SOILS OF THE LORMALONG EXTENSION AREA, KUNAK DISTRICT, TAWAU RESIDENCY

INTRODUCTION

Abstract

The soils of the Lormalong Extension Area north west of the present Lormalong Settlement Scheme in the northern part of the Semporna Peninsula are derived from various parent material and consequently give rise to different agricultural potentials. In the 10,000 acres surveyed, approximately 29% of the soils developed on steepland ultrabasic to basic igneous rocks are not considered useful for agriculture. A further 36% of the soils derived from lower expressions of this similar ultrabasic (slump) parent material and raised non-active alluvium are considered suitable for oil palm plantation. 15% of soils developed on gently rolling topography derived from vesicular lava are considered to be ideally suitable for cocoa plantation. The soils of the coastal margin and Tingkayu floodplain amounting to about 19% of the area would require drainage as a pre-requisite to any agricultural development.

Acknowledgements

The writer wishes to take this opportunity of thanking the officers of the Sabah Land Development Board, in particular their Senior Manager, Encik Graham Steele, the Tawau Regional Manager, Encik Denis Wyman and the Agronomist, Encik Christopher Hoh and whilst at Kunak, the warm hospitality of the Manager of Mostyn Estate, Encik Bill Tully. Their assistance with a light aireraft for aerial reconnaissance, a Land Rover for ground work and general willingness to help in all aspects assured the smooth running of the survey.

Purpose of the Survey and Description of the Area

The soil survey of the Lormalong Extension Area was undertaken in the period mid-April to mid-July, 1973 to delineate the essential types of the soils and draw some conclusions for their usefulness in a major extension of the Lormalong Settlement Scheme.

2/...

The area, existing largely to the north of the Madai - Baturong Forest Reserve boundary and west of the mangrove swamp up to the Sungei Tingkayu still remains to be developed and extends over 10,000 acres. This is almost entirely covered by primary equatorial forest except for a concession area on both sides of the Kunak - Lahad Datu Road where the Sabah Timber Company has removed the best amount of regenerated secondary forest in this area near the road. There has been no agricultural activity in the area held by the Sabah Land Development Board except in the very south east where shifting cultivation from a small Bajau kampong has encroached on the basalt derived soil immediately north of the present Lormalong Scheme.

The area consists of a variety of topographical features and is believed to have been subjected to considerable geological and geomorphological changes in Quaternary times. There are a series of 200-300 foot high ridges running roughly parallel to the coast in a north-westerly direction composed mainly of much-altered serpentenite (ultrabasic) material. This is generally known as the 'Slump Formation' and gives rise to fairly steep topography projecting out of the rolling terrain. Other components of the Slump Formation i.e. sandstone, mudstone and vesicular lava make up the predominently rolling topography which continues north eastwards out of the Madai-Baturong Forest Reserve into a coastal terraced alluvium. This in its turn merges into the lower active alluvium of the Tingkayu floodplain and mangrove margin. These major topographical features have been highlighted in the accompanying introductory map along with the location of the rentis system made during this survey and the previous regional reconnaissance soil survey in 1966.

Methods of Carrying out the Survey

A preliminary interpretation of the Sabah Forest Inventory Aerial Photograph Cover of the area at a scale of approximately 1:25,000 was undertaken. The runs 1731(19-27), 1732(34-41) and 1733(23-30) were taken in May 1970 and their photocentres have been marked on the introductory map. In addition to these, a very up-to-date cover was obtained from aerial photographs taken at a similar scale of the Kunak to Lahad Datu Road in early 1973 (Run 1972, Nos. 5-11).

3/...

At an early stage, it was decided to insert rentises (traces) at an angle of 30° (magnetic) from the main road at intervals of 2000 feet to cover the most hopeful area for agricultural development, i.e. to the NE and SW of the road. At a later stage, sub-rentises to check soil slopes and parent materials were inserted at 1000 foot intervals at right angles to the main rentises. From Chain 70 (100 foot chains) on Rentis 11, a radial set of rentises at 30° intervals was cut to check on the soil conditions in the northern part of the area. On all the main rentises, auger profiles were described at 1000 foot intervals with soil slope measurements at each chain interval (100 feet) and differences in parent material noted when they occurred on both the main rentises and sub-rentises. Pits were sunk and profiles described on diagnostic soils of the various parent materials. These have been subsequently chemically and mechanically analysed and are presented later in this report.

THE SOILS OF THE AREA

Discussion of Mapping and Classification Involved

Since the completion of the reconnaissance soil survey of the State earlier this year, there has been some doubt of how exactly to map the finer distinctions of the soil associations previously used. On ad hoc surveys, there is naturally a tendency to use larger scales - in this case 1:25,000, over the 10,000 acres under potential development. It depends entirely on the complexity of the soil types occurring and the need for finer detail with respect to the character of the agricultural development envisaged. Some thought has been given to this by the writer and it has been decided in this instance to use Roman numerals as mapping symbols for the seven distinct soil assemblages which are represented in the area.

For the purpose of this report, a soil assemblage is a local and finer distinction of the Sabah Soil Association which falls into a definite geomorphological unit and is derived from as certain a geological parent material as is practical to discover in the field. Tied in with the geomorphological part of the definition, are the slopes which are generally accepted to limit agricultural development.

4/...

The FAO Soil Units and their Sabah Soils Families are generally more restricted in an assemblage than in an association as a result of not only the finer definition but also the practicality of finding such variations in the limited area in the field.

There are seven assemblages in the area. Each will be described in turn with the soils found therein.

Assemblage I (See Profiles 1 & 2 in Appendix)

The soils in this assemblage are developed on sharply defined ridges running in a SE to NW direction through the area. Slopes on this hills are between 15° and 25° though some 40 of the slope results are excessively steep - up to 35°. The amplitude of this steep ground is about 150 rising to 300 feet on hills near the coast. The geology is almost entirely much-altered serpentenite. This ultrabasic rock (i.e. with little or no free silica in its matrix and high in ferro-magnesian minerals) has been dynamically metamorphosed with shining "slickenside" surfaces with chlorite and talc formed in the process. This gives the ultrabasic rock easily recognisable field characteristics.

The soils fall into two FAO soil units. The most common are Orthic Luvisols of the Tingkayu Family, which under the thin surface humic horizon are characteristically dark yellowish brown to yellowish brown and olive in colour. An appreciable clay shift with depth from a loam texture to a clay loam to clay is noted whilst at the same time the amount of the rotten rock fraction also increases. From the chemical results not only of the type profile at the old quarry side near the base camp but also from the reconnaissance survey undertaken by P. Thomas in 1966, the high results of the Mg and Ca levels bring the base saturation above 50% which marks the essential criterion in the Luvisol definition. These high levels come from the weathering of the above mentioned ferro-magnesian minerals and also the calcium - rich environment exemplified by the limestone mountains of Madai and Baturong immediately to the south and west of the area. On the other hand, the essential plant nutrients of K and Na are very low indeed. pH is almost neutral.

