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Land Resources Division, Ministry of Overseas Development,
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The soils of Sabah, Volume 5. References and appendixes

Land Resources Division

The soils of Sabah

Volume 5.

References and appendixes

B D Acres, R P Bower, P A Burrough,

C J Folland, M S Kalsi, P Thomas and

P S Wright

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1975

THE LAND RESOURCES DIVISION

The Land Resources Division of the Ministry of Overseas Development assists developing countries in mapping, investigating and assessing land resources, and makes recommendations on the use of these resources for the development of agriculture, livestock husbandry and forestry; it also gives advice on related subjects to overseas governments and organisations, makes scientific personnel available for appointment abroad and provides lectures and training courses in the basic techniques of resource appraisal.

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List of volumes

Volume 1	Classification and description (with an introduction to Volumes 1-5). B D Acres, R P Bower, P A Burrough, C J Folland, M S Kalsi, P Thomas and P S Wright. Volume 1 is accompanied by maps of the Soils of Sabah.
Volume 2	Sandakan and Kinabatangan Districts. B D Acres and C J Folland.
Volume 3	Western Parts of Tawau and Lahad Datu Districts. P S Wright.
Volume 4	South-Western Districts. R P Bower, P A Burrough, M S Kalsi and P Thomas.
Volume 5	References and appendixes. B D Acres, R P Bower, P A Burrough, C J Folland, M S Kalsi, P Thomas and P S Wright.

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Appendixes 1 - 7

Appendix 1

Soil profile descriptions and analyses

The profiles demonstrate the main properties of the soil families summarised in Volume 1. They have been selected largely from those described by surveyors of the Land Resources Division; when profile descriptions are derived from the work of other surveyors the sources are acknowledged.

Horizon nomenclature and the terms used in profile descriptions are outlined in Appendixes 2 and 3; the methods and interpretation of analyses are discussed in Appendixes 4 and 5.

The profiles are numbered using FAO soil unit codes and are listed in the following order:

Od	Dystric Histosol	Fo	Orthic Ferralsol
Oe	Eutric Histosol	E	Rendzina
Jt	Thionic Fluvisol	Ag	Gleyic Acrisol
Jc	Calcaric Fluvisol	Ah	Humic Acrisol
Jd	Dystric Fluvisol	Af	Ferric Acrisol
Je	Eutric Fluvisol	Ao	Orthic Acrisol
Gh	Humic Gleysol	Lg	Gleyic Luvisol
Gc	Calcaric Gleysol	Lk	Calcic Luvisol
Gd	Dystric Gleysol	Lf	Ferric Luvisol
Ge	Eutric Gleysol	Lc	Chromic Luvisol
Rc	Calcaric Regosol	Lo	Orthic Luvisol
Rd	Dystric Regosol	Bg	Gleyic Cambisol
Re	Eutric Regosol	Bc	Chromic Cambisol
Pg	Gleyic Podzol	Bd	Dystric Cambisol
Ph	Humic Podzol	Be	Eutric Cambisol
Po	Orthic Podzol	Qa	Albic Arenosol
Fr	Rhodic Ferralsol	Qc	Cambic Arenosol
Fx	Xanthic Ferralsol		

Elevations are quoted in metres and feet above sea level.

Measurements (in centimetres and inches) are made from the soil surface or from the base of an O horizon if present.

The following abbreviations are used in soil analyses:

avail.	available
extr.	extractable
n.d.	not determined
sat.	saturated
tr.	trace (less than 0.1%)
-	nil

In minerals of the clay fraction the following abbreviations are used:

dom.	dominant (>40%)	pres.	present (5-20%)
mod.	moderate (20-40%)	tr.	trace (<5%)

Dystric Histosols (Od)

PROFILE Od 1

Soil family	Klias
Location	About 2 km (1 mi) N of the Kinabatangan 2½ km (1½ mi) downstream from Kuala Koyah (grid ref. LC 963999)
Surroundings	Kinabatangan floodplain
Site	Peatswamps
Slope	Nil
Elevation	About 6 m (20 ft)
Site drainage	Freshwater flooding
Parent material	Peat
Vegetation	Swamp forest: *Glochidion* sp. dominant with dense undergrowth of *Mapania*
Soil drainage	Very poor

Horizon	Depth cm (in)	Description
Aa	0-23 (0-9)	Dark reddish brown (5YR 2/2); loamy peat; strong coarse granular structure; waterlogged, slightly sticky, slightly plastic; merging boundary
Co	23-125 (9-50)	Dark reddish brown (5YR 3/3; slightly humified fibrous peat composed of sedge and wood remains; waterlogged

Depth cm	Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn; %
				Ca	Mg	K	Na		
23-125	41.8	1.3	4.3	1.6	1.6	n.d.	n.d.	55.7	5

PROFILE Od 2

Soil family	Klias
Location	Near Sipitang airstrip (grid ref. LA 138542)
Surroundings	Depression
Site	Level
Slope	Nil
Elevation	30 m (100 ft)
Site drainage	Receiving
Parent material	Peat underlain by sand
Vegetation	Swamp forest; many *Nepenthes* spp.
Soil drainage	Very poor; watertable at 15 cm (6 in)

Horizon	Depth cm (in)	Description
Cg	0-15 (0-6)	Dark brown to brown(7.5YR 4/2); peaty silt; structureless, massive; fibrous; slightly sticky, wet; many roots of all sizes; smooth boundary
IIClo	15-30 (6-12)	Dark brown (7.5YR 3/2; fibrous peat; slightly humified; many roots; wet; gradual, smooth boundary
IIC2o	30-48 (12-19)	Black (10YR 2/1); fibrous peat; wet; clear, smooth boundary
IIICg	48-120 (19-48)	White (10YR 8/2; fine sand; structureless, single grain; loose, wet; very few yellowish red (5YR 4/6) sandstone fragments

Depth cm	Particle size distribution %				Org. C%	Total N%	Avail. P ppm	Exch. cations meq%				CEC meq%	Base satn. %	pH H_2O
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na			
0.15	1	6	57	5	5.8	0.19	3	0.3	–	tr.	–	16.2	2	3.8
15-30	n.d.	n.d.	n.d.	n.d.	32.7	1.08	26	1.1	3.0	0.5	0.2	93.4	5	3.4
30-48	n.d.	n.d.	n.d.	n.d.	18.4	0.70	7	0.2	1.3	0.3	0.1	57.3	3	3.5
48-120	12	70	16	1	0.5	0.02	1	0.1	–	–	–	1.2	8	4.6

PROFILE Od 3

Soil family Kaintano
Location Gunong Alab; 200 m (220 yd) SW of summit (grid ref. FW033436)
Surroundings Mountainous
Site Upper slope
Slope 30°
Elevation 1 920 m (6 400 ft)
Site drainage Normal
Parent material Sandstone and shale
Vegetation Stunted forest with thick moss ground cover
Soil drainage Poor

Horizon	Depth cm (in.)	Description
Co	0-46 (0-18)	Dark reddish brown (5YR 2/2); moderately decomposed peat; moist; very frequent roots; abrupt smooth boundary
Aa	46-51 (18-20)	Black (10YR 2/1); humic loam; week, very fine crumb structure; moist, very friable; abrupt wavy boundary
Eg	51-64 (20-25)	Greyish brown (10YR 5/2); loamy sand; week fine subangular blocky structure; moist friable; few roots; abrupt wavy boundary
BC	64-71 (25-28)	Yellowish red (5YR 5/6); sandy loam; structureless, massive, with lenses of overlying horizon; wet; compact; clear irregular boundary
C	71+ (28+)	Decomposing sandstone.

Depth cm	Particle size distribution %				Org. C%	Total N%	Avail. P ppm	Exch. cations meq%				CEC meq%	Base satn. %	pH H_2O
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na			
0-46	n.d.	n.d.	n.d.	n.d.	39.2	1.49	49	0.1	0.9	1.8	0.2	114.3	3	3.4
46-51	n.d.	n.d.	n.d.	n.d.	3.8	0.21	7	tr.	0.1	0.2	tr.	35.9	1	3.7
51-64	12	63	10	9	2.2	0.12	4	tr.	–	tr.	–	10.6	–	4.4
64-71	13	58	11	15	1.6	0.04	1	tr.	–	tr.	–	13.7	–	4.7

PROFILE Od 4

Soil family Arang
Location West bank of estuary of Sungai Sepilok Kechil (grid ref. FX 820423)
Surroundings Tidal swamp with few minor shallow gullies
Site Tidal flat
Slope Nil
Elevation Sea level; about 60 cm (24 in) above low water mark
Site drainage Tidal flooding; daily fluctuations of about 120 cm (48 in)
Parent material Peat
Vegetation *Rhizophora apiculata (Bangawat)* dominant
Soil drainage Very poor

Horizon	Depth cm (in)	Description
Co	0-125 (0-50)	Dark reddish brown (5YR 3/2); amorphous peat, becoming more fibrous below 45 cm (18 in); many fine fibrous roots

Depth cm	Org C %	Total N %	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	Total S %	Cond. mmhos/cm
				Ca	Mg	K	Na				
0-125	17.8	0.5	4.8	21.5	47.1	3.3	98.5	59.5	Sat.	4.0	15

PROFILE Od 5

Soil Family	Arang
Location	S W of Teck Guan Villa on Penampang Road (grid ref. FV 742563)
Surroundings	Plain
Site	Uneven, flat
Slope	Nil
Elevation	4 m (15 ft)
Site drainage	Receiving
Parent material	Sulphidic peat intercalated with clay
Land use	Neglected rubber plantation
Soil drainage	Very poor

Horizon	Depth cm (in)	Description
C1o	0-2 (0-1)	Very dark grey (10YR 3/1); peat; strong fine granular structure; moist, very friable; dominant roots; abrupt smooth boundary
C2o	2-10 (1-4)	Very dark brown (10YR 2/2); peat; strong fine granular structure; wet, slightly sticky, plastic; frequent roots; gradual smooth boundary
IICg	10-40 (4-16)	Light brownish grey (10YR 6/2) with few fine faint yellowish brown (10YR 5/4) mottles; clay; structureless; wet, plastic and sticky; few roots; clear smooth boundary
IIIC1o	40-71 (16-28)	Very dark grey (10YR 3/1); peat; structureless; wet. slightly sticky; very few roots; gradual smooth boundary
IIIC2o	71-125 (28-50)	Dark reddish brown (5YR 3/2); peat; structureless; wet, slightly sticky, slightly plastic; no roots

Depth cm	Particle size distribution%				Org. C%	Total N%	Avail. P ppm	Exch. cations meq%				CEC meq%	Base satn. %	pH H_2O	Total S%	$CaCO_3$ equiv.%
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na					
0-2	n.d.	n.d.	n.d.	n.d.	38.1	1.36	9	0.7	1.1	0.6	0.2	65.7	4	3.9	0.82	n.d.
2-10	n.d.	n.d.	n.d.	n.d.	35.5	1.23	6	–	tr.	0.3	0.1	58.8	2	3.8	0.95	0.04
10-40	–	2	25	62	7.3	0.83	2	0.1	0.6	0.3	0.1	39.6	3	3.9	0.08	n.d.
40-71	n.d.	n.d.	n.d.	n.d.	8.8	0.15	1	0.1	0.5	0.1	0.2	44.4	2	3.5	0.75	0.03
71-125	n.d.	n.d.	n.d.	n.d.	16.0	0.39	1	0.4	1.3	0.1	0.4	66.3	3	2.9	1.60	0.05

Eutric Histosols (Oe)

PROFILE Oe 1

Soil family	Mengalum
Location	Pulau Mengalum, about 500 m (550 yd) from E point of island
Surroundings	Swamp
Site	Flat
Slope	Nil
Elevation	3 m (10 ft)
Site drainage	Receiving
Parent material	Calcareous peat underlain by calcareous sand
Vegetation	Sedges
Soil drainage	Very poor

Horizon	Depth cm (in)	Description
C1o	0-41 (0-16)	Black (10YR 2/1); amorphous peat; occasional shell fragments, wet; few roots; gradual smooth boundary
C2o	41-64 (16-25)	Dark brown (10YR 3/3); fibrous peat; shells as above; abrupt smooth boundary
IICg	64-125 (25-50)	White (10YR 8/2); sand; structureless, single grain; wet, loose

Depth cm	Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
					Ca	Mg	K	Na		
0-41	37.5	3.26	70	6.1	19.03	7.2	0.7	2.4	167.3	sat.
41-64	10.8	0.64	–	7.0	50.0	3.5	0.5	0.7	26.8	sat.
64-125	0.6	0.03	–	8.0	26.6	24.3	0.0	0.5	51.4	sat.

Depth cm	Particle size distribution%				Org C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	pH after oxidn.	Total S%	Cond. mmhos/cm
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na					
0-25	1	25	26	40	3.4	0.2	2.6	7.9	9.1	0.1	12.1	22.7	sat.	2.0	n.d.	4.8
25-100	–	28	21	44	2.3	0.2	4.5	3.3	9.1	1.2	30.9	18.8	sat.	3.6	0.1	8
100-125	–	28	26	41	3.1	0.2	6.2	3.1	3.4	0.9	11.2	13.5	sat.	2.1	0.7	11

Calcaric Fluvisols (Jc)

PROFILE Jc 1

Soil family	Nunuyan
Location	Nunuyan Laut (grid ref. FX 993541)
Surroundings	Tidal swamp with low crab mounds separated by broad tidal flats
Site	Tidal flat
Slope	Level
Elevation	Sea level
Site drainage	Tidal flooding
Parent material	Medium-textured calcareous alluvium with many shell fragments
Vegetation	Mangrove dominant: *Rhizophora* sp., *Lumnitzera* sp., *Xylocarpus* sp., *Bruguiera cylindrica*
Soil drainage	Very poor

Horizon	Depth cm (in)	Description
C1g	0-50 (0-20)	Very dark greyish brown (10YR 3/2); gritty clay loam; many coral fragments of coarse sand size; wet, sticky and plastic
C2g	50-125 (20-50)	Very dark greyish brown (10YR 3/2); gritty clay loam; many coral fragments; wet, sticky and plastic

Depth cm	Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	pH after oxidn.	Total S%	Cond. mmhos/ cm^3	$CaCO_3$ equiv. %
				Ca	Mg	K	Na						
0-50	6.1	0.4	7.1	38.1	28.4	2.2	55.0	29.1	sat.	7.2	2.7	9	26.1
50-125	7.2	0.3	6.9	36.7	26.5	2.3	60.6	26.1	sat.	7.0	2.3	10	31.3

Dystric Fluvisols (Jd)

PROFILE Jd 1 (After Wilson, 1969b, p28-30)

Soil family	Tenghilan
Location	Tanjong Labuya, Tuaran
Surroundings	River floodplain
Site	Levee
Slope	2°
Elevation	6 m (20 ft)
Site drainage	Receiving
Parent material	Coarse-textured alluvium
Land use	Grassland
Soil drainage	Moderately well drained

Horizon	Depth cm (in)	Description
A	0-15 (0-6)	Brown to dark brown (10YR 4/3); loamy fine sand; weak fine crumb structure; moist, very friable; abrupt, smooth boundary
C1	15-25 (6-10)	Yellowish brown (10YR 5/4); fine sand; structureless; loose, abrupt, smooth boundary
C2	25-50 (10-20)	Brown to dark brown (10YR 4/3); loamy find sand; weak fine crumb structure; moist, very friable; gradual, smooth boundary
C3	50-90 (20-36)	Yellowish brown (10Y 5/4) with faint yellowish red (5YR 4/6) iron stains; fine sandy loam; weak fine crumb structure; moist, very friable; gradual smooth boundary
C4	90-125 (36-50)	Yellowish brown (10YR 5/6); loamy fine sand; weak fine crumb structure; very friable

