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CHARACTERISTICS OF SOME SOILS IN SABAH AND SARAWAK

Published as Part of the
Tour Guide for Post-Conference Tour
21-27 AUGUST 1977



CLAMATROPS

Conference on
Classification and
Management of Tropical Soils

KUALA LUMPUR, MALAYSIA
15-20 AUGUST 1977

MALAYSIAN SOCIETY OF SOIL SCIENCE

Donated by C.J. Sergeant
September 1990

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IN SABAH AND SARAWAK**

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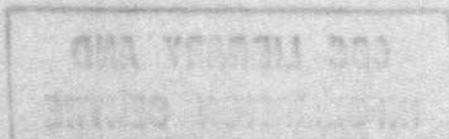
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PREFACE

The objective of this publication is to highlight the characteristics of some of the common soils mapped in Peninsular Malaysia, Sabah and Sarawak so that it serves as a guide or forms the basis for discussion during the pre- and post-conference tour of the Conference on Classification and Management of Tropical Soils, organised by the Malaysian Society of Soil Science, in Kuala Lumpur on 15-20th August 1977. For convenience the publication is presented in two volumes for the respective tours.

The agricultural sector plays an important role in the Malaysian economy. In 1976, Agricultural output accounted for 30 percent of the Gross Domestic product, and this expected to increase significantly in the coming years. The development in this sector will contribute significantly to the achievement of the objectives embodied in the new economic policy, particularly the eradication of poverty and the improvement of the productivity of the labour force through its transfer into high productivity agriculture. To accelerate the expansion and modernisation of the agriculture sector, large land development schemes are being launched. Optimum utilisation of land resources become imperative to sustain the high level of Agricultural productivity, and it is here that Soil Science plays a key role. A sound knowledge of the physical and chemical properties of the soil is necessary for us to be able to predict the behaviour and response of these soils to different levels of management.

In selecting the profiles, an attempt has been made to encompass a wide range of soils. From the landuse point of view, in this case primarily agricultural these include the good, marginal and problem soils.

The nature of these soils also focusses attention on some of the problems in field mapping and classification of these soils. It is

hoped that the examination of these profiles will highlight the need to reassess some of the criteria used in the classification of the tropical soils. For example, the permanent charge of 1.5 meq. is used in soil taxonomy to separate the highly weathered oxisols (Acrorthox) from other oxisols. The criteria is often very difficult to apply or determine. Another important criteria is the presence of ironstone nodules in the solum, a widely occurring feature in Peninsular Malaysia. Although these nodules form an important root restricting layer, this criteria is only considered at the family level in soil taxonomy. There may need to consider this criteria at a higher level.

Various organisations contributed towards the completion of these 2 volumes: these were the Department of Agriculture in Peninsular Malaysia, Sabah and Sarawak; MARDI; RRIM and UPM. Special mention must be made for the notable contributions made by Dr. H. Eswaran and all others in the Tours Sub-Committee without whose efforts, encouragement and advice this work would not have been possible. Additionally the contribution of Mr. Chew Poh Soon on the soil suitability evaluation for oil palm and cocoa is also acknowledge.

The composition of the committee responsible for the Tour and compilation of these two volumes are:

Chairman:	B. Gopinathan
Co-Chairman:	Dr. S. Paramanathan
Secretary:	Noordin Daud
Members:	C.P. Lim
	M.S. Kalsi
	Dr. H. Eswaran
	E. Pushparajah (Ex Officio, President MSSS)
	H.Y. Chan (Ex Officio, Secretary MSSS)

August, 1977

B. Gopinathan

PART I

1. THE SABAH AGREEMENT

THE PHYSICAL ENVIRONMENT

Location

The State of Sabah, Malaysia, occupies the northern portion of the island of Borneo. Its immediate neighbours are Sarawak, also a State in the Federation of Malaysia, Brunei, a State under British protection and Kalimantan, which is part of Indonesia. The total area of Sabah is 78100 km² (30158 mi²). The population at the time of the 1970 Census was 822822 with settlements mainly on the east and west coasts, the interior plains and along the main rivers. Most of the interior and eastern parts of Sabah are unhabited and consist of mountain ranges and broad valley tracts covered in dense forest. Kota Kinabalu, the State capital, is situated on the west coast. It has a population of 142430 and is the largest town, having a fine port on the northern shore of Sandakan Harbour. Tawau, Lained Datu and Kudat are also important ports on the east coast.

1. THE PHYSICAL ENVIRONMENT

Road networks radiate from the main towns, the majority of which are now linked by road. Kota Kinabalu, for example, is linked to Kudat in the north and Sipitang in the south by the West Coast Highway. It is also linked to Sandakan by the recently completed East-West Highway and to Tambunan and Keningau by a recently completed road across the Crocker Range. On the east coast a major network links Tawau, Kunak, Sepomua and Lained Datu and it is proposed to link this to the other networks by constructing a road from Lained Datu to the East-West Highway. In addition to roads, the main towns are all served by regular internal air services and there are also international flights to Singapore, West Malaysia and Hong Kong.

I. THE PHYSICAL ENVIRONMENT

Location

The State of Sabah, Malaysia, occupies the northern portion of the island of Borneo. Its immediate neighbours are Sarawak, also a State in the Federation of Malaysia, Brunei, a State under British protection and Kalimantan, which is part of Indonesia. The total area of Sabah is 76100 km^2 (29388 mi^2). The population at the time of the 1970 Census was 655622 with settlements mainly on the east and west coasts, the interior plains and along the main rivers. Most of the interior and eastern parts of Sabah are uninhabited and consist of mountain ranges and broad valley tracts covered in dense forest. Kota Kinabalu, the State capital, is situated on the west coast. It has a population of 61645. Sandakan, on the east coast, has a population of 72430 and is the largest town, having a fine port on the northern shore of Sandakan Harbour. Tawau, Lahad Datu and Kudat are also important ports on the east coast.

Road networks radiate from the main towns, the majority of which are now linked by road. Kota Kinabalu, for example, is linked to Kudat in the north and Sipitang in the south by the West Coast Highway. It is also linked to Sandakan by the recently completed East-West Highway and to Tambunan and Keningau by a recently completed road across the Crocker Range. On the east coast a major network links Tawau, Kunak, Semporna and Lahad Datu and it is proposed to link this to the other networks by constructing a road from Lahad Datu to the East-West Highway. In addition to roads, the main towns are all served by regular internal air services and there are also international flights to Singapore, West Malaysia and Hong Kong.

The rivers are still vital for communications particularly on the east coast. The Kinabatangan, which is the longest river, follows a course of over 550 km (340 mi) from its source in the Trusmadi Range to the sea south-east of Sandakan. It is navigable by large launches as far as Pintasan and as far as Pinangah by shallow draught boats powered by outboards engines.

Climate

The climate is hot and humid throughout the year and although Sabah lies outside the typhoon belt the coastal areas are occasionally affected by severe tropical storms. The average annual rainfall ranges from 1780 mm (70 in.) to about 3800 mm (150 in.). The highest rainfall is in the south-west (Beaufort and Labuan) and the lowest is in the interior (Tenom, Keningau and Tambunan) and at Tawau on the south-east coast. The contrasts in regional rainfall reflects the occurrence of 2 main seasons; the north-east monsoon begins in November and lasts until March and it is during this season that the north-east coast experiences its heaviest rainfall; the south west monsoon prevails from May until September. The temperature varies little with the season and averages about 27°C (80°F) near sea level. Surface temperatures inland falls at a rate of about 1.5°C (3°F) for every 300 m (100 ft.) increase in altitude so that above about 1200 m (4000 ft.) there is a change from Tropical Rainy Climate to Warm Temperate Rainy Climate (Trewartha, 1954); the latter affects much of the Crocker and the Trusmadi Ranges above 1200 m (4000 ft.). Climate data are very limited, but records of a reasonable length are available for Labuan, Kota Kinabalu, Kudat, Beaufort, Tenom, Sandakan, Tawau and Tambunan. The rainfall distribution of Sabah is shown in Map 1.

Physiography

Sabah can be divided into 4 main physiographic regions, namely the Western Lowlands, the Western Cordillera, the Central Uplands and the Eastern Lowlands (Collenette, 1963). The Western Lowlands include the foothills, plain and islands to the west of the Crocker Range. The Western Cordillera comprises a belt of mountainous country about 80 km (50 mi) in width parallel to the West Coast. It includes the Crocker, Trusmadi, Wittti and Maligan Ranges and associated intermontane plains and valleys. The Crocker Range is one of the main geographical features of the country and it culminates in Gunong Kinabalu, which at 4101 m (13455 ft.) is the highest mountain in South-east Asia. The Central Uplands comprise extensive tracts of mountainous country to the east of the Western Cordillera, including the Labuk, Kuamut, Segama and Tawau Highlands. The Eastern Lowlands stretch from the Bengkoka Peninsular in the north to the Semporna Peninsular in the south and include extensive tracts of moderate to low hills, the broad valleys of the Sugut, Labuk, Kinabatangan and Segama rivers and extensive deltas. (See Map 2).

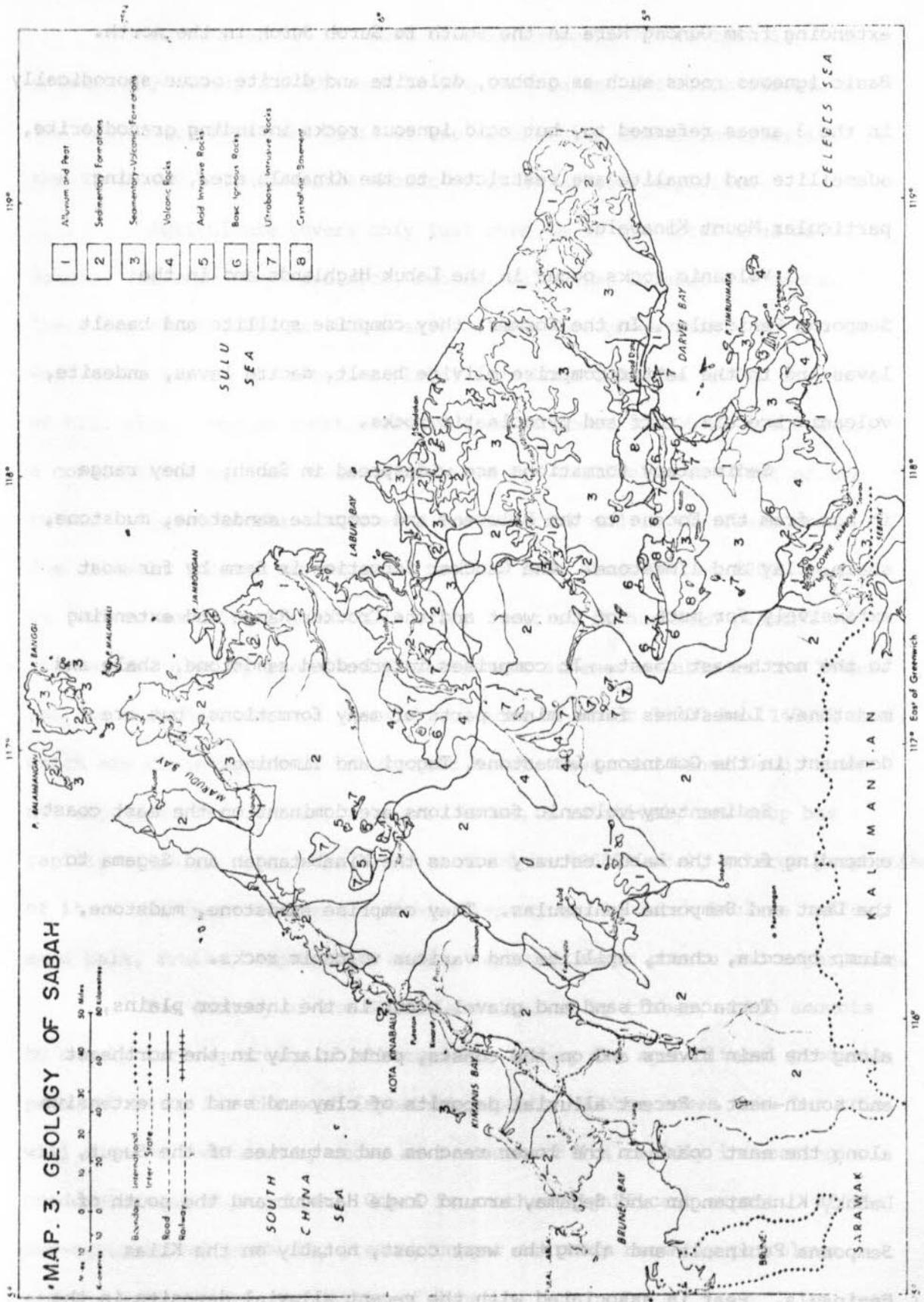
Geology

The geology of Sabah is described in the Memoirs of the Geological Survey of the Borneo Region of Malaysia; the main geological formations are shown in Map 3.

The oldest rocks in Sabah, referred to collectively as Crystalline, Basement, include granodiorite, gabbro, migmatite, amphibolite, hornblende, gneiss, hornfels and schist; they only occur in the Tawau and Lahad Datu Districts, notably in the Segama catchment.

Intrusive igneous rocks occur in 3 main areas, namely Kinabalu, the Labuk Highlands and in the Tawau and Lahad Datu Districts. Ultra basic rocks, composed largely of serpentized peridotite, are form

MAP. 3. GEOLOGY OF SABAH



- | | |
|---|---------------------------------|
| 1 | Aluminum and Bauxite |
| 2 | Sedimentary Formations |
| 3 | Sedimentary-Volcanic Formations |
| 4 | Volcanic Rocks |
| 5 | Acid Intrusive Rocks |
| 6 | Basic Igneous Rocks |
| 7 | Ultrabasic Intrusive Rocks |
| 8 | Cryotaphic Basement |

119°E

118°E

117°E

116°E

5°N

4°N

5°N

119°E

118°E

117°E

116°E

5°N

SULU
SEA

CELEBES SEA

SOUTH
CHINA
SEA

KALIMANTAN

SARAWAK

P. BALAMANGAU
P. BANGGI
P. MALAMBU

MARUDI BAY
JAMPONGAN

LABUK BAY

KOTA KINABALU

KINABALU BAY

BRUNEI BAY

DARVEI BAY

P. TIRUNIMBA

LIBATA

Paritangan

Tudau

Sanakan

most extensively, in particular, the mountain range in the Labuk Highlands extending from Gunong Rara in the south to Suroh Suroh in the north.

Basic igneous rocks such as gabbro, dolerite and diorite occur sporadically in the 3 areas referred to, but acid igneous rocks including granodiorite, adamellite and tonalite are restricted to the Kinabalu area, forming particular Mount Kinabalu.

Volcanic rocks occur in the Labuk Highlands and in the Semporna Peninsular. In the former, they comprise spillite and basalt lavas and in the latter comprise olivine basalt, dacite lavas, andesite, volcanic breccia, tuff and pyroclastic rocks.

Sedimentary formations are widespread in Sabah; they range in age from the Eocene to the Pliocene and comprise sandstone, mudstone, shale, clay and limestone. The Crocker formation is form by far most extensively for much of the west and the Crocker Range and extending to the north-east coast. It comprises interbedded sandstone, shale and mudstone. Limestones forms minor parts of many formations, but are dominant in the Gomantong Limestone, Togopi and Timohing.

Sedimentary-volcanic formations are dominant on the east coast, extending from the Labuk estuary across the Kinabatangan and Segama to the Dent and Semporna Peninsulas. They comprise sandstone, mudstone, slump breccia, chert, spillite and various volcanic rocks.

Terraces of sand and gravel occur in the interior plains, along the main rivers and on the coasts, particularly in the northeast and south-east. Recent alluvial deposits of clay and sand are extensive along the east coast in the lower reaches and estuaries of the Sugut, Labuk, Kinabatangan and Segama, around Cowie Harbour and the south of Semporna Peninsula and along the west coast, notably on the Klias Peninsula. Peat is associated with the recent alluvial deposits in the Klias Peninsula and the lower reaches of the Kinabatangan and Segama.

Land Use

As much as 92% of Sabah is still forest, 72% of this is primary diptocarp and 10% each of wet-land forest and scrub forest. The diptocarp forms the basis of the flourishing timber industry in the State but a considerable amount of it is already exploited.

Agriculture covers only just over 4% of the total area of Sabah. The main crops are rice, rubber, oil palm, coconut and cocoa. There are about 32000 ha (80000 ac.) of wet rice grown mainly on the west coast and on the interior plains and about 10000 ha (25000 ac.) of hill rice. Rubber constitutes an area of about 105000 ha (260000 ac.) a considerable portion of which is grown by smallholders. Most of the rubber is grown in the west coast, the interior and in the Tawau area. The oil palm acreage has expanded rapidly from about 800 ha (2000 ac.) in 1961 to some 58000 ha (145000 ac.); most of it has been planted by estates and also by governmental settlement schemes notable in the Tawau and Sandakan Residencies. Coconut acreages of about 56000 ha (140000 ac.), which are concentrated in three areas Kudat, Tawau and Lahad Datu, have not expanded over the last 5 years. Cocoa, a relatively new crop has rapidly expanded in acreage to about 10000 ha (25000 ac.), a large proportion of it in the Tawau Residency. Other crops grown in Sabah include coffee, sago palm, fruits, vegetables, maize, tapioca, sweat potato and sugar cane.

The economy of the State is dominated by timber, which amounts to nearly three-quarters of all exports. Among the agricultural products, palm oil is by far the most important export. Rubber comes next but this will soon be overtaken by cocoa as a result of its rapidly increasing production and high prices. Copra is another significant export. Of the non-agricultural products, prawns, copper and very recently petroleum are the main export commodities of Sabah.

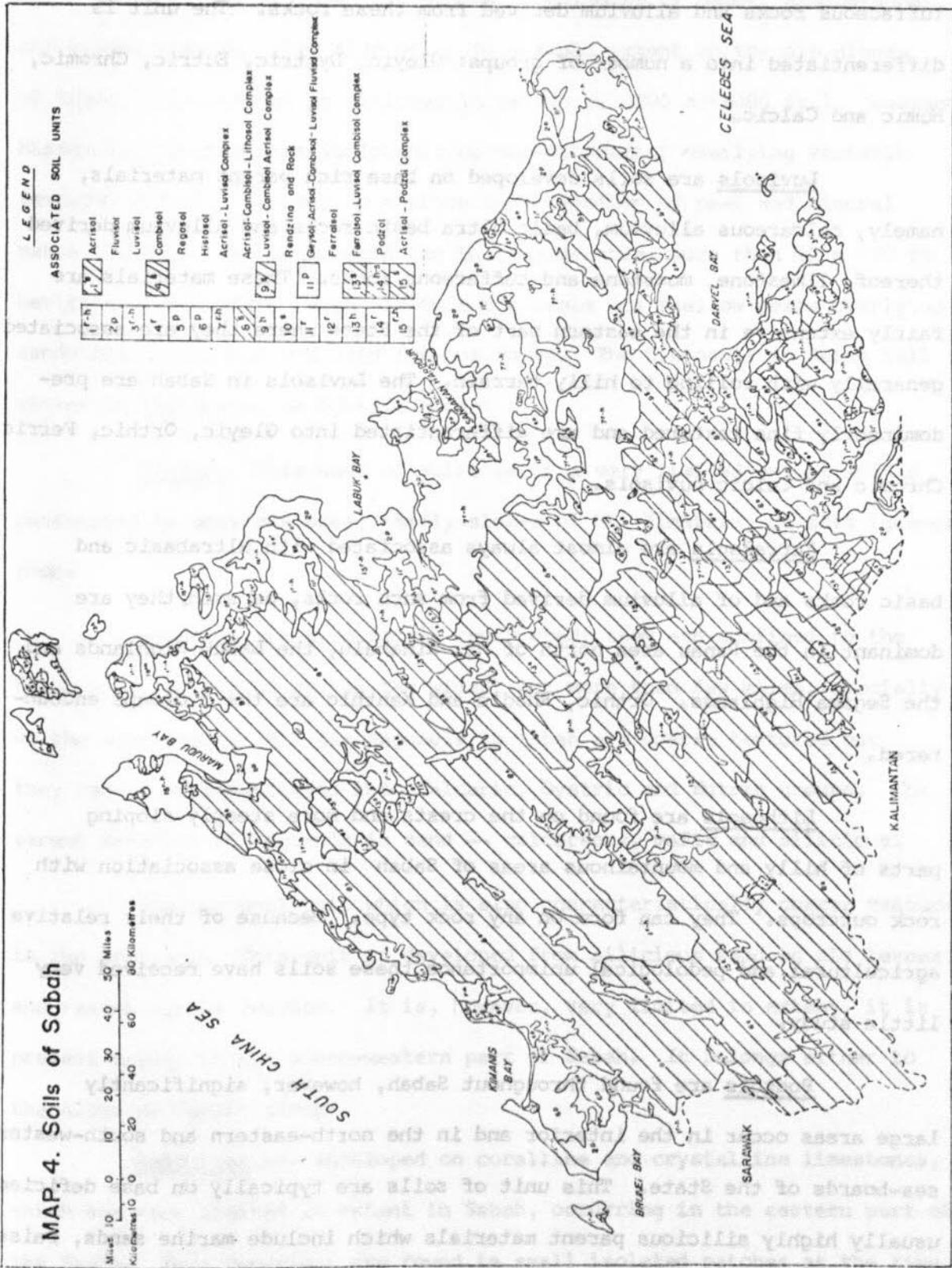
SOILS

The whole of Sabah has been covered by reconnaissance soil surveys. In addition some 295000 ha (730000 ac.) or 3.9% of the area of the State have been subjected to semi-detailed and detailed surveys. All these works are contained in various soil survey reports of the Department of Agriculture, with two of these reports formally published (Paton 1963; and Acres et al 1975). The broad soil units are shown in Map 4.

By far the most extensive soil in Sabah is the Acrisol. This soil unit occurs, apart from swamps and beach sand, on all landforms and on a wide range of parent materials (sandstone, shale, mudstone, igneous rocks, volcanic ash and alluvium) throughout the State. Four groups of Acrisols, namely, Orthic, Gleyic, Ferric and Humic Acrisols are present.