5/...

Less common are Orthic Acrisols to Chromic Luvisols tending towards the Malawali Family which are found at the foot of the ridges derived from colluvium. These have a characteristic dusky red colour throughout the profile and bring to mind the Rhodic Ferralsols of the Pinianakan Family found so commonly on other ultrabasic but more mountainous areas in the State. The texture increases in fineness with depth from a well structured loam to clay loam which tends to be massive in the lowest horizon surrounding the rotten ultrabasic parent material. An increase in clay is noted for the mechanical analysis which definitely put these soils in the Acrisol or Luvisol FAO Soil Units. However, the base saturation tends to be lower in the upper horizons than 50% required for classification into a Luvisol. This percentage is only surpassed in the lower less active horizons and thus in the type profile appended, a classification can only be given of an Orthic Acrisol. As in the previous profile, the Mg values are high whilst Ca has been removed in the colluviation and is represented in less quantity. Na and K are low and the pH is slightly more acid. The lack of advanced weathering of this soil into the FAO Ferralsol Unit is reflected in the lack of reddish purple staining which normally occurs on one's hands after examining similar soils in other areas of Sabah.

From an examination of the auger profiles taken on these steepland soils sampling could not take place under 20 inches depth in about 12% of the results. This assemblage of steepland soils extends over some 2732 acres of the area surveyed.

Assemblage II

The soils of this assemblage are associated with the landforms described in the previous assemblage. Slopes are similar and there is an abundance of vesicular lava boulders on the surface with soil only occupying interstices between the surface and subsoil boulders. The characteristics of the soils are similar to those in Assemblage IV described below. This assemblage has been found and delineated on a relatively small area of 183 acres.

6/...

Assemblage III (See Profile 3)

The landforms particularly relating to this assemblage are less intense expression of those described in Assemblage I, being low rolling hills with moderate slopes in the range of 5° to 15°. These hills, like those of Assemblage I, consist of mainly ultrabasic much-altered serpentenite. Paton in his original reconnaissance soil mapping of the area combined these two Assemblages giving a type name to the soils expressed thereon as Tingkayu. This name has been retained for the Orthic Luvisol family found most commonly in Assemblage III.

In the profile described of the Tingkayu Family soils there is again found an appreciable clay shift from a loam texture in the upper horizons to a clay loam in the lower horizon and this is further reflected in the mechanical analysis. The exceedingly high calcium and magnesium cation results brings the base saturation to an extremely high level though it must be noted again, as in the soils of Assemblage I, that the potassium and sodium cation figures are low. The pH of the soil is predominantly neutral. It was noted that secondary regrowth was particularly strong on these soils.

This Assemblage occupies a belt running NW from the present Lormalong Scheme flanking the steeper ridges of Assemblage I towards the Sungei Tingkayu and has a total area of some 1648 acres.

Assemblage IV (See Profiles 4, 5 & 6)

This assemblage contains economically the most important soils found in the area surveyed. Within this assemblage of low rolling hills and flat land, the soils are derived from vesicular lava from two provenances. The older and undoubtedly the more extensive is a component of the Slump Formation closely associated with the other parent materials of serpentenite of Assemblages I and III and sandstone of Assemblage V. At the very eastern and western end of the Kunak - Lahad Datu Road, the vesicular lava is known to be the northern-most tendrils of the Mostyn Flow - a much-later and characteristically olivine-rich lava. The lava, however, is contiguous in the field and distinction on the basis of crystalline composition not possible. The soils are similarly undistinguishable in all pedological characteristics.

7/...

The soils of this assemblage are characterised by the dark brown loam to clay loam appearance throughout the profile. The amount of parent vesicular lava boulders can vary in proportion to the soil fraction to a very high degree and it can be said that it is never less than 50%. Because of the high amount of parent material, it is difficult to determine a definite horizonal evolution although the pit profiles of the Eutric Cambisols representative of the Bombalai and Mostyn Families do show a slight increase in clay with depth. These first two profiles are taken in the west and east of the area respectively and are probably derived from the younger Mostyn Flow. Both are high in Calcium and Magnesium as in other soils in the area whilst the Eutric Cambisol of the Bombalai Family has a slightly higher content of Sodium and Potassium than the Dystric Cambisol of the Mostyn Family. The well developed fine to coarse granular structure with the high proportion of rock material give good drainage characteristics in these soils.

The Cambisols (or "changing" soils) with only a suggestion of a clay shift would indicate a certain juvenility over soils with a more appreciable clay shift i.e. Acrisols. A pit profile examined in the centre of the area most certainly on the vesicular lavas of the Slump Formation shows the definite characteristics of an Orthic Acrisol of the Tedong Series of the Lividoi Family. As before a brown to dark brown well structured soil occurs throughout the stoney profile and there is a very noticeable clay shift.

The only noticeable difference is the slightly higher acid values of pH for most of the profile and the lower results of the exchangeable cations bringing the base saturation to under 50% for most of the profile. However, the main root growth occurs in the upper horizons where the base saturation and organic nutrition is higher and the presence of rock material is lower. The concern for judicious land clearing is paramount therefore on the north-eastern area of this Assemblage. The Assemblage is found in two portions, the larger (906) acres being in the northwest and the smaller (582) in the southeast.

8/...

Assemblage V (See Profile 7)

This is the smallest assemblage delineated in the area surveyed, being made up of gently rolling land with sandstone as the diagnostic parent material. This again is one of the components of the Slump Formation complex. A profile described on this sandstone shows all the aspects of one of the commonest hill soils of Sabah - the Orthic Acrisols of the Tanjong Lipat Family and Series. Being deeply weathered there is a pronounced clay shift in the lowest horizons from a loamy sand to fine sandy loam to a clay loam at depth. The low base saturation figure reflects the poor quantities of exchangeable cations throughout the profile. The soil is moderately acid and typically, whatever nutrients, both organic and inorganic, are confined to a narrow surface horizon. Care thus must be taken in the clearance of this small area of 119 acres.

Assemblage VI (See Profiles 8 & 9)

The soils of this assemblage are expressed on gently rolling to flat land made up of high non-active alluvium. The feature is essentially a terrace lying between the mainland hills and ridge flanks and the coastal plain behind the mangrove swamps. There is no break in slope which can definitely be outlined and both in the field and on the aerial photographs, the boundary can only be given by a distant change in the vegetation. Pneumatophore roots become common on the lower alluvium of the following Assemblage VII and the canopy "greyer" and more closely knit.