Depth cm	Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
					Ca	Mg	K	Na		
0-15	1.1	0.15	3	5.4	3.3	0.9	0.1	0.1	6.4	69
15-25	0.2	0.03	2	5.8	1.3	0.6	0.1	0.1	3.6	58
25-50	0.4	0.05	3	5.5	0.7	0.5	0.1	0.1	4.8	29
50-90	0.3	0.05	3	5.4	0.3	0.4	0.1	0.2	5.2	19
90-125	0.2	0.04	2	5.2	0.3	0.8	0.1	0.1	4.4	30

Eutric Fluvisols (Je)

PROFILE Je 1

Soil family	Pegalan
Location	Tenom to Malalap road: Mile 3½ (grid ref. LA 633732)
Surroundings	Flood plain of the Sungai Pegalan
Site	Levee ridge
Slope	Nil
Elevation	195 m (650 ft)
Site drainage	Normal
Parent material	Coarse-textured alluvium
Vegetation	Riparian forest
Soil drainage	Well drained

Horizon	Depth cm (in)		Description
A	0-15	(0-6)	Brown to dark brown (10YR 4/3); silt loam; strong fine subangular structure; moist, friable; common fine pores; abundant roots; gradual smooth boundary
IIC	15-30	(6-12)	Yellowish brown (10YR 5/4); loamy fine sand; structureless, single grain; moist, loose; common fine roots; clear wavy boundary
IIIC	30-60	(12-24)	Pale brown (10YR 6/3); sand; structureless, single grain; moist, loose; few roots, clear wavy boundary
IVC	60-125	(24-50)	Yellowish brown (10YR 5/4); fine sand

Depth cm	Particle size distribution%				Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	Total		
	Coarse sand	Fine sand	Silt	Clay					Ca	Mg	K	Na			P ppm	K%	Mg%
0-15	2	49	27	18	1.2	0.16	17	6.4	8.8	2.2	0.2	0.1	12.4	92	326	0.13	0.50
15-30	8	70	12	9	0.3	0.06	11	6.3	3.0	1.5	0.1	–	5.5	86	197	0.11	0.40
30-60	65	29	3	2	0.1	0.03	15	6.1	0.9	0.4	0.1	–	1.7	78	144	0.75	0.33
60-125	9	80	6	4	0.1	0.03	5	5.7	1.4	0.7	0.1	–	2.1	sat.	126	0.44	0.31

PROFILE Je 2

Soil family	Pegalan
Location	Segama flood plain; 3 km (2 mi) N of Kuala Kawag;
Surroundings	Floodplain
Site	Levee
Slope	Nil
Site drainage	Receiving; frequent flooding
Parent material	Coarse-textured alluvium
Vegetation	Grass and small trees
Soil drainage	Poor

Horizon	Depth cm (in.)		Description
A	0-1½	(0-½)	Brown to dark brown (10YR 4/3); humic sand; structureless; moist, loose; abundant roots; clear smooth boundary
C1g	1½-22	(½-9)	Light grey (N 7) with common fine distinct strong brown (7.5YR 5/8) mottles; silt loam, structureless; moist, loose; common roots; clear smooth boundary
C2g	22-38	(9-15)	Greyish brown (2.5Y 5/2); sand, bedded with leaves; structureless; moist, loose; few roots; clear smooth boundary

Horizon	Depth cm (in)	Description
C3g	38-55 (15-22)	Greenish grey (5 BG); sand, bedded with leaves; structureless; moist, loose; few roots; clear smooth boundary
C4g	55-87 (22-35)	Greenish grey (5 BG); sand; structureless; moist, loose; few roots; clear smooth boundary
C5g	87-125 (35-50)	Dark greenish grey (5 GY 4/1); loamy sand; structureless; moist, loose; very few roots

Depth cm	Particle size distribution%			Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	Total			Avail. P ppm
	Sand	Silt	Clay				Ca	Mg	K	Na			K%	Mg%	P ppm	
0-1½	82	10	8	2.6	0.2	6.6	10.9	5.8	0.5	0.1	21.8	79	0.5	1.2	320	27
1½-22	52	35	13	2.2	0.1	6.3	13.8	8.5	0.2	0.2	28.3	80	0.7	1.7	418	19
22-38	84	8	8	4.0	0.7	5.7	14.7	6.7	0.2	0.2	28.3	77	0.4	1.1	310	21
38-55	82	10	8	3.4	0.3	5.5	10.6	4.8	0.2	0.2	23.9	66	0.4	1.1	282	21
55-87	87	8	5	1.0	0.1	6.2	8.3	4.2	0.2	0.2	15.0	86	0.3	1.1	264	25
87-125	84	8	8	1.0	0.1	5.7	7.1	3.1	0.1	0.2	13.2	80	0.4	1.0	238	32

PROFILE Je 3

Soil family	Pegalan
Location	Kampong Kepayan, Apin Apin (grid ref. FV 955015)
Surroundings	River flood plain
Site	Levee
Slope	Nil
Elevation	315 m (1 050 ft)
Site drainage	Receiving
Parent material	Coarse-textured alluvium
Land use	Playing field
Soil drainage	Moderately well drained

Horizon	Depth cm (in)	Description
A1	0-5 (0-2)	Brown to dark brown (10YR 4/3) with common fine distinct reddish brown mottles; sandy loam; moderate fine crumb structure; moist, friable; abundant fine roots; clear smooth boundary
A2	5-25 (2-10)	Dark yellowish brown (10YR 3/4) with common fine distinct brown and grey mottles; loam; moderate medium and coarse subangular blocky structure; moist, friable to firm; few roots; clear smooth boundary
IIC	25-47 (10-19)	Yellowish brown (10YR 5/8); loamy sand; structureless, single grain; moist, loose; few roots; abrupt smooth boundary
IIIC	47-75 (19-30)	Brown (7.5YR 5/4) with many fine distinct dark reddish brown mottles; loam; weak coarse angular blocky structure; moist friable; very few small soft iron nodules; very few roots; abrupt smooth boundary
IVC	75-125 (30-50)	River gravel

Depth cm	Particle size distribution%				Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay					Ca	Mg	K	Na		
0-5	13	59	13	12	1.4	0.25	5	5.5	2.0	1.2	0.2	0.3	6.7	54
5-25	1	59	24	16	0.5	0.14	2	5.9	3.0	1.2	0.1	0.2	7.4	60
25-47	1	89	6	3	0.1	0.05	1	6.5	1.9	1.1	0.1	0.1	5.1	65
47-75	1	62	28	11	0.2	0.07	1	6.1	2.3	1.8	0.1	0.2	7.1	62

Humic Gleysols (Gh)

PROFILE GH 1

Soil family	Guan
Location	Umas Umas (grid ref. LH 432100)
Surroundings	Terraces and valley floors; amplitude 6 m (20 ft)
Site	Valley floor
Slope	Nil
Elevation	90 m (300 ft)
Site drainage	Receiving; frequent flooding
Parent material	Medium-textured alluvium
Vegetation	Dipterocarp forest
Soil drainage	Very poor

Horizon	Depth cm (in)	Description
O	3-0 (1-0)	Very dark greyish brown (10YR 3/2); mor; abundant roots; abrupt smooth boundary
Eg	0-20 (0-8)	Light grey (5Y 7/1) with many coarse light brownish grey (10YR 6/2) humus stains and few fine faint brownish yellow (10YR 6/6) mottles; sandy loam; weak fine subangular blocky structure; moist, firm; common roots; diffuse boundary
EBg	20-70 (8-28)	Light grey (5Y 7/1) with common fine distinct reddish yellow (7.5YR 6/8) mottles and common coarse distinct light brownish grey (10YR 6/2) humus stains; sandy clay loam; moderate fine medium subangular blocky structure; moist, firm; common roots; diffuse boundary
Bg	70-125 (28-50)	Light grey (N 7) with common fine distinct yellowish red (5YR 5/8) mottles; sandy clay; weak coarse angular blocky structure; wet, sticky and plastic; very few roots

Depth cm	Particle size distribution%			Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn %
	Sand	Silt	Clay					Ca	Mg	K	Na		
0-20	32	48	20	1.4	0.08	10	4.4	tr.	0.3	0.1	0.1	6.9	7
20–70	35	37	28	0.5	0.05	2	4.7	–	0.3	0.1	0.1	8.5	6
70-125	35	35	30	0.3	0.04	1	5.3	–	0.9	0.1	0.2	8.6	14

PROFILE Gh 2

Soil family	Guan
Location	Near Sipitang to Beaufort road junction E of Weston (grid ref. FV 245740)
Surroundings	Valley floor
Site	Flat
Slope	Nil
Elevation	8 m (25 ft)
Site drainage	Receiving
Parent material	Fine-textured alluvium over peat
Land use	Moribund rubber
Soil drainage	Very poor

Horizon	Depth cm (in)	Description
A1g	0-10 (0-4)	Light brownish grey (10YR 6/2) with common prominent reddish brown (5YR 4/4) mottles; silty clay; weak medium subangular blocky structure; wet, sticky and plastic; abundant roots; clear wavy boundary

Horizon	Depth cm (in)	Description
A2g	10-18 (4-7)	Dark grey (10YR 4/1); clay; as above; gradual wavy boundary
Cg	18-60 (7-24)	Dark grey (10YR 4/1); clay; structureless, massive; wet, sticky; clear smooth boundary
IICo	60-125 (24-50)	Very dark red (2.5YR 2/2); partly decomposed peat

Depth cm	Particle size distribution%				Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay					Ca	Mg	K	Na		
0-10	1	14	52	30	1.5	0.16	8	4.9	0.2	1.9	0.2	tr.	12.6	10
10-18	2	10	38	46	7.0	0.49	7	4.7	0.2	1.7	0.2	0.1	18.7	12
18-60	1	4	24	67	1.5	0.64	9	4.4	0.4	2.6	0.7	0.1	47.4	8
60-125	n.d.	n.d.	n.d.	n.d.	17.6	1.07	7	4.1	0.2	0.9	0.1	0.1	51.5	2

PROFILE Gh 3

Soil family Guan
Location About 15 km (8½ mi) N of the Kinabatangan at Tangkulap (grid ref. LC 164987)
Surroundings Low hills and flats; amplitude about 15 m (50 ft)
Site Alluvial flat
Slope Level with minor undulations and gullies
Elevation 60 m (200 ft)
Site drainage Freshwater flooding
Parent material Coarse-textured alluvium
Vegetation Primary forest with low small trees and saplings; ground vegetation of sedges and climbing rotan
Soil drainage Very poor; water table at 75 cm (30 in)

Horizon	Depth cm (in)	Description
O	3-0 (1-0)	Very dark brown (10YR 2/2); humic sand; strong fine and medium granular structure; moist, very friable; abrupt smooth boundary
C1g	0-17 (0-7)	Light grey (10YR 7/2) with common small distinct strong brown mottles; sand; weak subangular blocky structure; moist, very friable; clear smooth boundary
C2g	17-90 (7-36)	Light grey (10YR 7/2); sand; structureless, single grain; moist very friable, becoming wet, non-sticky, non-plastic above water table

Depth cm	Particle size distribution%				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn %
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na		
3-0	n.d.	n.d.	n.d.	n.d.	14.8	0.9	4.0	4.5	4.1	1.1	0.2	43.5	23
0-17	12	74	8	5	0.5	0.04	4.2	0.1	0.2	–	–	2.7	13
17-90	33	66	1	1	0.3	0.02	5.3	0.1	0.2	–	–	0.9	34

Dystric Gleysols (Gd)

PROFILE Gd 1

Soil family	Koyah
Location	Sook Plain (grid ref. LA 993680)
Surroundings	River floodplain
Site	Flat
Slope	Nil
Elevation	336 m (1 120 ft.)
Site drainage	Receiving
Parent material	Fine-textured alluvium
Vegetation	Grassland (*Imperata cylindrica)*
Soil drainage	Poor

Horizon	Depth cm (in)		Description
A	0-5	(0-2)	Pale brown (10YR 6/3); silty clay; moderate coarse and fine subangular blocky; moist, firm; many roots; abrupt smooth boundary
Bg	5-25	(2-10)	Light brownish grey (2.5Y 6/2) with many fine distinct yellowish brown (10YR 5/6) mottles; silty clay; moderate medium to coarse subangular blocky structure; wet, sticky; few roots; gradual, smooth boundary
Clg	25-60	(10-24)	Grey (5Y 6/1) with many medium prominent reddish yellow mottles; clay; structureless, massive; wet, sticky, plastic
C2g	60-125	(24-50)	Grey (5Y 6/1); mottled as above; clay

Depth cm	Particle size distribution %				Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq %	Base satn.%
	Coarse sand	Fine sand	Silt	Clay					Ca	Mg	K	Na		
0-5	–	11	45	46	3.0	0.32	5	4.5	0.7	2.4	0.4	0.2	19.1	19
5-25	–	8	43	50	1.0	0.17	2	4.4	0.5	0.6	0.2	0.1	19.1	8
25-60	–	2	37	61	0.3	0.11	2	4.7	0.2	0.2	0.2	0.1	15.6	4
60-125	–	2	37	62	0.2	0.08	1	4.8	0.1	0.2	0.1	0.1	12.7	4

For mineralogical analyses see Eswaran and Sys, 1971b.

PROFILE Gd 2

Soil family	Koyah
Location	Kalabakan valley (grid ref. 310870)
Surroundings	Floodplain of Sungai Kalabakan
Site	Flat
Slope	Nil
Elevation	3 m (10 ft)
Site drainage	Receiving; freshwater flooding
Parent material	Fine-textured alluvium
Vegetation	Secondary forest
Soil drainage	Poor; water table at 115 cm (46 in.)