Fluvisols are perhaps the next most extensive soil unit in the State. This unit is developed from recent alluvial deposits and is dominant along the coastal area particularly on the east coast of Sabah. It is also extensive in river valleys which are subjected to periodic flooding and addition of alluvium. The four groups of Fluvisol recognized by FAO, namely, Thionic, Calcic, Dystric and Eutric all occur in Sabah. Another unit significant in the river valley is Gleysol. In the river valleys, Gleysols are formed on alluvium where gleyic horizons results from the fluctuation of groundwater, but they also occur at high altitudes, on sandstone and acid igneous rocks, under continuous moist conditions where gleying is caused by surface water effects. Humic, Dystric, Eutric Gleysols (the last two with or without the Thionic subgroup) have been described in Sabah.

Cambisol is also quite a common unit. It is associated with areas of strong active erosion or alluvial deposition generally occurring on steep land, river levees and flood plains. The parent materials include



...large areas occur in the north-eastern and ...
 ...parent materials which include ...
 ...acid igneous rocks. There are four groups ...

acid to ultra basic igneous rocks, sandstone, mudstone, limestone, chert, tuffaceous rocks and alluvium derived from these rocks. The unit is differentiated into a number of groups: Gleyic, Dystric, Eutric, Chromic, Humic and Calcic.

Luvisols are soils developed on base rich parent materials, namely, calcareous alluvium, basic ultra basic rocks and alluvium derived thereof, limestone, mudstone and tuffaceous rocks. These materials are fairly extensive in the eastern part of the State where they are associated generally with rolling to hilly terrain. The Luvisols in Sabah are predominantly fine textured and are differentiated into Gleyic, Orthic, Ferric Chromic and Calcic Luvisols.

Ferralsols are almost always associated with ultrabasic and basic rocks and of alluvium derived from such rocks, as such, they are dominant in the Ranau area north of Mt. Kinabalu, the Labuk Highlands and the Segama Highlands. Orthic, Rhodic and Xanthic are the 3 groups encountered.

Lithosols are found on the crests and more steeply sloping parts of hilly and mountainous areas of Sabah in close association with rock outcrops. They can form on any rock type. Because of their relative agricultural and pedological unimportance these soils have received very little study.

Podzols are found throughout Sabah, however, significantly large areas occur in the interior and in the north-eastern and south-western sea-boards of the State. This unit of soils are typically on base deficient usually highly silicious parent materials which include marine sands, raised riverine alluvium, sandstone and acid igneous rocks. There are four groups of Podzols recognized in Sabah, these are Placic, Gleyic, Humic and Orthic.

Histosols These organic soils occur extensively in the south-western part of Sabah and on the floodplains of Labuk, Kinabatangan and Segama rivers. They also occur to a small extent on the dip slopes of higher mountains at an altitude in excess of 1200 m (4000 ft.). Lowland Histosols comprise peat (sulphidic or non-sulphidic) overlying variable textured alluvial deposit, but often intercalation of peat and mineral matter occurs. The peat depth can be considerable, more than 12 m (40 ft.) having been recorded. High altitude Histosols are shallow peats overlying sandstone, ironstone and acid igneous rocks. The Histosols in Sabah fall either in the Eutric or Dystric group.

Rankers This unit of soils is of a very limited extent and is restricted to only one area, namely slopes of Mt. Kinabalu, on acid igneous rocks.

IV. PROFILE CHARACTERISTICS OF SELECTED SOILS

Regosols are also fairly restricted; they are confined to the beach areas as narrow strips the widest not more than few miles, specially on the west coast. All the Regosols in Sabah are coarse textured but they can be differentiated into Calcaric, Dystric and Eutric groups. The parent material of Regosols is sand -- calcareous, mafic and silicious.

Another soil unit which is also characteristically coarse textured is the Arenosol. This unit is developed from silicious sand on old levees and raised marine beaches. It is, however, very limited in extent, it is present mainly in the south-western part of Sabah. It belongs either to the Albic or Cambic group.

Rendzinas are developed on coralline and crystalline limestones, which are very limited in extent in Sabah, occurring in the eastern part of the State. Thus rendzinas are found in small isolated patches at the tips of Dent and Semporna Peninsular, Bum Bum Islands, Banggi Island, and in a small number of prominent steep karst like hills in the Kinabatangan Valley and Tingkayu Area.

EDROWAN FAMILY

Field 16A Table Estate (S.M.), Pagan

Quaternary basalt

Weakly dissected flat to gently rolling plateau

2⁰

Above (at the time of description)

Well drained

Depth (cm)	Description
0-4 (0-4)	Very dark grey (5 YR 3/1) silty clay; strong medium crumb structure; loose; few quartz fragments; few basalt fragments (basalt); few

2. PROFILE CHARACTERISTICS OF SELECTED SOILS

0-7 (0-7)	Dark brown (7.5 YR 3/2) clay; strong medium fine subangular blocky, breaking into fine crumb structure; few angular quartz fragments; many pores; distinct cutans; few gravels; few roots; gradual smooth boundary
-----------	--

FROM

17-22 (7-22)	Brown to dark brown (7.5 YR 4/2) clay; strong fine subangular blocky, breaking into fine crumb structure; very friable; few quartz fragments; many pores; distinct cutans; few roots; gradual smooth boundary
--------------	---

SABAH

55-100 (72-81)	Dark yellowish brown (10 YR 3/4) clay; strong fine crumb structure; very friable; few quartz fragments; few pores; distinct cutans.
----------------	---

100-200 (60-80)	Similar to the above horizon
-----------------	------------------------------

Soil Classification

GEMIC LUVISOL, EDROWAN FAMILY (tentative) (Sabah soil classification)

See The Soils of Sabah Vol. 1 Acres et al. 1975

KOBOVAN FAMILY

KOBOWAN FAMILY

The KOBOWAN FAMILY (ORTHIC LUVISOL) formed on basaltic lava of quaternary origin is so far encountered in the area at BAL Estates and at Mostyn on the Semporna Peninsula. It occurs in association with the soils of Jarangan Family (Xanthic Ferralsol) and of Table Family (Orthic Ferralsol) also developed on basaltic lava, on gently undulating to rolling land surface with pronounced terrace features which are believed to mark the original successive lava flows. The altitude of this landforms range from 250 to 600 feet a.s.l.

All the soil developed from basaltic lava have deep uniform profiles, and are very friable and porous with generally weak to moderate medium subangular blocky structures but easily breaking into fine strongly developed crumbs. Soils of the Kobovan Family however, are distinguished from the rest by having a fairly marked Bt horizon in their profile.

Kobovan Family has not been mapped separately; it appears so far as part of the mapping unit Table Association (Acres et al 1975). This mapping unit occurs only in three places, BAL Estates, Quoin Hill area and at Mostyn and in all amounts to 18000 ha (45000 ac.) in Sabah.

Most of the Kobovan Family formed on basalt has been planted up with cocoa, oil palm, rubber and to some extent pepper.

PEDON 1. KOBOVAN FAMILY

Physico-chemical Data

Horizon	Depth (cm)	Particle size distribution (%)				Org. C (%)	Total N (%)	Easily sol. P (ppm)	pH	
		C Sand	F Sand	Silt	Clay				H ₂ O	0.01N KCl
Ah	0-2	7.7	18.7	51.3	22.3	7.18	0.791	64	7.3	6.6
AB	2-17	6.1	11.5	32.5	49.9	1.16	0.220	7	6.3	5.6
B1	17-55	4.7	8.2	24.3	62.8	0.37	0.134	3	6.2	5.6
Bt2	55-120	3.4	8.7	18.7	69.2	0.06	0.058	2	6.2	5.7
	120-150	3.1	5.5	20.6	70.8	0.30	0.064	3	6.0	5.5
Bt3	150-175	6.5	7.9	17.5	65.6	0.40	0.09	1	5.7	5.1
	175-200	19.0	13.3	14.6	52.4	0.34	0.06	1	5.8	5.5

Exchangeable Cations (meq %)				C.E.C. (meq %)	Base Satr. (%)	Ex.H (m.e.%)	Total P (ppm)	Extr. Fe pH 3 (ppm)	Ext. 1N K (ppm)
Ca	Mg	K	Na						
27.81	5.15	1.81	0.28	39.74	88	0.72	3750	12	5
7.96	1.20	0.60	0.19	14.35	69	1.20	1452	3	5
6.17	0.69	0.19	0.16	10.81	67	0.88	935	3	5
5.20	0.87	0.31	0.18	8.42	78	2.40	831	3	5
3.05	1.35	0.40	0.08	8.01	61	3.28	835	3	6
3.48	0.76	1.06	0.06	8.96	60	1.24	1600	10*	2
2.93	0.68	0.77	0.06	8.58	52	1.25	1950	11*	Trace

Depth (cm)	Total analysis %					
	K ₂ O	CaO	MgO	Fe ₂ O ₃	Al ₂ O ₃	PPM MnO
0-175	0.22	1.05	0.74	11.87	20.80	0.067
175-200	0.27	1.51	1.57	12.39	18.02	0.045

Pedon 1 --- ctd.

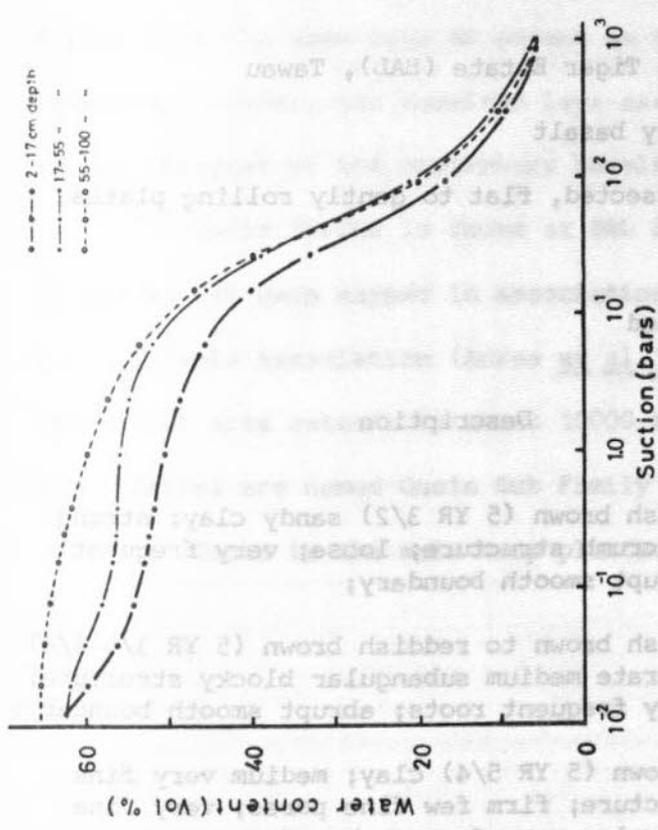
PHYSICO-CHEMICAL DATA

Depth (cm)	Mineralogical composition	
	Clay	Sand fraction (%)
0-2	-	Quartz 99; ore 1;
2-17	Dominant:- Poorly Crystallized	Quartz 99; ore 1; Augite t; hypersthene t.*
17-55	Kaolinite with some Gibbsite	Quartz 99; ore 1; Enstatite t; Rock fragments t
55-120		Quartz 98; ore 2; Zircon t.
120-150		Quartz 98; org. SiO ₂ ; ore t.
150-175		Not determined
175-200		"

* t = trace In pH 4.8

Depth (cm)	Three phase distribution %			Bulk density (g/cc)	True density (g/cc)	Soil hardness (mm)	Water permea- bility (cm/sec)
	Solid	Water	Air				
0-17	22.2	54.2	23.6	0.63	2.84	21.0	9.3 x 10 ⁻⁴
18-55	27.9	57.6	14.5	0.80	2.87	19.8	7.5 x 10 ⁻⁶
55-100	55.9	64.4	9.7	0.74	2.86	21.0	4.4 x 10 ⁻⁶
100-150	29.7	62.6	7.7	0.85	2.86	21.9	2.8 x 10 ⁻⁶

Depth (cm)	pF 0	Moisture Content (Vol. %)			Moisture Amount Released (%)		
		pF 1.9 (0.08 bars)	pF 3.0 (0.98 bars)	pF 9.2 (15.6 bars)	pF 0-1.9	pF 1.9-3.0	pF 3.0-4.2
0-17	65.6	54.2	51.0	40.2	11.4	3.2	10.8
17-55	62.8	57.6	54.6	45.5	5.2	3.0	9.1
55-100	66.7	64.4	60.0	46.1	2.3	4.4	13.9
100-150	66.5	62.6	58.5	46.5	3.9	4.1	12.0



pF - moisture distribution curve

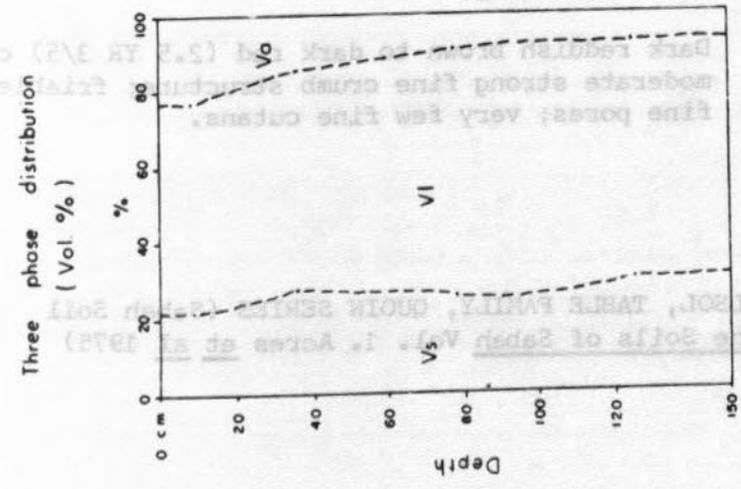
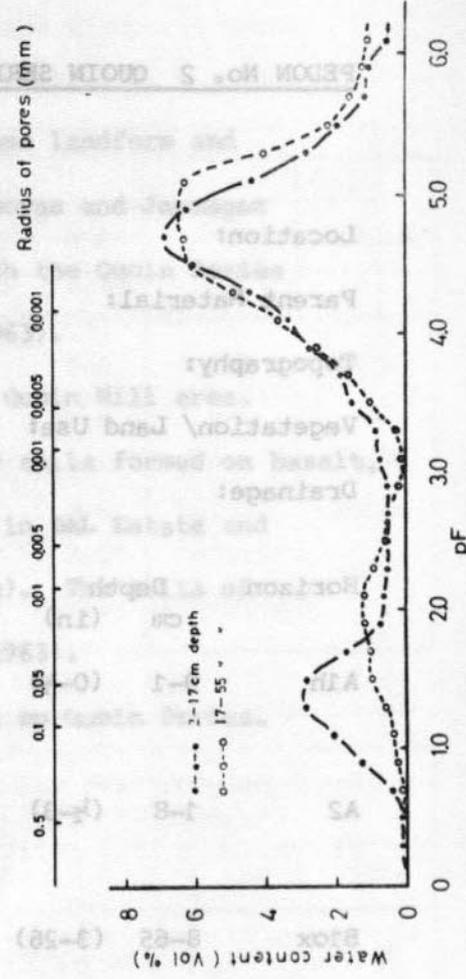


FIG. 1. SOIL MOISTURE CHARACTERISTICS OF KOBOVAN FAMILY

PEDON No. 2 QUOIN SERIES

Location: Field NJ 5 Tiger Estate (BAL), Tawau
 Parent Material: Quarternary basalt
 Topography: Weakly dissected, flat to gently rolling plateau
 Vegetation/ Land Use: Cocoa
 Drainage: Well drained

Horizon	Depth cm (in)	Description
A1h	0-1 (0- $\frac{1}{2}$)	Dark reddish brown (5 YR 3/2) sandy clay; strong very fine crumb structure; loose; very frequent roots; abrupt smooth boundary;
A2	1-8 ($\frac{1}{2}$ -3)	Dark reddish brown to reddish brown (5 YR 3/4-5/4) clay; moderate medium subangular blocky structure; loose; very frequent roots; abrupt smooth boundary;
B1ox	8-65 (3-26)	Reddish brown (5 YR 5/4) clay; medium very fine crumb structure; firm few fine pores; very fine quartz gravels; very few cracks; few roots; diffuse smooth boundary
B2ox	65-108 (26-43)	Reddish brown (5 YR 4/4) clay; moderate very fine crumb structure; friable; few fine pores; very few fine quartz gravels; very few thin cutans; diffuse smooth boundary;
B3ox	108-187 (43-75)	Dark reddish brown to dark red (2.5 YR 3/5) clay; moderate strong fine crumb structure; friable; few fine pores; very few fine cutans.

Soil Classification

ORTHIC FERRALSOL, TABLE FAMILY, QUOIN SERIES (Sabah Soil classification. See The Soils of Sabah Vol. 1. Acres et al 1975)

TABLE FAMILY (QUOIN SERIES)

Physico-chemical Data

The soils of QUOIN SERIES occur on the same landform and formed from the same type of parent as soils of Kobovan and Jarangan Families, however, the basaltic lava associated with the Quoin Series is the youngest of the quaternary basalts (Paton 1963).

Quoin Series is found at BAL Estates and Quoin Hill area.

It has so far been mapped in association with other soils formed on basalt, e.g. as Table Association (Acres et al 1975) which in BAL Estate and Quoin Hill area extends to about 10000 ha (24000 ac). The soils of Quoin Series are named Quoin Sub Family by Paton (1963).

Cocoa is the main crop planted at present on Quoin Series.

Soil No.	Depth (cm)	Cation Exchange Capacity (meq/100g)			pH	Total P (ppm)	Ex. H (ppm)	Exchangeable Cations (meq/100g)		
		Ca	Mg	K				Ca	Mg	K
10	0-10	0.10	0.03	0.16	0.02	2.02	0.37	0.10	0.03	0.16
10	10-20	0.15	0.03	0.07	0.02	4.29	0.40	0.10	0.03	0.07
10	20-30	0.16	0.02	0.06	0.02	4.69	0.24	0.09	0.06	0.02
10	30-40	0.50	0.08	0.08	0.02	7.26	0.40	0.08	0.08	0.02
10	40-50	1.22	0.21	0.10	0.02	13.70	0.68	0.21	0.10	0.02
10	50-60	2.10	0.34	0.13	0.02	29.43	0.84	0.34	0.13	0.02

Soil No.	Depth (cm)	Total Moisture Content (%)				Moisture Released (%)			
		0-10	10-20	20-30	30-40	0-10	10-20	20-30	30-40
10	0-10	12.1	11.7	12.9	12.9	1.2	1.4	1.8	1.8
10	10-20	12.1	11.7	12.9	12.9	1.2	1.4	1.8	1.8
10	20-30	12.1	11.7	12.9	12.9	1.2	1.4	1.8	1.8
10	30-40	12.1	11.7	12.9	12.9	1.2	1.4	1.8	1.8
10	40-50	12.1	11.7	12.9	12.9	1.2	1.4	1.8	1.8
10	50-60	12.1	11.7	12.9	12.9	1.2	1.4	1.8	1.8

PEDON 2. QUOIN SERIES

Physico-chemical Data

(TABLE FAMILY) QUOIN SERIES

Horizon	Depth (cm)	Particle size distribution (%)				Org. C (%)	Total N (%)	Easily sol. P (ppm)	pH	
		C Sand	F Sand	Silt	Clay				H ₂ O	0.01N KCl
A1h	0-1	4.5	7.0	32.9	55.0	7.35	0.583	25	5.0	4.2
A2	1-8	1.5	3.7	21.2	73.6	2.58	0.248	17	4.2	
B1ox	8-65	0.9	2.6	11.5	85.0	0.70	0.114	1	4.4	3.7
B2ox	65-108	0.8	1.5	8.9	88.8	0.34	0.068	t	4.4	3.8
B3ox	108-150	0.6	1.2	8.2	90.0	0.16	0.049	t	4.4	3.7
	150-187	0.9	2.6	2.9	94.2	0.15	0.03	1	3.9	3.6

Exchangeable Cations (meq %)				C.E.C (meq %)	Base Satr. (%)	Ex. H (m.e.%)	Total P (ppm)	Ext. Fe pH 3 (ppm)	Ext. N 1N KCl (ppm)
Ca	Mg	K	Na						
9.10	2.74	0.59	0.13	29.43	43	0.84	942	18	15
1.25	0.42	0.21	0.10	13.70	14	0.68	632	74	138
0.20	0.12	0.06	0.07	6.73	7	0.40	331	10	108
0.16	0.09	0.06	0.05	4.69	8	0.24	278	12	93
0.12	0.09	0.07	0.05	4.59	7	0.40	241	3	146
0.10	0.03	0.16	0.01	5.05	6	0.37	69	9*	209

Depth (cm)	Total analysis %					
	K ₂ O	CaO	MgO	Fe ₂ O ₃	Al ₂ O ₃	MnO
150-185	0.18	0.83	0.71	12.33	18.35	0.047

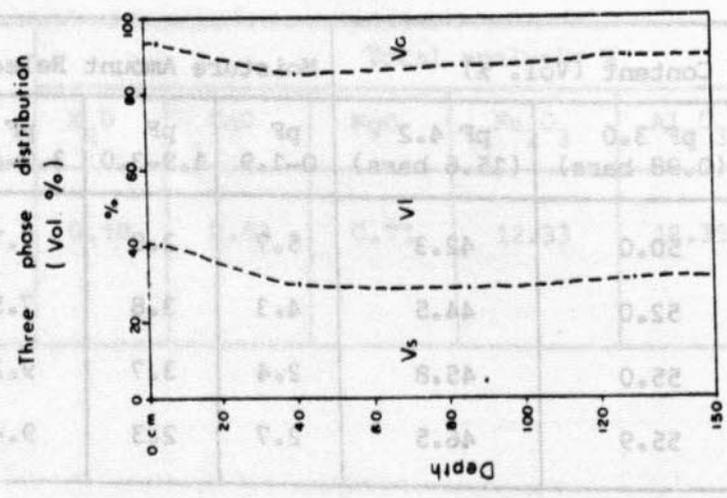
Pedon 2 --- ctd.

