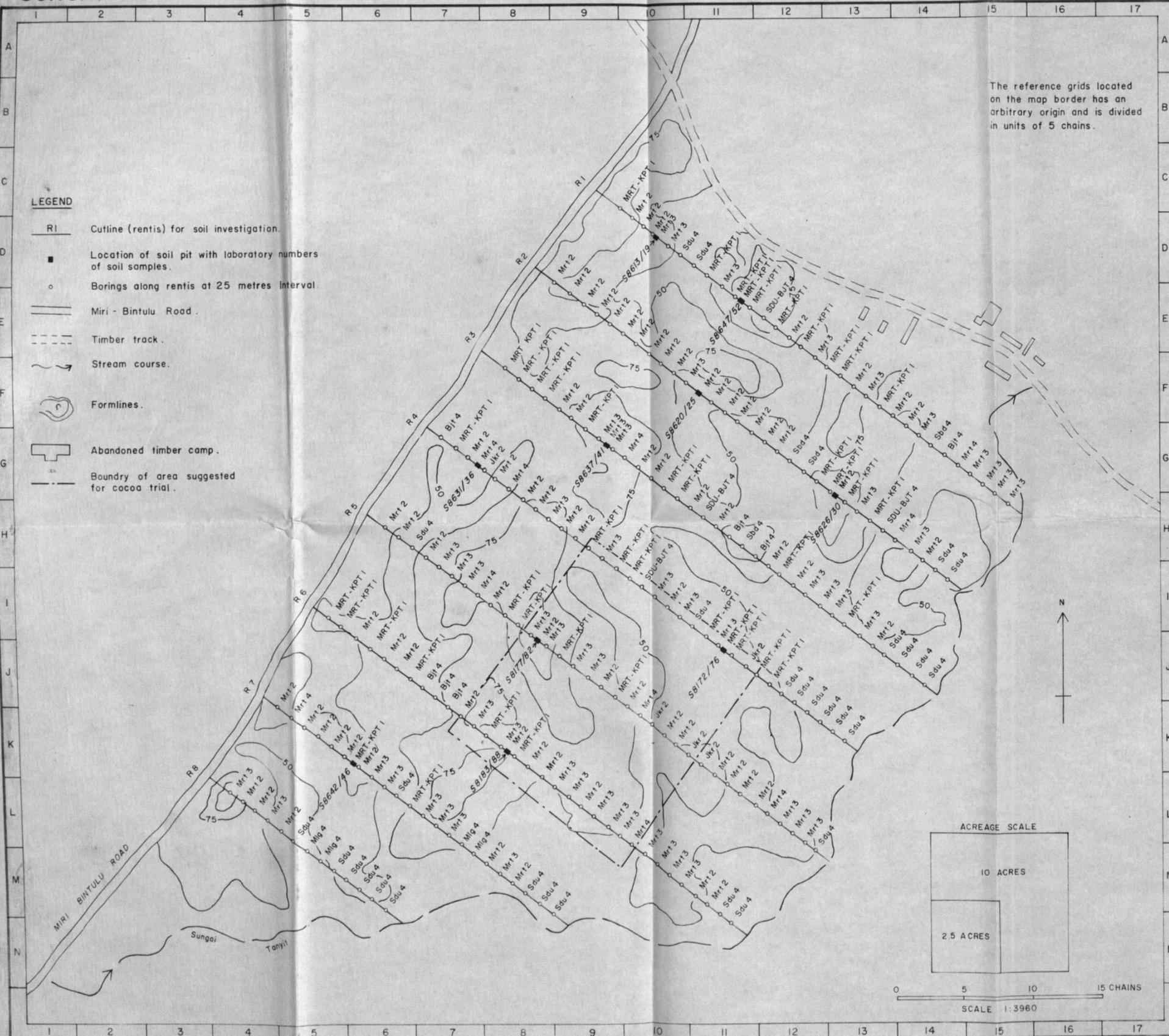
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APPENDIX - 29

Profile: S.8631/36

Lab. No.	S.8631	S.8632	S.8633	S.8634	S.8635	S.8636
Depth - inches	0-3	3-11	11-22	22-30	30-44	44-64
Sand						
Silt						
Clay						
Texture Class						
Fine Sand						
Coarse Sand						
Medium Sand						
Carbon %	2.68	0.55	0.31	0.29	0.23	0.18
Nitrogen %	0.265	0.094	0.070	0.077	0.071	0.084
C/N	10	6	4	4	3	2
pH						
H2O	4.8	4.6	4.7	4.8	4.8	4.8
KCL	4.5	3.9	3.8	3.9	3.9	3.9
<u>Exchangeable</u>						
Ca.	6.38	0.52	0.26	0.20	0.20	0.26
Mg.	1.76	0.50	0.10	0.06	0.02	0.10
K.	0.25	0.18	0.12	0.10	0.10	0.12
Na.	0.36	0.29	0.31	0.35	0.31	0.36
CEC	11.97	8.81	9.36	10.70	10.20	10.79
BS%	73	16	8	6	6	7
<u>Reserve</u>						
Ca.	1249	351	352	344	398	476
Mg.	1483	1893	2080	2436	3027	3095
K.	2928	3727	4226	5362	5808	6315
P.	243	150	135	138	143	148
Group III %	7.13	8.74	9.88	12.87	14.66	17.14
<u>Phosphate</u>						
Total	232	130	140	143	162	138
Available	11	1	1	1	1	1