Horizon	Depth cm (in)		Description
A	0-9	(0-4)	Dark greyish brown (10YR 4/2) with many fine distinct rust mottles; silty clay loam; structureless; wet, sticky and plastic; common roots; abrupt smooth boundary

Horizon	Depth cm (in)		Description
Bl	9-43	(4-17)	Brownish yellow (10YR 6/6) with many fine distinct rust mottles in root channels; silty clay; moderate very fine angular blocky structure; wet, sticky and plastic; few roots; diffuse smooth boundary
B2g	43-68	(17-27)	Brownish yellow (10YR 6/6) and grey (N 7) with common fine distinct red (10 R 4/8) mottles; silty clay; moderate very fine angular blocky structure; wet, sticky and slightly plastic; few roots; diffuse smooth boundary
B3g	68-88	(27-35)	Grey (N7) with common fine distict brownish yellow (10YR 6/6) and abundant fine prominent red (10 R 4/8) mottles; silty clay; moderate very fine angular blocky structure; wet, sticky and slightly plastic; few roots; gradual smooth boundary
Cg	88-125	(35-50)	Dark grey (5YR 4/1) with common fine distinct rust mottles in root channels; silty clay; structureless; wet, sticky and plastic; few roots

Depth cm	Particle size distribution %			Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn.%
	Sand	Silt	Clay					Ca	Mg	K	Na		
0-9	25	37	38	3.1	0.33	3	3.6	0.9	1.3	0.4	0.2	9.8	28
9-43	15	27	58	0.6	0.12	–	3.5	0.2	0.6	0.2	0.2	20.2	6
43-68	20	22	58	0.5	0.16	–	3.5	0.2	0.6	0.2	0.3	19.1	7
68-88	20	29	51	0.3	0.09	1	3.5	0.2	0.5	0.3	0;3	18.4	7
88-125	12	35	53	0.7	0.12	1	3.7	0.3	0.9	0.3	0.3	20.5	9

PROFILE Gd 3

Soil family	Koyah
Location	Binaong, Keningau (grid ref. LA 884945)
Surroundings	River terrace
Site	Level
Slope	Nil
Elevation	285 m (950 ft.)
Site drainage	Receiving
Parent material	Medium-textured alluvium
Land use	Wet rice
Soil drainage	Poor

Horizon	Depth cm (in)		Description
Ap	0-8	(0-3)	Greyish brown (10YR 5/2); loam; weak fine subangular blocky structure; moist, friable; common fine roots; gradual smooth boundary
Blg	8-20	(3-8)	Dark greyish brown (10YR 4/2) with common fine prominent reddish brown mottles; loam; weak fine subangular blocky; moist, firm; common roots; gradual smooth boundary
B2g	20-30	(8-12)	Dark greyish brown (2.5 Y 4/2) with common fine prominent reddish brown and light grey mottles; sandy loam; weak medium and coarse subangular blocky structure; moist, firm; few small soft iron-manganese nodules; few roots; clear smooth boundary
Cg	30-125	(12-50)	Light brownish grey (10 YR 6/2) with many fine prominent yellowish brown (10YR 5/6) mottles; sandy loam; weak coarse angular blocky structure; moist, firm; nodules as above

Depth cm	Particle size distribution %				Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn.%
	Coarse sand	Fine sand	Silt	Clay					Ca	Mg	K	Na		
0-8	6	58	21	15	0.9	0.14	2	5.4	2.2	0.8	0.1	0.2	6.2	52
8-20	4	55	23	17	0.6	0.09	1	5.4	2.1	0.7	0.1	0.2	6.7	45
20-30	8	56	19	15	0.4	0.08	0	5.8	2.0	1.1	tr.	0.2	6.4	51
30-125	8	56	23	17	0.3	0.07	0	5.7	1.0	0.7	0.1	0.1	6.9	27

PROFILE Gd 4

Soil family Koyah
Location About 15 km (8½ mi) N of the Kinabatangan at Tangkulap (grid ref. LC 165986)
Surroundings Low hills and flats; amplitude 15 m (50 ft.)
Site Alluvial flat
Slope Level
Elevation 60 m (200 ft.)
Site drainage Freshwater flooding
Parent material Coarse-textured alluvium
Vegetation Primary forest; low small trees and saplings; ground vegetation dominated by small fan palms
Soil drainage Poor

Horizon	Depth cm (in)		Description
A	0-3	(0-1)	Brown to dark brown (10YR 4/3); loamy sand; moderate medium granular structure; moist, very friable; abrupt smooth boundary
Bg	3-23	(1-9)	Light grey (10YR 7/2) with many distinct strong brown and yellowish red mottles; loamy sand; weak subangular blocky structure; moist, very friable; many channels filled with organic matter; clear smooth boundary
Clg	23-60	(9-24)	Light grey (10YR 7/1) with many distinct strong brown mottles loamy sand; weak subangular blocky structure; moist, very friable; merging boundary
C2g	60-125	(24-50)	Light grey to grey (10YR 6/1) with common distinct strong brown mottles; loamy sand; weak subangular blocky structure; moist, very friable

Depth cm	Particle size distribution %				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn.%
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na		
0-3	14	69	5	6	5.3	0.19	4.6	1.4	1.0	0.1	0.1	7.0	37
3-23	15	70	7	6	0.5	0.05	4.6	0.1	0.2	0.1	–	2.4	18
23-60	15	68	6	12	0.2	0.02	5.1	0.2	0.3	0.1	0.1	3.1	21
60-125	15	66	7	11	0.2	0.04	6.1	0.2	0.8	0.1	0.2	3.8	34

PROFILE Gd 5

Soil family	Metah
Location	About 1½ km (1 mi) W of Abai, 400 m (¼ mi) N of the Kinabatangan (grid ref. FY 289288)
Surroundings	Tidal swamps with scattered crab mounds and minor gullies
Site	Narrow platform about 50 cm (20 in) above tidal flat
Slope	Uneven
Elevation	Sea level; platform about 15 cm (6 in) above high water mark
Site drainage	Tidal flooding
Parent material	Medium-textured sulphidic alluvium
Vegetation	Nipah *(Nypa fruticans)* dominant; *Beilschoniedia micrantha, Ardisia elliptica, Strychnos ignatii, Erycibe borneensis, Cyathea* sp. (common)
Soil drainage	Poor; water table at 50 cm (20 in)

Horizon	Depth cm (in)		Description
Bg	0-25	(0-10)	Brown (7.5YR 5/2) with common prominent strong brown (7.5YR 5/6) and light brownish grey (2.5Y 6/2) mottles; loam; strong medium subangular blocky structure; moist, firm; clear boundary
C1g	25-30	(10-12)	Grey (5Y 5/1) with common prominent dark bluish grey (5 B 4/1) decaying organic matter and yellowish red (5YR 4/6) iron crusts; sandy clay loam; structureless, massive; wet, sticky and plastic; gradual boundary
C2g	30-125	(12-50)	Dark olive grey (5Y 3/2); sandy clay loam; structureless, massive; wet, sticky and plastic

Depth cm	Particle size distribution %				Org. C%	Total N%	pH H_2O	Exch. cations meq %				CEC meq%	Base satn.%	pH (after oxidn.)	Total S%	Cond. mmhos/cm
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na					
0-25	2	43	27	27	2.0	0.16	3.7	0.7	1.0	0.2	0.3	12.9	17	3.1	0.1	0.2
20-30	1	44	26	28	1.6	0.11	4.2	0.8	1.5	0.2	0.5	11.0	28	3.2	tr.	0.2
30-125	–	49	21	28	4.3	0.16	2.6	4.2	7.6	0.1	1.5	15.7	86	1.5	1.6	1.7

Eutric Gleysols (Ge)

PROFILE Ge 1

Soil family	Bangawat
Location	Sungai Kinabatangan downstream from Subak (grid ref. FY 026036)
Surroundings	Succession of low ridges forming a meander scroll about 120 m (400 ft) wide in front of an old levee
Site	Low ridge
Slope	Level
Elevation	About 6 m (20 ft)
Site drainage	Receiving; freshwater flooding
Parent material	Medium-textured alluvium
Vegetation	Vigorous stand of *Octomeles/Anthocephalus* secondary forest
Soil drainage	Poor

Horizon	Depth cm (in)	Description
Cg	0-10 (0-4)	Greyish brown (10YR 5/2) with common fine faint dark yellowish brown (10YR 4/4) mottles; loam; dry, hard; vertical cracks 2 cm wide; abrupt boundary
IIABg	10-20 (4-8)	Greyish brown (10YR 5/2) with dark reddish brown (5YR 3/4) stains on ped faces; clay loam; moderate coarse subangular blocky structure; moist, slightly firm; gradual boundary
IIBCg	20-53 (8-21)	Grey (10YR 5/1) with many medium distinct dark reddish brown (5YR 3/4) mottles; clay loam; strong coarse subangular blocky structure; moist, firm; diffuse boundary
IICg	53-100 (21-40)	Grey 2.5Y 6/1) with dusky red (2.5YR 3/2) in root channels; clay loam; very coarse subangular blocky structure; moist, firm

Depth cm	Particle size distribution %				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na		
0-10	2	33	41	26	2.0	0.2	5.3	7.8	6.3	0.3	0.2	20.2	73
10-20	3	23	50	29	2.0	0.3	5.6	7.7	6.3	0.3	0.2	20.1	73
20-53	1	28	44	29	1.1	0.16	6.4	7.7	12.2	0.3	0.2	19.8	sat.
53-100	1	20	50	31	0.8	0.4	6.4	6.4	12.4	0.3	0.2	18.4	sat.

PROFILE Ge 2

Soil family	Bangawat
Location	Tanjong Aru (grid red. FY 102456)
Surroundings	Coastal beach; flat, but dissected by narrow troughs; amplitude about 90 cm (36 in)
Site	Beach flat
Slope	Nil
Elevation	About 150 cm (5 ft)
Site drainage	Receiving
Parent material	Beach sand
Land use	Coconut plantation with shrub and grass undergrowth
Soil drainage	Very poor; water table at 30 cm (12 in)

Horizon	Depth cm (in)	Description
Ag	0-13 (0-5)	Dark grey (10YR 4/1) with common distinct reddish brown and light grey mottles; sand; weak fine subangular blocky structure; moist, friable

Horizon	Depth cm (in)	Description
C1g	13-23 (5-9)	Greyish brown (10YR 5/2) with common yellowish brown mottles; sand; structureless, single grain; moist, loose
C2g	23-120 (9-48)	Greyish brown (10YR 5/2); sand; structureless, single grain; wet, non-sticky, non-plastic

Depth cm	Particle size distribution %				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	Cond. mmhos/cm
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na			
0-13	–	88	4	6	3.6	0.15	4.3	1.2	2.0	0.2	6.6	5.1	sat.	n.d.
13-23	–	91	2	8	0.3	0.04	6.4	1.2	2.7	0.2	8.1	2.6	sat.	2.8
23-120	–	94	3	5	0.2	0.02	6.2	0.9	2.0	0.2	6.2	2.0	sat.	2.0

PROFILE Ge 3

Soil family	Rasang
Location	Segama group of mud volcanoes on Segama ridge W of Tomanggong (grid ref. LD 515972)
Surroundings	Large mud volcano clearing
Site	Flat
Slope	Nil; uneven surface
Elevation	About 75 m (250 ft)
Site drainage	Receiving
Parent material	Mudflow
Vegetation	Scattered grasses and shrubs
Soil drainage	Poor

Horizon	Depth cm (in)	Description
Ag	0-3 (0-1)	Greyish brown (10YR 5/2); silt loam; moderate fine platy structure; dry, slightly hard abrupt boundary
ABg	3-15 (1-6)	Greyish brown (10YR 5/2) with many fine distinct light yellowish brown (10YR 6/4) mottles; clay loam; weak subangular blocky structure around fine grass roots; moist, very firm; many small stones
BCg	15-40 (6-16)	Dark greyish brown (10YR 4/2); gritty clay; structureless massive; moist, very firm; many stones ranging from gravel to small in size
Cg	40-90 (16-36)	Grey (10YR 5/1); clay loam; structureless, massive; wet, slightly sticky and plastic; many stones

Depth cm	Particle size distribution %				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na		
0-3	1	6	76	15	0.7	0.08	8.4	4.1	1.7	0.2	3.5	15.0	63
3-15	3	29	36	31	0.8	0.09	8.2	5.3	2.4	0.2	3.9	15.4	77
15-40	3	16	38	43	0.6	0.08	8.5	13.8	4.8	0.5	7.7	14.4	sat.
40-90	3	18	37	40	0.6	0.04	8.6	11.6	3.2	0.5	9.7	11.2	sat.

Depth cm	Minerals of the clay fraction						Total %					
	Kaolinite	Halloysite	Illite	Vermiculite	Montmorillonite	Chlorite	Fe	Al	Mn	Mg	Ni	Cr
0-3	mod.	–	mod.	tr.	–	tr.	5.8	1.9	0.1	0.1	0.01	0.01
3-15	mod.	–	dom.	tr.	–	tr.	6.4	2.2	0.1	0.1	0.01	0.01
15-40	mod.	–	dom.	tr.	–	tr.	7.4	2.3	0.1	0.1	0.01	0.01
40-90	dom.	–	mod.	tr.	–	tr.	8.0	2.8	0.1	0.1	0.01	0.01

PROFILE Ge 4

Soil family	Libur
Location	About 800 m (½ mi) N of the Sungai Kalibong 9 km (5½ mi)NE of Abai (grid ref. FY 366339)
Surroundings	Tidal swamp with microtopography of coalescent crab mounds and platforms separated by narrow gullies
Site	Narrow platform
Slope	Level
Elevation	Platform level about 90 cm (36 in) above low water mark
Site drainage	Tidal flooding in gullies; platforms above high water mark and only rarely flooded
Parent material	Fine-textured alluvium
Vegetation	*Avicennia alba* (Api Api), with lower storey of *Ceriops tagal* and undergrowth of *Acrostrichum aureum* and *Allophyllus ternatus*
Soil drainage	Poor

Horizon	Depth cm (in)	Description
A	0-3 (0-1)	Dark yellowish brown (10YR 3/4); silty clay loam
Bg	3-30 (1-12)	Greyish brown (10YR 5/2) with many prominent fine and medium diffuse yellowish brown (10YR 5/8) and strong brown (7.5YR 5/8) mottles on root channels; clay; weak to moderate medium subangular blocky structure; wet, sticky and plastic
Cg	30-125 (12-50)	Greyish brown (2.5Y 5/2) with few distinct medium olive brown (2.5Y 4/4) mottles on root channels; clay; structureless, massive; wet, very sticky; many dead roots and wood fragments

Depth cm	Particle size distribution %				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn.	pH after oxidn.	Total S%	Cond. mmhos/cm
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na					
3-30	1	18	33	44	2.0	0.2	6.3	1.9	6.3	0.9	17.7	24.7	sat.	6.0	0.1	12
30-125	–	20	33	47	2.1	0.16	6.1	4.9	14.4	2.6	43.3	20.2	sat.	3.1	0.5	12

Calcaric Regosols (Rc)

PROFILE Rc 1

Soil family	Usukan
Location	Labuan, near Suaganlanda (grid ref. PE 748863)
Surroundings	Beach
Site	Beach flat
Slope	Nil
Elevation	3 m (10 ft)
Site drainage	Normal
Parent material	Coralline sand
Vegetation	Coconut plantation with grass ground cover
Soil drainage	Imperfect

Horizon	Depth cm (in)	Description
A	0-9 (0-3)	Dark greyish brown (10YR 4/2); loamy sand; structureless, single grain; moist, very friable; many fine roots; abrupt smooth boundary
C1	9-41 (3-16)	Light yellowish brown (10YR 6/4); sand; structureless, single grain; moist, loose; few roots; gradual smooth boundary
C2	41-96 (16-38)	Very pale brown (10YR 7/3); sand structureless, single grain; moist, loose, very few roots; gradual smooth boundary
C3g	96-125 (38-50)	Light grey (10YR 7/2); sand; structureless, single grain; moist, loose

Depth cm	Particle size distribution %				Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	$CaCO_3$ equiv %
	Coarse sand	Fine sand	Silt	Clay					Ca	Mg	K	Na			
0-9	40	45	6	–	3.4	0.39	5	7.5	31.1	1.4	0.1	0.4	13.1	sat.	23.5
9-41	66	30	1	1	0.4	0.09	1	8.1	29.5	0.3	–	0.4	1.2	sat.	70.4
41-96	40	59	1	1	0.1	0.03	tr.	8.4	34.1	–	–	0.5	0.4	sat.	60.4
96-125	70	29	–	1	0.1	0.03	tr.	8.4	35.7	1.7	–	0.5	0.5	sat.	75.4

Dystric Regosols (Rd)

PROFILE Rd 1

Soil family	Tamanong
Location	1 km (¾ mi) S of Palakat (grid ref. LA 163645)
Surroundings	Beach
Site	Beach flat
Slope	1°
Elevation	2 m (7 ft)
Site drainage	Normal**Parent material**
Parent material	Siliceous sand
Vegetation	Coconut plantation with grasses and shrubs
Soil drainage	Imperfect; excessive at surface