Depth (cm)	Mineralogical composition	
	Clay	Sand fraction (%)
0-1	Dominant:- Poorly crystallized Kaolinite with some mixture of gibbsite and goethite	Quartz 97; org. SiO ₂ ; ore 1; Rock fragments t, Zircon t.
1-8		Quartz 93; org. SiO ₂ ; Rock fragments 2; ore 1; hyperstene t.
8-65		Quartz 98; ore 1, org. SiO ₂ ; Zircon t.
65-108		Quartz 98; rock fragments 1; ore 1, Zircon t.
108-150		Quartz 95, rock fragments 3, ore 2; Org. Si ₂ O ₇ Epidote t.
150-187		Not determined

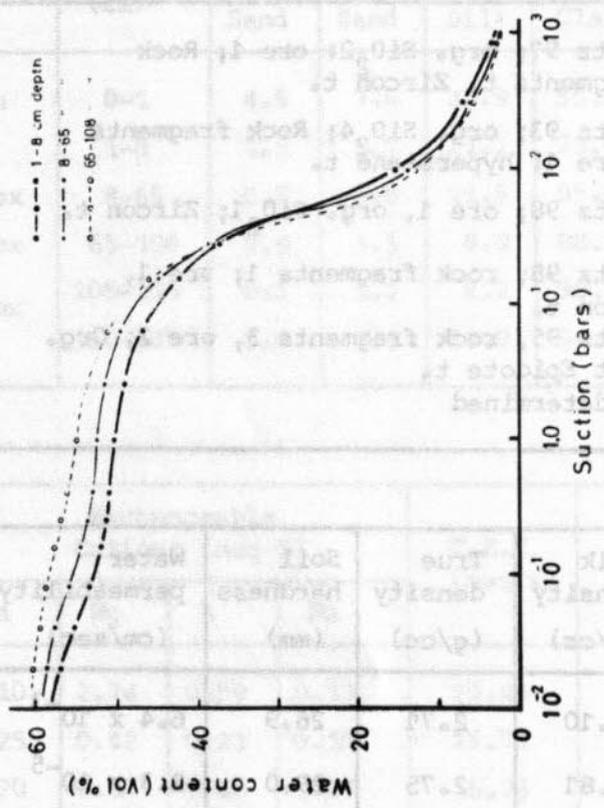
Depth (cm)	Three phase distribution %			Bulk density (g/cc)	True density (g/cc)	Soil hardness (mm)	Water permeability (cm/sec)
	Solid	Water	Air				
0-8	40.6	52.9	6.9	1.10	2.71	26.9	6.4 x 10 ⁻³
8-65	29.5	55.8	14.7	0.81	2.75	29.0	2.3 x 10 ⁻⁵
65-108	28.7	58.6	12.7	0.80	2.79	28.3	5.1 x 10 ⁻⁶
108-150	30.7	58.2	11.1	0.86	2.80	27.4	7.2 x 10 ⁻⁷

Depth (cm)	Moisture Content (Vol. %)				Moisture Amount Released (Vol. %)			
	pF 0	pF 1.9 (0.08 bars)	pF 3.0 (0.98 bars)	pF 4.2 (15.6 bars)	pF 0-1.9	pF 1.9-3.0	pF 3.0-4.2	pF 1.9-4.2
0-8	58.6	52.9	50.0	42.3	5.7	2.9	7.7	10.6
8-65	60.1	55.8	52.0	44.5	4.3	3.8	7.5	11.3
65-108	61.1	58.7	55.0	45.8	2.4	3.7	9.2	12.9
108-150	60.9	58.2	55.9	46.5	2.7	2.3	9.4	11.7

Three phase distribution



Soil moisture characteristic curve



pf-moisture distribution curve

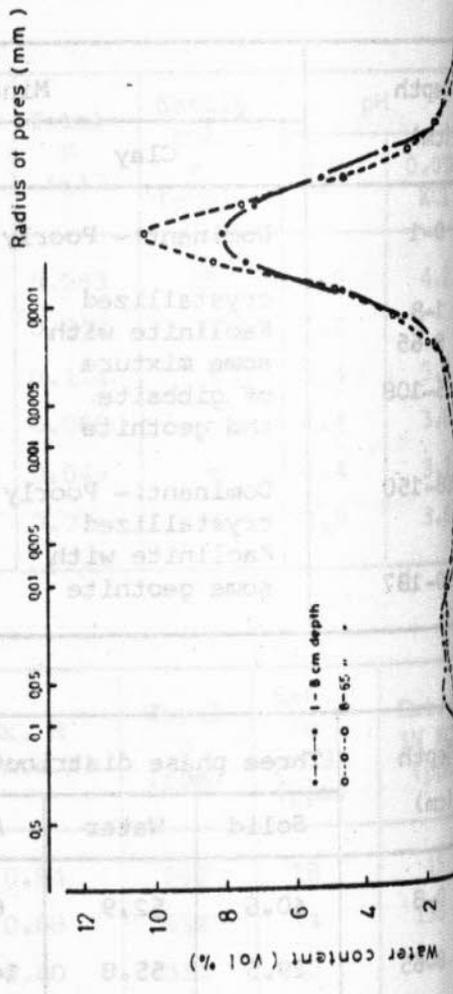


FIG. 2. SOIL MOISTURE CHARACTERISTICS OF QUIN FAMILY

PEDON No. 3 JARANGAN FAMILY

JARANGAN FAMILY

Location: Field 94, Table Estate (BAL), Tawau
 Parent Material: Quarternary basalt
 Topography: Weakly dissected flat to gently rolling plateau
 Vegetation/Land Use: Oil Palm
 Drainage: Well drained

Horizon	Depth cm	Depth (in)	Description
A1L	0- $\frac{1}{2}$	(0- $\frac{1}{4}$)	Very dark greyish brown (10 YR 3/2) silty clay; strong medium crumb structure; loose; frequent roots;
A2	$\frac{1}{2}$ -15	($\frac{1}{4}$ -6)	Dark yellowish brown (10 YR 4/4) clay; moderate strong fine subangular blocky, breaking into strong fine crumb structure; very friable; few gradual smooth boundary;
AB	15-43	(6-17)	Yellowish brown (10 YR 5/6) clay; strong fine subangular blocky, breaking into strong fine crumb structure; very friable; frequent pores; few fine quartz; frequent roots; gradual smooth boundary
B1ox	43-60	(17-24)	Light yellowish brown (10 YR 6/4) clay; moderate fine subangular blocky, breaking into strong very fine crumb structure; friable to firm; very few quartz grains; very few thin cutans; few roots; gradual smooth boundary,
B2ox	60-140	(24-56)	Light yellowish brown to brownish yellow (10 YR 6/8) clay; moderate very fine crumb structure; friable; few fine quartz grains; few thin cutans; moderate porosity, diffuse, diffuse smooth to
B3ox	140-175	(56-70)	Brown (7.5 YR 5/4) clay; weak medium subangular blocky breaking to moderate very fine granular; friable; many fine shining quartz grains; clear smooth boundary to
B4ox	175-200	(70-80)	Very pale brown (10 YR 7/4) with few fine clear white (7.5 YR N/8) mottles; clay; weak medium subangular blocky; friable; many fine shining quartz grains.

Soil Classification:

XANTHIC FERRALSOL, JARANGAN FAMILY (Sabah soil classification - see The Soils of Sabah Vol. 1 Acres et al 1975)

JARANGAN FAMILY

JARANGAN FAMILY

The soils of this Family are present is very close association with other soils formed on quaternary basaltic lava and as such are associated with the same landform as mentioned in respect of Kobovan Family (Profile 1). The lava associated with Family is the oldest of the quaternary basalts in the region (Paton 1963).

JARANGAN FAMILY has so far been reported to occur in BAL Estate and Quoin Hill area on Semporna Peninsular. It has not been mapped separately and therefore its exact extent is not known. On the Soil Map of Sabah (Acres et al 1975) it is shown as a component of the Table Association. Paton (1963) has described the soils of this Family as Jarangan Sub Family.

Soils of Jarangan Family have been utilized for the planting of oil palm, cocoa and rubber.

Box	43-80 (17-24)	Light yellowish brown (10 YR 6/4) clay; moderate fine subangular blocky, breaking into strong very fine crumb structure; friable to firm; very few quartz grains; very few thin cutans; few roots; gradual smooth boundary.
Box	60-140 (24-28)	Light yellowish brown to brownish yellow (10 YR 6/8) clay; moderate very fine crumb structure; friable; few fine quartz grains; few thin cutans; moderate porosity; diffuse, diffuse smooth to
Box	140-175 (28-70)	Brown (7.5 YR 5/4) clay; weak medium subangular blocky breaking to moderate very fine granular; friable; many fine shining quartz grains; clear smooth boundary to
Box	175-200 (30-80)	Very pale brown (10 YR 7/4) with few fine clear white (7.5 YR 8/8) mottled clay; weak medium subangular blocky; friable; many fine shining quartz grains.

PEDON 3. JARANGAN FAMILY

Physico-chemical Data

Horizon	Depth (cm)	Particle size distribution (%)				Org. C (%)	Total N (%)	Easily sol. P (ppm)	pH	
		C Sand	F Sand	Silt	Clay				H ₂ O	0.01N KCl
A1L	0- $\frac{1}{2}$	10.3	12.4	39.7	37.6	9.01	0.877	19	4.8	4.1
A2	$\frac{1}{2}$ -15	9.4	7.0	23.7	59.9	2.95	0.338	6	4.8	4.0
AB	15-43	6.6	4.3	15.3	73.8	1.21	0.179	1	4.6	3.9
B1ox	43-60	5.8	5.8	11.1	77.3	0.60	0.111	1	4.3	3.8
B2ox	60-140	4.6	4.2	14.0	77.2	0.36	0.072	1	4.2	3.9
B3ox	140-175	17.1	10.9	18.5	53.1	0.20	0.04	Trace	4.2	4.0
B4ox	175-200	7.1	7.4	21.6	63.6	0.16	0.03	Trace	4.1	3.9

Exchangeable Cations (meq %)				C.E.C. (meq %)	Base Satr. (%)	Ext.H (m.e.%)	Total P (ppm)	Ext. Fe pH 3 (ppm)	Ext. Al 1N KCl (ppm)
Ca	Mg	K	Na						
9.83	2.52	1.25	0.21	37.44	67	0.76	1482	26	68
2.89	0.44	0.50	0.16	15.70	25	0.40	1097	46	140
0.35	0.11	0.46	0.08	12.60	8	0.96	837	48	135
0.28	0.06	0.43	0.11	12.17	7	0.40	720	17	119
0.68	0.36	0.11	0.12	10.19	12	0.23	-	-	155
0.43	0.05	0.23	0.02	10.45	7	0.41	268	15*	219
0.19	0.03	0.11	0.02	11.88	3		420	14*	

Depth (cm)	Total analysis %					
	K ₂ O	CaO	MgO	Fe ₂ O ₃	Al ₂ O ₃	MnO
140-175	0.17	0.79	0.64	12.47	22.28	0.037
175-200	0.15	0.69	0.57	6.23	28.24	0.011

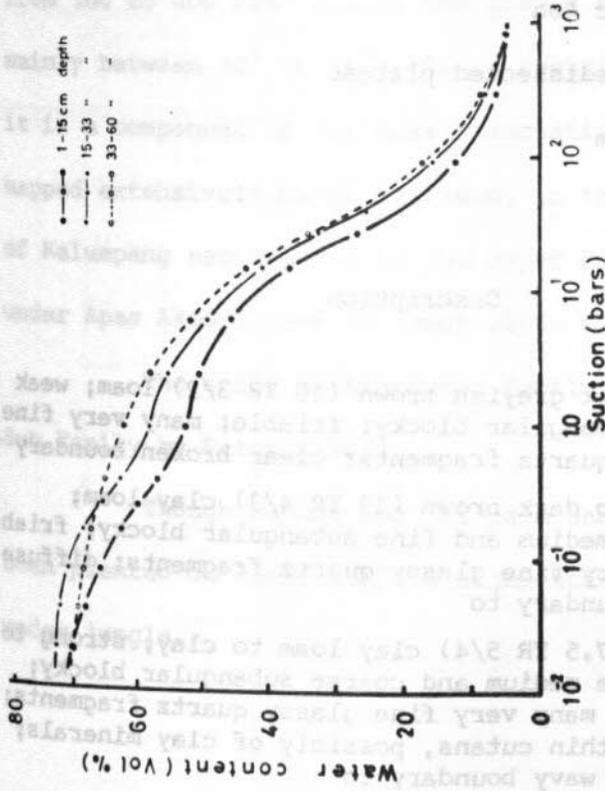
Pedon 3 --- ctd.

Depth (cm)	Mineralogical composition	
	Clay	Sand fraction (%)
0- $\frac{1}{2}$	Dominant poorly Crystallized kaolinite with some mixture of gibbsite and goethite	Quartz 99; ore 1; Rock fragments t.
$\frac{1}{2}$ -15		Quartz 98; ore 2; Rock fragments t.
15-43		Quartz 99; ore 1; Rock fragments t.
43-60		Quartz 98; ore 2
60-140		Quartz 99; ore 1;
140-175		Not determined
175-200		"

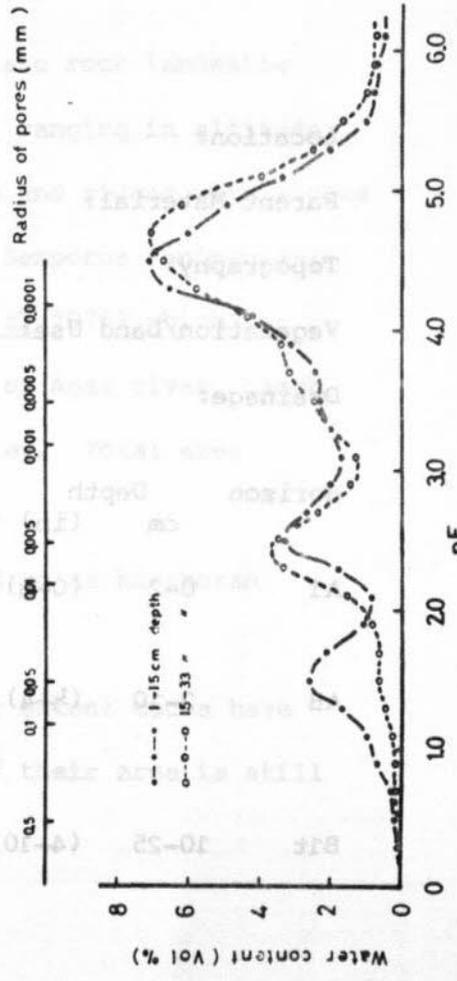
Depth (cm)	Three phase distribution %			Bulk density (g/cc)	True density (g/cc)	Soil hardness (mm)	Water Permeability (cm/sec)
	Solid	Water	Air				
0-15	24.6	63.8	11.6	0.65	2.64	18.0	1.1×10^{-3}
15-33	22.2	70.5	7.3	0.60	2.70	17.9	6.6×10^{-5}
33-60	25.3	68.0	6.7	0.69	2.73	18.4	6.9×10^{-6}
60-140	22.1	66.6	11.3	0.61	2.76	18.0	4.3×10^{-6}
140-174	31.1	66.6	2.3	0.85	2.73	19.4	-

Depth (cm)	Moisture Content (Vol. %)				Moisture Amount Released (Vol. %)		
	pF 0	pF 1.9 (0.08 bars)	pF 3.0 (0.98 bars)	pF 4.2 (15.6 bars)	pF 0-1.9	pF 1.9-3.0	pF 3.0-4.2
0-15	73.1	63.8	52.5	36.8	9.3	11.3	15.7
15-33	73.7	70.5	57.6	40.8	3.2	12.9	16.8
33-60	71.6	68.0	62.0	43.0	3.6	6.0	19.0
60-140	71.0	66.6	59.4	47.0	4.4	7.2	12.4
140-175	-	-	-	-	-	-	-

Soil moisture characteristic curve



pF - moisture distribution curve



Three phase distribution

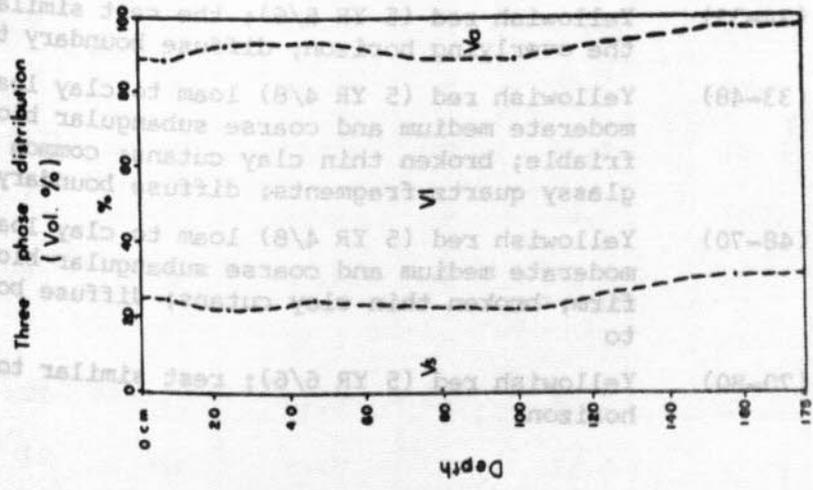


FIG. 3. SOIL MOISTURE CHARACTERISTICS OF JARANGAN FAMILY

Soil Classification: ORTIC ACRISOL, KINABUTAN FAMILY (Sapan soil classification, see The Soils of Sapan Vol. 1 Acres et al 1975)

PEDON No. 4 KINABUTAN FAMILY

Location: Field OF 32 Burut Estate BAL E Tawau
 Parent Material: Andestic Ash
 Topography: Moderatedissected plateau
 Vegetation/Land Use: Oil palm
 Drainage: Well

Horizon	Depth cm	Depth (in)	Description
A1	0-2	(0- $\frac{1}{2}$)	Very dark greyish brown (10 YR 3/2) loam; weak fine subangular blocky; friable; many very fine glassy quartz fragments; clear broken boundary to
AB	2-10	($\frac{1}{2}$ -4)	Brown to dark brown (19 YR 4/3) clay loam; strong medium and fine subangular blocky; friable; many very fine glassy quartz fragments; diffuse wavy boundary to
B1t	10-25	(4-10)	Brown (7.5 YR 5/4) clay loam to clay; strong to moderate medium and coarse subangular blocky; friable many very fine glassy quartz fragments; broken thin cutans, possibly of clay minerals; diffuse wavy boundary to
B2t	25-60	(10-24)	Brown to dark brown (7.5 YR 4/4) clay loam to clay; moderate to strong medium and coarse subangular blocky; friable and slightly plastic; broken thin cutans, possibly of clay minerals; many fine glassy quartz fragments; diffuse boundary to
B3t	60-82	(24-33)	Yellowish red (5 YR 5/6); the rest similar to the overlying horizon; diffuse boundary to
B4t	82-120	(33-48)	Yellowish red (5 YR 4/8) loam to clay loam; moderate medium and coarse subangular blocky; friable; broken thin clay cutans; common fine glassy quartz fragments; diffuse boundary to
B5t	120-175	(48-70)	Yellowish red (5 YR 4/8) loam to clay loam; moderate medium and coarse subangular blocky; firm; broken thin clay cutans; diffuse boundary to
B6t	175-200	(70-80)	Yellowish red (5 YR 6/6); rest similar to overlying horizon

Soil Classification:

ORTHIC ACRISOL, KINABUTAN FAMILY (Sabah soil classification, see The Soils of Sabah Vol. 1 Acres et al 1975)

KINABUTAN FAMILY

KINABUTAN FAMILY

Physical-Chemical Data

The KINABUTAN FAMILY develops on intermediate rock (andesite and decite) occurs on moderately dissected landform, ranging in altitude from 100 to 400 feet a.s.l. and giving rise to hills and ridges with slopes mainly between 10° to 20°. It is restricted to the Semporna Peninsular; it is a component of the Apas Association (Acres et al 1975) which is mapped extensively north of Tawau, in the catchment of Apas river, north of Kalumpang estuary and in the upper Kalumpang valley. Total area under Apas Association is about 25000 ha (61000 ac).

The soils of Kinabutan Family are referred to as Kinabutan Sub Family by Paton (1963).

Though rubber and oil palm and to a lesser extent cocoa have been planted on these soils a significant portion of their area is still under jungle.

Soil No.	Depth (cm)	Base-Sat. (x)	Base-Ex. H. (m.e. %)	Base-Sat. (x)	C.E.C. (meq %)	Ca-Mg (meq %)	Ca-Mg (meq %)	Ca-Mg (meq %)	Ca-Mg (meq %)
234	10	7	0.81	15.73	0.02	0.11	0.02	0.02	0.02
234	11	8	0.41	2.88	0.02	0.03	0.07	0.36	0.36
232	12.5	8	0.40	2.78	0.01	0.01	0.02	0.24	0.24
203	4	4	0.32	2.81	0.04	0.02	0.03	0.13	0.13
204	5	5	0.32	2.78	0.02	0.02	0.01	0.06	0.06
204	1	5	0.36	2.32	0.02	0.03	0.01	0.06	0.06
224	10	2	0.41	2.10	0.01	0.02	0.01	0.06	0.06
222	11	3	0.41	2.32	0.02	0.02	0.01	0.11	0.11

PEDON 4. KINABUTAN FAMILY

KINABUTAN FAMILY

Physico-chemical Data

The KINABUTAN FAMILY develops on intermediate rock (andesite)

Horizon	Depth (cm)	Particle size distribution (%)				Org. C (%)	Total N (%)	Easily sol. P (ppm)	pH	
		C Sand	F Sand	Silt	Clay				H ₂ O	0.1N KCl
A1	0-2	32	22	9	34	2.52	0.173	3	4.3	3.7
AB	2-10	21	15	10	53	0.56	0.067	1	4.7	3.9
B1t	10-25	19	13	9	58	0.48	0.064	Trace	4.6	4.0
B2t	25-60	18	11	8	59	0.29	0.042	Trace	4.4	4.0
B3t	60-82	15	9	8	70	0.27	0.052	Trace	4.4	4.0
B4t	82-120	15	9	8	69	0.22	0.039	Trace	4.8	4.1
B5t	120-175	14	9	6	72	0.24	0.044	Trace	3.9	3.5
B6t	175-200	15	9	4	72	0.22	0.036	Trace	3.9	3.6

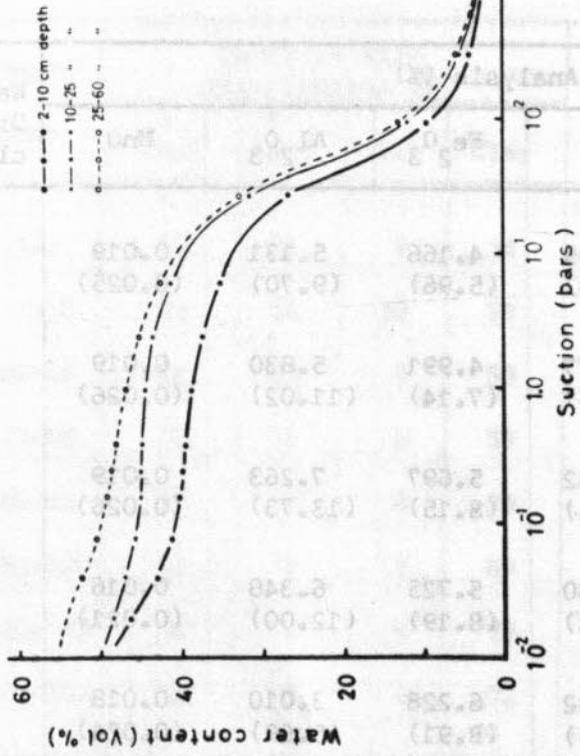
Exchangeable Cations (meq %)				C.E.C. (meq %)	Base Satr. (%)	Ex. H (m.e. %)	Total P (ppm)	Ext. Fe ppm in NH ₄ OAc pH 4.8	Ext. Al 1N KCl (ppm)
Ca	Mg	K	Na						
0.65	0.09	0.11	0.02	12.73	7	0.41	134	10	224
0.36	0.07	0.03	0.02	5.66	8	0.41	124	11	214
0.24	0.05	0.03	0.01	5.76	6	0.40	189	12.5	131
0.13	0.03	0.02	0.04	5.61	4	0.32	152	4	103
0.06	0.01	0.02	0.02	5.56	2	0.32	114	2	144
0.06	0.01	0.03	0.02	5.35	2	0.36	188	1	144
0.06	0.01	0.02	0.01	5.10	2	0.41	134	10	224
0.11	0.01	0.02	0.02	5.33	3	0.41	124	11	212

Pedin 4. ---ctd.