The soils on these non-flooding high ground have been subjected to processes of weathering in which a definite clay shift can be seen in the profile. Textures of the brown to strong brown soils range with depth from fine sandy loam to silty clay loam. The exchangeable cation content of the Orthic Acrisol of the Paliu Family is extremely low with Magnesium, and to a lesser extent Calcium, present beyond 0 or trace levels in most of the profile. The advanced state of weathering is also indicated in the numerous small black manganese concretions found in lower horizons. The Orthic Luvisol of the Numatoi Family has a higher base saturation although it is the high presence of Calcium and other cations washed out from the vesicles (amygdales) of the adjacent lava near Lormalong that accounts for this general enrichment.

9/...

The area of this assemblage which is split into two portions, one in the north and one flanking the Slump Formation hills in the south, totals 1834 acres.

Assemblage VII (See Profiles 10, 11 & 12)

The soils of this assemblage are developed on the plain between the above assemblages and the mangrove swamps and on the floodplain of the Sungei Tingkayu. There is a permanently high water table during average climatic conditions. This is reflected in gley mottling occuring throughout the profile. Clay movement is impeded though there is a general increase in fineness of texture with depth. The structure of the peds tends to be weakly developed and an abundance of iron staining and manganese concretion formation is noted. The low lying plain merges insignificantly into the inland assemblages and consequently river valleys running through the latter have the gleyed characteristics of the former. Such pits profiles examined on a valley floor is made up of loam to fine sandy loam to clay loam from an alluvium still bearing the enrichment of Calcium and Magnesium cations from the parent materials of the above assemblages. The base saturation is brought above 50% and higher, as the pH becomes more neutral in the Eutric Gleysol of the Kinarasaban Family and the Eutric Fluvisol of the Sumilad Family and Series respectively.

At a further distance from the derivation of the alluvium, the cation availability becomes less. In two pit profiles, one of which is appended in this report, it is again only the magnesium and to a lesser extent the calcium that are present whilst the pH drops to moderately acid. Gypsum was found at a depth of 45 - 70 cm in a second pit which brought up the cation level of calcium to 30.68 me %. The crystalline calcium sulphate occupied 1.3% of the bulk mass of a sample from this horizon. A general test of the acidity and sulphur content revealed that the soil was on the verge of being classified as "acid sulphate". The soluble sulphate expressed as a percentage sulphur in the gypsum horizon was 0.132 whilst the pH is 0.01N KCl was 3.6. The values (which are not complete enough to include in this report) indicate that the upper plant growth horizons are normal with acid pH's.

10/...

The acreage of this assemblage which is largely on the periphery of the area surveyed is 1927 acres.

AGRICULTURAL RECOMMENDATIONS AND CONCLUSIONS

Assemblage I:

The soils of this assemblage (2732 acres) are not considered generally suitable for agriculture because of the general steepness of the terrain. Trial areas are recommended for judicial planting cocoa on the lower slopes. Similarly, but not generally, some areas within this assemblage may be useful for under brushing, pasture establishment and cattle grazing.

Assemblage II:

The recommendations for the above stand although trial of cocoa would probably be more useful.

Assemblage III:

The soils of this assemblage (1648 acres) are considered suitable for oil palm - although the low status of Na and K will call for a fairly heavy general fertilization programmes. The near neutral pH's may well be combatted by the higher clay content and thence higher moisture retention capacity than on the soils where internal drainage is excessive (i.e. the near neutral Mostyn soils). Trial plots of cocoa may well be established on freely drained sites with particular emphasis on general fertiliser application.

Assemblage IV:

The soils of this assemblage (1488 acres) are considered ideal for cocoa plantation as has been experienced on similar basaltic soils in the Tawau Residency. It is felt that an early establishment of fertilizer and shade arrangement trials would add to the knowledge and success of cocoa in Sabah.

11/...

Assemblage V:

The soils of this small assemblage (119 acres) have been proved to be suitable for oil palm in areas of higher annual rainfall. Judicious timing of planting would probably help in the ultimate success of oil palm on these soils in this area.

Assemblage VI:

The soils of this assemblage (1834 acres) are considered suitable for oil palm plantations so long as adequate drainage is provided in colluvial hollows. A supplemented programme of general fertilizer similar to that on Assemblage III is recommended.

Assemblage VII:

The soils of this assemblage (1927 acres) are considered only to be suitable for oil palm plantation with adequate drainage. Because of the tendency for acid sulphate conditions to occur near the mangrove regular flushing by a finer pattern of drainage would be necessary.

Conclusion:

It is suggested that a medium sized estate could well be planned on the area surveyed with a joint development of cocoa and oil palm. Out of nearly 10,000 acres surveyed the following acreage of soils are nearly pertinent.

Soil not considered suitable for plantation	= 2915 acs	(Assemblage I & II)
Soil considered suitable for plantation of oil palm	= 3601 acs	(Assemblages III, V & VI)
Soil considered suitable for plantation of cocoa	= 1488 acs	(Assemblage IV)
Soil considered suitable for plantation of oil palm with adequate drainage	= 1927 acs	- 7016 acres.
Total	= 9931 acs	

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Land under road at present
(7 miles @ av. 50 feet wide) = 67 acs

Grand total = 9997 acs

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22-8-73

Assemblage I

PROFILE 1 — Orthic Luvisol - Tingkayu Family

Location — Section at top of road stone quarry at top of hill near Rentis 12A

(grid ref.) (Mapping Unit ( )

Site: Macrorelief — Hill
Microrelief — Quarry face
Slope — 10 - 20°
Elevation — 150 feet a.s.l.
Drainage — Free
Parent Material — Chloritised serpentenite
Vegetation/Land use — Quarry
Soil Drainage — Well drained

Horizon	Depth cm	Depth (in)	Description
Ah	(9-0)	3½-0	Dark brown (7.5 YR 3/2) humic loam; friable; moderately developed medium crumb structure; many sharp fragments of rotten ultrabasic rocks; porous; roots many woody and fibrous; boundary abrupt and irregular to:
A1	(0-7.5)	0-3	Dark yellowish brown to yellowish brown (10 YR 4/4-5/4) gravelly clay loam; with rotten fragments of ultrabasic material; friable; moderate to well developed medium to coarse granular structure; porous; roots few fibrous; merging gradual and smooth to:
B1	(7.5-18)	3-7	Colour as above with mottles common fine distinct 15% olive (5 Y 4/3) gravelly clay loam/clay; moderate friable; structure as above; porous; few fibrous roots; merging gradual and smooth to:
BC	(18-38)	7-15	Yellowish brown (10 YR 5/4) common fine distinct 12% olive (5 Y 5/4) mottles; gravelly clay; sticky; moderately developed fine to coarse granular to fine subangular blocky structure; abundant rotting ultrabasic material; no roots; merging irregular and wavy to:
C	(38 +)	15 +	Bed rock of chloritised ultrabasic serpentinite