Horizon	Depth cm (in)	Description
A1	0-20 (0-8)	Dark yellowish brown (10YR 3/4); loamy sand; weak, medium to fine crumb structure; moist, very friable to loose; some coarse charcoal fragments; gradual smooth boundary
A2	20-28 (8-11)	Borwn to dark brown (10YR 4/3); loamy sand; very weak medium to fine crumb structure; loose; gradual, smooth boundary
AC	28-40 (11-16)	Dark yellowish brown (10YR 4/4); sand; very weak, medium to fine subangular blocky structure; loose; gradual smooth boundary
C1	40-53 (16-21)	Brown to dark brown (7.5YR 4/4); sand; structureless, single grain; slightly firm; gradual smooth boundary
C2	53-105 (21-42)	Dark yellowish brown (10YR 4/4) with few faint medium yellowish brown (10YR 5/4) mottles; sand; structureless, single grain; loose gradual smooth boundary
IICg	105-125 (42-50)	Light grey (10YR 7/2); coarse sand; common lumps of fibrous peat; structureless, single grain; moist slightly firm

Depth cm	Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
					Ca	Mg	K	Na		
0-20	0.8	0.03	3	5.3	0.1	–	–	–	2.6	4
20-28	1.2	0.09	2	5.1	–	–	–	–	3.8	–
28-40	0.4	0.03	2	5.4	–	–	–	–	2.0	–
40-53	0.4	0.02	2	5.3	–	–	–	–	2.0	–
53-105	0.2	0.01	2	5.6	–	–	–	–	1.5	–
105-125	1.7	0.13	2	4.9	0.2	0.1	0.1	tr.	6.8	6

Eutric Regosols (Re)

PROFILE Re 1

Soil family	Tanjong Lita
Location	Tanjong Aru, Sandakan (grid ref. FY 145449)
Surroundings	Coastal beach
Site	Beach flat with minor undulations
Slope	Nil
Elevation	1.5 m (5 ft)
Site drainage	Normal
Parent material	Beach sand
Vegetation	*Imperata cylindrica*
Soil drainage	Imperfect; water table at 120 cm (48 in); excessive at surface

Horizon	Depth cm (in)	Description
Ap	0-5 (0-2)	Very dark brown (10YR 2/2) with many bleached sand grains; fine sand; weak very fine granular structure; moist, friable
AC	5-20 (2-8)	Brown (10YR 5/3); fine sand; weak fine granular structure; dry, loose
C1	20-75 (8-30)	Pale brown (10YR 6/3) with many coarse distinct brownish yellow (10YR 6/6) and common medium prominent strong brown (7.5YR 5/8) mottles; sand; structureless, single grain; moist, loose
C2g	75-115 (30-46)	Light brownish grey (2.5Y 6/2) with common distinct yellowish brown (10YR 5/4) mottles; sand; structureless, single grain; moist, loose
C3g	115-125 (46-50)	Dark greenish grey (5GY 4/1); sand; structureless, single grain; wet, non-sticky, non-plastic

Depth cm	Particle size distribution %				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	Total Fe%
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na			
0-5	1	94	1	5	1.1	0.1	6.1	2.1	1.1	0.2	0.2	4.3	84	n.d.
5-20	2	95	1	4	0.4	0.06	5.2	0.9	0.4	tr.	0.2	2.5	62	0.5
20-75	1	98	1	3	0.1	0.02	5.6	0.5	0.6	tr.	0.1	1.5	83	0.6
75-115	1	99	–	–	0.02	0.01	6.1	0.7	0.4	tr.	0.2	1.3	sat.	n.d.

PROFILE Re 2 (After Wilson, 1969a, p19)

Soil family	Tanjong
Location	Kota Belud coastal plain
Surroundings	Beach
Site	Swale
Slope	Nil
Elevation	2 m (7 ft)
Site drainage	Normal
Parent material	Mafic sand
Land use	Grassland; *Imperata cylindrica* dominant
Soil drainage	Imperfect

Horizon	Depth cm (in)	Description
A	0-8 (0-3)	Very dark grey (10YR 3/1) with common yellowish red (5YR 5/6) iron staining along root channels; loamy sand; weak fine granular structure; very friable; common roots; clear, smooth boundary

Horizon	Depth cm (in)	Description
AC	8-15 (3-6)	Very dark greyish brown (10YR 3/2) and brown to dark brown (10YR 4/3) with common greyish brown (10YR 5/2) mottles; fine sand; structureless; very friable; few roots; gradual, wavy boundary
C1g	15-27 (6-11)	Grey (10YR 5/1) with many yellowish brown (10YR 5/6) mottles; fine sand; structureless; very friable; few humus stains along cracks and root channels
C2g	27-90 (11-36)	Light brownish grey (10YR 6/2); fine sand; structureless; very friable; few roots

Depth cm	Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
					Ca	Mg	K	Na		
0-8	2.3	0.61	3	6.5	1.9	15.7	0.2	0.3	15.2	sat.
8-15	1.8	0.15	1	6.6	0.9	7.4	0.1	0.2	7.4	sat.
15-27	0.3	0.04	1	7.8	0.4	5.9	0.1	0.2	5.5	sat.
27-90	–	0.03	–	8.0	0.3	5.3	0.1	0.1	5.3	sat.

Gleyic Podzols (Pg)

PROFILE Pg 1

Soil family	Baiayo
Location	Near Brantian, Tawau (grid ref. 425955)
Surroundings	Undulating terrace; amplitude 12 m (40 ft)
Site	Terrace flat
Slope	Nil
Elevation	15 m (50 ft)
Site drainage	Normal
Parent material	Coarse-textured alluvium overlying medium-textured alluvium
Vegetation	Secondary forest; originally heath forest
Soil drainage	Imperfect

Horizon	Depth cm (in)		Description
O	5-0	(2-0)	Mor; abundant roots; abrupt smooth boundary
E	0-28	(0-11)	Light grey to grey (5YR 6/1); sand; structureless; moist, very friable; common roots; clear smooth boundary
B1hfe	28-48	(11-19)	Very pale brown (10YR 7/4) with common fine distinct yellowish red (5YR 5/8) mottles and dark reddish brown (5YR 3/4) humus stains; sand; structureless; moist, firm; indurated; very few roots; diffuse wavy boundary
B2hfe	48-68	(19-27)	Dark reddish brown humus pan (5YR 2/2) with many fine coarse distinct light grey (N 7) mottles; sand; structureless; moist, firm; indurated; very few roots, diffuse wavy boundary
II B1tg	68-83	(27-33)	Grey (5YR 5/1) with few fine distinct rust mottles; sandy loam; structureless; moist, firm; indurated, very few roots; diffuse smooth boundary
II B2tg	83-98	(33-39)	White (5Y 8/1) with few fine distinct yellowish red (5YR 5/6) mottles; loam; weak fine and medium subangular blocky structure; wet, slightly sticky and slightly plastic; very few roots; diffuse smooth boundary
II B3tg	98-125	(39-50)	White (5Y 8/1) with many medium prominent yellowish red (5YR 5/8) mottles; sandy clay loam; weak fine and medium subangular blocky structure; wet, sticky and plastic; very few roots

Depth cm	Particle size distribution %			Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	Total ppm		
	Coarse sand	Silt	Clay					Ca	Mg	K	Na			Mg	K	P
0-28	80	17	3	0.2	0.01	1	5.0	0	0	tr.	0.1	0.7	14	70	50	10
28-48	80	15	5	0.9	0.05	5	4.7	0	0	tr.	0.1	6.2	2	40	30	22
48-68	80	15	5	0.5	0.01	6	5.1	0	0	tr.	0.1	4.5	2	40	0	22
68-83	67	15	18	0.1	0.01	2	4.6	0	0	tr.	0.1	6.3	2	280	180	88
83-98	57	13	30	0.3	0.02	1	4.6	0	0	tr.	0.1	6.8	2	480	330	82
98-125	52	10	38	0.3	0.02	1	4.6	0	0	tr.	0.1	6.7	2	400	300	116

PROFILE Pg 2

Soil family	Baiayo
Location	Ulu Maligan (grid ref. LA 241108)
Surroundings	Large depression
Site	Flat
Slope	Nil
Elevation	1 440 (4 800 ft)
Site drainage	Receiving
Parent material	Sandstone colluvium
Vegetation	Scrub forest
Soil drainage	Imperfect

Horizon	Depth cm (in)	Description
O	1-0 (½-0)	Very dark greyish brown (10YR 3/2); slightly humified peat; abundant roots wet; sharp, smooth boundary
A	0-5 (0-2)	White (10YR 8/2); sand; structureless, single grain; wet, loose; abundant roots; gradual, smooth boundary
AE	5-10 (2-4)	Light grey (10YR 7/2) and white (10YR 8/1); sand; structureless, single grain; wet, loose; abundant roots; clear, smooth boundary
E	10-60 (4-24)	White (10YR 8/1); sand; structureless, single grain; wet, slightly firm; sharp, smooth boundary
B1h	60-65 (24-26)	Dark reddish brown (2.5YR 2/4); fine sand; weak, coarse subangular blocky structure; moist, firm; gradual wavy boundary
B2	65-85 (26-34)	Brownish yellow (10YR 6/6) and dark yellowish brown (10YR 4/4) with common strong brown (7.5YR 5/8) organic strains; fine sand; weak coarse subangular blocky structure; wet, firm; few dead roots; gradual, smooth boundary
BCg	85-125 (34-50)	Light grey (10YR 7/2) and very pale brown (10YR 7/4); sand; structureless, single grain; wet, loose

Depth cm	Particle size distribution %				Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	Al		Fe	
	Coarse sand	Fine sand	Silt	Clay					Ca	Mg	K	Na			Total %	Extr. (pH 4.8) ppm	Total %	Extr. (pH 2.5) ppm
1-0	n.d.	n.d.	n.d.	n.d.	7.3	0.23	11	4.2	0.9	1.2	0.3	–	12.8	19	0.18	1	0.20	28
0-5	28	66	1	3	2.0	0.10	8	4.6	0.2	0.7	0.2	–	5.2	21	0.05	1	0.06	7
5-10	36	60	1	2	0.4	0.03	1	4.5	–	tr.	–	–	0.6	–	0.06	1	0.06	1
10-60	36	63	–	1	–	–	1	5.4	–	–	–	–	0.9	–	0.08	1	0.03	1
60-65	21	69	2	5	1.4	0.05	0	4.3	tr.	–	–	–	8.8	–	0.74	160	0.30	2
65-85	10	68	14	7	1.1	0.03	0	4.3	–	–	–	–	5.7	–	1.30	290	0.13	3
85-125	20	67	9	3	0.4	0.07	0	4.6	tr.	0.9	–	–	1.7	6	0.33	100	0.06	6

PROFILE Pg 3

Soil family	Baiayo
Location	About 2 km (1¼ mi) NE of Lakutan (grid ref. LA 182677)
Surroundings	Terrace
Site	Gentle slope
Slope	2°
Elevation	15 m (50 ft)
Site drainage	Normal
Parent material	Siliceous sand
Vegetation	Heath forest with many ferns and pitcher plants
Soil drainage	Imperfect

Horizon	Depth cm (in)	Description
O	1-0 (½-0)	Mor
Ah	0-15 (0-6)	Dark reddish brown (5YR 2/2) humic sandy loam with common, light grey (5YR 7/1) sand grains; weak fine to medium crumb structure; moist, friable; abundant fine and medium roots; clear, wavy boundary
E	15-35 (6-14)	Brown (7.5YR 5/2); very fine sand with common white (10YR 8/2) bleached sand grains; massive breaking to single grain; moist, very firm; compact; few fine and medium roots; clear, wavy boundary
B1h	35-39 (14-15)	Dark reddish brown (5YR 2/2) and dark brown (7.5YR 3/2); very fine sand; massive, breaking to single grain; moist, very firm, compact; few fine roots, gradual wavy boundary
B2	39-45 (15-18)	Strong brown (7.5YR 5/6) with common dusky red (2.5YR 3/2) streaks; fine sand, massive, breaking to single grain; dry, very hard; compact, few fine roots; clear smooth boundary
B3	45-120 (18-48)	Pale brown (10YR 6/3) with common very dark brown (10YR 2/2) streaks and common strong brown (7.5YR 5/8) mottles; fine sandy clay; structureless, massive; moist, firm

Depth cm	Particle size distribution %				Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay					Ca	Mg	K	Na		
0-15	8	73	12	3	2.3	0.14	5	4.0	–	0.1	tr.	–	7.0	1
15-35	9	75	13	2	0.7	0.03	3	5.4	–	–	–	–	1.1	–
35-39	8	71	13	7	1.9	0.05	4	4.0	–	–	–	–	7.7	–
39-45	8	69	15	8	0.6	0.02	3	4.3	–	–	–	–	6.1	–
45-120	7	64	15	13	0.4	0.02	1	4.5	–	–	–	–	4.5	–

Depth cm	Al		Fe		Minerals of the clay fraction		
	Total %	Extr. (pH 4.8) ppm	Total %	Extr. (pH 2.5) ppm	Quartz	Vermic-ulite	Kaolin-ite
0-15	0.19	20	0.03	70	dom.	–	–
15-35	0.04	20	0.04	70	dom.	–	–
35-39	0.79	660	0.05	20	–	dom.	mod.
39-45	1.30	1 200	0.15	70	–	dom.	mod.
45-120	1.90	970	0.46	120	–	dom.	dom.

PROFILE Pg 4

Soil family	Pa Sia
Location	Footslopes of Gunong Trusmadi; interfluve between Sungai Kaintano Kechil and Sungai Kaintano Besar (grid ref. FW 257113)
Surroundings	Steep mountains
Site	Upper slope of main ridge about 45 m (150 ft) below crest
Slope	30°
Elevation	1 620 m (5 400 ft)
Site drainage	Shedding
Parent material	Dominant shale with minor interbedded sandstone
Vegetation	Transition to moss forest; *Podocarpaceae, Ericaceae* and *Myrtaceae* dominant
Soil drainage	Poor

Horizon	Depth cm (in)	Description
Of	10-0 (4-0)	Dark reddish brown (2.5YR 2/4); raw humus
AE	0-5 (0-2)	Light grey (10YR 7/2) and brown to dark brown (10YR 4/3); silt loam; weak fine subangular blocky structure; moist, friable; abrupt wavy boundary
EBg	5-15 (2-6)	Light grey (10YR 7/2) with common fine prominent yellowish red (5YR 5/8) mottles; sandy clay loam; moderate to strong medium subangular blocky structure; moist, firm; moderately thick broken cutans; humus staining on structure faces; gradual boundary
Bfe	15-20 (6-8)	Brownish yellow (10YR 6/6) with common prominent reddish yellow (5YR 6/8) mottles; sandy clay loam; moderate medium subangular blocky structure; moist, friable; many to dominant weathered shale with some interbedded sandstone; humus staining on structure faces; common soft iron concretions
C	20-90 (8-36)	Dominant weathered shale and sandstone with brownish yellow (10YR 6/6) sandy clay loam matrix; common humus staining and yellowish red mottles on weathering rock faces

Depth cm	Particle size distribution %				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na		
0-5	5	45	29	19	5.2	0.39	3.9	0.2	0.2	0.1	0.1	12.0	4
5-15	7	45	28	22	1.3	0.09	4.1	0.1	0.1	–	0.1	7.1	5
15-20	21	31	27	22	0.8	0.10	4.5	0.2	0.1	0.1	0.1	7.6	7

Total %		Minerals of the clay fraction		
Al	Fe	Kaolinite	Illite	Vermiculite
n.d.	n.d.	n.d.	n.d.	n.d.
2.7	1.1	tr.	dom.	–
3.9	5.7	mod.	dom.	tr.