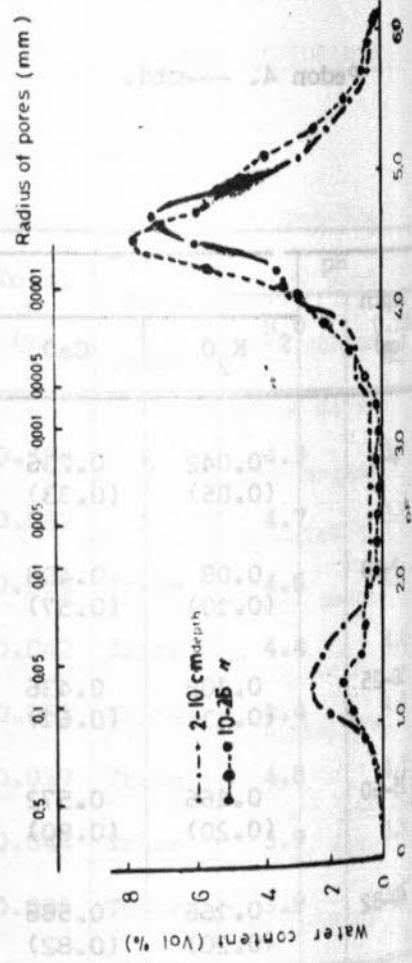
Depth (cm)	Total Analysis (%)						Water Dispersible clay (%)
	K ₂ O	CaO	MgO	Fe ₂ O ₃	Al ₂ O ₃	MnO	
0-2	0.042 (0.05)	0.236 (0.33)	0.109 (0.18)	4.166 (5.96)	5.131 (9.70)	0.019 (0.025)	nd
2-10	0.08 (0.10)	0.408 (0.57)	0.277 (0.46)	4.991 (7.14)	5.830 (11.02)	0.019 (0.026)	nd
10-25	0.108 (0.13)	0.436 (0.61)	0.332 (0.55)	5.697 (8.15)	7.263 (13.73)	0.019 (0.026)	nd
25-60	0.166 (0.20)	0.572 (0.80)	0.380 (0.63)	5.725 (8.19)	6.348 (12.00)	0.016 (0.021)	0.2
60-82	0.166 (0.20)	0.586 (0.82)	0.392 (0.65)	6.228 (8.91)	3.010 (5.69)	0.018 (0.024)	0.1
82-120	0.158 (0.19)	0.543 (0.76)	0.380 (0.63)	6.263 (8.96)	7.374 (13.94)	0.018 (0.024)	0.5
120-175	0.066 (0.08)	0.408 (0.57)	0.289 (0.48)	5.718 (6.18)	9.977 (18.86)	0.018 (0.024)	0.6
175-200	0.091 (0.11)	0.458 (0.64)	0.332 (0.55)	2.803 (4.01)	12.595 (23.81)	0.018 (0.024)	nd

nd = not determined

Soil moisture characteristic curve



pF - moisture distribution curve



Three phase distribution

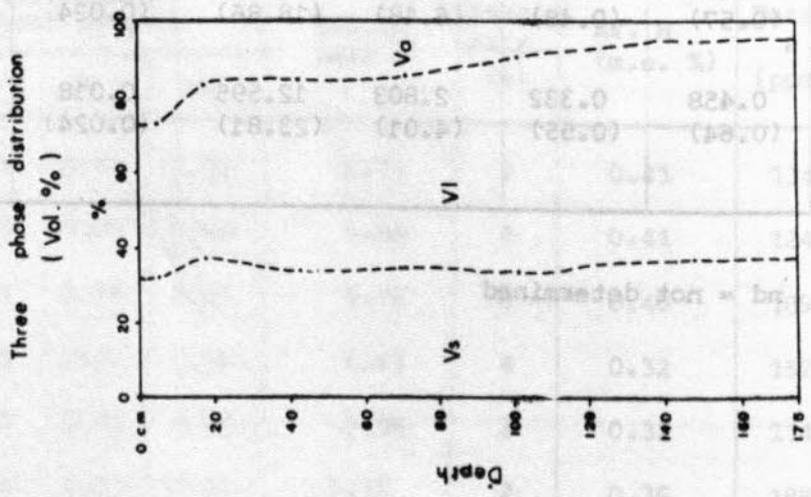


FIG. 4. SOIL MOISTURE CHARACTERISTICS OF KINABUTAN FAMILY

Location: Field 16C Merotai - Manusi Division (BAL) Tawau

Parent Material: Volcanic ash

Topography: Moderately dissected plateau

Vegetation/Land Use: Oil palm

Drainage: Well

Horizon	Depth cm (in)	Description
A1	0-2 (0-1)	Dark greyish brown (10 YR 4/2) loam; moderate to strong medium granular; very hard; very common roots; clear smooth boundary to
A2	2-10 (1-4)	Yellowish brown (10 YR 5/4) and dark greyish brown (10 YR 4/2) due to worm-cast; loam to sandy clay loam; moderate to strong fine to medium subangular blocky and coarse granular; hard (dry); many roots; gradual smooth boundary to
AB	10-20 (4-8)	Dark yellowish brown (10 YR 4/4) sandy clay loam; strong medium subangular blocky; very hard; many roots; few fine fragments of decomposing moderately hard rock; common moderately thick humus staining along cracks and pores; common roots; diffuse smooth boundary to
B1	20-30 (8-12)	Yellowish brown (10 YR 5/6) clay loam; structure as above; rock fragments as above; common roots; common moderately thick humus staining along cracks and pores; diffuse smooth boundary
B2	30-45 (12-18)	Brown to dark brown (7.5 YR 4/4) sandy clay to clay loam; structure similar to above; hard; common decomposed rock fragments as above; common roots; diffuse boundary to
B3t	45-60 (18-24)	Brown to strong brown (7.5 YR 4/4) with few fine distinct light olive grey (5 Y 6/2) mottles; sandy clay; structure as above; hard; broken thin clay cutan on ped surfaces and pore channel; decomposed rock fragments as above; common roots; diffuse boundary to

PEDON No. 5 (contd)

PEDON No. 5 LUMISIR FAMILY

- B4t 60-87 (24-35) Reddish brown 5 YR 5/4) with common fine distinct light olive brown (2.5 Y 5/4) mottles; clay; structure as above; firm (moist); decomposed rock as above; few fine reddish concretions; few roots; broken thin cutan on ped surfaces; diffuse boundary to
- B5t 87-120 (35-48) Yellowish red (5 YR 5/6) with common medium to coarse distinct light yellowish brown (2.5 Y 6/4) mottles; clay; strong coarse subangular blocky; firm; decomposed rock fragments as above; iron concretions as above; few roots; broken thick cutans on ped surfaces; abrupt wavy boundary to
- B6cn 120-153 (48-62) Yellowish red (5 YR 4/8) with common coarse distinct light yellowish brown (2.5 Y 6/4) mottles; clay; abundant (+ 80%) (2-10 mm diameter) hard subangular dusky red iron concretion; common rounded stones (25 mm diam.) decomposed rock fragments as above; slightly firm; abrupt wavy boundary to
- B7cn 153-210 (62-84) Red (2.5 YR 5/6) with common to many coarse light yellowish brown (2.5 Y 6/4) mottles; clay; moderately medium subangular blocky; many but decrease at depth iron concretions (size as above) few decomposed rock fragments; friable to firm.

Soil Classification:

FERRIC ACRISOL, LUMISIR FAMILY (Sabah soil classification. See The Soils of Sabah Vol. 1 Acres et al 1975)

30-30 (8-12) Yellowish brown (10 YR 5/5) as above; rock fragments as above; common roots; cracks

30-42 (15-18) Brown to dark brown (7.5 YR 4/4) sandy clay to clay loam; structure similar to above; hard; common decomposed rock fragments as above; common roots; diffuse boundary to

42-50 (18-24) Brown to strong brown (7.5 YR 4/4) with few fine distinct light olive grey (5 Y 6/2) mottles; sandy clay; structure as above; hard; broken thin clay cutan on ped surfaces and pore channels; decomposed rock fragments as above; common roots; diffuse boundary to

LUMISIR FAMILY

The LUMISIR FAMILY formed on late Pliocene volcanic ash are found on weakly dissected low coastal platform of mainly less than 150 feet a.s.l. which occurs in the southern portion of the Semporna Peninsular between the Merotai and Kalumpang rivers.

Paton (1963) includes these soils in the Gading Family of which he mapped some 36000 ha (90000 ac) in the Semporna Peninsular. In the new soil map of Sabah (Acres et al 1975) they are mapped as part of a very broad unit, Brantian Association.

Rubber, oil palm and coconut are the main crops so far planted on the soils of this Family.

Soil No.	Total P ₂ O ₅ (ppm)	Total K (ppm)	Base Sat. (%)	C.E.C. (meq/100g)	Exchangeable (meq/100g)		
					Ca	Mg	K
393	78	0.31	1	10.35	0.05	0.04	0.01
392	71	0.21	2	6.05	0.05	0.04	0.01
389	71	0.21	1	7.82	0.05	0.03	0.01
388	76	0.41	1	6.99	0.05	0.04	0.01
387	68	0.41	2	6.17	0.05	0.04	0.01
386	71	0.41	3	2.70	0.05	0.03	0.01
385	70	0.21	6	4.92	0.05	0.03	0.01
384	70	0.21	6	4.92	0.05	0.03	0.01
383	80	0.40	6	4.92	0.05	0.03	0.01
382	81	0.32	12	4.92	0.05	0.03	0.01
381	116	0.21	21	6.47	0.05	0.03	0.01
380	156	0.08	31	2.90	0.04	0.01	0.01

PEDON 5 LUMISIR FAMILY

Physico-chemical Data

Horizon	Depth (cm)	Particle size distribution (%)				Org. C (%)	Total N (ppm)	Easily sol. (ppm)	pH	
		C Sand	F Sand	Silty	Clay				H ₂ O	0.1N KCl
A1	0-2	18.2	43.9	12.7	22.8	2.85	0.23	4	4.2	3.8
A2	2-10	19.5	44.1	10.4	20.0	1.93	0.13	3	4.0	3.5
AB	10-20	19.4	43.6	12.0	25.8	0.72	0.08	1	3.7	3.5
B1	20-30	17.3	41.3	11.2	27.8	0.47	0.05	1	3.8	3.5
B2	30-45	18.5	38.3	10.5	29.5	0.39	0.04	1	4.0	3.5
B3t	45-60	14.8	31.8	9.7	41.6	0.30	0.04	Trace	3.8	3.5
B4t	60-87	12.6	26.7	0.7	56.2	0.28	0.04	1	3.8	3.5
B5t	87-120	10.8	19.9	7.5	57.0	0.26	0.03	Trace	3.8	3.5
B6cn	120-153	36.5	19.0	6.9	34.3	0.23	0.03	Trace	3.8	3.7
B7cn	153-210	12.4	13.5	9.3	63.3	0.19	0.04	Trace	3.7	3.5

Exchangeable Cations (meq %)				C.E.C. (meq %)	Base Satr. (%)	Ex. H m.e %	Total P ppm	Ext. Fe ppm in NH ₄ OAc pH 4.8	Ext. Al 1N KCl (ppm)
Ca	Mg	K	Na						
2.15	0.81	0.11	0.04	9.90	31	0.08	126	175	63
0.82	0.43	0.06	0.02	6.41	21	0.51	116	303	139
0.41	0.19	0.07	0.02	4.61	15	0.32	81	318	179
0.14	0.09	0.03	0.02	4.95	6	0.40	80	242	225
0.16	0.09	0.03	0.02	5.10	6	0.51	70	166	231
0.08	0.07	0.03	0.01	6.17	3	0.41	71	20	224
0.06	0.04	0.03	0.02	6.99	2	0.41	68	14	291
0.03	0.02	0.03	0.02	7.85	1	0.41	76	13	383
0.06	0.01	0.04	0.02	6.02	2	0.51	71	12	249
0.03	0.01	0.04	0.02	10.35	1	0.31	76	11	393

Pedon 5 ---ctd.

Depth (cm)	Three phase distribution %			Bulk density (g/cc)	True density (g/cc)	Soil hardness (mm)	Water Permeability (cm/sec)
	Solid	Water	Air				
0-2.5	50.2	37.9	11.9	1.29	2.57	19.3	2.6×10^{-4}
2.5-10	49.2	37.9	12.9	1.29	2.62	25.1	2.6×10^{-4}
10-20	49.1	36.2	14.7	1.30	2.65	25.1	5.0×10^{-4}
20-30	46.6	36.2	17.2	1.24	2.66	25.9	-
30-45	43.2	43.6	13.2	1.15	2.66	23.9	-
45-60	44.2	43.6	12.2	1.18	2.67	25.7	5.8×10^{-6}
60-87	40.7	48.5	10.8	1.09	2.68	25.9	-
87-120	38.4	53.3	8.3	1.03	2.68	23.9	1.5×10^{-7}

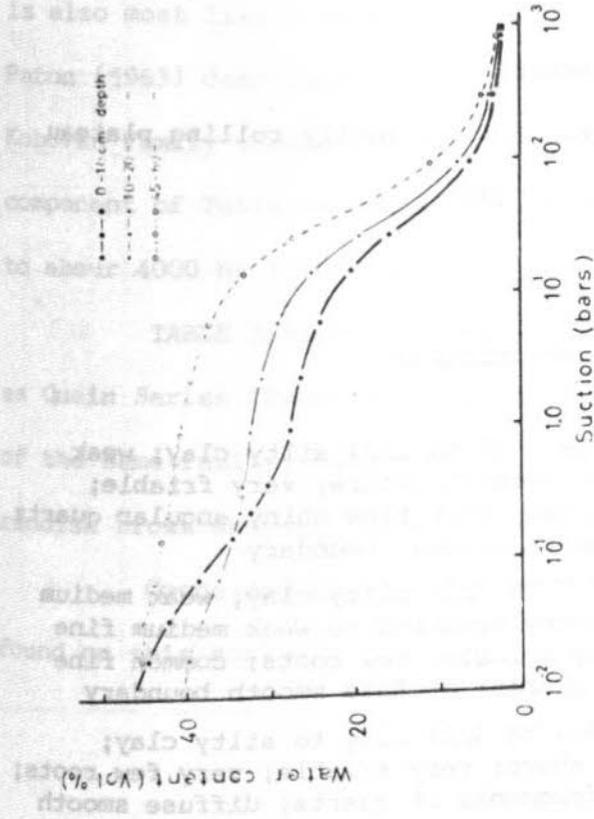
Depth (cm)	Moisture content (Vol. %)				Moisture amount released (Vol.%)			
	pF 0	pF 1.9 (0.08 bars)	pF 3.0 (0.98 bars)	pF 4.2 (15.6 bars)	pF 0-1.9	pF 1.9-3.0	pF 3.0-4.2	pF 1.9-4.2
0-2.5	47.8	37.9	28.5	20.2	9.9	9.4	8.3	12.7
2.5-10	47.8	37.9	28.5	20.2	9.9	9.4	8.3	17.7
10-20	41.0	36.2	32.2	24.8	4.8	4.0	7.4	11.4
20-30	-	-	-	-	-	-	-	-
30-45	-	-	-	-	-	-	-	-
45-60	46.6	43.6	40.8	32.6	2.8	2.8	8.2	11.0
60-87	-	-	-	-	-	-	-	-
87-120	55.0	53.3	50.6	40.0	1.7	2.7	10.6	13.3

Pedon 5. ---ctd.

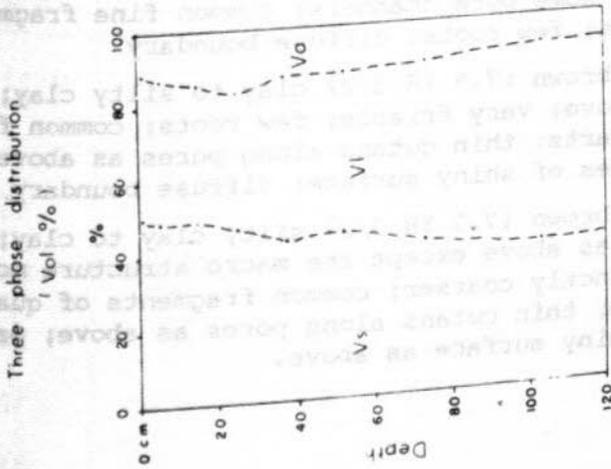
Depth (cm)	Total Analysis (%)						Water Disper- sible clay (%)
	K (K ₂ O)	Ca (CaO)	Mg (MgO)	Fe (Fe ₂ O ₃)	Al (Al ₂ O ₃)	Mn (MnO)	
0-2	0.017 (0.02)	0.157 (0.22)	0.096 (0.16)	1.929 (2.76)	3.338 (6.31)	0.015 (0.020)	nd
2-10	0.025 (0.03)	0.136 (0.19)	0.103 (0.17)	2.069 (2.96)	3.555 (6.72)	0.014 (0.018)	nd
10-20	0.025 (0.03)	0.107 (0.15)	0.090 (0.15)	2.558 (3.66)	4.687 (8.86)	0.015 (0.019)	nd
20-30	0.033 (0.04)	0.186 (0.26)	0.139 (0.23)	2.754 (3.94)	5.311 (10.04)	0.011 (0.015)	nd
30-45	0.033 (0.07)	0.200 (0.28)	0.151 (0.25)	2.747 (3.93)	4.465 (8.44)	0.013 (0.017)	19.6
45-60	0.008 (0.10)	0.443 (0.62)	0.283 (0.47)	3.285 (4.70)	6.247 (11.81)	0.010 (0.013)	10.7
60-87	0.008 (0.10)	0.436 (0.61)	0.356 (0.59)	3.747 (5.36)	7.242 (13.69)	0.010 (0.013)	2.3
87-120	0.108 (0.13)	0.450 (0.63)	0.344 (0.57)	4.222 (6.04)	8.363 (15.81)	0.008 (0.011)	0.7
120-153	0.133 (0.16)	0.501 (0.70)	0.519 (0.86)	8.234 (11.78)	7.274 (13.75)	0.013 (0.017)	0.7
153-210	0.108 (0.13)	0.379 (0.53)	0.332 (0.55)	6.913 (9.89)	11.426 (21.60)	0.073 (0.098)	nd

nd = not determined

Soil moisture characteristic curve



Three phase distribution



pF - moisture distribution curve

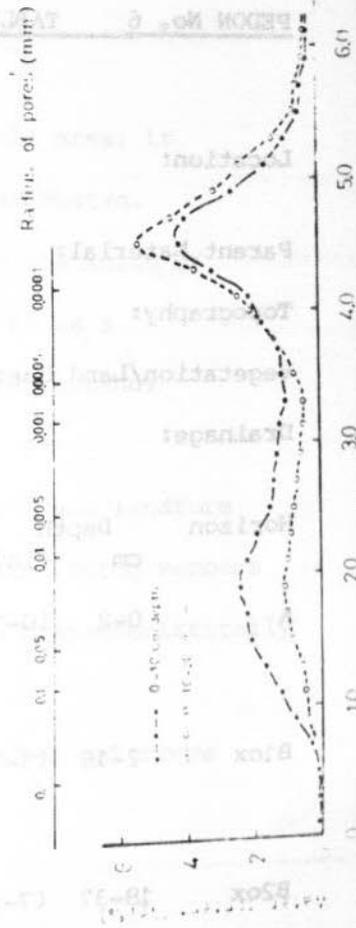


FIG. 5. SOIL MOISTURE CHARACTERISTICS OF LUMISIR FAMILY

ORGIC FERRALLOID, TABLE SERIES, TAINI SERIES (Tapan Soil classification - see The Soils of Japan Vol. 1 (1975))

PEDON No. 6 TABLE SERIES

Location: Field No. 9, Quoin Hill Cocoa Research Station,
Tawau.