Depth (cm)	Lab. No	Particle size distribution (%) C Sand	F Sand	Silt	Clay	Org. C (%)	Total N (%)	Easily sol. P (ppm)	pH H_2O	Exchangeable cations (meq%) Ca	Mg	K	Na	C.E.C. (meq%)	Base satn (%)
9-0	C2634	35	14	25	24	1.7	0.17	1	7.2	6.0	25.9	0.4	0.1	28.7	>100
0-7.5	35	24	25	27	27	0.6	0.06	1	7.5	2.9	31.3	0.2	t	33.1	>100
7.5-18	36	20	20	24	35	0.4	0.05	1	7.6	1.5	23.2	t	0	34.2	72
18-38	37	14	27	30	30	0.2	0.02	1	7.8	0.2	24.8	0	0	32.04	78

Assemblage I

PROFILE 2 — Orthic Acrisol - Chromic Luvisol tending towards the Malavali Family

Location — Pit at Chain 3 on Subrentis (120°) from Chain 10 on Rentis 11

(grid ref.) (Mapping Unit I)

Site: Macrorelief	Hill
Microrelief	Near foot of 10° slope
Slope	10°
Elevation	65 feet a.s.l.
Drainage	Free
Parent Material	Ultrabasic rock colluvium
Vegetation/Land use	Broken Primary Forest
Soil Drainage	Excessively well drained

Horizon	Depth cm	Depth (in)	Description
A11	(0-2)	0-7	Very dusky red (2.5 YR 2/2) humic loam; friable; well developed fine to medium crumb structure; porous; roots, many woody and fibrous; merging gradual and indistinct to:
A12	(2-10)	7-18	Dusky red (2.5 YR 3/2) loam; friable; structure as above; porous; few large woody and fibrous roots; merging gradual and smooth to:
B21	(10-14)	18-37	Dusky red (2.5 YR 3/2) clay loam; friable to firm; well developed medium to coarse subangular blocky structure; porous; very few fibrous; merging wavy and indistinct to:
B22	(14-14.5)	37-44	Dusky red (2.5 YR 3/2) clay loam/clay; friable to firm; well developed coarse granular to medium subangular blocky structure; porous; very few fibrous; merging wavy and indistinct to:
C	(14.5+)	44+	Variegated horizon predominantly dark reddish brown (2.5 YR 3/4) with many mottles coarse distinct 40-45% yellowish brown (10 YR 5/6) mixture of clay soil and fine sandy rotten rocks; firm; massive; porous; very few small, scattered, fragments of yellowish brown rotting rocks; no roots.

Depth (cm)	Lab. No	Particle size distribution (%) C Sand	F Sand	Silt	Clay	Org. C (%)	Total N (%)	Easily sol. P (ppm)	pH H_2O	Exchangeable cations (meq%) Ca	Mg	K	Na	C.E.C. (meq%)	Base satn (%)
0-18	32538	11	33	41	16	1.3	0.17	2	7.0	11.1	4.1	0.2	0.1	13.8	39
18-40	39	7	24	33	36	0.3	0.10	1	5.6	0.5	4.1	t	0.2	12.5	38
40-79	40	7	22	30	42	0.1	0.04	1	6.1	0.5	5.2	t	0.4	13.8	45
79-115	41	3	17	32	49	0.1	0.03	1	6.2	0.4	8.3	0.1	0.7	18.0	52
115+	42	8	46	29	20	0.1	0.02	1	6.3	0.4	8.1	t	0.5	13.5	66

Assemblage III

PROFILE 3 — Orthic Luvisol - Tingkayu Family

Location — Pit at Chain 3 Rentis 17A

(grid ref.) (Mapping Unit III)

Site: Macrorelief — Rolling raised coastal plain
Microrelief — Mid slope of small hill
Slope — 5°
Elevation — 40 feet a.s.l.
Drainage — Free
Parent Material — Chloritised serpentenite and slump material
Vegetation/Land use — Secondary forest
Soil Drainage — Moderately well drained

Horizon	Depth cm	Depth in	Description
Ah	(0-2.5)	0-1	Dark brown (10 YR 3/3) humic loam; friable; well developed medium crumb structure; consisting mainly of worm casts; porous; roots many fibrous; abrupt and clear boundary:
A1	(2.5-13)	1-5	Brown to dark brown (10 YR 4/3) loam; friable; well developed coarse granular to medium subangular blocky structure; porous; roots many fibrous and woody; merging gradual and smooth to:
AE	(13-28)	5-11	Dark yellowish (10 YR 4/4) loam; friable; well developed coarse granular to medium subangular blocky structure; porous; roots common fibrous; merging gradual and smooth to:
Bt	(28-53)	11-21	Yellowish brown (10 YR 5/4) many fine faint 20-25% light yellowish brown (2.5 Y 6/4) mottles; clay loam; firm; poorly developed medium - coarse subangular blocky structure; common rotten fragments of parent material; few fibrous roots; merging abrupt and smooth to:
	(53 +)	21 +	Olive (5 Y 4/3) many fine distinc 30-40% yellowish brown (10 YR 5/6) mottles; gravelly clay; firm but soft; massive; few pores; no roots:

Depth (cm)	Lab. No.	Particle size distribution (%) C Sand	F Sand	Silt	Clay	Org. C (%)	Total N (%)	Easily sol. P	pH H_2O	Exchangeable cations (meq%) Ca	Mg	K	Na	C.E.C. (meq%)	Base satn (%)
0-2.5	C2643	11	32	28	27	3.9	0.39	1	7.2	29.1	7.3	0.2	0.3	33.7	>100
2.5-13	44	13	29	24	32	1.7	0.35	1	6.8	22.2	6.9	1	0.2	27.4	>100
13-28	45	15	31	24	32	0.7	0.10	0	7.0	16.5	9.1	0	0.2	24.8	87
28-53	46	21	20	18	42	0.4	0.05	1	7.2	21.3	12.2	0	0.4	33.8	100
53 +	47	34	24	13	27	0.2	0.03	1	7.3	21.3	13.5	0	0.3	35.2	100

Assemblage IV

PROFILE 4 — Eutric Cambisol - Bombalai Family & Series, B1

Location — Pit at Chain 11, Rentis 6A
(grid ref.) (Mapping Unit IV)

Site: Macrorelief — Rolling terrain of lava flow
Microrelief — Midway up a short slope
Slope — 5°
Elevation — 100 ft. a.s.l.
Drainage — Free
Parent Material — Vesicular lava
Vegetation/Land use — Broken Primary Forest
Soil Drainage — Excessively well drained