Profile: S.8631/36

Lab. No.	S.8631	S.8632	S.8633	S.8634	S.8635	S.8636
Depth - inches	0-3	3-11	11-22	22-30	30-44	44-64
Sand						
Silt						
Clay						
Texture Class						
Fine Sand						
Coarse Sand						
Medium Sand						
Carbon %	2.68	0.55	0.31	0.29	0.23	0.18
Nitrogen %	0.265	0.094	0.070	0.077	0.071	0.084
C/N	10	6	4	4	3	2
<u>pH</u>						
H2O	4.8	4.6	4.7	4.8	4.8	4.8
KCL	4.5	3.9	3.8	3.9	3.9	3.9
<u>Exchangeable</u>						
Ca.	6.38	0.52	0.26	0.20	0.20	0.26
Mg.	1.76	0.50	0.10	0.06	0.02	0.10
K.	0.25	0.18	0.12	0.10	0.10	0.12
Na.	0.36	0.29	0.31	0.35	0.31	0.36
CEC	11.97	8.81	9.36	10.70	10.20	10.79
BS%	73	16	8	6	6	7
<u>Reserve</u>						
Ca.	1249	351	352	344	398	476
Mg.	1483	1893	2080	2436	3027	3095
K.	2928	3727	4226	5362	5808	6315
P.	243	150	135	138	143	148
Group III %	7.13	8.74	9.88	12.87	14.66	17.14
<u>Phosphate</u>						
Total	232	130	140	143	162	138
Available	11	1	1	1	1	1



The reference grids located on the map border has an arbitrary origin and is divided in units of 5 chains.

- LEGEND**
- R1 Cutline (rentis) for soil investigation.
 - Location of soil pit with laboratory numbers of soil samples.
 - Borings along rentis at 25 metres interval.
 - Miri - Bintulu Road.
 - - - Timber track.
 - ~ Stream course.
 - Formlines.
 - ⊞ Abandoned timber camp.
 - - - Boundary of area suggested for cocoa trial.

Family	Mapping Unit	Mapping Symbol	Main Soil Characteristics
MERIT	Merit Series	Mrt	Clay from non-calcareous shale and fine sandy shale parent materials; colour yellowish brown or brownish yellow in the surface 20 inches (50 cm); pH H ₂ O less than 6.0, base saturation less than 35 per cent and exchangeable Ca of clay less than 5 milliequivalents in all horizons below a depth of 30 inches (75 cm) or immediately above a paralithic or lithic contact if shallower than 30 inches (75 cm).
	Jakar Series	Jkr	As for Merit Series but colour redder than yellowish brown or brownish yellow throughout the control section.
MERIT KAPIT Family Intergrade	MERIT-KAPIT Family Intergrade	MRT-KPT	As for Merit Family but soil depth between 10-20 inches (20-50 cm) over paralithic contact.
SEDUAU	Seduau Series	Sdu	Accreting well to moderately well drained riverine clay; colour yellowish brown or yellow throughout the surface 20 inches (50 cm) of the control section; cation exchange capacity less than 30 milliequivalents / 100 gm.
	Malang Series	Mlg	As for Seduau Series but colour redder than yellowish brown in some horizon above 20 inches (50 cm) of the control section.
BIJAT	Bijah Series	Bjt	Accreting gleyed riverine clay colour light grey to grey no surface peat conductivity less than 100 micromhos throughout the control section, base saturation 30 per cent or more.
	Sabandi Series	Sbd	As for Bijat Series but with surface peat of less than 10 inches (25 cm) present.
	Seduau-Bijah Series Intergrade	Sdu-Bjt	As for Seduau Series but imperfectly drained.

Soil depth phases mapped are shown by number coding as follows:

Soil Depth	Depth phase Mapping
0 - 10 inches (0 - 25 cm)	Family Division
10 - 20 inches (25 - 50 cm)	1
20 - 30 inches (50 - 75 cm)	2
30 - 40 inches (75 - 100 cm)	3
more than 40 inches (more than 100 cm)	4

Depth of soil control section is 40 inches (100 cm) measured from the base of the A1 horizon.