Parent Material: Quarternary basalt

Topography: Weakly dissected flat to gently rolling plateau

Vegetation/Land Use: Cocoa, planted in 1961

Drainage: Well drained

Horizon	Depth cm (in)	Description
A	0-2 (0-1)	Very dark brown (7.5 YR 2/2) silty clay; weak to moderately crumb structure; very friable; common roots; many very fine shiny angular quartz fragments; smooth gradual boundary
B1ox	2-18 (1-7)	Dark brown (7.5 YR 3/2) silty clay; weak medium subangular blocky breaking to weak medium fine granular; very friable; few roots; common fine fragments of quartz; diffuse smooth boundary
B2ox	18-37 (7-15)	Dark brown (7.5 YR 3/2) clay to silty clay; structure as above; very friable; very few roots; common fine fragments of quartz; diffuse smooth boundary
B3ox	37-100 (15-40)	Dark brown (7.5 YR 3/2) clay; weak coarse to medium subangular blocky breaking easily into weak medium to fine granular; very friable; thin cutan (grey) along some pore channels; common fine fragments of quartz; few roots; diffuse boundary
B4ox	100-150 (40-60)	Dark brown (7.5 YR 3/2) clay to silty clay; structure as above; very friable; few roots; common fragments of quartz; thin cutans along pores as above; common patches of shiny surface; diffuse boundary
B5ox	150-210 (60-84)	Dark brown (7.5 YR 3/2) silty clay to clay; structure same as above except the macro structure more distinctly coarser; common fragments of quartz as above; thin cutans along pores as above; patches of shiny surface as above.

Soil Classification:

ORTHIC FERRALSOL, TABLE FAMILY, TABLE SERIES (Sabah Soil classification. See The Soils of Sabah Vol. 1 Acres et al 1975)

TABLE FAMILY (TABLE SERIES)

This soil is so far encountered in the Quoin Hill area; it

is also most likely to occur in the BAL Estate area and at Mostyn.

Paton (1963) described it as Table Sub Family, along with the soils of

Kobovan Family (Pedin No. 1). Acres et al (1975) mapped it as a

component of Table Association which in the Quoin Hill area extends

to about 4000 ha (10000 ac).

TABLE SERIES is formed on similar parent material and landform as Quoin Series (Pedin No. 2). Both are physically similar, being members

of the same family, Table Family, but the Quoin Series is characteristically reddish brown whereas Table brown to dark brown.

Cocoa and to lesser extent oil palm are the 2 principal crops found on this soil.

Depth (cm)	Moisture (%)	Temperature (°C)	pH	EC (µmhos/cm)	Organic Matter (%)	Total N (%)	Total P (ppm)	Total K (ppm)	Ca (ppm)	Mg (ppm)	Na (ppm)	Cl (ppm)	S (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	B (ppm)
0-10	12.0	28.0	5.5	150	1.5	0.15	10	150	100	50	10	5	10	100	10	1	0.5	0.1
10-20	11.0	27.0	5.5	140	1.4	0.14	9	140	90	45	9	4	9	90	9	0.9	0.4	0.09
20-30	10.0	26.0	5.5	130	1.3	0.13	8	130	80	40	8	3	8	80	8	0.8	0.3	0.08
30-40	9.0	25.0	5.5	120	1.2	0.12	7	120	70	35	7	2	7	70	7	0.7	0.2	0.07
40-50	8.0	24.0	5.5	110	1.1	0.11	6	110	60	30	6	1	6	60	6	0.6	0.1	0.06
50-60	7.0	23.0	5.5	100	1.0	0.10	5	100	50	25	5	0	5	50	5	0.5	0.0	0.05
60-70	6.0	22.0	5.5	90	0.9	0.09	4	90	40	20	4	0	4	40	4	0.4	0.0	0.04
70-80	5.0	21.0	5.5	80	0.8	0.08	3	80	30	15	3	0	3	30	3	0.3	0.0	0.03
80-90	4.0	20.0	5.5	70	0.7	0.07	2	70	20	10	2	0	2	20	2	0.2	0.0	0.02
90-100	3.0	19.0	5.5	60	0.6	0.06	1	60	10	5	1	0	1	10	1	0.1	0.0	0.01

PEDON 6. TABLE SERIES

Physico-chemical Data

Horizon	Depth (cm)	Particle size distribution (%)				Org. C (%)	Total N (%)	Easily sol. P (ppm)	pH	
		C Sand	F Sand	Silty	Clay				H ₂ O	0.1M KCl
A	0-2	5.1	9.0	26.4	54.0	4.64	0.46	5	4.4	3.6
B _{1ox}	2-18	5.4	9.8	15.6	65.8	1.52	0.23	2	4.1	4.1
B _{2ox}	18-37	4.5	21.3	10.3	58.7	1.35	0.17	Trace	4.2	3.9
B _{3ox}	37-60	7.0	5.7	13.8	71.8	0.93	0.11	1	4.2	4.0
	60-100	4.0	4.0	9.0	81.4	0.66	0.08	1	4.2	4.0
B _{4ox}	100-125	3.4	3.6	7.6	83.3	0.48	0.07	Trace	4.2	4.1
	125-150	3.0	3.3	7.5	84.9	0.29	0.06	1	4.4	4.1
B _{5ox}	150-210	3.3	3.2	6.7	85.6	0.19	0.05	1	4.3	4.2

Exchangeable Cations (meq %)				C.E.C. (meq %)	Base Satr. (%)	Ex. H m.e. (%)	Total P (ppm)	Ext. Fe ppm in NH OAc pH ^{4.8}	Ext. Fe in KCl (ppm)
Ca	Mg	K	Na						
2.10	0.78	0.46	0.05	15.65	22	1.25	1624	37	37
0.19	0.13	0.22	0.02	8.29	7	0.62	1553	31	208
0.19	0.11	0.13	0.03	8.76	5	0.41	1770	16	77
0.26	0.07	0.11	0.03	8.55	5	0.45	1200	13	58
0.31	0.06	0.21	0.05	6.13	10	0.41	895	12	50
0.16	0.06	0.26	0.02	6.39	8	0.43	861	12	32
0.16	0.10	0.12	0.01	7.52	5	0.37	829	11	10
0.06	0.11	0.20	0.02	5.82	7	0.41	797	11	44

Pedon 6. ---ctd.

Depth (cm)	Total Analysis (%)						Water Disper- sible clay (%)
	K (K ₂ O)	Ca (CaO)	Mg (MgO)	Fe (Fe ₂ O ₃)	Al (Al ₂ O ₃)	Mn (MnO)	
0-2	0.116 (0.14)	0.472 (0.66)	0.356 (0.59)	7.577 (10.84)	10.823 (20.46)	0.037 (0.048)	nd
2-18	0.108 (0.13)	0.422 (0.59)	0.404 (0.67)	7.941 (11.36)	11.368 (21.49)	0.33 (0.042)	nd
18-37	0.083 (0.10)	0.365 (0.51)	0.338 (0.56)	7.920 (11.33)	11.786 (22.28)	0.030 (0.039)	nd
37-60	0.091 (0.11)	0.443 (0.62)	0.386 (0.64)	8.192 (11.72)	12.146 (22.96)	0.025 (0.032)	1.2
60-100	0.091 (0.11)	0.450 (0.63)	0.283 (0.47)	8.703 (12.45)	13.564 (25.64)	0.020 (0.026)	0.8
100-125	0.125 (0.15)	0.443 (0.62)	0.422 (0.70)	8.661 (12.39)	12.156 (22.98)	0.016 (0.021)	0.4
125-150	0.091 (0.11)	0.400 (0.56)	0.362 (0.60)	7.458 (10.67)	10.358 (19.58)	0.013 (0.017)	nd
150-210	0.125 (0.15)	0.501 (0.70)	0.410 (0.68)	7.36 (10.53)	13.214 (24.98)	0.067 (0.087)	nd

nd = not determined

77-100 (30-40)

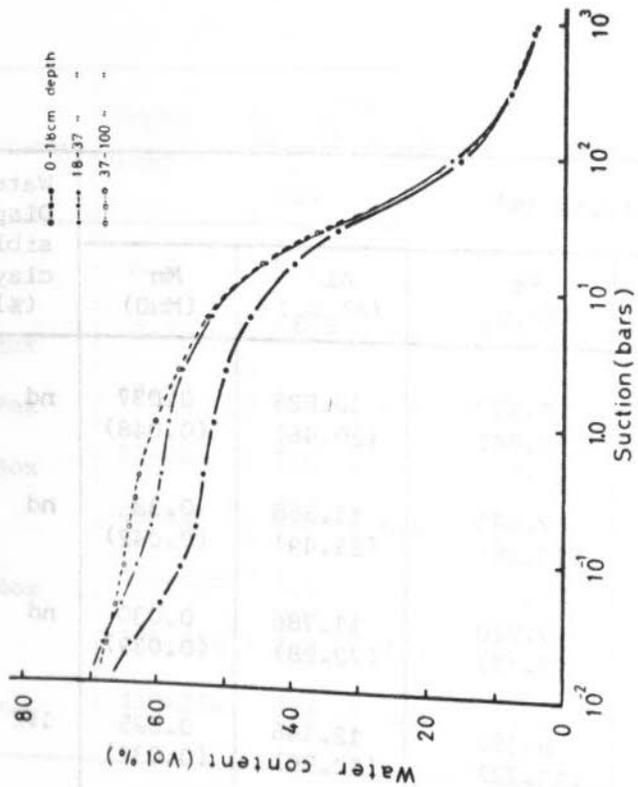
Predominantly (C, 60%) decomposing loose coral debris with soil material in between cracks.

100+ (40+)

Similar to above except weathered coral increases with depth.

Soil Classification:

CALCIC LUSTIC



pF-moisture distribution curve

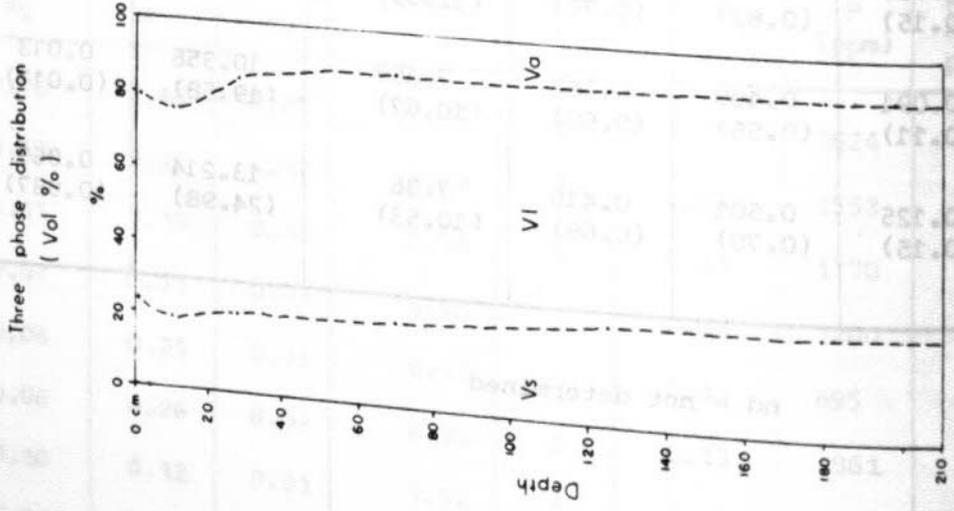
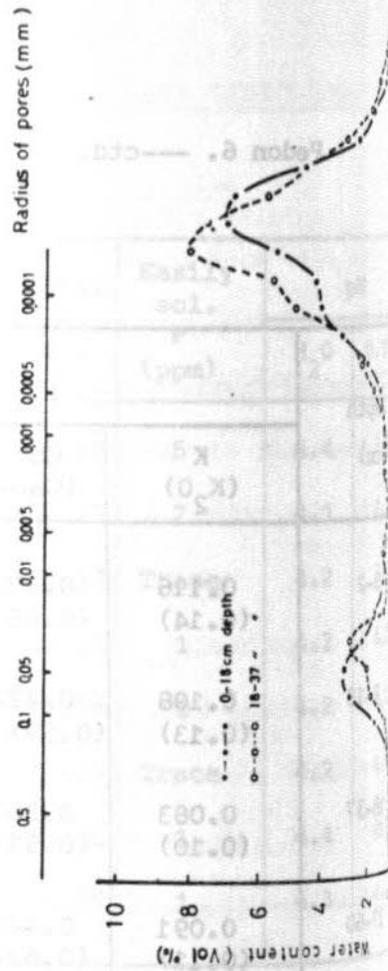


FIG. 6. SOIL MOISTURE CHARACTERISTICS OF TABLE FAMILY

PEDON No. 7 SEMPORNA FAMILY

Location: Semporna Agricultural Station

Parent Material: Coralline limestone

Topography: Flat coastal terrace sloping very gently towards the sea.

Vegetation/Land Use: Lallang Imperita cylindrica

Drainage: Well drained

Horizon	Depth cm	Depth (in)	Description
A1	0-5	(0-2)	Dark to very dark brown (10 YR 2/2 - 2/4) silty clay; strong very coarse to coarse granular and medium crumb; hard; many roots; few fragments of charcoal; diffuse boundary
A2	5-10	(2-4)	Dark brown (10 YR 3/3) silty clay; strong medium angular to subangular blocky; firm and plastic; many roots; clear wavy boundary
Blt	10-18	(4-7)	Yellowish brown (10 YR 5/4) with many very dark distinct greyish brown worm cast, silty clay; plastic; strong to moderately medium angular to subangular blocky; continuous cutans on ped surfaces; common humus, staining crack walls; common roots; gradual boundary
B2t	18-37	(7-15)	Yellowish brown (10 YR 5/6) clay to silty clay; strong coarse to medium subangular blocky; plastic and sticky; continuous thick cutans (greyish brown) on ped surfaces; many fine dead roots; common fine roots; gradual wavy boundary
B3t	37-55	(15-22)	Brownish yellow to yellowish brown (10 YR 5/6 -6/6) clay; moderate coarse subangular breaking to medium fine angular blocky; sticky and plastic; continuous thick cutans on ped surfaces; common fine soft iron concretions; few dead roots; few fine roots; diffuse boundary
B4t	55-75	(22-30)	Brownish yellow (10 YR 6/6) clay; weak coarse columnar breaking into medium to fine angular blocky friable and slightly sticky; many soft and few hard reddish iron concretions; few roots; continuous thick cutans on ped surfaces; abrupt boundary
C	77-100	(30-40)	Predominantly (C.80%) decomposing loose coral debris with soil material in between cracks.
R	100 +	(40 +)	Similar to above except weathered coral increases with depth.

Soil Classification:

CALCIC LUVISOL, SEMPORNA FAMILY (Sabah soil classification see
The Soils of Sabah Vol. 1 Acres et al 1975)

SEMPORNA FAMILY

This soil family is confined to the tip of Semporna Peninsular and nearby islands and on the Dent Peninsular on the east coast of Sabah. It occurs on low gently sloping land (slopes generally 5°) formed from coralline limestone.

It is relatively of limited extent. It has so far been mapped at a detailed reconnaissance level. On the soil map of Sabah (Acres et al 1975) it is mapped along with Tegupi Family (Chromic Luvisol) and Loc Sambuang Family (Rendzina) as Semporna Association. The total area of Semporna Association in the whole of Sabah is 21400 ha (53000 ac).

Paton (1963) refers to the soils of SEMPORNA FAMILY and of the closely associated Tegupi Family as Semporna Sub Family.

Coconuts, oil palm maize and recently cocoa are the main crops planted on soils of the Semporna Family.

100 + (40 +)	Stabil to above except weathered coral increases with depth.
77-100 (30-40)	Predominantly (C80X) decomposing loose coral debris with soil material in between cracks.
55-75 (22-30)	Brownish yellow (10 YR 6/8) clay; weak coarse columnar breaking into medium to fine angular blocky friable and slightly sticky; many soft and few hard reddish iron concretions; few roots; continuous thick cutans on ped surfaces; abrupt boundary.
37-52 (12-22)	Brownish yellow to yellowish brown (10 YR 5/6-6/6) clay; moderate coarse angular breaking to medium strong coarse to medium angular blocky; plastic and sticky; continuous thick cutans (greyish brown) on ped surfaces; many fine dead roots; common fine roots; gradual wavy boundary.
18-37 (7-12)	Yellowish brown (10 YR 5/6) clay to silty clay; strong coarse to medium angular blocky; plastic

Soil Classification:

THE SOILS OF SABAH VOL. 1 ACRES ET AL (1975)
CALCIC LUVISOL, SEMPORNA FAMILY (Sabah soil classification see

Pedon 7. --ctd.

Depth (in)	Total Analysis (%)						Water Disper- sible clay (%)
	K (K ₂ O)	Ca (CaO)	Mg (MgO)	Fe (Fe ₂ O ₃)	Al (Al ₂ O ₃)	Mn (MnO)	
0-5	0.332 (0.40)	1.737 (2.43)	0.669 (1.11)	4.544 (6.50)	8.332 (15.75)	0.015 (0.020)	nd
5-10	0.357 (0.43)	1.502 (2.10)	0.814 (1.35)	4.879 (6.98)	10.162 (19.21)	0.018 (0.024)	nd
10-18	0.390 (0.47)	1.594 (2.23)	0.929 (1.54)	4.837 (6.92)	7.358 (13.91)	0.015 (0.019)	4.1
18-37	0.415 (0.50)	1.852 (2.59)	1.007 (1.67)	4.984 (7.13)	10.379 (19.62)	0.010 (0.013)	1.3
37-55	0.457 (0.55)	1.83 (2.56)	1.031 (1.71)	4.921 (7.04)	8.268 (15.63)	0.011 (0.014)	3.0
55-75	0.332 (0.40)	1.737 (2.43)	0.965 (1.60)	4.963 (7.10)	8.808 (16.65)	0.012 (0.015)	nd
75-100	0.349 (0.42)	16.903 (23.64)	0.356 (0.59)	2.209 (3.16)	6.623 (12.52)	0.048 (0.062)	nd
100 +	0.448 (0.54)	13.542 (18.94)	0.344 (0.57)	1.132 (1.62)	5.718 (10.81)	0.045 (0.058)	nd

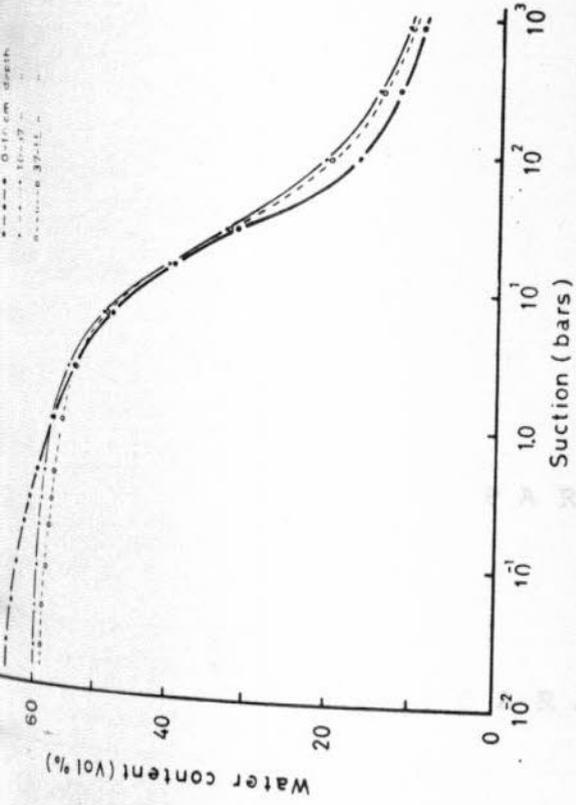
nd = not determined

PEDON 7. SEMPORNA FAMILY

Physico-chemical Data

Horizon	Depth (cm)	Particle size distribution (%)				Org. C (%)	Total N (%)	Easily sol. P (ppm)	pH	
		C Sand	F Sand	Silty	Clay				H ₂ O	0.1 N
A ₁	0-5	3.1	12.0	18.8	58.4	4.56	0.40	5	6.1	0.1
A ₂	5-10	3.7	10.8	15.9	69.3	1.66	0.22	1	6.5	0.1
B _{1t}	10-18	2.8	12.4	15.4	68.2	0.81	0.16	Trace	6.6	0.1
B _{2t}	18-37	} Not able to disperse the material				0.53	0.11	2	6.8	0.1
B _{3t}	37-55					0.41	0.09	Trace	7.0	0.1
B _{4t}	55-75					0.37	0.08	Trace	7.4	0.1
C	75-100					0.09	0.04	1	7.8	0.1
R	100 +					0.07	0.03	Trace	7.8	0.1

Exchangeable Cations (meq %)				C.E.C. (meq %)	Base Satr. (%)	Ex. H m.e. %	Total P (ppm)	Ext. Fe ppm in NH ₄ OAc pH 4.8	Ext. Al 1N KCl (ppm)
Ca	Mg	K	Na						
60.52	1.67	0.56	0.45	62.76	100	1.39	760	16	3
54.50	0.76	0.34	0.48	55.96	100	0.96	430	22	2
50.68	0.45	0.24	0.49	53.42	97	1.17	297	22	Trace
55.17	0.22	0.25	0.51	56.34	100	1.18	231	16	Trace
55.65	0.17	0.18	0.46	57.40	98	1.17	206	13	Trace
56.18	0.16	0.16	0.46	55.48	100	0.21	208	12	Trace
64.03	0.13	0.05	0.49	31.15	100	0.21	186	23	Trace
64.64	0.21	0.08	0.51	35.05	100	0.21	169	17	Trace



pf - moisture distribution curve

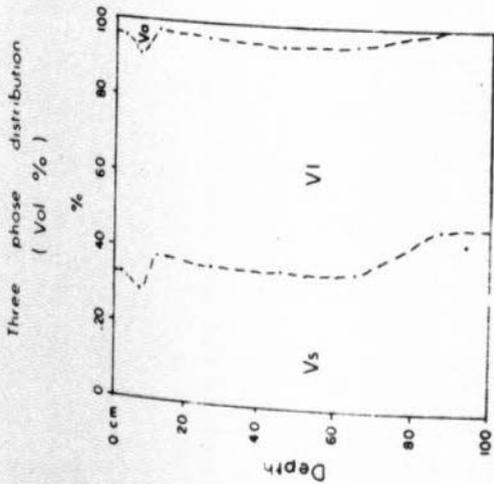
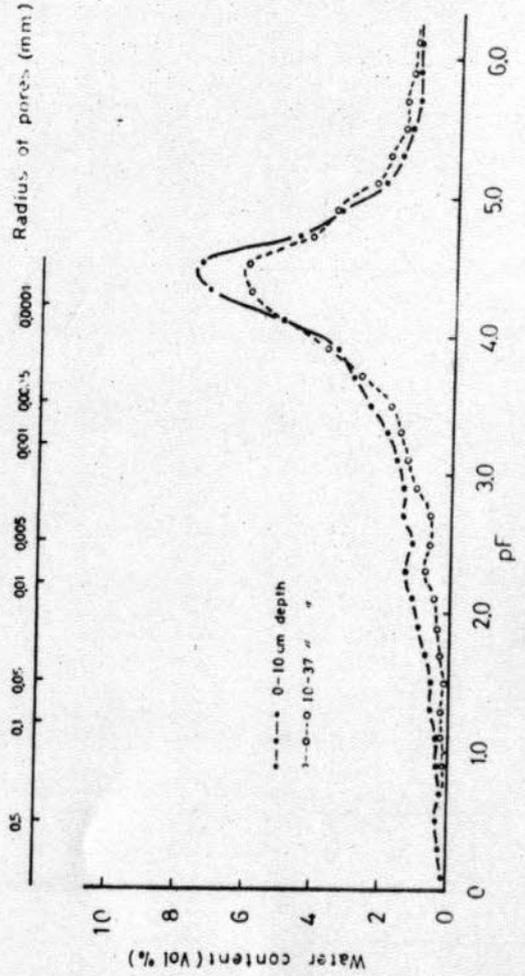


FIG.7. SOIL MOISTURE CHARACTERISTICS OF SEMIPORNA FAMILY

PART II

SARAWAK

Location

Sarawak lies between latitudes 0° and 5° N and longitudes 109° 36' and 112° 40' East, occupying most of the northwestern coastal area of the island of Borneo. The area of Sarawak, about 148,000 sq. miles (124,400 sq. kilometers) is approximately one-sixth of the whole island of Borneo. The boundary between Sarawak and Indonesian Borneo (Kalimantan) following watersheds between the rivers flowing generally north-westerly into the South China Sea and those flowing into the Malacca and the Java seas. In the north, Sarawak adjoins Sabah, and to the north-west the state of Brunei forms a double enclave.