PROFILE Pg 5

Soil family	Pa Sia
Location	Water catchment station, Sandakan (grid ref. FX 972462)
Surroundings	Cuesta with steep often sheer scarp slopes and long moderately steep dip slopes
Site	Upper slope of long dip slope
Slope	8°
Elevation	60 m (200 ft)
Site drainage	Normal
Parent material	Sandstone colluvium
Vegetation	Heath forest
Soil drainage	Imperfect

Horizon	Depth cm (in)	Description
AE	0-15 (0-6)	Brown (7.5YR 5/2); loamy sand; moderate medium granular structure; moist, friable; abrupt smooth boundary
E	15-20 (6-8)	Light grey (10YR 7/2); loamy sand; weak subangular blocky structure; moist; very friable; abrupt smooth boundary
B1h	20-25 (8-10)	Dark brown (7.5YR 3/2) and brown (7.5YR 5/2); loamy sand; slightly coherent; abrupt smooth boundary

Horizon	Depth cm (in)	Description
B2hfe	25-33 (10-13)	Strong brown (7.5YR 5/8) and brownish yellow (10YR 6/6) with prominent rust mottles; sandy loam; weak platy structure; weakly cemented; slightly hard; clear smooth boundary
B3tg	33-83 (13-33)	Light grey (2.5Y 7/2) and strong brown (7.5YR 5/8) with prominent rust mottles and humus coatings on ped faces; loam; moderate medium prismatic structure; moist, firm; thin patchy cutans; common iron concretions; merging boundary
B4tg	83-125 (33-50)	Light grey (2.5Y 7/2) with many large prominent strong brown (7.5YR 5/8) and red (2.5YR 5/8) mottles; clay loam; moderate medium prismatic structure; moist, firm; thin patchy cutans; common subangular and tubular iron concretions

Depth cm	Particle size distribution %				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na		
0-15	–	82	15	3	1.5	0.1	4.2	0.2	0.1	0.1	0.1	2.5	19
15-20	–	82	17	3	0.2	0.04	4.8	0.3	0.1	–	0.1	1.0	40
20-25	–	79	15	5	1.1	0.01	4.2	0.2	0.1	–	0.1	6.3	7
25-33	–	73	13	10	1.4	0.07	4.4	0.2	0.1	–	0.1	11.3	3
33-83	–	65	14	21	0.1	0.03	4.6	0.2	0.1	–	0.1	5.4	7
83-125	–	59	18	24	0.1	0.05	4.6	0.2	0.1	0.1	0.1	6.8	6

Humic Podzols (Ph)

PROFILE Ph 1

Soil family	Karamatoi
Location	Ulu Sipitang (grid ref. LA 188612)
Surroundings	Terrace
Site	Terrace edge
Slope	3°
Elevation	15 m (50 ft)
Site drainage	Normal
Parent material	Alluvium
Vegetation/Land use	Low shrubs and bracken; small pineapple plots
Soil drainage	Well drained

Horizon	Depth cm (in)		Description
O	1-0	(½-0)	Litter layer
A	0-15	(0-6)	Dark greyish brown (10YR 4/2); sand; structureless, single grain; dry, loose; many roots; gradual, wavy boundary
AE	15-35	(6-14)	Pinkish grey (7.5YR 6/2); sand; structureless, single grain; moist, loose; few charcoal fragments; roots; gradual, wavy boundary
E	35-55	(14-22)	White (5YR 8/1); sand; structureless, massive, breaking to single grain; moist, firm; few roots; clear wavy boundary
B1h	55-65	(22-26)	Dark reddish brown (5YR 3/2) and yellowish red (5YR 4/6) (ignited colour 2.5Y 8/2); sand to loamy sand; structureless, massive massive breaking to single grain; moist, very firm; gradual, wavy boundary
B2	65-98	(26-39)	Brown to dark brown (7.5YR 4/3) (ignited colour 5Y 8/2) with few dark reddish brown (5YR 3/3) streaks; sand; massive, breaking to single grain; moist, firm; gradual, smooth boundary
B3	98-125	(39-50)	Brown to dark brown (7.5YR 4/4) (ignited colour 5Y 8/1); sand; very weak coarse subangular blocky breaking to single grain structure; moist, slightly firm

Depth cm	Particle size distribution %				Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay					Ca	Mg	K	Na		
0-15	27	59	7	2	2.0	0.11	6	4.2	0.2	–	0.1	–	9.5	3
15-35	22	69	8	1	0.3	0.02	2	4.9	–	–	–	–	0.7	–
35-55	21	66	13	1	0.1	0.01	3	5.6	0.1	–	–	–	0.1	sat.
55-65	21	59	8	6	2.7	0.10	4	4.8	0.1	–	–	–	16.9	1
65-98	20	62	9	6	1.2	0.06	3	5.2	–	–	–	–	6.2	–
98-125	23	64	7	5	0.7	0.03	2	5.2	–	–	–	–	4.3	–

Depth cm	Al		Fe		Total Ti %	Minerals of the clay fraction			
	Total %	Extr. (pH 4.8) ppm	Total %	Extr. (pH 2.5) ppm		Quartz	Vermiculite	Kaolinite	Illite
0-15	0.18	24	0.01	13	n.d.	n.d.	n.d.	n.d.	n.d.
15-35	0.28	20	0.03	7	n.d.	n.d.	n.d.	n.d.	n.d.
35-55	0.18	6	0.01	8	0.25	n.d.	n.d.	n.d.	n.d.
55-65	1.71	1 400	0.05	9	0.31	dom.	mod.	pres.	–
65-98	1.94	1 800	0.09	11	0.28	pres.	dom.	dom.	pres.
98-125	1.92	1 400	0.09	13	0.23	tr.	dom.	dom.	mod.

Orthic Podzols (Po)

PROFILE Po 1

Soil family	Silimpopon
Location	Sandakan airport; E of old airstrip (grid ref. FX 952498)
Surroundings	Low hills backing terrace
Site	Middle slope
Slope	15°
Elevation	22.5 m (75 ft)
Site drainage	Shedding
Parent material	Quartz pebbles and sand
Vegetation	Clear felled for building
Soil drainage	Excessive

Horizon	Depth cm (in)		Description
A	0-10	(0-4)	Very dark brown (10YR 2/2); sand; moderate granular structure; common quartz pebbles
E1	10-40	(4-16)	Light grey (10YR 7/2); sand; structureless, single grain; many quartz pebbles
E2	40-73	(16-29)	Light grey (10YR 7/1); sand; structureless, single grain; many quartz pebbles
B1hfe	73-83	(29-33)	Dark brown (7.5YR 3/2); sand; weak fine subangular blocky structure; moist, friable; common quartz pebbles
B2fe	83-88	(33-35)	Yellowish red (5YR 5/8); loamy sand; indurated; many quartz pebbles
B3fe	88-125	(35-50)	Reddish yellow (5YR 6/8); sandy clay loam; indurated; many quartz pebbles

Depth cm	Particle size distribution %				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn.%	Total %	
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na			Fe	Al
0-10	19	58	14	5	2.2	0.15	4.7	1.7	0.8	0.1	0.2	6.5	42	n.d	n.d
10-40	32	51	12	3	0.2	0.01	4.2	0.5	0.1	0.1	0.2	2.2	37	n.d	n.d
40-73	37	48	11	3	0.02	0.003	4.6	0.4	0.1	–	0.2	1.9	37	n.d	n.d
73-83	30	49	11	7	2.6	0.13	4.5	0.3	0.1	–	0.2	17.6	4	2.5	0.02
83-88	34	41	9	12	0.3	0.01	4.6	0.3	–	–	0.3	13.9	4	0.4	0.02
88-125	48	23	5	22	0.3	0.02	4.6	0.8	0.1	0.1	0.3	8.7	4	0.9	0.1

PROFILE Po 2

Soil family	Sibuga
Location	800 m (½ mi) S of Natab Batu on the Maligan to Long Pa Sia path (grid ref. LV 371989)
Surroundings	Mountains
Site	Middle slope
Slope	16°
Elevation	1 080 m (3 600 ft)
Site drainage	Normal
Parent material	Sandstone
Vegetation	Primary forest
Soil drainage	Well to excessive

Horizon	Depth cm (in)		Description
O	5-0	(2-0)	Very dusky red (10R 2/2); fibrous peat; abundant fine roots; clear, smooth boundary
A1	0-5	(0-2)	Dark grey (5YR 4/1); sand; many fine and medium roots; gradual, smooth boundary
A2	5-10	(2-4)	Very dark grey (5YR 3/1); loamy sand; very weak coarse subangular blocky structure; moist, firm; many fine and medium roots; gradual, smooth boundary
AE	10-18	(4-7)	Reddish grey (5YR 5/2); sand; structureless, single grain; moist, loose; few fine and medium roots; gradual wavy boundary
E	18-33	(7-13)	Light grey (10YR 7/1); fine sand; structureless, massive breaking to single grain; very firm; compact; occasional medium roots; gradual wavy boundary
B1h	33-40	(13-16)	Dark reddish brown (5YR 2/2), (ignited colour 5YR 8/3); loamy fine sand; weak medium to coarse subangular blocky structure; compact; occasional fine roots; gradual smooth boundary
B2fe	40-43	(16-17)	Red (2.5YR 4/8) and very dark grey (5YR 3/1) (ignited colour 5YR 6/8); sand; structureless, massive; compact; merging smooth boundary
C	43+	(17+)	White (7.5YR 8/0); weathering sandstone

Depth cm	Particle size distribution %				Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn.%
	Coarse sand	Fine sand	Silt	Clay					Ca	Mg	K	Na		
5-0	n.d.	n.d.	n.d.	n.d.	15.1	0.62	87	3.9	1.3	2.3	1.2	0.1	44.7	11
0-5	31	52	8	2	2.7	0.11	8	4.2	0.1	0.2	0.1	–	8.3	5
5-10	39	49	8	3	1.3	0.07	4	4.2	tr.	0.1	tr.	–	3.4	3
10-18	34	53	9	2	0.2	0.08	1	4.5	0.1	–	–	–	1.1	9
18-33	35	50	1	11	0.1	0.01	–	5.3	0.1	–	–	–	0.7	14
33-40	27	46	19	4	1.4	0.06	4	4.5	tr.	–	–	–	9.5	–
40-43	27	41	14	13	3.1	0.13	2	4.7	–	–	tr.	–	20.2	–

Depth cm	Al		Fe		Mn	Minerals of the clay fraction		
	Total %	Extr. (pH 4.8) ppm	Total %	Extr. (pH 2.5) ppm	Extr. (pH 7.0) ppm	Quartz	Kaolinite	Illite
5-0	0.36	9	0.09	84	15	dom.	–	–
0-5	0.45	35	0.07	38	1.1	dom.	tr.	–
5-10	0.34	30	0.06	15	0.4	dom.	tr.	–
10-18	0.40	14	0.03	7	0.1	dom.	tr.	–
18-33	0.61	9	0.05	10	0.2	dom.	tr.	–
33-40	1.24	760	0.45	39	0.7	tr.	dom.	–
40-43	2.33	2 750	2.91	90	1.1	tr.	dom.	–
43 +	3.11	1 210	1.31	185	0.3	tr.	mod.	dom.

Goethite was present between 40-43 cm.

Rhodic Ferralsols (Fr)

PROFILE Fr I (After Thomas, 1967a, p. 46)

Soil family	Apas
Location	Bakapit Timber Camp
Surroundings	Hilly
Site	Middle slope
Slope	10°
Elevation	24 m (80 ft)
Site drainage	Shedding
Parent material	Volcanic ash
Land use	Grass
Soil drainage	Well drained

Horizon	Depth cm (in)		Description
A	0-5	(0-2)	Reddish brown (5YR 4/3) silty clay; strong fine angular blocky breaking to very fine crumb structure; friable; many roots; abrupt smooth boundary
B1ox	5-22	(2-9)	Reddish brown to dark reddish brown (5YR 4/4); clay; structure as above; friable; many roots; gradual smooth boundary
B2ox	22-42	(9-17)	Dark red (2.5YR 3/6); clay; structure as above; friable; many roots; gradual smooth boundary
B3ox	42-120	(17-48)	Reddish brown (2.5YR 4/4); clay; structure as above; friable; few fine roots

Depth cm	Particle size distribution %				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	Fe		Al total %
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Ma			Total %	Extr. ppm	
0-5	1	4	30	65	3.8	0.22	5.4	2.4	2.0	0.1	0.3	9.1	59	11.9	8	6
5-22	1	2	17	80	1.6	0.13	4.8	0.5	1.5	0.1	0.2	9.3	25	11.9	8	5
22-42	1	2	16	81	1.0	0.11	4.9	0.3	1.4	0.1	0.1	7.6	25	11.2	8	6
42-120	1	2	18	79	0.4	0.08	5.1	0.7	0.6	tr.	0.2	8.2	18	9.8	8	6

Xanthic Ferralsols (Fx)

PROFILE Fx 1

Soil family	Tungau
Location	Juak road traverse
Surroundings	Terraces of Sungai Juak; amplitude 6 m (20 ft)
Site	Upper terrace
Slope	5^{0}, convex
Site drainage	Shedding
Parent material	Medium-textured stony alluvium
Vegetation	Logged forest
Soil drainage	Well drained

Horizon	Depth cm (in)	Description
A	0-3 (0-1)	Dark yellowish brown (10YR 3/4); humic loam; strong very fine and fine subangular blocky structure; moist, friable; abundant roots; clear smooth boundary
E	3-17 (1-7)	Yellowish brown (10YR 5/6); loam; moderate coarse and medium subangular blocky structure; moist, friable; common roots; diffuse smooth boundary
B1ox	17-50 (7-20)	Strong brown (7.5YR 5/8); clay loam; moderate coarse and medium subangular blocky structure; moist, friable; few gravels; few roots; diffuse smooth boundary
B2ox	50-85 (20-34)	Strong brown (7.5YR 5/8); clay loam; moderate coarse and medium subangular blocky structure; moist, friable; common gravels and few rounded dolerite stones; few roots; diffuse smooth boundary
B3ox	85-125 (34-50)	Strong brown (7.5YR 5/8); clay loam; moderate fine and coarse subangular blocky structure; moist, friable; common gravels and few stones and boulders of tuff; very few roots

Depth cm	Particle size distribution %			Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	Total %			Avail P ppm
	Sand	Silt	Clay				Ca	Mg	K	Na			K	Mg	P	
0-3	27	20	53	6.0	0.44	5.3	9.3	4.9	0.3	0.1	44.1	30	0.06	0.3	0.04	1
3-17	14	20	66	1.2	0.14	4.8	0.5	0.9	0.1	–	11.3	13	0.06	0.3	0.01	tr.
17-50	22	22	56	0.7	0.09	5.0	0.1	1.2	tr.	–	10.3	13	0.06	0.4	0.01	tr.
50-85	24	28	48	0.4	0.07	5.2	0.1	0.8	tr.	–	5.0	20	0.07	0.3	0.01	tr.
85-125	54	25	21	0.4	0.04	5.4	tr.	0.4	0.1	–	6.6	9	0.08	0.3	0.01	tr.