Horizon	Depth cm	Depth (in)	Description
A1	(0-15)	0-6	Very dark greyish brown (10 YR 3/2) humic loam; very friable; well developed medium to coarse crumb structure; many pores; many large rounded surface separate stones of vesicular lava; roots abundant woody and fibrous; merging gradual and smooth to:
AE	(15-30)	6-12	Very dark greyish brown (10 YR 3/2) loam; very friable; well developed fine to coarse granular structure with stones surrounded by soil to give apparent of coarse subangular blocky structure; this horizon is interpersed with stones of boulders of vesicular lava; porous; roots very common woody and fibrous; merging smooth and gradual to:
BCr	(30 +)	12 +	This horizon is predominantly rock matrix with skin of soils dark yellowish brown (10 YR 3/4) clay loam; friable with rotten rocks give appearance of peds, predominantly of rounded rotting boulders of vesicular lava:

Depth (cm)	Lab. No.	Particle size distribution (%) C Sand	F Sand	Silt	Clay	Org. C (%)	Total N (%)	Easily sol. P	pH H_2O	Exchangeable cations (meq%) Ca	Mg	K	Na	C.E.C. (meq%)	Base satn (%)
0-15	C6201	6	14	25	50	3.9	0.46	1	7.0	20.6	5.5	0.8	0.1	24.5	96
15-30	02	15	19	28	39	1.1	0.14	1	6.9	8.0	3.4	1.0	0.1	14.3	87
30 +	03	18	23	19	41	0.8	0.11	0	6.8	3.5	5.4	0.9	0.1	14.5	67

Assemblage IV

PROFILE 5 — Dystric Cambisol - Mostyn Family

Location — Pit at Chain 4, Rentis 22
(grid ref.) (Mapping Unit IV)

Site: Macrorelief — Rolling terrain of lava flow
Microrelief — Small undulations
Slope — Nil
Elevation — 50 feet a.s.l.
Drainage — Free
Parent Material — Vesicular lava
Vegetation/Land use — Ladang clearance infested with Siam Weed
Soil Drainage — Excessively well drained

Horizon	Depth cm	Depth (in)	Description
AE	(0-5)	0-2	Dark brown (7.5 YR 3/2) humic loam; very friable; well developed fine crumb structure; very porous; many fragments of rotting lava few fibrous roots; irregular and indistinct boundary:
B2 t	(5-18)	2-7	Dark reddish brown (5 YR 3/4) clay loam; friable; structure as above; few fragments of rotting; merging gradual and smooth to:
B3	(18-51)	7-20	Dark yellowish brown (10 YR 3/4) clay loam; friable; well developed coarse crumb structure; many fragments of rotting porous; very few roots.

Depth (cm)	Lab. No.	Particle size distribution (%) C Sand	F Sand	Silt	Clay	Org. C (%)	Total N (%)	Easily sol. P	pH H_2O	Exchangeable cations (meq%) Ca	Mg	K	Na	C.E.C. (meq%)	Base satn (%)
0-5	C2656	5	17	37	38	2.8	0.3	2	6.5	18.2	3.1	0.4	0.1	24.2	90
5-18	57	3	11	27	60	0.9	0.2	1	5.4	4.9	1.6	0.1	t	13.4	49
18-51	58	12	18	21	50	0.4	0.1	1	4.5	2.1	1.9	t	0.1	10.5	39

Assemblage IV

PROFILE 6 — Orthic Acrisol - Lividol Family and Tedong Series

Location — Pit at Chain 3, Rentis 11
(grid ref.) (Mapping Unit IV)

Site: Macrorelief — Rolling terrain of lava flow
Microrelief — Near foot of short slope
Slope — 4°
Elevation — 75 ft. a.s.l.
Drainage — Free
Parent Material — Vesicular lava
Vegetation/Land use — Secondary forest
Soil Drainage — Excessively well drained

Description

Horizon	Depth cm	Depth (in)	
Ah	(0-2.5)	0-1	Dark greyish (10 YR 3/3) humic loam; very friable; well developed fine to medium crumb structure; porous; many woody and fibrous roots merging smooth and abrupt to:
E	(2.5-10)	1-4	Dark brown (10 YR 3/3) loam; slightly firm; well developed fine to medium subangular blocky and breaking to fine crumb structure; many pores; few weathering stones of vesicular lava; many woody and fibrous roots; merging clear and smooth to:
B1	(10-23)	4-9	Brown to dark brown (10 YR 3/3) clay loam; friable; well developed fine subangular blocky breaking into fine crumb structure; many pores; few weathering stones; merging clear and smooth to:
B2t	(23-33)	9-13	Brown to dark brown (10 YR 4/3) clay loam; friable; well developed fine subangular blocky and breaking to fine crumb structure; porous; few woody and fibrous roots; merging smooth and gradual to:
BCr	(33-51)	13-20	Brown to dark brown (10 YR 4/3) clay loam; well developed fine subangular breaking to fine crumb structure; porous with big boulders of vesicular lava; very few fibrous roots;
(Cr)	(51 +)	20 +	As above but becoming more stony at base

Depth (cm)	Lab. No.	Particle size distribution (%) C Sand	F Sand	Silt	Clay	Org. C (%)	Total N (%)	Easily sol. P	pH H_2O	Exchangeable cations (meq%) Ca	Mg	K	Na	C.E.C. (meq%)	Base satn (%)
0-2.5	C62208	7	28	23	31	5.6	0.47	4	6.5	18.8	9.5	0.5	0.2	30.1	96
2.5-10	09	6	26	26	39	1.4	0.18	0	5.6	2.7	3.2	0.2	t	11.0	56
10-23	10	5	22	25	46	1.3	0.11	1	5.1	0.2	3.5	t	t	10.4	36
23-33	11	4	15	14	64	0.6	0.09	5	5.2	0.2	2.4	t	t	11.3	24
33-51	12	3	13	18	67	0.5	0.08	1	5.8	0.2	1.8	0.1	0.1	24.3	9
51 +	13	3	13	18	67	0.4	0.07	1	5.3	0.2	2.1	t	0.1	11.8	21

Assemblage V

PROFILE 7 — Orthic Acrisol of the Tanjong Lipat Family and Series

Location — Pit at Chain 14.5, Rentis 11

(grid ref.) (Kapping Unit V)

Site: Macrorelief — Low rolling peneplain
Microrelief — Near top of short slope
Slope — 5°
Elevation — 50 ft. a.s.l.
Drainage — Free
Parent Material — Sandstone
Vegetation/Land use — Broken Primary Forest
Soil Drainage — Well drained