Kuching, the capital with a population of over 61,000

(1970 census) is situated on the Sarawak River 21 miles from the sea.

1. THE PHYSICAL ENVIRONMENT

Kuching is the commercial centre of Sarawak and handles a large

proportion of the import and export trade of the country.

Other important administrative centres are Miri, Sibu, and Bintulu.

The total population of Sarawak as at 1970

was 775,918. A section of soil pits are shown in Map 5.

Climate

The climate of Sarawak is characterized by heavy rainfall

throughout the year, a relatively uniform temperature and a high relative

humidity.

The mean annual rainfall in Sarawak ranges from 2550 to 7000 mm

(90 to 280 inches). The heaviest rainfall occurs in a belt running

generally south-southeast from Limbang area to central interior Sarawak

whereas the driest areas are located at the western tip of Sarawak,

I. THE PHYSICAL ENVIRONMENT

Location

Sarawak lies between latitudes 05° and 5° N and longitudes $109^{\circ}36''$ and $115^{\circ}40''$ East, occupying most of the northwestern coastal area of the island of Borneo. The area of Sarawak, about 48,050 sq. miles (124,450 sq. kilometers) is approximately one-sixth of the whole island of Borneo. The boundary between Sarawak and Indonesian Borneo (Kalimantan) follows the watersheds between the rivers flowing generally north-westerly into the South China Sea and those flowing into the Celebes and the Java seas. In the north, Sarawak adjoins Sabah, and in the north-west the state of Brunei forms a double enclave.

Kuching, the capital with a population of over 63,000 (1970 census) is situated on the Sarawak river 21 miles from the sea.

Sibu is the commercial centre of Sarawak and handles a large proportion of the import and export trade of the country.

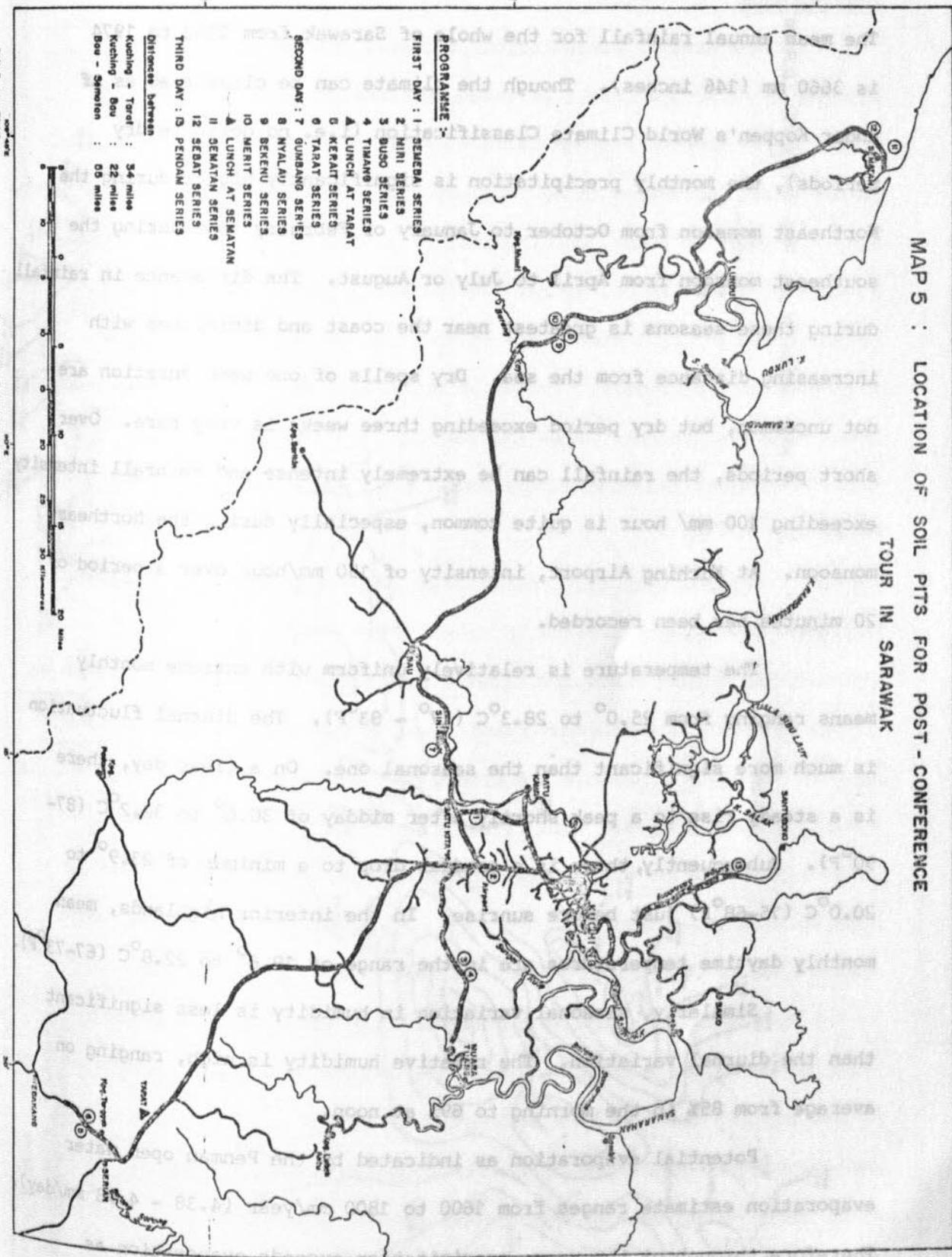
Other important administrative centres are Miri, Simmangang, Limbang, Sarikei and Kapit. The total population of Sarawak as at 1970 was 975,918. Location of soil pits are shown in Map 5.

Climate

The climate of Sarawak is characterized by heavy rainfall throughout the year, a relatively uniform temperature and a high relative humidity.

The mean annual rainfall in Sarawak ranges from 2550 to 7000 mm (90 to 280 inches). The heaviest rainfall occurs in a belt running generally south-southeast from Limbang area to central interior Sarawak whereas the driest areas are located at the western tip of Sarawak,

MAP 5 : LOCATION OF SOIL PITS FOR POST - CONFERENCE TOUR IN SARAWAK



Soil Survey Division
Department of Agriculture, Sarawak

Bareo - Long Semado area and the coastal region from Niah to Miri.

The mean annual rainfall for the whole of Sarawak from 1963 to 1974 is 3660 mm (146 inches). Though the climate can be classified as Af under Koppen's World Climate Classification (i.e. no definite dry periods), the monthly precipitation is significantly higher during the Northeast monsoon from October to January or February than during the southeast monsoon from April to July or August. The difference in rainfall during these seasons is greatest near the coast and diminishes with increasing distance from the sea. Dry spells of one week duration are not uncommon, but dry period exceeding three weeks is very rare. Over short periods, the rainfall can be extremely intense and rainfall intensity exceeding 100 mm/hour is quite common, especially during the Northeast monsoon. At Kuching Airport, intensity of 150 mm/hour over a period of 20 minutes has been recorded.

The temperature is relatively uniform with extreme monthly means ranging from 25.0° to 28.3°C (77° - 83°F). The diurnal fluctuation is much more significant than the seasonal one. On a clear day, there is a steady rise to a peak shortly after midday of 30.6° to 32.2°C (87 - 90°F). Subsequently, there is a gradual drop to a minimum of 23.9° to 20.0°C (75 - 68°F) just before sunrise. In the interior highlands, mean monthly daytime temperatures are in the range of 19.6° to 22.8°C (67 - 73°F).

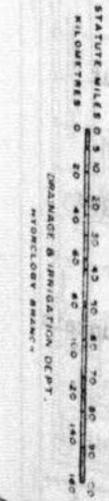
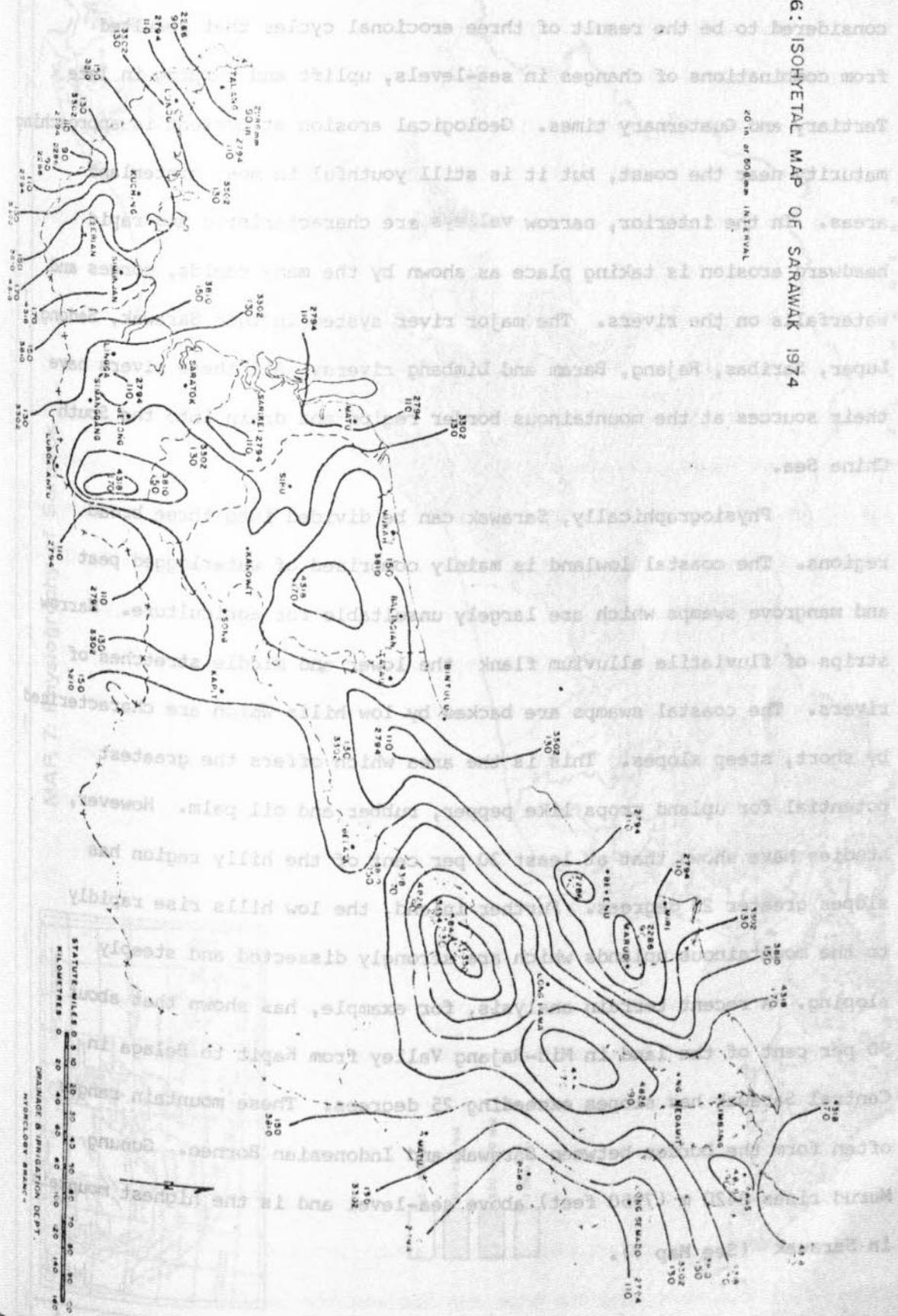
Similarly, seasonal variation in humidity is less significant than the diurnal variation. The relative humidity is high, ranging on average from 85% in the morning to 69% at noon.

Potential evaporation as indicated by the Penman open water evaporation estimate ranges from 1600 to 1800 mm/year (4.38 - 4.93 mm/day). Therefore, throughout the year, precipitation exceeds evaporation as measured from free water surface. The rainfall distribution of Sarawak is shown in Map 6.

Physiography

MAP 6: ISOHYETAL MAP OF SARAWAK 1974

40 IN. or 50 Mm. INTERVAL

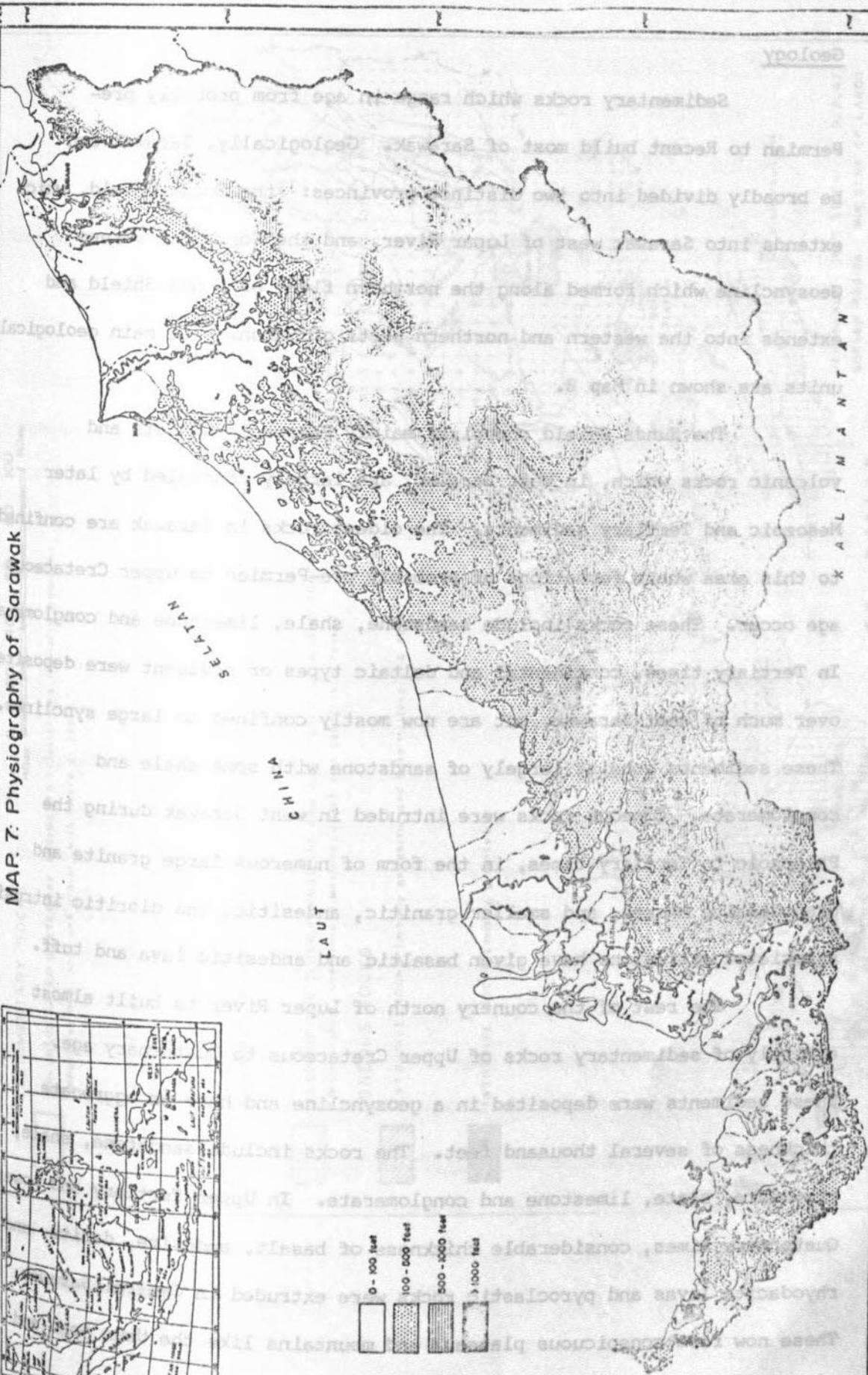
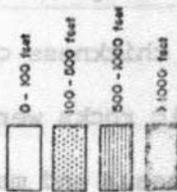


Physiography

The present morphological features of most of Sarawak are considered to be the result of three erocional cycles that resulted from combinations of changes in sea-levels, uplift and warping in late Tertiary and Quaternary times. Geological erosion at present is approaching maturity near the coast, but it is still youthful in most hinterland areas. In the interior, narrow valleys are characteristic and rapid headward erosion is taking place as shown by the many rapids, gorges and waterfalls on the rivers. The major river system include Sarawak, Sadong, Lupar, Saribas, Rajang, Baram and Limbang rivers. All these rivers have their sources at the mountainous border region and drain into the South China Sea.

Physiographically, Sarawak can be divided into three broad regions. The coastal lowland is mainly comprised of waterlogged peat and mangrove swamps which are largely unsuitable for agriculture. Narrow strips of fluviatile alluvium flank the lower and middle stretches of rivers. The coastal swamps are backed by low hills which are characterized by short, steep slopes. This is the area which offers the greatest potential for upland crops like pepper, rubber and oil palm. However, studies have shown that at least 30 per cent of the hilly region has slopes greater 25 degrees. Further inland, the low hills rise rapidly to the mountainous uplands which are strongly dissected and steeply sloping. A recent terrain analysis, for example, has shown that about 90 per cent of the land in Mid-Rajang Valley from Kapit to Belaga in Central Sarawak has slopes exceeding 25 degrees. These mountain ranges often form the border between Sarawak and Indonesian Borneo. Gunung Murud rises 2420 m (7950 feet) above sea-level and is the highest mountain in Sarawak (See Map 7).

MAP. 7: Physiography of Sarawak



Geology

Sedimentary rocks which range in age from probably pre-Permian to Recent build most of Sarawak. Geologically, Sarawak can be broadly divided into two distinct provinces: the Sunda Shield, which extends into Sarawak west of Lupar River, and the Northwest Borneo Geosyncline which formed along the northern flank of Sunda Shield and extends into the western and northern parts of Sabah. The main geological units are shown in Map 3.

The Sunda Shield comprises mainly Paleozoic schists and volcanic rocks which, in West Sarawak, are largely concealed by later Mesozoic and Tertiary sediments. The oldest rocks in Sarawak are confined to this area where formations of probably pre-Permian to upper Cretaceous age occur. These rocks include sandstone, shale, limestone and conglomerate. In Tertiary times, continental and deltaic types of sediment were deposited over much of west Sarawak, but are now mostly confined to large synclines. These sediments consist largely of sandstone with some shale and conglomerate. Igneous rocks were intruded in west Sarawak during the Paleozoic to Tertiary times, in the form of numerous large granite and granodiorite masses, and smaller granitic, andesitic, and dioritic intrusions. Associated extrusions have given basaltic and andesitic lava and tuff.

The rest of the country north of Lupar River is built almost entirely of sedimentary rocks of Upper Cretaceous to Quaternary age. These sediments were deposited in a geosyncline and have an aggregate thickness of several thousand feet. The rocks include sandstone, shale, greywacke, slate, limestone and conglomerate. In Upper Tertiary and Lower Quaternary times, considerable thickness of basalt, andesite, dacite, and rhyodacite lavas and pyroclastic rocks were extruded in Central Sarawak. These now form conspicuous plateaus and mountains like the Usun Apau and Linau-Balui Plateaus, and the Hose and Nieuwenhius Mountains.