PROFILE Fx 2 (After Thomas, 1968)

Soil family	Jarangan
Location	Table Estate, Tawau
Surroundings	Plateau
Site	Gently undulating
Slope	Nil
Elevation	150 m (500 ft)
Site drainage	Free
Parent material	Basalt
Land use	Oil palm
Soil drainage	Well drained

Horizon	Depth cm (in)		Description
0	1-0	(½-0)	Very dark greyish brown (10YR 3/2); silty clay; strong medium crumb structure; loose; many roots; clear smooth boundary
A1	0-15	(0-6)	Dark yellowish brown (10YR 4/4); clay; moderate to strong fine subangular blocky breaking to strong fine crumb structure; very friable; many pores; few angular quartz gravels; many roots; gradual smooth boundary
B1	15-32	(6-17)	Yellowish brown (10YR 3/6); clay; strong fine subangular breaking to strong fine crumb structure; very friable; many pores; few angular quartz gravels; many roots; gradual smooth boundary
B2ox	32-60	(17-24)	Light yellowish brown (10YR 6/4) clay; moderate fine subangular breaking into strong fine crumb structure; friable; thin patchy cutans; common pores; very few angular quartz gravels; few roots; gradual smooth boundary
B3ox	60-125	(24-50)	Brownish yellow (10YR 6/8) with few fine grey mottles, clay; moderate very fine crumb structure; friable; thin patchy cutans; common pores; very few fine angular quartz gravels

Depth cm	Particle size distribution %				Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	Total %	
	Coarse sand	Fine sand	Silt	Clay					Ca	Mg	K	Na			Al	Fe
1-0	10	12	40	38	9.0	0.87	18	4.8	9.8	2.5	12.5	0.2	37.4	61	12	6
0-15	9	7	24	60	2.9	0.34	6	4.8	2.9	0.4	0.5	0.2	15.7	24	16	8
15-32	7	4	15	74	1.2	0.18	1	4.6	0.3	0.1	0.5	0.1	12.6	7	17	8
32-60	6	8	11	77	0.6	0.11	1	4.3	0.3	0.1	0.4	0.1	12.1	1	18	9
60-125	5	4	14	77	0.4	0.08	1	4.2	0.7	0.4	0.1	0.1	10.2	12	19	9

Depth cm	Trace elements in soil on adjacent site (Allen, 1966) ppm				
	Co	Cr	Cu	Mn	Ni
0-5	3	30	20	300	5
5-20	3	30	20	300	5
20-40	3	30	20	300	5
40-85	3	30	20	300	5
85-145	3	30	20	300	5

Orthic Ferralsols (Fo)

PROFILE Fo 1

Soil family	Ambun
Location	About 2 000 m (1¼ mi) E of the Sungai Karamuak at Tanjong Kapok (grid ref. FX 841057)
Surroundings	Steep mountain slopes passing to flat plateau above
Site	Lower slope of spur
Slope	18°
Elevation	375 m (1 250 ft)
Site drainage	Normal
Parent material	Colluvium derived from ultrabasic igneous rocks
Vegetation	Dipterocarp forest with *Dipterocarpus lowii* and *Heritiera borneensis*
Soil drainage	Well drained

Horizon	Depth cm (in)		Description
A	0-1	(0-½)	Brown to dark brown (7.5YR 4/4); silt loam; strong medium granular structure; moist; friable; abrupt boundary
B1	1-8	(½-3)	Yellowish red (5YR 4/6); clay; strong fine subangular blocky structure; moist, friable; merging boundary
B2ox	8-40	(3-16)	Yellowish red (5YR 4/6) with reddish brown and purple sheen on ped faces; clay; moderate medium and coarse subangular blocky structure; moist, friable; very porous; diffuse boundary
B3ox	40-125	(16-50)	Yellowish red (5YR 4/6) with reddish brown (5YR 4/4) and purple sheen on ped faces; clay; strong fine granular structure; moist, very friable

Depth cm	Particle size distribution %				Org. C%	Total N%	pH		Exch. cations meq %				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay			H_2O	KCl	Ca	Mg	K	Na		
0-1	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	4.4	4.3	2.7	6.1	1.1	2.2	43.7	27
1-8	4	9	28	55	5.1	0.34	4.8	4.6	0.2	0.8	0.2	0.3	9.1	17
8-40	6	19	25	55	1.2	0.12	5.2	5.2	0.2	0.1	0.1	0.2	1.6	31
40-125	43	39	10	12	0.2	0.02	5.2	6.2	0.1	–	0.1	0.2	0.7	53

Depth cm	Total %						Minerals of the clay fraction	
	Fe	Al	Mn	Mg	Ni	Cr	Haematite	Goethite
0-1	–	–	–	–	–	–	tr.	dom.
1-8	36.4	2.6	0.2	0.1	0.1	1.9	mod.	dom.
8-40	48.5	2.9	0.2	0.1	0.1	1.8	mod.	dom.
40-125	51.0	4.7	0.2	0.1	0.1	1.6	mod.	dom.

PROFILE Fo 2 (After Thomas, 1968)

Soil family	Table
Location	Tiger Estate, Tawau
Surroundings	Gently rolling plateau
Site	Flat
Slope	Nil
Elevation	120 m (400 ft)
Site drainage	Normal
Parent material	Basalt
Land use	Cocoa
Soil drainage	Well drained

Horizon	Depth cm (in)		Description
A1	0-1	(0-½)	Dark reddish brown (5YR 3/2); sandy clay loam;strong very fine crumb structure; moist, loose; very frequent roots; abrupt smooth boundary
A2	1-8	(½-3)	Dark reddish brown (5YR 3/4); clay; moderate medium subangular blocky breaking to fine crumb structure; moist, firm; few quartz gravels; very frequent roots; abrupt smooth boundary
B1ox	8-66	(3-26)	Reddish brown (5YR 5/4); clay; moderate very fine crumb structure; moist, firm; few quartz gravels; few roots; abrupt smooth boundary
B2ox	66-109	(26-43)	Reddish brown (5YR 4/4); clay; moderate very fine crumb structure; moist, friable; few quartz gravels; patchy cutans; very few roots; diffuse smooth boundary
B3ox	109-125	(43-50)	Dark reddish brown to dark red (2.5YR 3/5); clay; moderate to strong fine crumb structure; moist, friable; patchy cutans

Depth cm	Particle size distribution %				Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay					Ca	Mg	K	Na		
0-1	4	7	32	55	7.4	0.58	25	5.0	9.1	2.7	0.6	0.1	29.4	43
1-8	1	3	21	73	2.6	0.25	17	4.2	1.2	0.4	0;2	0.1	13.7	14
8-66	–	2	11	85	0.7	0.11	1	4.4	0.2	0.1	0.1	0.1	6.7	7
66-109	–	1	8	88	0.3	0.07	tr.	4.4	0.2	0.1	0.1	tr.	4.7	8
109-125	–	1	8	90	0.2	0.05	tr.	4.4	0.1	0.1	0.1	tr.	4.6	7

PROFILE Fo 3 (After Thomas, 1968)

Soil family	Table
Location	Quoin Hill Cocoa Research Station, Tawau
Surroundings	Gentle rolling plateau
Site	Flat
Slope	Nil
Elevation	180 m (600 ft)
Site drainage	Normal
Parent material	Basalt
Land use	Cocoa
Soil drainage	Well drained

Horizon	Depth cm (in)		Description
A1	0-1	(0-½)	Dark brown (7.5YR 3/2); clay; strong fine crumb structure; moist, loose, few fine angular quartz gravels; few roots; abrupt smooth boundary
A2	1-15	(½-6)	Brown to dark brown (7.5YR 4/2); clay; strong fine crumb structure; moist, very friable; very few fine angular quartz gravels; few roots; clear smooth boundary
Box	15-125	(6-50)	Brown (7.5YR 5/2); clay; strong medium fine crumb structure; moist, very friable; thin patchy cutans; few angular quartz gravels; very few roots

Depth cm	Particle size distribution %				Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay					Ca	Mg	K	Na		
0-1	2	9	41	51	8.5	0.74	12	4.6	3.1	1.4	0.8	0.1	26.7	20
1-15	3	6	34	55	1.9	0.29	3	4.7	0.3	0.2	0.1	0.1	11.4	7
15-46	2	2	18	76	0.9	0.13	3	4.7	0.5	0.1	0.2	0.1	7.5	12
46-91	2	1	17	77	0.3	0.07	1	4.7	0.7	0.2	0.2	0.1	8.5	13
91-125	2	1	14	81	0.1	0.06	1	4.4	0.3	0.1	0.1	0.1	7.9	7

Depth cm	Total %		Minerals of the clay fraction	
	A1	Fe	Kaolinite	Goethite
0-1	11	8	dom.	tr.
1-15	15	12	dom.	tr.
15-46	18	13	dom.	tr.
46-91	18	12	dom.	tr.
91-125	17	11	dom.	tr.

Profile Fo 4

Soil family	Benuou
Location	Near Forest Station, Sook Plain (grid ref LA 965678)
Surroundings	Undulating surface of low relief
Site	Near top of convex slope
Slope	3°
Elevation	339 m (1 130 ft)
Site drainage	Normal
Parent material	Medium-textured alluvium
Vegetation	*Imperata cylindrica* (lalang) and bracken
Soil drainage	Well drained

Horizon	Depth cm (in)		Description
A1	0-7	(0-2)	Very dark greyish brown (2.5Y 3/2); sandy clay loam; weak medium crumb structure; moist, friable; abundant roots; clear smooth boundary
AB	7-17	(2-7)	Light brownish grey (2.5Y 6/2); sandy clay loam; weak fine and medium subangular blocky structure; moist, friable; common roots; diffuse boundary

Horizon	Depth cm (in)	Description
B1ox	17-50 (7-20)	Yellowish brown (10YR 5/5); sandy clay loam; very weak fine subangular blocky breaking to very fine granular structure; moist, very friable; common roots; diffuse boundary
B2ox	50-80 (20-32)	Strong brown (7.5YR 5/8); sandy clay loam; very weak fine subangular blocky breaking to very fine granular structure; moist, very friable; few roots; gradual smooth boundary
B3ox	80-120 (32-48)	Yellowish red (5YR 5/6) with few fine faint yellow (10YR 7/7) and red (2.5YR 5/8) mottles; sandy clay; moderate coarse subangular blocky structure

Depth cm	Particle size distribution %				Org. C%	Total N %	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	Total %	
	Coarse sand	Fine sand	Silt	Clay					Ca	Mg	K	Na			Al	Fe
0-7	6	63	11	23	2.8	0.22	5	4.8	0.5	0.8	tr.	0.1	8.4	17	3.2	1.4
7-17	7	61	12	22	1.2	0.12	2	5.0	0.1	tr.	0.1	0.1	6.3	5	3.8	1.7
17-50	7	60	10	22	0.6	0.08	1	4.9	0.1	tr.	0.1	0.2	4.0	10	4.6	1.9
50-80	7	62	9	25	0.2	0.06	1	4.8	0.1	tr.	tr.	0.1	4.2	5	6.4	2.5
80-120	6	55	8	35	0.1	0.04	1	4.7	0.2	0.1	tr.	0.1	6.0	7	6.2	2.3

For mineralogical analyses see Eswaran and Sys, 1971 b.

Rendzinas (E)

PROFILE E 1

Soil family	Loc Sambuang
Location	Sinarun, Pensiangan (grid ref. LB 330200)
Surroundings	Steep hills
Site	Limestone outcrop over river
Slope	32°
Elevation	270 m (900 ft)
Site drainage	Shedding
Parent material	Limestone
Vegetation	Forest
Soil drainage	Well drained

Horizon	Depth cm (in)	Description
A1	0-10 (0-4)	Dark reddish brown (5YR 2/2); loam; strong fine crumb structure; moist, friable; many fine pores; abundant roots; clear smooth boundary
A2	10-20 (4-8)	Dark yellowish brown (10YR 4/4); silty clay loam; strong fine angular blocky structure; moist, friable; many fine pores; common roots; abrupt wavy boundary
R	20+ (8+)	White crystalline limestone

Depth cm	Particle size distribution %				Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay					Ca	Mg	K	Na		
0-10	2	6	22	48	11.5	1.24	9	6.6	73.6	7.7	0.1	0.6	86.1	96
10-20	1	7	23	58	4.7	0.68	1	6.5	56.3	2.6	0.4	0.4	61.4	97

Depth cm	Total				Minerals of the clay fraction			
	P ppm	K %	Mg %	Fe %	Vermiculite	Illite	Kaolinite	Quartz
0-10	1 357	1.16	0.72	3.67	dom.	tr.	tr.	tr.
10-20	1 179	1.33	0.85	4.61	dom.	tr.	tr.	tr.

Gleyic Acrisols (Ag)

PROFILE Ag 1

Soil family	Inanam
Location	About 400 m (440 yd) E of the Kinabatangan 8 km (5 mi) upstream from Batu Puteh (grid ref. FX 785013)
Surroundings	Narrow floodplain
Site	Old levee
Slope	Nil
Elevation	About 12 m (40 ft)
Site drainage	Receiving; freshwater flooding
Parent material	Fine-textured alluvium
Vegetation	Disturbed riverain forest
Soil drainage	Imperfect

Horizon	Depth cm (in)	Description
A	0-10 (0-4)	Brown (10YR 5/3) with many distinct light grey (10YR 7/1) and brown to dark brown (7.5YR 4/4) mottles; sandy clay loam; strong medium subangular blocky structure; moist, friable; clear boundary
AB	10-25 (4-10)	Yellowish brown (10YR 5/4) with few fine light grey (10YR 7/1) mottles; clay loam; strong coarse angular blocky structure; dry, hard; moderately thick continuous cutans; abrupt boundary
B1t	25-80 (10-32)	Light yellowish brown (10YR 5/4) with common light grey (10YR 6/1) mottles; clay; strong coarse prismatic structure; moist, firm; thick continuous cutans; clear boundary
B2tg	80-120 (32-48)	Light grey (5Y 7/1) with many medium brown to dark brown (7.5YR 4/4) mottles; clay; moderate coarse prismatic structure; moist, firm; thick broken cutans

Depth cm	Particle size distribution %				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na		
0-10	2	67	2	27	0.2	0.1	6.1	0.2	10.9	0.2	0.2	12.5	92
10-25	1	26	39	35	0.1	0.1	5.8	0.2	12.1	0.2	0.3	19.8	65
25-80	1	19	33	51	0.7	0.2	4.9	0.5	5.8	0.3	0.2	17.6	38
80-120	1	26	27	52	1.8	0.3	4.5	2.2	4.7	0.3	0.2	16.6	45

PROFILE Ag 2

Soil family	Inanam
Location	Ulu Danum
Surroundings	Low hills and valley floors; amplitude 75 m (250 ft)
Site	Valley floor
Slope	2°; convex
Site drainage	Receiving
Parent material	Medium-textured stony alluvium
Vegetation	Dipterocarp forest
Soil drainage	Poor

Horizon	Depth cm (in)	Description
A	0-3 (0-1)	Dark brown (10YR 3/3); humic loam; moderate fine and medium crumb structure; moist, very friable; abundant roots; clear smooth boundary

Horizon	Depth cm (in)	Description
Eg	3-28 (1-11)	Light yellowish brown (10YR 6/4) and light grey (N 7) with many fine medium prominent yellowish red (5YR 5/8) mottles; sandy loam; moderate medium subangular blocky structure; moist, friable; few fine soft yellowish red (5YR 4/8) concretions; common roots; clear smooth boundary
B1tg	28-50 (11-20)	Light grey (N 7) with many coarse distinct light yellowish brown (10YR 6/4) mottles; loam; moderate fine and medium subangular blocky structure; moist, friable; thin patchy cutans; common fine soft yellowish red (5 YR 4/8) concretions; common roots; diffuse smooth boundary
B2tg	50-73 (20-29)	Light grey (N 7) with common fine medium prominent yellowish red (5YR 5/8) and light yellowish brown (10YR 6/4) mottles; sandy loam; weak coarse and medium subangular blocky structure; wet, slightly sticky and slightly plastic; moderately thick patchy cutans; few roots; clear smooth boundary
B3tg	73-95 (29-38)	Bluish grey (5B 6/1) and yellowish red (5YR 5/8); sandy clay loam; structureless; wet, sticky and plastic; thick broken cutans; common sandstone, mudstone and chert gravel and stones
BCg	95+ (38+)	Dominant stones