Horizon	Depth cm	Depth (in)	Description
A1	(0-5)	0-2	Brown (7.5 YR 4/2) humic sandy loam; very friable; poorly developed fine crumb structure; porous; abrupt smooth merging to:
E	(5-19)	2-7½	Reddish yellow (7.5 YR 6/6) loamy sand; very friable; poorly developed medium to fine subangular blocky structure; porous; few woody and fibrous roots; merging smooth and gradual to:
B1	(19-63)	7½-25	Strong brown (7.5 YR 5/6) few coarse distinct 2-3% brownish yellow (10 YR 6/6) mottles; sandy loam; friable and damp; moderate developed medium subangular blocky structure; porous; few woody and fibrous roots; merging gradual and smooth to:
B2t	(63 +)	25 +	Yellowish red (5 YR 5/6) few medium distinct 3-5% brownish yellow (10 YR 6/6) mottles; clay loam; moderate firm; well developed medium subangular blocky structure; porous roots, few fibrous;

Depth (cm)	Lab. No.	Particle size distribution (%) C Sand	F Sand	Silt	Clay	Org. C (%)	Total N (%)	Easily sol. P	pH H_2O	Exchangeable cations (meq%) Ca	Mg	K	Na	C.E.C. (meq%)	Base satn (%)
0-5	C2604	14	51	14	13	3.5	0.29	8	4.1	0.5	0.5	0.2	0.1	10.8	7
5-19	05	14	54	17	13	0.7	0.07	1	4.5	t	t	t	0	7.4	2
19-63	06	14	53	11	20	0.2	0.03	1	4.8	t	0	0	0	7.5	2
63 +	07	11	45	15	28	0.2	0.03	1	4.8	t	0	t	0	11.1	1

Assemblage VI

PROFILE 8 — Orthic Acrisol - Paliu Family, Lucia Series

Location — Pit at Chain 10, Rentis 17A
(grid ref.) (Mapping Unit VI)

Site: Macrorelief — Slightly dissected terrace
Microrelief — " "
Slope — Nil
Elevation — 50 feet a.s.l.
Drainage — Free
Parent Material — Terraced alluvium
Vegetation/Land use — Secondary regrowth
Soil Drainage — Well drained

Horizon	Depth cm	Depth (in)	Description
A1	(0-8)	0-3	Dark yellowish brown (10 YR 4/4) humic sandy loam; friable; poorly developed fine to medium crumb structure; porous; roots, many woody and fibrous; merging gradual and smooth to:
E	(8-39)	3-15½	Brown to dark brown (7.5 YR 4/4) sandy loam; friable; poorly developed fine to medium crumb structure; porous; roots, many woody and fibrous merging gradual and smooth to:
B1	(39-58)	15½-23	Brown to dark brown (7.5 YR 4/4) loam; friable; structure as above; porous; roots few fibrous; merging gradual and smooth to:
B2tC	(58-84)	23-33	Strong brown (7.5 YR 5/6) with many fine to medium black manganese concretions, clay loam; slightly firm; well developed medium to coarse subangular blocky structure; porous; roots, very few fibrous; merging gradual and smooth to:
BC	(84 +)	33 +	Strong brown (7.5 YR 5/6) common fine distinct 20% yellowish red (5 YR 4/6) mottles; silty clay loam; slightly firm; moderately developed coarse subangular blocky structure with few fine to medium black manganese concretions; no roots.

Depth (cm)	Lab. No.	Particle size distribution (%) C Sand	F Sand	Silt	Clay	Org. C (%)	Total N (%)	Easily sol. P	pH H_2O	Exchangeable cations (meq%) Ca	Mg	K	Na	C.E.C. (meq%)	Base satn (%)
0-8	C2648	12	61	16	9	1.4	0.14	0	4.9	0.7	0.5	0.1	0	5.6	22
8-39	49	11	60	10	14	0.3	0.05	1	5.1	0	0.2	0	0	3.6	8
39-58	50	10	55	17	19	0.1	0.03	1	5.3	0.1	0.3	0	0	4.9	8
58-84	51	10	45	18	29	0.1	0.03	3	5.3	0	0.3	0	0	8.6	4
84 +	52	6	43	17	36	0.1	0.02	0	5.2	t	0.3	t	0	10.6	4

Assemblage VI

PROFILE 9 Orthic Luvisol - Numatoi Family

Location

(grid ref.) (Mapping Unit VI)

Site: Macrorelief Edge of lava flow-terrace site
Microrelief On small hillock
Slope Hil
Elevation 35 feet a.s.l.
Drainage Free
Parent Material Colluvial material from edge of lava flow
Vegetation/Land use Belukar with Siam Weed
Soil Drainage Well drained

Horizon	Depth cm	Depth (in)	Description
A	(0-5)	0-2	Brown to dark brown (10 YR 4/3) humic loam; friable; well developed fine - coarse crumb structure; porous; many fibrous roots; merging clear and smooth to:
AE	(5-30.5)	2-12	Yellowish brown (10 YR 5/4) loam; friable (damp) well developed medium to coarse subangular blocky structure; porous; few fibrous roots; merging gradual and smooth to:
Bt	(30.5-41)	12-16	Yellowish brown (10 YR 5/4) loam; friable; massive; poorly developed medium to coarse subangular blocky structure; porous; few fibrous roots;

Depth (cm)	Lab. No.	Particle size distribution (%) C Sand	F Sand	Silt	Clay	Org. C (%)	Total N (%)	Easily sol. P	pH H_2O	Exchangeable cations (meq%) Ca	Mg	K	Na	C.E.C. (meq%)	Base satn (%)
0-5	C2653	11	40	20	26	3.6	0.33	2	7.5	26.9	2.6	0.2	0.2	25.0	>100
5-31	54	14	44	18	23	0.9	0.11	t	6.4	9.8	1.8	0.1	0.1	13.8	85
31-41	55	10	24	14	52	0.6	0.08	1	6.0	15.4	2.2	0.2	0.2	24.9	92

Assemblage VII

PROFILE 10 — Eutric Gleysol - Kansarahan Family

Location — Pit at Chain 11, Rentis 11
(grid ref.) (Mapping Unit VII)

Site: Macrorelief	Shallow valley
Microrelief	On levee near stream
Slope	Flat
Elevation	60 feet a.s.l.
Drainage	Impeded
Parent Material	Alluvium
Vegetation/Land use	Broken primary forest
Soil Drainage	Poorly drained