MAP 8. GEOLOGY OF SARAWAK

SEDIMENTARY ROCKS



UNCONSOLIDATED QUATERNARY SEDIMENTS (coastal and fluvial/terrestrial alluvium comprising mud, sand and gravel, with layers of peat)

NEOGENE FORMATIONS (mainly marine sandstones, shale, and limestone, coal seams occur and Miocene oil is worked)

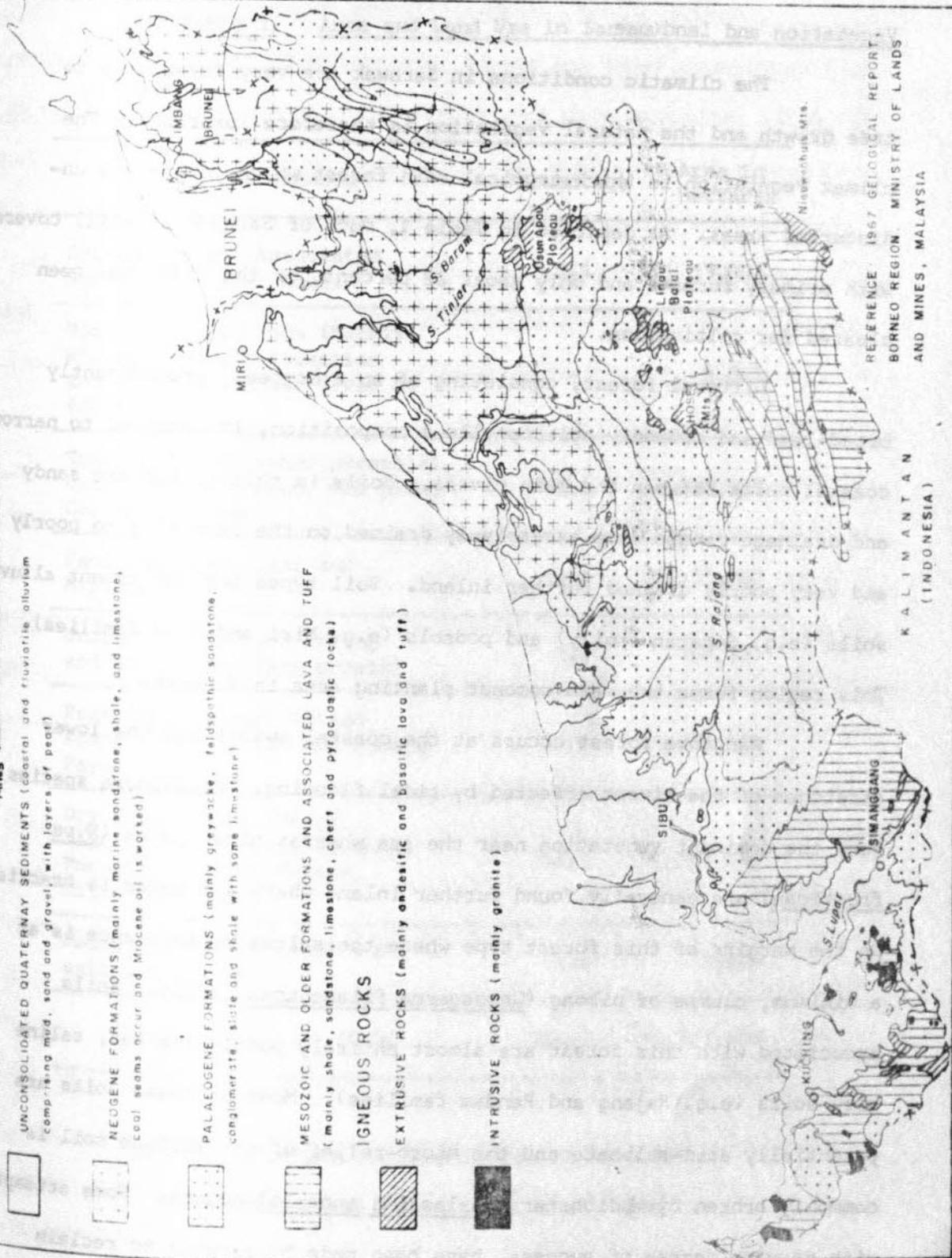
PALAEOGENE FORMATIONS (mainly greywacke, feldspathic sandstone, conglomerate, slate and shale with some limestone)

MESOZOIC AND OLDER FORMATIONS AND ASSOCIATED LAVA AND TUFF (mainly shale, sandstone, limestone, chert and pyroclastic rocks)

IGNEOUS ROCKS

EXTRUSIVE ROCKS (mainly andesitic and basaltic lava and tuff)

INTRUSIVE ROCKS (mainly granite)



REFERENCE: 1967 GEOLOGICAL REPORT,
BORNEO REGION. MINISTRY OF LANDS
AND MINES, MALAYSIA

KALIMANTAN
(INDONESIA)

Vegetation and land use

The climatic conditions in Sarawak are very favourable to tree growth and the natural vegetation is therefore luxuriant. The climax vegetation is thick tropical rain forest which covers all undisturbed areas. As depicted in Table 1, much of Sarawak is still covered with primary forests and only about 22 percent of the State has been cleared for cultivation.

Littoral forest, consisting of an evergreen, predominantly broad-leaf and commonly sclerophyllous composition, is confined to narrow coastal belts between the main rivers. Soils in this region are sandy and drainage ranges from excessively drained on the shoreline to poorly and very poorly drained further inland. Soil types include recent alluvial soils (e.g. Sematan family) and podzols (e.g. Miri and Buso families). This region forms the main coconut planting area in Sarawak.

Mangrove forest occurs at the coastal swamps and the lower stretches of the rivers affected by tidal flooding. *Rhizophora* species form the dominant vegetation near the sea whereas nipah palms (*Nypa fructican*) are generally found further inland where the water is brackish. On the margins of this forest type where the saltwater influence is at a minimum, clumps of nibong (*Oncosperma filamentosa*) occur. Soils associated with this forest are almost entirely poorly drained, saline gley soils (e.g. Rajang and Pendam families). Most of these soils are potentially acid-sulphate and the micro-relief of the surface soil is commonly broken by mudlobster (*Thalassima anomala*) mounds. Some attempts, with varying degree of success, have been made by farmers to reclaim these soils for wet padi and coconut cultivations. The availability of fresh water seems to play an important role in determining the degree of success for padi cultivation.

Table 1. Area and Land Use in Sarawak

Land Use Classes	Percentage	Area in hectares
Settlement and Associated Non-agricultural Lands	0.1	13,002
Horticultural Lands (Mainly miscellaneous cultivation and including small areas of fruit trees)	-	8,003
Tree, palm and other perennial crops (Rubber, Sago, Oil plum, Coconut, Pepper)	3.1	376,515
Padi land (Wet padi and Hill padi)	18.9	2,325,860
Unused land (sheet lalang and other secondary growth)	1.4	169,337
Peat Swamp Forest (Mixed swamp forest, Alan and Padang Paya)	12.0	1,473,684
Dry forest land (Mixed Dipterocarp Forest, Kerangas Forest, Riparian Forest, Littoral Forest)	63.1	7,785,207
Swamp (including fresh and salt water swamps)	1.4	173,870
TOTAL	100.0	12,325,478

Source: Planimetric Measurement of Land Use

Map, Land Survey Department, 1966

Further inland, freshwater swamp forest occurs as a narrow belt along river banks and merges into peat swamp forest further away. The soils associated with this forest type are predominantly poorly to very poorly drained with or without a peaty surface layer and they form the best medium for wet padi cultivation. Riparian forest occupies the thin fringe on the river banks where the drainage is good. The soils are typically recent alluvial soils (e.g. Bemang family). This better drained alluvial soils form the main vegetable and fruit trees growing areas and some dry land padi is also grown.

Peat swamp forest is widespread in the coastal lowland. It is an evergreen, broadleaf forest with perceptible zonations from the fringes towards the centre (Anderson, 1963). The peat, invariably waterlogged, and can attain a depth up to 20 m. The shallower members (up to 1 m) of this soil type are usually used in association with the non-saline gley soils for wet padi cultivation with little problems. Wet rice growing on deeper peats is usually very problematic whereas sago palms (*Metroxylon* spp.) have been reported to grow remarkably well on peat with practically no fertilizer inputs. Some pineapples are also grown on drained peat for the local fruit market. A peat research station at Stapok on the outskirts of Kuching has started to investigate the agricultural utilisation of this important land resource in Sarawak. Peat swamp forest contains many valuable timber species like "ramin" (*Gonystylus bancanus*) and "Meranti" (*Shorea* spp.).

"Kerangas" or heath forest is characterised by sandy soils, more or less podzolised and of low fertility. It is usually found on flat to slightly sloping land like terraces and plateaus but it also occurs in minor areas associated with skeletal soils and steep slopes. The vegetation tends to be dominated by small, pole-like trees of a sclerophyllous nature giving a general appearance of poor growth. The

associated soils are mainly podzols (e.g. Miri and Buso families).

"Kerangas" in Iban means land which cannot support hill rice cultivation. Therefore this forest type is rarely cleared for cultivation.

Mixed Dipterocarp forest is the dominant forest type in all upland areas where well drained conditions prevail. This type of forest is a source of many valuable timber species, but no general indication can be given to their location which depends very much on the overall ecology of the site. The associated soils include the Red-Yellow Podzolic, Grey-White Podzolic and Lateritic soils (e.g. Merit, Bekenu, Nyalau, Kerait, Bandang, Saratok and Tarat families). Upland crops like rubber, oil palm, pepper and hill rice are grown in areas where the slopes are not too steep. As indicated in Section 2, the low hills sandwiched between the swamps and the mountainous interior provide the greatest potential for these upland crops. The indigenous populace still practises shifting cultivation of hill rice, sometimes on very steep slopes. The hazard of erosion in such areas is expected to increase as the population growth results in the greater use of the steeper land with increasingly shorter fallow periods. In areas where cultivation is more intensive, secondary regrowth of trees is very slow and the land is covered with lallang (Imperata cylindrica). As pepper gardens are normally clean weeded pepper cultivations also constitutes a hazardous form of land use on steep slopes in terms of erosion unless conservation measures are taken. Where slopes permit, perennials like rubber, oil palm and cocoa can grow very well in this region.

TYPE: ...

Location: ...

Parent: ...

Topography: ...

Aspect: ...

Vegetation: ...

Soil: ...

Notes:

2. PROFILE CHARACTERISTICS OF SELECTED SOILS

FROM

SARAWAK

PEDON No. 1 SEMEBA SERIES

Location: Jalan Datu Stephen Yong

Parent Material: Old terrace deposits

Topography: On hill top of old terrace

Slope: 12° aspect east

Vegetation/Land Use: Cleared old rubber with thick young secondary undergrowth

Drainage: Well-drained

Horizon	Depth	
	2 - 0 cm:	Reddish brown (5 YR 4/4) humus and rootmat
A ₁	0 - 20 cm:	Very dark grey (10 YR 3/1) loamy fine sand; moist, friable; very weak medium subangular blocky structure; many fine to medium roots; few fine pores; common charcoal pieces; some quartz grits; diffuse wavy boundary;
A ₂	20 - 45 cm:	Dark greyish brown (10 YR 4/2) loamy fine sand; moist, friable; weak medium subangular blocky structure; few fine pores; few fine roots; few charcoal pieces; common quartz grits; clear wavy boundary;
B ₁	45 - 76 cm:	Pale brown (10 YR 6/3) fine sandy loam with common dark greyish brown organic cutans along cracks and root channels; weak coarse subangular blocky structure; few quartz grits; few fine roots; few fine pores; indistinct boundary;
B ₂₁	76 - 110 cm:	Brownish grey (10 YR 6/2) fine sandy loam; few dark greyish brown organic cutans along old root channels; few fine pores; many termite activities; indistinct wavy boundary;
B ₂₂	110 - 150 cm:	Light grey (10 YR 7/2) fine sandy loam; many coarse dark greyish brown (10 YR 3/2) organic cutans along old root channels and some organic leaching from above; many medium subangular blocky structure; many termites activities; few fine pores, some cracks; common quartz grits and gravels; few fine roots; abruptly overlying;
11C	150 - 180 cm:	Light grey (10 YR 7/2) sandy clay loam mixed with more than 50 percent subrounded quartz and pebbles.

PEDON 1: SEMEBA SERIES
Physico-chemical Data

FROM No. 1, SEMEBA SERIES

Lab. No:	MS1391	MS1392	MS1393	MS1394	MS1395
Depth (cm)	0-20	20-45	45-76	76-110	110-150
Sand %	63.4	81.0	76.0	74.3	70.9
Silt %	9.1	9.7	10.0	10.2	11.2
Clay %	7.5	9.3	14.0	15.5	17.9
Texture Class	LS	LS	SL	SL	SL
C %	0.55	0.53	0.42	0.23	0.13
N %	0.06	0.04	0.04	0.03	0.03
C/N	11	13	11	8	4
pH (H ₂ O)	4.7	5.0	5.1	5.2	4.9
pH (KCl)	3.8	4.2	4.5	4.5	4.4
Excn. (me/100g) (NH ₄ OAc, pH 7.0)					
Ca	0.35	0.53	0.32	0.35	0.51
Mg	0.02	0.01	0.02	0.01	0.02
K	0.04	0.02	0.02	0.04	0.03
Na	0.03	0.03	0.03	0.04	0.07
CEC	3.02	3.23	2.64	2.63	2.54
BS %	15	18	15	17	24
Excn. (me/100g) (KCl)					
A1	1.21	1.55	0.89	0.94	1.20
H	0.08	0.00	0.00	0.03	0.03
CEC	1.87	1.87	1.15	1.54	1.54
Ext. Acidity (me/100g)	4.42	3.35	7.36	6.37	5.42
Free Fe ²⁺ (%)	0.03	0.10	0.11	0.07	0.07
Clay: total (%)					
SiO ₂	48.4	43.4	41.7	41.7	43.6
Fe ₂ O ₃	2.2	3.4	2.8	2.5	2.3
Al ₂ O ₃	19.4	31.7	33.1	33.0	32.6
Moist ret (%)					
1/10 atm.	26.8	30.6	30.7	31.6	33.1
1/3 atm.	10.4	12.9	16.0	17.7	18.1
15 atm.	3.4	4.5	7.2	6.3	9.2

PEDON No. 2 BUSO SERIES

Location: 10th mile, Muara Tuang Road
 Parent Material: Probably residual & colluvium
 Topography: Terrace/colluvial footslope
 Slope: \angle 5 degrees
 Vegetation/Land Use: Ferns and Imperata cylindrica
 Drainage: Int. medium
 Ext. imperfect

Horizon	Depth	
A ₁₁	0 - 8 cm:	Dark grey (10 YR 4/1) medium loamy sand with bleached sand, single grained with some fine crumbs; low biological activity; common fine medium roots; few large roots; diffuse boundary to;
A ₁₂	8 - 20 cm:	Grey to greyish brown (10 YR 5/1 - 5/2) loamy sand with few coarse grains; weak, fine subangular blocky; few fine and large roots; low biological activity; sharp boundary to;
A ₂₁	20 - 30 cm:	Light grey (10 YR 7/2) loamy sand with few quartz grits; massive compact; very few fine roots; diffuse boundary to;
A ₂₂	30 - 40/45 cm:	Light grey (10 YR 7/2) loamy sand but with very coarse sand; few root channels; compact; very low biological activity; sharp and wavy boundary to;
IIB _{2h}	40/45 - 60 cm:	Brown to dark brown (10 YR 4/3) coarse sandy loam; slightly massive; pedotubules; sharp boundary to;
IIB _{2h/ir}	60 - 77 cm:	Very pale brown (10 YR 7/3) sandy loam with mottles (brownish yellow (10 YR 6/8) and patches of organic matter (dark brown 10 YR 3/3) texture as above; massive many or common former root channels with decomposed organic matter; common pedotubules; common large mottles; sharp boundary to;
IIIC ₁	77 - 105 cm:	Light grey (10 YR 7/1 - 8/1) sandy loam with strong brown (7.5 YR 5/8) mottles; fine sandy clay with coarse grit; massive; common root channels with decaying roots; abrupt boundary to;
IVC _{2g}	105 - 135 cm:	Light grey (10 YR 7/2) clay loam with reddish yellow (7.5 YR 6/8) mottles; heavy clay; massive; common root channels with decaying organic matter; rather sharp boundary to;
VC _{3g}	135 - 145+ cm:	Light grey (10 YR 7/1) clay loam with coarse grit, few mottles.

Classification: AQUIC TROPOHUMOD

PEDON 2 : BUSO SERIES
Physico-chemical Data

Lab. No:	MS1325	MS1326	MS1327	MS1328	MS1329	MS1330	MS1331	MS1332	MS1333
Depth (cm)	0-8	8-20	20-30	30-45	45-60	60-77	77-105	105-135	135-145
Sand %	77.8	81.5	79.5	79.2	78.0	76.2	64.0	30.1	22.2
Silt %	17.2	14.5	17.7	17.1	13.5	9.7	16.5	41.1	45.2
Clay %	5.0	4.0	2.8	3.7	8.7	14.1	19.5	28.8	32.6
Texture Class	LS	LS	LS	LS	SL	SL	SL	CL	CL
C %	<.23	0.92	0.31	0.37	1.24	0.45	0.29	0.33	0.36
N %	0.12	0.05	0.01	<0.01	0.03	0.02	0.02	0.03	0.01
C/N	19	16	31	37	41	23	15	11	36
pH (H ₂ O)	4.4	4.4	4.8	4.5	4.6	5.1	4.9	4.7	4.8
pH (KCl)	3.8	3.6	3.8	3.9	3.9	4.1	3.8	3.6	3.5
Exch. (me/100g) (NH ₄ OAc, pH 7.0)									
Ca	1.11	0.45	0.20	0.10	0.10	0.45	0.51	0.51	0.21
Mg	0.28	0.13	<0.01	<0.01	<0.01	0.05	0.10	0.12	0.10
K	0.13	0.04	0.03	0.01	0.03	0.03	0.04	0.05	0.05
Na	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
CEC	8.09	3.82	3.01	1.60	7.49	6.25	7.50	10.87	14.82
SS %	19	16	8	7	2	9	9	6	2

PEDON 2: BUSO SERIES
 Physico-chemical Data ctd.

Exch. (me/100g) (KCl)	A1	0.31	0.47	0.17	0.33	2.50	2.02	5.07	14.83	15.40
H		0.42	0.28	0.14	0.06	0.08	0.06	0.11	0.40	0.40
CEC		5.51	0.87	0.14	0	7.05	5.58	8.64	7.93	13.07
Ext. Acidity (%)		11.05	5.16	0.95	1.54	14.53	3.67	6.92	20.32	22.50
Free Fe as Fe ₂ O ₃ (ppm)		188	108	46	25	108	6018	2716	3152	2943
Clay: total (%)		84.2	-	55.3	50.4	57.2	41.4	45.1	46.0	46.4
SiO ₂		0.4	-	1.8	0.8	1.2	5.6	3.0	2.6	2.4
Fe ₂ O ₃		3.5	-	11.8	17.3	25.2	29.8	30.7	27.6	29.5
A1 ₂ O ₃										
Moist ret (%)										
1/10 atm.		32.1	22.8	17.5	16.3	23.0	27.6	31.2	49.0	52.3
1/3 atm.		20.5	13.9	11.9	11.1	16.8	20.7	25.2	35.7	45.8
15 atm.		10.8	5.1	2.4	2.2	7.6	8.0	9.9	26.1	30.4

PEDON No. 3 MIRI SERIES

Location: End of north Pan Road, Kuching Airport
 Parent Material: Old alluvium
 Topography: Flat, terrace
 Vegetation/Land Use: Old secondary small pole like trees
 Drainage: Int. very poor

Horizon	Depth	
A ₀	4 - 0	cm: Dark reddish brown (5 YR 3/2) finely decomposed humus in rootmat, moist, friable;
A ₁	0 - 23	cm: Brown (7.5 YR 5/2) loamy fine sand; moist, friable; few fine roots; few fine pores; low faunal activity; clear wavy boundary, tongues into most of the next horizon;
A ₂	23 - 55	cm: White (10 YR 8/1) loamy fine sand; massive, very compact, no roots; no pores or cracks; containing common tongues of material of above horizon;
B _{2h}	55 - 60	cm: Very dark (10 YR 3/1) fine sandy loam, very compact and firm.

Water table perched above B_{2h} horizon.

PEDON 3 : MIRI SERIES
PHYSICO-CHEMICAL DATA

Lab. No:	MS1400	MS1401	MS1402	MS1403
Depth (cm)	4-0	0-23	23-55	55-100
Sand%	-	75.8	78.0	72.6
Silt %	-	16.9	16.8	10.7
Clay %	-	7.3	5.2	16.7
Texture Class	-	LS	LS	SL
C %	24.23	1.38	0.01	4.64
N %	1.19	0.06	0.01	0.09
C/N	20	23	-	52
pH (H ₂ O)	3.6	4.4	5.2	4.1
pH (KCl)	3.2	3.4	4.8	3.3
Exch. (me/100g) (NH ₄ OAc, pH 7.0)				
Ca	10.10	0.36	0.35	0.21
Mg	3.32	1.01	0.01	0.02
K	1.18	0.09	0.03	0.16
Na	0.20	0.05	0.03	0.04
CEC	78.98	4.09	0.41	25.18
BS %	19	37	84	2
Exch. (me/100g) (KCl)				
A1	0.00	0.24	0.00	0.73
H	4.58	0.75	0.00	0.21
CEC	30.80	1.89	0.05	1.91
Ext. Acidity (me/100g)	89.50	6.92	0.00	55.67
Free Fe as Fe ₂ O ₃ (ppm)	229	26	14	0.41
Moist ret (%)				
1/10 atm.	175.9	40.8	23.1	54.5
1/3 atm.	103.3	15.4	8.4	25.3
15 atm.	80.1	5.1	1.9	13.3

PEDON No. 4 TARAT SERIES

SOILS OF THE
TARAT SERIES

Location:	3rd mile Serian-Tebakang Road (Upper Sadang District)
Parent Material:	Altered Basalt and Andesite (Triassic)
Topography:	Moderately steep terrain with slopes of 25° and over, strongly dissected
Slope:	10°
Vegetation/Land Use:	Young rubber with dense mixed undergrowth in which ferns are dominant.
Drainage:	Good

Horizon	Depth	
A1	0 - 10 cm:	Reddish brown (5 YR 4/4) clay, fine subangular blocky to fine angular blocky structure (nutty); dry; friable; abundant rootlets; porous; distinct boundary to;
B1	10 - 35 cm:	Red (2.5 YR 5/6) clay; moist, friable; crumbly structure; coarse prismatic structure; many roots; shiny natural ped surfaces; distinct boundary to;
B2	35 - 53 cm:	Red (2.5 YR 5/6) clay; as above horizon but the soil is firm and does not break into crumbs on pressure; slightly moist (possible influence of difference in moisture content); distinct boundary to;
B3	53 - 130 cm:	Red (2.5 YR 5/6) clay which breaks into small crumbs and fine angular blocky peds if slight pressure is applied; dry; soft; porous; slight development of shiny ped surfaces; many roots; scattered small weathered rock pieces (possibly colluvial); distinct wavy boundary to;
C	130 - 300 cm:	Red (2.5 YR 5/6) clay loam, very friable to powdery, and crumbly, thoroughly weathered parent material in 50% - 50% proportion; slightly moist, few rootlets; porous.

NOTE: This horizon continues to a depth of approximately 8 feet where solid rock is met.