Depth cm	Particle size distribution %			Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Sand	Silt	Clay					Ca	Mg	K	Na		
0-3	64	23	13	3.9	0.24	3	4.3	1.0	0.8	0.3	0.1	10.8	20
3-28	44	30	26	0.6	0.06	1	4.7	0	0.2	0.1	0.1	6.4	6
28-50	52	22	26	0.3	0.04	1	4.5	0	0.3	0.1	0.1	5.7	9
50-73	54	20	26	0.3	0.03	2	5.1	0.2	0.5	0.1	0.1	5.3	17
73-95	20	32	48	0.5	0.07	2	5.6	2.9	4.3	0.2	0.3	12.5	62

PROFILE Ag 3

Soil family	Inanam
Location	South of Ranchangan Kalabakan; (grid ref. LH 364848)
Surroundings	Flat terrace; amplitude 6 m (20 ft)
Site	Terrace flat
Slope	Nil
Elevation	6 m (20 ft)
Site drainage	Normal
Parent material	Medium-textured alluvium
Vegetation	Dipterocarp forest
Soil drainage	Poor

Horizon	Depth cm (in)	Description
A	0-3 (0-1)	Very dark greyish brown (10YR 3/2); humic loam; moderate very fine and fine subangular blocky structure; wet, non-sticky, non-plastic; abundant roots; abrupt smooth boundary
E1g	3-20 (1-8)	Light grey (5Y 7/1) with common fine distinct yellowish brown (10YR 5/6) mottles; silt loam; weak fine and medium subangular blocky structure; wet, slightly sticky, slightly plastic; common roots; clear smooth boundary
E2g	20-40 (8-16)	Light grey (5Y 7/1) and yellowish brown (10YR 5/6); silt loam; moderate fine and medium subangular blocky structure; wet, sticky and plastic; common roots; clear smooth boundary

Horizon	Depth cm (in)	Description
B1tg	40-65 (16-26)	Light grey (2.5YN 7) and strong brown (7.5YR 5/8); silty clay loam; moderate fine and medium subangular blocky structure; wet, sticky and plastic; thick broken cutans; few roots; diffuse wavy boundary
B2tg	65-90 (26-36)	Light grey (2.5Y N 7) with common fine prominent strong brown (7.5YR 5/8) and few fine distinct red (10YR 4/6) mottles; silty clay loam to silty clay; moderate very fine and fine subangular blocky structure; wet, sticky and plastic; very few roots; diffuse wavy boundary
B3tg	90-125 (36-50)	Light grey (2.5Y N 7) with many medium prominent red (10YR 4/6) and many medium distinct pale brown (20YR 6/3) mottles; silty clay; weak medium and coarse angular blocky structure; wet, very sticky and plastic; very few roots

Depth cm	Particle size distribution %			Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	Minerals of the clay fraction		
	Sand	Silt	Clay					Ca	Mg	K	Na			Vermi-culite	Kaolin-ite	Illite
0-3	44	43	13	3.9	0.26	17	4.1	0.1	0.4	0.2	0.1	8.1	10	n.d.	n.d.	n.d.
3-20	39	43	18	0.5	0.05	3	4.4	–	0.1	0.1	0.1	7.0	4	n.d.	n.d.	n.d.
20-40	39	48	23	0.2	0.03	1	4.6	–	0.1	0.1	0.1	n.d.	n.d.	dom.	dom.	–
40-65	32	30	38	0.4	0.07	1	4.6	–	0.1	0.1	0.1	12.0	3	dom.	mod.	–
65-90	27	28	45	0.3	0.07	1	4.9	–	0.1	0.1	0.1	7.8	4	dom.	mod.	tr.
90-125	22	28	50	2.2	0.06	1	4.9	–	0.1	0.2	0.1	7.6	5	dom.	mod.	tr.

PROFILE Ag 4 (After Thomas 1967a, p.48)

Soil family	Koung
Location	Agricultural Station, Lahad Datu
Surroundings	Low hills
Site	Lower slope
Slope	5°
Site drainage	Shedding
Parent material	Bentonitic shale
Land use	Cocoa with shade trees
Soil drainage	Imperfect

Horizon	Depth cm (in)	Description
Ah	0-3 (0-1)	Dark brown (10YR 3/3); humic silt loam; weak very fine granular structure; moist, friable; many roots; abrupt smooth boundary
E	3-23 (1-9)	Yellowish brown (10YR 5/6); silty clay; strong fine subangular blocky structure; moist, very friable; few roots
B1t	23-33 (9-13)	Strong brown (7.5YR 5/6); clay; strong fine subangular blocky structure; moist, friable; common roots
B2t	33-53 (13-21)	Light yellowish brown (10YR 6/4) with many strong brown (7.5YR 5/6) mottles; clay; moderate very fine subangular blocky structure; moist, friable; very few roots
B3tg	53-85 (21-34)	Pale olive (5Y 6/3) with common brownish yellow (10YR 6/6) mottles; clay; moderate very fine subangular blocky structure; friable; very few roots
BCg	85-120 (34-48)	Light olive grey (5Y 6/2) with common yellowish brown (10YR 5/8) mottles; clay; strong very fine angular blocky structure; moist, firm; very few fragments of weathered mudstone and shale; very few roots

Depth cm	Clay %	Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
						Ca	Mg	K	Na		
0-30	33	3.8	0.46	3	6.1	21.5	11.5	0.6	0.4	30.0	sat.
3-23	55	0.6	0.16	1	4.6	1.6	6.1	0.6	0.3	21.3	40
23-33	73	0.6	0.13	2	4.7	0.6	9.9	0.6	0.4	31.8	36
33-53	74	0.1	0.11	3	4.9	0.1	11.4	0.8	0.5	34.8	37
53-85	70	0.3	0.10	tr.	5.3	0.9	14.2	0.9	0.5	26.7	62
85-120	66	0.2	0.07	2	5.8	2.5	15.5	0.8	1.0	32.2	61

PROFILE Ag 5

Soil family Gunong Alab
Location 8 km (5 mi) ESE of Katutar (grid ref. LG 413911)
Surroundings Mountains
Site Concave lower slope
Slope 27°
Elevation 930 m (3 100 ft)
Site drainage Receiving
Parent material Mudstone and sandstone
Vegetation Primary forest
Soil drainage Poor

Horizon	Depth cm (in)	Description
0	1-0 (½-0)	Leaf litter
Ag	0-30 (0-12)	Strong brown (7.5YR 5/8) and light grey (10YR 4/2) with dark greyish brown (10YR 4/2) organic stains; sandy clay loam; very weak coarse angular blocky structure; moist, firm; many roots; gradual smooth boundary
AB	30-50 (12-20)	Yellowish brown (10YR 5/8) with many light grey (10YR 7/1) mottles; sandy clay loam; weak, coarse to medium angular blocky structure; moist, firm; very few sandstone fragments; some fine and medium roots; gradual, smooth boundary
B1t	50-85 (20-34)	Brownish yellow (10YR 6/6) with common light grey (10YR 7/1) streaks; sandy clay loam; weak coarse subangular blocky structure; moist, sticky; occasional medium and fine roots; gradual smooth boundary
B2t	85-120 (34-48)	Brownish yellow (10YR 6/6) with few light grey (10YR 7/1) mottles; sandy clay loam; structureless, massive; moist, sticky

Depth cm	Particle size distribution %				Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	Al		Fe	
	Coarse sand	Fine sand	Silt	Clay					Ca	Mg	K	Na			Total %	Extr. (pH 4.8) ppm	Total %	Extr. (pH 2.5) ppm
0-30	14	53	12	20	0.4	0.05	1	4.8	0.3	0.1	0.1	–	7.9	6	3.01	610	1.43	320
30-50	12	51	14	22	0.2	0.03	tr.	4.8	0.3	0.1	0.1	–	8.0	6	1.43	150	1.53	300
50-85	11	48	14	25	0.2	0.04	1	4.8	0.1	tr.	0.1	–	8.1	2	3.72	550	1.89	140
85-120	10	46	19	27	0.2	0.04	1	4.8	0.1	tr.	0.1	tr.	8.6	2	3.57	630	2.04	131

PROFILE Ag 6

Soil family	Gunong Alab
Location	Sungai Koyah Timber Camp; Mile 12 on main railway (grid ref. LD 017850)
Surroundings	Minor hillocks and alluvial flats
Site	Lower slope immediately above alluvial flat
Slope	8° concave
Elevation	About 22.5 m (75 ft)
Site drainage	Receiving
Parent material	Shale and fine sandstone
Vegetation	Lowland dipterocarp forest
Soil drainage	Imperfect

Horizon	Depth cm (in)		Description
A	0-3	(0-1)	Pale brown (10YR 6/3); loam; strong medium and coarse subangular blocky structure; dry, slightly hard; abrupt smooth boundary
AB	3-18	(1-7)	Brownish yellow (10YR 6/6) with few large light grey and rust mottles; loam; moderate medium and coarse subangular blocky structures; dry, slightly hard; merging boundary
B1t	18-48	(7-19)	Yellowish brown to brownish yellow (10YR 5/6 to 6/6); clay loam; strong medium and coarse subangular blocky structure; dry, hard; few shale fragments; thin broken cutans; merging boundary
B2	48-73	(19-29)	Light yellowish brown (2.5Y 6/4) with many prominent yellowish brown mottles; clay loam; moderate medium and coarse subangular blocky structure; dry, hard; many fine sandstone fragments and concretions; thin broken cutans; merging boundary
BCg	73-125	(29-50)	Variegated greenish grey (5GY 6/1) and yellowish brown (10YR 5/8); clay; weak subangular blocky structure; moist, firm; black manganese coatings on ped faces

Depth cm	Particle size distribution %				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	Minerals of the clay fraction		
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na			Kaolinite	Illite	Vermiculite
0-3	2	45	30	22	0.7	0.08	4.6	0.9	1.8	0.4	0.2	13.0	25	n.d.	n.d.	n.d.
3-18	1	42	32	26	1.0	0.14	4.5	0.2	0.4	0.2	0.7	13.1	7	mod.	dom.	mod.
18-48	1	30	33	38	0.4	0.10	4.7	0.1	1.1	0.2	0.1	14.5	10	mod.	dom.	mod.
48-73	3	40	29	29	0.2	0.10	5.8	0.1	5.4	0.2	0.2	14.0	43	dom.	dom.	tr.
73-125	2	15	35	48	0.2	0.10	6.5	0.3	21.6	0.3	1.6	22.5	sat.	dom.	dom.	tr.

PROFILE Ag 7

Soil family	Masaum
Location	Sepilok Forest Reserve; Research Plot 87 (grid ref. FX 802443)
Surroundings	Low hills and alluvial flats
Site	Flat top of low hill
Slope	5°; convex
Elevation	7.5 m (25 ft)
Site drainage	Normal
Parent material	Red mudstone
Vegetation	Lowland dipterocarp forest
Soil drainage	Imperfect

Horizon	Depth cm (in)		Description
A	0-3	(0-1)	Brown (7.5YR 5/4); clay loam; strong coarse granular structure; moist, friable; abrupt boundary
EB	3-8	(1-3)	Yellowish red (5YR 5/6); clay; moderate medium and coarse subangular blocky structure; moist, friable; thin patchy cutans; many worm casts; clear boundary
B1tcn	8-35	(3-14)	Yellowish red (5YR 5/8) with few fine distinct light grey and common fine distinct red (2.5YR 5/8) mottles; clay; strong coarse subangular blocky structure; moist; friable; common iron concretions; thick continuous cutans; clear boundary
B2tcn	35-58	(14-23)	Light grey (2.5Y 7/2) and reddish yellow (5YR 6/6) with fine distinct red (2.5YR 5/8) mottles; clay; strong medium and fine blocky structure; moist, friable; common iron concretions; thick continuous cutans; gradual boundary
BC1gcn	58-78	(23-31)	Grey (2.5 YN 6/0) with fine distinct reddish yellow and red mottles; clay; strong medium and fine blocky structure; moist, friable; common iron concretions; thick continuous cutans; gradual boundary
BC2g	78-125	(31-50)	Light grey (5Y 7/1) with common distinct red mottles; clay; strong fine and medium subangular blocky structure; moist, friable; thick continuous cutans; common small red mudstone fragments

Depth cm	Particle size distribution %				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na		
3-8	2	23	31	42	1.3	0.21	4.6	1.3	5.2	0.6	0.2	23.2	31
8-35	1	8	26	66	0.4	0.20	4.8	0.3	5.1	0.7	0.3	32.5	20
35-58	–	6	29	66	0.3	0.10	5.2	0.3	7.6	0.7	0.5	34.6	26
58-78	–	7	31	61	0.1	0.05	5.3	0.3	10.3	0.7	0.7	34.3	35
78-125	2	9	31	60	0.1	0.05	5.5	0.8	15.6	0.8	1.0	36.0	51

PROFILE Ag 8

Soil family	Masaum
Location	5¼ km (3 mi) NW of Kuala Kawag
Surroundings	Low hills; amplitude 15 m (50 ft)
Site	Middle slope
Slope	10° convex
Site drainage	Normal
Parent material	Slump deposit of sandstone, mudstone, tuffaceous sandstone and chert
Vegetation	Dipterocarp forest
Soil drainage	Imperfect

Horizon	Depth cm (in)		Description
A	0-3	(0-1)	Very dark greyish brown (10YR 3/2); humic loam; moderate fine crumb structure; moist, friable; abundant roots; clear smooth boundary
E	3-15	(1-6)	Brown (10YR 5/3) with common fine distinct yellowish brown (10YR 5/6); mottles; loam; moderate fine subangular blocky structure; moist, friable; common roots; diffuse smooth boundary

Horizon	Depth cm (in)	Description
B1t	15-28 (6-11)	Yellowish brown (10YR 5/6) with common fine faint pale olive (5Y 6/4) mottles; clay loam; moderate coarse and fine subangular blocky structure; moist, friable; few gravels; moderately thick patchy cutans; common roots; clear smooth boundary
B2t	28-45 (11-18)	Pale olive (5Y 6/4) and brown to dark brown (10YR 4/3) with common fine distinct yellowish red (5YR 4/8) mottles; clay loam; moderate fine and medium subangular blocky structure; moist, friable; few stones and gravel; moderately thick patchy cutans; common roots; diffuse smooth boundary
B3tg	45-85 (18-34)	Light greenish grey (5GY 7/1) with many fine distinct brownish yellow (10YR 6/6) mottles; weak coarse and medium subangular blocky structure; moist, firm; common stones and gravel; thick broken cutans; few roots; diffuse smooth boundary
B4tg	85-125 (34-50)	Grey (n 6) with many fine distinct brownish yellow (10YR 6/6) mottles; clay; weak coarse and medium subangular blocky structure; moist, firm; common stones and gravels; thick continuous cutans; few roots

Depth cm	Particle size distribution %			Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	Total %		Avail. P ppm
	Sand	Silt	Clay				Ca	Mg	K	Na			Mg	K	
0-3	42	38	20	7.1	0.55	6.1	18.1	6.9	0.5	0.2	45.8	56	0.9	0.50	7
3-15	32	38	30	3.0	0.29	5.8	7.9	5.9	0.4	0.2	26.4	55	1.3	0.71	2
15-28	22	35	43	1.1	0.15	5.1	4.2	5.9	0.4	0.2	20.8	51	1.3	0.64	tr.
28-45	20	35	45	1.9	0.20	4.7	3.5	6.9	0.4	0.2	22.0	50	1.6	0.83	1
45-85	15	35	50	0.4	0.09	5.4	0.3	10.6	0.5	0.3	26.1	45	1.8	0.96	tr.
85-125	12	35	53	0.4	0.09	5.5	1.9	15.0	0.5	0.5	25.2	71	1.8	1.07	tr.