Horizon	Depth cm	Depth (in)	Description
AL	(0-1)	0-½	Dark brown (10 YR 3/3) humic loam; friable; well developed fine subangular blocky, breaking into fine crumb structure; porous; many woody and fibrous roots; merging abrupt and wavy to:
AC	(1-15)	½-6	Dark yellowish brown (10 YR 4/4) common medium to coarse distinct 10-12% pinkish grey (7.5 YR 3/2) and many fine medium distinct 20-25% strong brown (7.5 YR 5/8) mottles; fine sandy loam; friable and damp; mod. weakly developed medium to coarse subangular blocky structure; porous; few woody and fibrous roots; merging gradual and diffuse to:
C1g	(15-36)	6-14	Brown to dark brown (7.5 YR 4/4) few fine to medium distinct 3-5% pinkish grey (7.5 YR 6/2) and few fine dist. 5-7% strong brown (7.5 YR 5/8) mottles; fine sandy loam; friable; (moist) moderately developed medium to coarse subangular blocky structure; many pores; few woody and fibrous roots; merging gradual and smooth to:
C2gcn	(36-58)	14-23	Brown to dark brown (10 YR 4/3) few fine point 2-3% yellowish brown (10 YR 5/8) mottles; clay loam; damp and firm; moderately developed medium to coarse subangular blocky structure; many pores; many soft dark brown concretions; very few fibrous roots; merging smooth and gradual to:
C3gcn	(58-81)	23-32	Light brownish grey (10 YR 6/2) many fine to medium dist. 20% dark yellowish brown (10 YR 4/4) mottles; clay loam-clay; firm and damp - weakly developed coarse subangular blocky structure; many soft dark brown concretions; many pores; no roots.

Depth (cm)	Lab. No.	Particle size distribution (%) C Sand	F Sand	Silt	Clay	Org. C (%)	Total N (%)	Easily sol. P	pH H_2O	Exchangeable cations (meq%) Ca	Mg	K	Na	C.E.C. (meq%)	Base satn (%)
0-1	00214	3	63	14	14	1.7	0.10	5	6.4	9.0	3.8	0.3	0.1	18.8	67
1-15	15	3	63	15	17	0.4	0.07	t	5.5	1.1	7.3	0.1	0.1	13.9	61
15-36	16	4	63	13	19	0.3	0.05	t	5.7	0.8	6.5	0.1	0.1	14.4	55
36-58	17	2	57	18	24	0.3	0.06	0	6.7	2.9	13.5	0.1	0.2	18.4	87
58-81	18	4	49	18	27	0.2	0.04	1	7.1	1.4	16.1	0.1	0.2	22.0	81

Assemblage VII

PROFILE 11 — Eutric Fluvisol - Sumliad Family and Series SD

Location — Pit at Chain 40, Rentis 11
(grid ref.) (Mapping Unit VII)

Site: Macrorelief — Flat small valley floor
Microrelief — Flat about 30 feet from small stream
Slope — Nil
Elevation — 50 feet a.s.l.
Drainage — Impeded
Parent Material — Alluvium
Vegetation/Land use — Primary Forest
Soil Drainage — Poorly drained

Horizon	Depth cm	Depth (in)	Description
[illegible]	(0-2.5)	0-1	Brown (10 YR 5/3) common coarse to very coarse distinct 7-10% iron staining dark reddish brown (2.5 YR 3/4); slightly humic sandy loam; friable and damp; weak medium to coarse subangular blocky structure; porous; common woody and fibrous roots; merging smooth and abrupt to:
A1	(2.5-28)	1-11	Dark yellowish brown (10 YR 4/3) many fine to medium distinct 15-20% grey (10 YR 6/1) and common medium distinct 10-12% strong brown (7.5 YR 5/6) mottles; fine sandy loam; friable and damp; moderately developed coarse subangular blocky structure; porous; few woody and fibrous roots; merging smooth and gradual to:
AC	(28-58.5)	11-23	Light brownish grey (10 YR 6/2) common fine distinct 5-7% yellowish brown (10 YR 5/6) and many medium to coarse distinct washed down material down from above 20-25% brown to dark brown (10 YR 4/3) mottles; sandy loam; friable and damp; moderately developed fine to coarse subangular blocky structure; porous; many fine soft dark brown concretions; no roots;
C	(58.5 +)	23 +	Light brownish grey (10 YR 6/2) many coarse to very coarse distinct 20-25% strong brown (7.5 YR 5/6) mottles; sandy clay loam; friable and damp; moderately weak developed medium to coarse subangular blocky structure; many soft block material porous; no roots

Depth (cm)	Lab. No.	Particle size distribution (%) C Sand	F Sand	Silt	Clay	Org. C (%)	Total N (%)	Easily sol. P	pH H_2O	Exchangeable cations (meq%) Ca	Mg	K	Na	C.E.C. (meq%)	Base satn (%)
0-2.5	CP719	4	75	11	5	1.0	0.11	7	5.6	3.9	3.5	0.2	0.1	16.7	45
2.5-28	20	8	54	21	16	0.3	0.05	1	5.6	1.0	6.1	0.1	0.1	11.7	63
28-58	21	11	59	15	14	0.1	0.03	2	5.9	0.6	4.0	0.1	0.1	7.5	64
58 +	22	19	55	10	16	0.1	0.03	1	6.2	1.9	6.4	0.1	0.3	11.7	74

Assemblage VII

PROFILE 12 — Dystric Gleycol - Padang Family

Location — Pit at Chain 70, Rentis 11

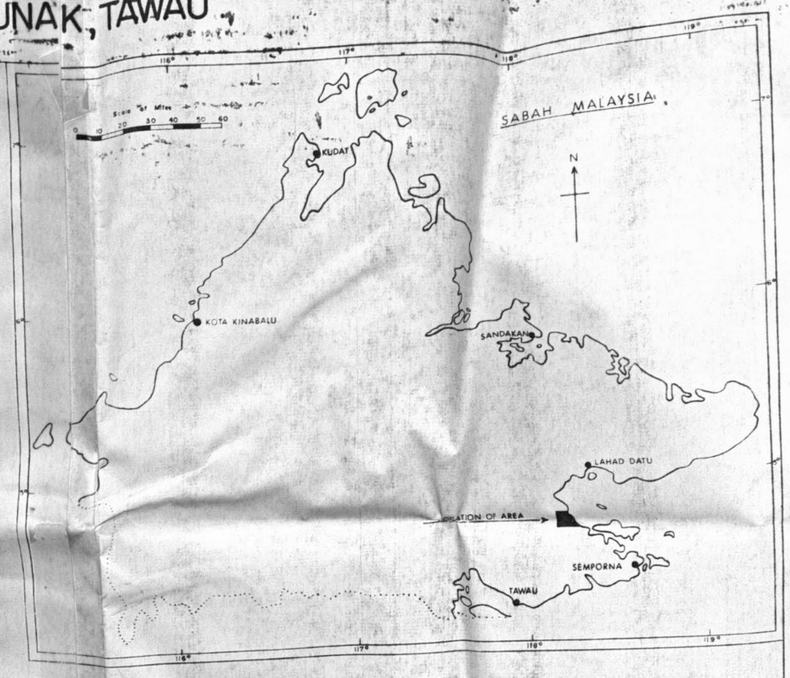
(grid ref.) (Mapping Unit VII)