PEDON 4: TARAT SERIES
Physico-chemical Data

PEDON No. 2 KERALA SERIES

Lab. No:	MS1213	MS1214	MS1215	MS1216	MS1217	MS1218
Depth (cm)	0-10	10-35	35-53	53-130	130-160	160-200
Sand %	11.0	13.3	16.2	14.4	33.9	31.2
Silt %	24.5	21.5	19.2	31.1	28.6	33.7
Clay %	64.5	64.7	63.7	54.7	37.7	35.4
Texture Class	C	C	C	C	CL	CL
C %	8.31	4.50	3.86	2.90	2.63	2.37
N %	0.57	0.21	0.15	0.07	0.02	0.02
C/N	15	22	26	46	109	113
pH (H ₂ O)	4.5	4.9	5.1	5.5	5.4	5.3
pH (KCl)	3.8	4.0	4.2	4.5	4.5	4.3
Exch. (me/100g) (NH ₄ OAc, pH 7.0)						
Ca	0.57	0.28	0.07	0.35	0.14	0.14
Mg	1.55	0.49	0.70	0.62	0.39	0.55
K	0.42	0.08	0.07	0.01	0.02	0.03
Na	0.31	0.08	0.09	0.10	0.17	0.09
CEC	14.75	9.12	10.54	5.50	6.36	5.98
ES %	19	10	9	20	16	14
Reserve (ppm)						
Ca	221	111	109	194	65	289
Mg	979	759	913	791	1646	1271
K	386	167	163	216	594	268
Group III %	39.45	46.99	50.29	47.79	48.48	45.64
Clay: Total (%)						
SiO ₂	30.6	32.9	33.7	32.4	34.2	36.1
Fe ₂ O ₃	17.0	20.7	17.3	22.2	19.7	22.3
Al ₂ O ₃	38.6	42.9	51.3	44.2	53.40	41.6
Total Phosphate (ppm)	559	430	391	400	414	411
Av. Phosphate (ppm)	4	1	1		1	1

PEDON No. 6 NYALAU SERIES

Location: 1:50,000 sheet No: 1/109/8 Grid Y887,717.

Parent Material: Fine sandstone of Tertiary Age

Topography: Low hill, approx. 50 feet amplitude

Slope: Mid-slope, 15° aspect east

Vegetation/Land Use: Poor primary log

Drainage: Int. medium,
Ext. well drained

Depth

0 - 12 cm:

Yellowish brown (10 YR 5/4) sandy loam; weak subangular blocky structure; moist, friable; many roots, few pores; smooth gradual boundary to;

12 - 35 cm:

Yellowish brown (10 YR 5/4) sandy loam; weak subangular blocky structure; moist, friable; many roots, few pores; smooth gradual boundary to;

35 - 60 cm:

Brownish yellow (10 YR 6/6) sandy loam; weak subangular blocky structure; moist, friable; many fine roots, many pores; smooth gradual boundary to;

60 - 90 cm:

Yellow (10 YR 7/8) sandy loam; weak medium subangular blocky structure; moist, friable; few roots and pores smooth gradual boundary to;

90 - 120 cm:

Yellow (10 YR 7/8) sandy loam; weak subangular blocky structure; moist, slightly firm; few pores and roots; merging into;

120 - 150 cm:

Yellow (10 YR 7/8) sandy loam; weak subangular blocky structure; moist, slightly firm; few pores and roots; merging into;

150 - 165 cm:

Yellow (10 YR 7/8) sandy loam moist, firm almost massive; few roots.

PEDON 6: NYALAU SERIES
Physico-chemical Data

Lab. No:	MS1354	MS1355	MS1356	MS1357	MS1358	MS1359	MS1360
Depth (cm)	0-12	12-35	35-60	60-90	90-120	120-150	150-185
Sand %	80.8	78.3	77.1	76.5	76.2	75.2	73.9
Silt %	7.8	8.3	7.5	6.8	6.5	7.2	7.1
Clay %	11.4	13.4	15.4	16.7	17.4	17.6	19.0
Texture Class	SL	SL	SL	SL	SL	SL	SL
C %	1.30	0.59	0.33	0.17	0.11	0.09	0.10
N %	0.06	0.03	0.02	<0.01	<0.01	<0.01	<0.01
C/N	22	23	17	17	11	9	10
pH (H ₂ O)	4.7	4.8	4.8	4.8	4.9	4.9	5.0
pH (KCl)	4.0	4.2	4.2	4.0	4.0	4.0	4.0
EXCH. (me/100g) (NH ₄ OAc, pH 7.0)							
Ca	0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
K	0.09	0.05	0.03	0.03	0.03	0.03	0.03
Na	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
ClC	5.89	3.44	2.82	3.02	3.02	2.83	3.03
SS %	2	2	1	1	1	1	1

PEDON No. 7 BEKENU SERIES

Location: Mile 24, Bau-Lundu Road

Parent Material: Fine sandstone of Tertiary Age

Topography: Low hilly, approx. 50 feet amplitude

Slope: Upper slope, 12°

Vegetation/Land Use: Primary forest

Drainage: Int. medium
Ext. well-drained

Horizon	Depth	
A ₁₋₃	0 - 12 cm:	Yellowish brown (10 YR 5/6) sandy loam; weak medium to fine subangular blocky; very friable; many medium to fine roots; few coarse; few fine charcoal fragments; moderate biological activity diffuse boundary to;
B ₁₁	12 - 36 cm:	Yellow (10 YR 7/8) sandy loam; weak medium to coarse subangular blocky; very friable; no clayskins; few medium roots; many fine roots; moderate biological activity; diffuse boundary to;
B ₁₂	36 - 58 cm:	Yellow (10 YR 7/8) sandy loam; weak coarse subangular blocky; breaking to medium fine subangular blocky; very friable; moderate biological activity; few faint fine mottles; few medium to coarse roots; diffuse boundary to;
B _{21t}	58 - 100 cm:	Yellow (10 YR 7/8) sandy clay loam; very friable; weak medium to coarse subangular blocky; occasional large roots; thin patching cutans; few faint diffuse mottles (red 2.5 YR 4/8) low biological activity; diffuse boundary to;
B _{22t}	100 - 130 cm:	Colour same as above, sandy clay loam; friable; moderate medium subangular blocky; thin patching cutans on ped faces; diffuse boundary to;
B _{23t}	130 - 160 cm:	Colour same as above, fine sandy clay loam; moderate medium subangular blocky; friable; thin patching cutans on roots; no biological activity; diffuse boundary to;
B _{24t}	160 - 180+cm:	Colour same as above, fine sandy clay loam; weak medium to fine subangular blocky; friable; thin patching cutans.

PEDON 7 : BEKUNU SERIES
Physico-chemical data

Lab. no:	MS1347	MS1348	MS1349	MS1350	MS1351	MS1352	MS1353
Depth (cm)	0-12	12-36	36-58	58-100	100-130	130-160	160-180
Sand %	75.7	72.1	67.8	66.6	68.4	66.2	64.3
Silt %	8.5	8.9	8.6	8.1	7.6	8.7	8.9
Clay %	15.8	19.0	23.6	25.3	24.0	25.2	26.8
Texture Class	SL	SL	SCL	SCL	SCL	SCL	SCL
C %	2.51	0.57	0.19	0.14	0.10	0.16	0.12
N %	0.17	0.04	0.02	0.01	<0.01	<0.01	<0.01
C/N	15	14	10	14	10	16	12
pH (H ₂ O)	4.6	4.9	4.8	4.9	5.0	5.1	5.1
pH (KCl)	3.8	4.0	4.0	4.0	3.9	3.9	3.9
Exch. (me/100g) (NH ₄ OAc, pH 7.0)							
Ca	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mg	0.21	0.07	<0.01	<0.01	<0.01	<0.01	<0.01
K	0.19	0.05	0.03	0.07	0.08	0.06	0.03
Na	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
CEC	8.46	3.86	4.06	3.65	3.24	3.45	3.65
BS %	5	3	1	2	3	2	1

PEDON 7 : BEKUNU SERIES
 Physico-chemical Analysis ...ctd.

Exch. (KCl) (me/100g)	A1	2.81	1.86	1.39	2.22	2.25	2.29	2.34
	H	0.18	0.06	0.06	0.03	0.06	0.06	0.06
	CBC	4.66	2.50	1.90	2.16	2.38	0.52	1.76
Ext. Acidity (me/100g)		12.58	2.55	2.55	3.12	4.57	4.86	4.82
Free Fe as Fe ₂ O ₃ (%)		0.80	1.18	1.37	1.39	1.38	0.47	0.54
Clay: Total (%)	SiO ₂	37.1	38.0	37.9	38.7	39.3	39.2	40.3
	Fe ₂ O ₃	6.1	7.0	6.9	7.2	7.2	7.01	6.7
	Al ₂ O ₃	23.6	31.9	32.8	34.5	33.6	32.8	32.8
Moist ret (%)	1/10 atm.	27.3	26.4	29.7	29.7	31.0	31.6	30.6
	1/3 atm.	19.0	18.7	20.9	21.6	20.1	21.7	22.1
	15 atm.	15.6	10.2	11.0	11.1	10.7	10.9	11.8

PEDON No.8 MERIT SERIES

Location: Mile 26, Bau-Lundu Road
 Parent Material: Carbonaceous shale of Tertiary Age
 Topography: Low hill, approx. 50 feet amplitude
 Slope: Upper slope, 15 degrees
 Vegetation/Land Use: Low secondary regrowth
 Drainage: Int. medium
 Ext. moderately well-drained

Horizon	Depth	
A ₁₋₃	0 - 12 cm:	Brown to dark brown (10 YR 4/3) fine sandy clay loam; strong medium to fine subangular blocky; friable; moderate medium to fine roots; moderate charcoal fragments; moderate biological activity; rather sharp boundary to;
B ₁	12 - 38 cm:	Brownish yellow (10 YR 6/8) fine sandy clay loam to fine sandy clay; moist, strong coarse to medium subangular blocky; slightly friable; many medium to few fine roots; occasional organic staining on ped faces; diffuse boundary to;
B _{21t}	38 - 60 cm:	Brownish yellow (10 YR 6/8) fine sandy clay loam; moist, moderate medium to coarse subangular blocky; friable; thin patchy clayskins on ped faces and in pores; occasional organic staining along old root channels; few medium roots; no biological activity; diffuse boundary to;
B _{22t}	60 - 90 cm:	Colour same as above; sandy clay; strong coarse angular blocky; firm; discontinuous clayskins on ped faces; very few faint red mottles; very few fine roots; diffuse boundary to;
B _{23t}	90 - 120 cm:	Colour same as above; clay; strong coarse angular blocky; firm; faint reddish mottles increasing with depth; no root; discontinuous thin clayskins; diffuse boundary to;
B _{24t}	120 - 155+cm:	Colour same as above; clay; strong coarse angular blocky; firm; common faint mottles (red 2.5 YR 4/8) thin patchy argillans; no root; no biological activity; occasional fine pieces of completely weathered rocks.

Taxonomic Classification: TYPIC (OXIC) PALEUDULT.

Remarks: Top 60 cm of material is probably colluvial

PEDON No. 9 SEMATAN SERIES

PEDON 9 SEMATAN SERIES
Physico-chemical Data

Location:	½ mile from Sematan town	
Parent Material:	Recent marine sand	
Topography:	Flat, recent beach	
Slope:	Flat	
Vegetation/Land Use:	Imperata cylindrica (lalang)	
Drainage:	Ext. very rapid Int. excessive	
Horizon	Depth	
A ₁₁	0 - 12 cm:	Brown to dark brown (10 YR 4/3) loamy sand to sand, single grained; dry, loose; few roots from lalang; few fine pores; merging smooth boundary to;
A ₁₂	12 - 37 cm:	Brown (10 YR 5/3) fine sand, single grained; dry to moist, loose; few fine roots from lalang; clear smooth change to;
B ₁	37 - 55 cm:	Strong brown (7.5 YR 5/8) fine sand; dry to moist; slightly firm; few fine roots and pores; gradual smooth change to;
B ₂₁	55 - 100 cm:	Strong brown (7.5 YR 5/8) fine sand; moist, slightly firm; clear irregular change to;
	100 - 160 cm:	Strong brown (7.5 YR 5/8) fine sand; moist, slightly firm; with common pockets of black (7.5 YR 2/0) soft concretions of iron and mottles of pinkish red; few roots and pores.

PEDON No. 10 SEBAT SERIES

Location: Footpath to Kampung Sebat

Parent Material: Alluvium/colluvium from adamellite and metamorphosed rocks in the Serabang Formation

Topography: Flat

Vegetation/Land Use: Old secondary and fruit trees

Drainage: Int. medium
Ext. moderately well-drained

Horizon	Depth	
	¼ - 0	cm: Fresh litters;
A ₁	0 - 13	cm: Yellowish brown (10 YR 5/6) clay loam; moist, friable; weak fine subangular blocky structure; many medium roots; few fine pores; few cracks; abundant muscovite flakes; smooth gradual boundary to;
B ₁	13 - 38	cm: Yellowish brown (10 YR 5/6) clay loam; moist, slightly firm; moderate fine subangular blocky structure; few fine roots; many medium pores; few cracks; abundant muscovite flakes; smooth gradual boundary to;
B ₂	38 - 67	cm: Yellowish brown (10 YR 5/6) sandy clay loam, few fine faint pale olive (5 YR 6/3) mottles; moist, slightly firm; weak medium subangular blocky structure; few fine roots; many fine pores; abundant fine muscovite flakes; gradual smooth change to;
C	67 - 138	cm: Yellowish brown (10 YR 5/6) clay, few fine faint pale olive (5 Y 6/3) and strong brown mottles; moderate coarse subangular blocky structure; few fine roots; many pores and abundant cracks; faint clayskin along vertical ped faces; abundant muscovite flakes; lower boundary is abrupt, with increase of pale olive mottles;
11C _g	138 - 200	cm: Sandy loam with abundant coarse muscovite flakes; wet.

PEDON No 11 PENDAM SERIES

Location:	Rampangi Scheme East of Coconut trial plot
Parent Material:	Marine alluvium
Topography:	Flat
Vegetation/Land Use:	Cleared nipah planted with chiku
Drainage:	Very poor drained
Depth	
0 - 18 cm:	Brown to dark brown (10 YR 3/3) silt loam; moist, slightly firm; weak coarse blocky structure; few distinct streaks of pale yellow (2.5 Y 7/3) jarosite; common decomposed leaves and roots; abrupt boundary to;
18 - 35 cm:	Dark grey (5 Y 4/1) silty clay loam, common distinct dark brown coating on structural faces; common undecomposed leaves and roots; massive structure; N value more than 0.7;
35 - 70 cm:	Dark greenish grey (5 GY 4/1) silty clay; wet, non-sticky; N value more than 0.7; strong hydrogen sulphide smell; common undecomposed leaves and roots.
Water table 25 cm below surface	
Groundwater conductivity: 1179 micromhos/cm at 25°C.	

(a) Total (%)

0.22	0.21	0.23	0.25	0.28
0.11	0.12	0.14	0.17	0.21
0.08	0.09	0.10	0.12	0.15

0.22	0.21	0.23	0.25	0.28
0.11	0.12	0.14	0.17	0.21
0.08	0.09	0.10	0.12	0.15

(b) Total (%)

0.10	0.11	0.12	0.13	0.14
0.05	0.06	0.07	0.08	0.09
0.03	0.04	0.05	0.06	0.07

PEDON 11: PENDAM SERIES
Physico-chemical Data

Lab. No:	MS1396	MS1397	MS1398	MS1399
Depth (cm)	0-18	18-35	35-70	70-95
Sand %	19.6	17.0	11.5	9.7
Silt %	55.5	54.1	54.7	47.7
Clay %	24.9	28.9	33.8	42.6
Texture Class	SiL	SiCL	SiCL	SiC
C %	3.82	4.30	6.02	5.97
N %	0.20	0.18	0.21	0.19
C/N	19	24	29	31
pH (H ₂ O)	3.3	3.1	4.0	4.5
pH (KCl)	3.0	2.9	3.9	4.3
Exch. (me/100g) (NH ₄ OAc. pH 7.0)				
Ca	0.42	0.67	5.55	5.36
Mg	0.17	0.89	3.58	3.45
K	0.11	0.22	0.22	0.50
Na	0.17	0.67	1.02	0.90
CEC	10.98	14.71	20.12	16.59
Ext. (me/100g) (KCl)				
A1	3.47	6.63	9.36	5.51
H	2.02	4.12	6.76	6.93
CEC	6.06	8.89	9.33	12.93
Ext. Acidity (me/100g)	34.92	35.05	38.19	31.78
Free Fe as Fe ₂ O ₃ (%)	1.67	1.10	1.34	1.54
Clay: Total (%)				
SiO ₂	40.9	41.5	37.4	43.4
Fe ₂ O ₃	5.9	5.6	7.7	6.9
Al ₂ O ₃	25.0	24.8	24.5	26.6
Moist ret (%)				
1/10 atm.	68.2	66.4	72.8	70.7
1/3 atm.	49.6	51.2	52.9	48.9
15 atm.	18.7	20.8	22.6	26.6

PEDON No.12 TIMANG SERIES

Location: 9½ mile, Muara Tuang Road

Parent Material: Residual, with minor colluvium

Topography: Low hilly, less than 20 feet amplitude

Slope: Less than 5°

Vegetation/Land Use: Young secondary

Drainage: Int. medium
Ext. imperfect

Horizon	Depth	
A ₁	0 - 20 cm:	Brown (10 YR 5/3) fine sandy loam; weak fine subangular blocky; common fine roots decreasing with depth, few large roots; few charcoal fragments; sharp boundary to;
A ₂	20 - 38 cm:	Light grey (10 YR 7/1) sandy loam; coarse subangular blocky to massive; few light yellowish brown (10 YR 6/4) mottles; very few fine roots; low biological activity; rather diffuse boundary to;
B ₁	38 - 52 cm:	Light grey (10 YR 7/2) loam; moderate coarse angular blocky; common brownish yellow (10 YR 6/8) mottles; no argillans; few coarse columnar elements with silt coating; few roots; diffuse boundary to;
B _{2tg}	52 - 75 cm:	Light grey (10 YR 7/2) clay loam, with clear common mottles (reddish yellow (7.5 YR 6/8) clay; coarse angular blocky moderately clear thick coating in larger pores; few large columnar elements with silt coating; few fine roots; diffuse boundary to;
B _{3tg}	75 - 95 cm:	Colour same as above; clay loam; coarse angular blocky; more mottles; clayskins as above but less frequent; very few fine roots; diffuse boundary to;
C _{1g}	95 - 115 cm:	White to light grey (10 YR 8/1 - 7/1) clay with very coarse sand; massive; mottles same as above; diffuse boundary to;
11C _{2g}	115+cm :	Colour same as above; clay loam with pockets of coarse sand; massive; less mottles; some stains (grey to dark grey (10 YR 5/1 - 4/1)

PEDON 12: TIMANG SERIES
Physico-chemical Data

Lab. No:	MS1334	MS1335	MS1336	MS1337	MS1338	MS1339	MS1340
Depth (cm)	0-20	20-36	38-52	52-75	75-95	95-115	115+
Sand %	58.7	60.4	47.8	32.8	27.2	25.1	30.8
Silt %	29.8	29.6	29.5	34.5	37.5	28.7	43.9
Clay %	11.5	10.0	22.7	32.7	35.3	46.2	25.3
Texture Class	SL	SL	L	CL	CL	G	CL
C %	1.52	0.27	0.12	0.10	0.18	1.17	0.12
N %	0.11	0.02	0.03	0.05	0.09	0.10	0.07
C/N	14	14	4	2	2	2	2
pH (H ₂ O)	4.3	4.7	4.7	4.7	4.7	4.7	4.8
pH (KCl)	3.4	3.6	3.6	3.6	3.6	3.7	3.7
Exch. (me/100g) (NH ₄ OAc, pH 7.0)							
Ca	0.20	0.10	0.20	0.05	0.05	0.10	0.10
Mg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
K	0.10	0.04	0.05	0.05	0.06	0.06	0.07
Na	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
CEC	0.48	3.02	5.86	8.34	8.55	8.13	7.30
BS %	5	5	4	1	1	2	3

Exch (me/100g) (KCl)	A1	3.73	3.30	5.73	7.01	6.59	6.69	5.88
	H	0.25	0.11	0.92	0.22	0.19	0.11	0.08
	CFC	3.32	2.47	6.50	6.99	7.44	8.31	8.78
Ext. Acidity (me/100g)		8.30	2.40	5.22	8.69	6.73	27.89	25.87
Free Fe as Fe ₂ O ₃ (%)		0.03	0.06	0.26	0.57	0.66	0.19	0.14
Clay: Total (%)	SiO ₂	52.0	47.3	44.5	45.5	46.3	44.8	47.1
	Fe ₂ O ₃	1.4	1.6	2.1	2.7	2.5	1.6	1.7
	Al ₂ O ₃	26.0	29.8	30.5	31.0	30.5	29.8	32.1
	Moist ret (%)							
Moist ret (%)	1/10 atm.	38.0	26.2	33.7	50.9	60.3	54.9	53.1
	1/3 atm.	26.3	20.5	28.0	41.3	50.7	45.8	45.4
	15 atm.	12.3	4.3	13.8	20.0	25.7	17.8	20.8

PEDON No. 13 : GUMBANG SERIES

Location: G. Serambu
 Parent Material: Quartz Dacite
 Topography: Footslopes.
 Slope: 18°
 Vegetation/Land Use: Primary forest
 Drainage: Well drained

Horizon	Depth	Profile Description
A ₁₋₃	0 - 8 cm:	Yellowish brown (10 YR 5/8); fine sandy loam; strong medium and fine subangular blocky; slightly friable; common very fine roots; low biological activity; diffuse boundary.
(B) ₁	8 - 20 cm:	Reddish yellow (7.5 YR 6/8) clay loam; strong coarse angular blocky; slightly friable; thin organic staining on some ped faces; few medium and coarse roots; very few fine soft reddish concretions; few fine termite chambers; diffuse boundary.
(B) ₂	20-42/65 cm:	Strong brown (7.5 YR 5/8) very fine sandy loam; with pockets of sand (white 10 YR 8/1); strong coarse angular blocky to massive; common fine soft mottles (7.5 R 3/8) dark red and brown 5 YR 3/2); very few very fine roots; rather sharp boundary.
C ₁	65 - 60 cm:	Variegated 50% of matrix brownish yellow 10 YR 6/8 and white 10 YR 8/1); fine sand (silt?); massive; very friable; pockets of white are remnants of rock; very few fine concretions diffuse boundary.
C ₂	90 - 130 cm:	As above but yellow and white spots appear laminated.
C ₃	130 - 150 cm:	As above white completely weathered rock fragments (White forms more than 70% of the horizon).
(R)	150 - 170+cm:	Completely weathered rock.

Classification:

- a) Taxonomy: OXIC DYSTROPEPT
 b) FAO: DYSTRIC CAMBISOL