Site: Macrorelief — Coastal Plain
Microrelief — Small undulations
Slope — Nil
Elevation — 30 feet a.s.l.
Drainage — Impeded
Parent Material — Alluvium
Vegetation/Land use — Primary forest
Soil Drainage — Poorly drained

Horizon	Depth cm	Depth (in)	Description
Ah	(0-2.5)	0-1	Dark yellowish brown (10 YR 4/4) loam; friable; poorly developed fine to medium crumb structure; porous; roots many woody and fibrous roots; boundary abrupt and smooth to:
A?	(2.5-15)	1-5	Yellowish brown (10 YR 5/4) silt loam; friable; moderately developed coarse crumb to fine subangular blocky structure; porous; roots many woody and fibrous; merging gradual and smooth to:
[illegible]	(15-25)	5-10	Light grey to grey (10 YR 6/2) common fine to medium distinct 15-20% yellowish brown (10 YR 5/6) mottles; silt loam; friable; structure as above porous; roots common woody and fibrous; few fine to medium black concretions merging gradual and smooth to:
[illegible]	(25-53)	10-21	Yellowish brown (10 YR 5/6) common 10-15% fine to medium distinct light brownish grey (10 YR 6/2) and many 15-20% fine distinct strong brown (7.5 YR 5/6) mottles; silty clay loam; friable; well developed medium to coarse subangular blocky structure; porous; roots few woody and fibrous merging gradual and smooth to:
[illegible]	(53-81)	21-32	Light grey (10 YR 6/1) common 15-20% medium distinct brownish yellow (10 YR 6/8) mottles; clay; firm; well developed medium to coarse subangular blocky structure with few faint grey (10 YR 5/1); slightly porous; few medium to coarse black concretions; few fibrous roots; merging gradual and smooth to:
[illegible]	(81-119.5)	32-46	Light grey (10 YR 6/1) many coarse distinct 25-40% brownish yellow (10 YR 6/8) mottles; clay, firm and damp, massive; concretions as above; very few pores; no roots.

Depth (cm)	Lab. No.	Particle size distribution (%) C Sand	F Sand	Silt	Clay	Org. C (%)	Total	Easily sol. P	pH H2O	Exchangeable cations (meq%) Ca	Mg	K	[illegible]	C.E.C. (meq%)	Base satn (%)
0-2.5	62823	3	45	34	14	2.6	0.26	4	5.2	3.5	2.4	0.3	0.1	14.4	44
2.5-15	24	2	46	37	15	0.7	0.09	1	5.0	0.1	1.0	t	t	7.1	17
15-25	25	5	42	39	15	0.3	0.07	2	5.5	0.1	1.5	t	0.1	7.5	23
25-53	26	5	36	41	19	0.2	0.03	1	5.9	0.3	1.2	t	0.1	8.4	18
53-81	27	3	38	26	34	0.1	0.03	1	5.7	1.1	2.3	0.1	0.3	16.3	23
81-120	28	7	34	22	38	0.1	0.03	0	5.8	2.0	3.5	0.2	0.4	18.9	33

INTRODUCTORY MAP LORMALONG EXTENSION AREA, KUNAK, TAWAU.



LEGEND

- River
- Road
- Present Survey Rentis (1973)
- Reconnaissance Survey Rentis (1966)
- Forest Reserve Boundary Including Proposed V.J.R
- Contours (50 Feet Intervals)
- Forest Inventory Aerial Photo Centres 1970

(Not under survey)

DARVEL BAY

S. Tingkayu

S. Wahong

S. Madai

S. Materis

S. Lormalong

Kuala Madai

To Lahad Datu

(V.J.R)

MADAI - BATURONG FOREST RESERVE

PRESENT LORMALONG SCHEME

SCALE 1:25,000

MILE 0 1/4 1/2 3/4 1 2 MILES

FOOT 0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10000 FEET

Detailed by D.W. McCredie, Soil Scientist,
Drawn by The Cartographic Division,
Agricultural Research Centre, Tuaran.
Dated July 1973
Index No. 1/SP/62

SOIL MAP - LORMALONG EXTENSION AREA, KUNAK, TAWAU.

MAP SYMBOL	DESCRIPTION	ALLIED SABAH SOILS ASSOCIATION	LAND USE RECOMMENDATION	ACREAGE
I	Assemblage of soils developed on steepland (slopes 15° - 25°) derived from mainly much altered ultrabasic rocks (serpentenite) of the Slump Formation	Beruang Association	Not recommended for agriculture because of steepness and possible nutrient problems	2732
II	Assemblage of soils developed on steepland (slopes 15° - 25°) derived from mainly vesicular lava of the Slump Formation	Segama Association	Not recommended for agriculture because of steepness	183
III	Assemblage of soils developed on rolling to hill land (5° - 15°) derived from a heterogeneous parent materials mainly much altered ultrabasic rocks (serpentenite) of the Slump Formation	—	Recommend for general planting of oil palm (with trial plots of cocoa)	1648
IV	Assemblage of soils developed on rolling to hill land (5° - 15°) derived from vesicular lava - a component of the Slump Formation and nearer Lormalong, an extension of the Mostyn Flow	Mostyn Association	Recommended for general planting of cocoa	1488
V	Assemblage of soils developed on rolling to hill land (5° - 15°) derived from medium grained sandstone - a component of the Slump Formation	Rumidi Association	Recommend for general planting of oil palm or cocoa	119
VI	Assemblage of soils developed on flat to gently rolling land derived from raised alluvium	Brantian Association	Recommended for general planting of oil palm with drainage in places	1834
VII	Assemblage of soils developed on flat terrain derived from active alluvium	Kinabatangan Association	Recommended for general planting of oilpalm and coconuts with drainage as a pre-requisite	1927

LEGEND

- River
- Road
- Forest Reserve Boundary
- Soil Boundary

(NOT UNDER SURVEY)

MANGROVE

DARVEL BAY

S. Tingkayu

To Lahad Datu

S. Wahong

(V.J.R.)

MADAI - BATURONG FOREST RESERVE

S. Medai

S. Matarid

MANGROVE

PRESENT LORMALONG SCHEME

N

SCALE 1:25,000

MILE 0 1/4 1/2 3/4 1 2 MILES

FOOT 0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10000 FEET

Detailed by D.W. McCredie, Soil Scientist,
Drawn by The Cartographic Division,
Agricultural Research Centre, Tuaran
Dated July 1973
Index No. 1/SP/62A