Humic Acrisols (Ah)

PROFILE Ah 1

Soil family	Kiau
Location	Gunong Alab; SW of summit (grid ref. FW 032428)
Surroundings	Mountains
Site	Steep convex slope
Slope	44°
Elevation	1 850 m (6 000 ft)
Site drainage	Shedding
Parent material	Sandstone
Vegetation	Stunted forest with moss ground cover
Soil drainage	Moderately well drained

Horizon	Depth cm (in)	Description
O	5-0 (2-0)	Very dark greyish brown (10YR 3/2); humus; frequent roots; clear smooth boundary
A	0-5 (0-2)	Dark brown (10YR 3/3); humic sandy loam; moderate fine subangular blocky structure; moist, very friable; frequent roots; abrupt smooth boundary
EB	5-10 (2-4)	Yellow (10YR 7/8) with few light brownish grey (10YR 6/2) mottles; loam; moderate fine subangular blocky structure; moist, friable; frequent roots; abrupt smooth boundary
B1t	10-36 (4-14)	Reddish yellow (7.5YR 6/8); silty clay loam; moderate fine subangular blocky structure; moist, friable; thick continuous cutans; few fine sandstone fragments; few roots; gradual smooth boundary
B2t	36-61 (14-24)	Strong brown (7.5YR 5/8); silty clay; moderate fine subangular blocky structure; moist, friable; thick continuous cutans; frequent grey sandstone fragments; very few roots; abrupt smooth boundary
BC	61+ (24+)	Grey sandstone rubble

Depth cm	Particle size distribution %				Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	Total			
	Coarse sand	Fine sand	Silt	Clay					Ca	Mg	K	Na			Al%	Fe%	Mn ppm	SiO_2%
5-0	n.d.	n.d.	n.d.	n.d.	25.0	1.05	41	3.7	1.3	3.1	0.6	0.2	59.3	9	3.66	1.53	220	44.0
0-5	6	40	21	19	5.6	0.40	5	4.1	0.1	0.5	0.2	0.2	29.8	3	2.64	1.24	110	76.0
5-10	6	46	22	21	2.4	0.20	1	4.3	tr.	0.1	0.1	tr.	25.2	1	3.31	1.73	100	79.9
10-36	6	39	25	25	1.5	0.14	tr.	4.5	–	0.1	0.1	–	23.9	1	5.56	2.95	140	69.7
36-61	25	21	25	26	0.4	0.10	2	4.9	–	0.1	0.2	–	18.8	2	9.56	4.38	530	70.0

Orthic Acrisols (Ao)

PROFILE Ao 1 (After Hooper and Ives, 1974, p117)

Soil family	Katai
Location	Ruku Ruku valley
Surroundings	Terraces
Site	Lower terrace
Slope	Level
Site drainage	Normal
Parent material	Alluvium derived from basic and ultrabasic rocks
Vegetation	Forest
Soil drainage	Well drained

Horizon	Depth cm (in)	Description
O	2-0 (1-0)	Surface litter of decaying twigs and leaves
A1	0-3 (0-1½)	Dark brown to brown (10YR 4/3); loam; moderate to strong fine blocky and medium to fine crumb structure; friable; abundant fine fibrous and common small woody roots; smooth merging boundary
A2	3-16 (1½-6½)	Dark brown (7.5YR 3/2); clay loam; moderate fine and medium blocky structure; friable; few fine fibrous and small woody roots; smooth diffuse boundary
B1	16-43 (6½-17)	Dark brown (7.5YR 3/2) with many fine strong brown (7.5YR 5/6) mottles; clay loam; moderate medium and fine blocky structure; friable; very few small woody roots; smooth diffuse boundary
B2	43-80 (17-32)	Dark reddish brown (5YR 3/4) with few faint fine yellowish red (5YR 4/6) mottles, clay loam; weak medium to fine blocky structure; friable, smooth diffuse boundary
B3t	80-105 (32-42)	Brown to dark brown (7.5YR 4/4); clay loam to clay; moderate medium to fine blocky structure; friable; smooth diffuse boundary
BC	105-150 (42-60)	Strong brown (7.5YR 5/6); clay loam to clay; weak medium to fine blocky and fine granular structure; many rounded gravels and stones

Depth cm	Org C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
					Ca	Mg	K	Na		
0-3	9.6	0.44	1	6.3	2.4	19.0	0.2	0.2	42.3	52
3-16	1.9	0.25	2	6.6	1.0	8.8	0.1	0.1	21.9	46
16-43	1.1	0.11	3	6.6	0.4	4.5	tr.	0.1	17.1	29
43-80	0.7	0.06	3	6.7	0.1	3.5	tr.	tr.	14.3	24
80-105	0.2	0.05	1	6.7	0.5	2.5	–	0.1	8.1	38
105-150	0.4	0.04	3	6.7	0.5	2.7	–	0;1	10.0	33

PROFILE Ao 2

Soil family	Paliu
Location	4 km (2½ mi) NW of Sapong Estate office (grid ref. LA 583628)
Surroundings	Dissected terrace
Site	Terrace flat
Slope	2°
Elevation	330 m (1 100 ft)
Site drainage	Normal
Parent material	Coarse-textured alluvium

Land use	Rubber plantation
Soil drainage	Well drained

Horizon	**Depth cm (in)**		**Description**
A	0-15	(0-6)	Brown to dark brown (10YR 4/3); loamy sand; moderate fine and medium subangular blocky structure; moist, friable; common fine and medium roots; clear smooth boundary
E1	15-40	(6-16)	Yellowish brown (10YR 5/6); loamy sand; weak fine subangular blocky structure; moist, friable; common roots; diffuse boundary
E2	40-63	(16-25)	Strong brown (7.5YR 5/6); loam to sandy loam; weak medium breaking to very fine subangular blocky structure; moist, friable; few roots; diffuse boundary
Bt	63-120	(25-48)	Strong brown (7.5YR 6/8); sandy loam; weak medium subangular blocky structure; moist; thin broken cutans; few roots

Depth cm	Particle size distribution %				Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn.%	Total		
	Coarse sand	Fine sand	Silt	Clay					Ca	Mg	K	Na			P ppm	K%	Mg%
0-15	27	46	15	10	1.3	0.15	4	4.5	0.2	0.1	0.1	–	6.1	6	117	0.14	0.08
15-40	26	47	16	11	0.5	0.07	1	4.5	0.1	–	–	–	4.8	1	91	0.18	0.09
40-63	23	48	17	12	0.4	0.05	1	4.5	0.1	–	–	–	4.8	3	77	0.16	0.09
63-120	24	44	15	16	0.2	0.05	tr.	4.5	0.1	–	–	–	5.9	2	75	0.22	0.13

Depth cm	Minerals of the clay fraction			
	Quartz	Kaolinite	Vermiculite	Illite
15-40	dom.	tr.	tr.	–
40-63	dom.	tr.	tr.	tr.

PROFILE Ao 3

Soil family	Paliu
Location	About 10½ km (6 m) S of the Sungai Kinabatangan at Sakilan Timber Camp (grid ref. LC 541831)
Surroundings	Low hillocks; amplitude 15 m (50 ft)
Site	Crest
Slope	Level with 10° slopes away from crest
Elevation	About 45 m (150 ft)
Site drainage	Shedding
Parent material	Medium-textured alluvium with pebbles
Vegetation	Recently logged dipterocarp forest
Soil drainage	Well drained

Horizon	**Depth cm (in)**		**Description**
A	0-3	(0-1)	Sandy loam; moderate fine subangular blocky structure; moist, very friable; abrupt smooth boundary
AB	3-13	(1-5)	Yellowish brown (10YR 5/6); sandy loam; moderate fine and medium subangular blocky structure; moist, friable; inclusions of organic matter; clear smooth boundary
B1	13-53	(5-21)	Yellowish brown (10YR 5/8); sandy clay loam; moderate medium subangular blocky structure; moist, friable; moderately thick broken cutans; merging boundary

Horizon	Depth cm (in)		Description
B2t	53-83	(21-33)	Strong brown (7.5YR 5/8); sandy clay loam; moderate medium subangular blocky structure; moist, firm; few white chert fragments; moderately thick continuous cutans; clear wavy boundary
BC	83-125	(33-50)	Strong brown (7.5YR 5/8) with common distinct brownish yellow (10YR 6/6) mottles; clay loam; moderate medium subangular blocky structure; moist, firm; few sandstone pebbles up to 13 cm (5 in.) diameter; few iron concretions; moderately thick continuous cutans

Depth cm	Particle size distribution %				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn.%
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na		
3-13	9	53	17	17	1.1	0.16	4.2	0.2	0.2	0.1	–	10.9	5
13-53	7	48	18	25	0.4	0.10	4.2	0.1	0.1	0.1	–	10.3	3
53-83	5	44	18	29	0.2	0.05	4.2	0.1	0.1	0.1	–	10.6	3
83-125	5	40	20	34	0.2	0.05	4.4	0.1	0.2	0.1	–	28.8	2

PROFILE Ao 4

Soil family	Paliu
Location	About 3½ km (2 mi) SW of the Sungai Karamuak at Enteleben (grid ref. FW 782092)
Surroundings	Low terrace; generally flat with minor dissection
Site	Flat
Slope	Nil
Elevation	90 m (300 ft)
Site drainage	Normal
Parent material	Medium-textured alluvium
Vegetation	Lowland dipterocarp forest
Soil drainage	Moderately well drained

Horizon	Depth cm (in)		Description
A	0-3	(0-1)	Dark brown (7.5YR 3/2); loamy sand; strong fine to coarse granular structure; moist, very friable; abrupt boundary
E	3-25	(1-10)	Yellowish brown (10YR 5/6) with few distinct light grey mottles; loamy sand; weak subangular blocky structure; moist, very friable; clear boundary
B1	25-50	(10-20)	Reddish yellow to strong brown (7.5YR 6/6-5/6); sandy loam; weak subangular blocky structure; moist, friable; thin patchy cutans; gradual boundary
B2t	50-93	(20-37)	Reddish yellow (7.5YR 6/8) with few large prominent light grey and many faint yellowish red mottles; sandy clay loam; moderate medium subangular blocky structure; moist, friable; moderately thick patchy cutans

Depth cm	Particle size distribution %				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na		
0-3	n.d.	n.d.	n.d.	n.d.	7.1	0.35	4.1	1.3	1.4	0.4	0.1	21.0	15
3-25	14	62	9	12	0.8	0.08	4.5	0.1	–	0.1	0.1	6.8	4
25-50	11	62	8	18	0.2	0.05	4.7	0.1	–	–	0.1	5.6	4
50-93	11	58	10	21	0.1	0.01	4.7	0.1	–	0.1	0.1	6.1	4
93-125	13	53	8	23	0.1	0.01	4.7	0.1	0.1	0.1	0.1	7.2	5

PROFILE Ao 5

Soil family	Kinabutan
Location	About 800 m (½ mi) N of the Sungai Milian at Kumansi (grid ref. LC 858834)
Surroundings	Moderate hill with amplitude of 90 m (300 ft) and moderate to steep slopes
Site	Middle slope
Slope	19°
Elevation	75 m (250 ft)
Site drainage	Shedding
Parent material	Colluvium derived from basic igneous rocks
Vegetation	Dipterocarp forest
Soil drainage	Well drained

Horizon	Depth cm (in)		Description
A	0-3	(0-1)	Brown to dark brown (10YR 4/3); sandy loam; strong fine to coarse granular structure; moist, very friable; abrupt smooth boundary
EB	3-23	(1-9)	Yellowish brown (10YR 5/4); sandy clay loam; moderate medium and coarse subangular blocky structure; moist, friable; thin patchy cutans; clear smooth boundary
B1t	23-40	(9-16)	Strong brown (7.5YR 5/6); clay loam; moderate coarse subangular blocky structure; moist, friable; few small basic rock fragments; moderately thick broken cutans gradual wavy boundary
B2t	40-125	(16-50)	Strong brown (7.5YR 5/8); clay; moderate to strong medium and fine subangular blocky structure; moist, friable; few rotten basic rock boulders; thick continuous cutans

Depth cm	Particle size distribution %				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na		
0-3	n.d.	n.d.	n.d.	n.d.	6.0	0.50	5.6	7.8	8.3	0.3	0.3	23.6	41
3-23	26	27	18	28	0.8	0.07	5.0	0.9	4.6	0.1	0.2	11.3	51
23-40	18	21	19	41	0.4	0.06	5.3	0.8	4.7	0.1	0.2	15.2	45
40-125	9	19	15	57	0.3	0.07	4.3	0.2	5.8	0.2	2.9	16.7	55

PROFILE Ao 6

Soil family	Dagat
Location	About 3 km (1¾ mi) NW of the Sungai Tabin 800 m (½ mi) NW of Quoin Hill (grid ref. LD 672878)
Surroundings	Low hills with moderate slopes
Site	Upper slope
Slope	15°
Elevation	About 75 m (250 ft)
Site drainage	Shedding
Parent material	Tuffite
Vegetation	Lowland dipterocarp forest
Soil drainage	Well drained

Horizon	Depth cm (in)		Description
A	0-5	(0-2)	Brown to dark brown (7.5YR 4/3); clay; strong medium and fine subangular blocky structure; moist, friable; abrupt boundary

Horizon	Depth cm (in)		Description
B1t	5-15	(2-6)	Reddish brown (5YR 4/4); clay; strong medium angular blocky breaking to fine subangular blocky structure; moist, friable; common gravel-sized tuffite fragments; thin broken cutans; abrupt boundary
B2t	15-28	(6-11)	Yellowish red (5YR 4/6); clay; strong medium angular blocky breaking to fine subangular blocky structure; moist, friable; many small tuffite fragments; thin continuous cutans; clear boundary
B3t	28-50	(11-20)	Red (2.5YR 4/6); clay; moderate fine to coarse subangular blocky structure; moist, friable; many small tuffite fragements; thin continuous and thick patchy cutans; clear boundary
BC	50-80	(20-32)	Red (2.5 YR 4/6); sandy clay; moderate medium subangular blocky structure; moist, friable; many weathered tuffite fragments; thin broken cutans; merging boundary
C	80-125	(32-50)	Weathered tuffite with coatings of red (2.5YR 4/6); clay

Depth cm	Particle size distribution %				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na		
0-5	8	18	25	46	2.0	0.33	4.4	5.1	15.0	1.0	0.2	49.2	43
5-15	6	17	26	50	1.3	0.21	4.4	0.9	8.0	0.3	0.2	49.4	19
15-28	9	16	22	52	1.1	0.55	4.6	0.7	9.0	0.3	0.2	49.7	20
28-50	20	20	15	44	0.7	0.14	4.7	0.4	9.4	0.2	0.2	49.1	21
50-80	35	22	12	30	0.3	0.10	4.8	0.3	22.3	0.2	0.2	58.1	40

PROFILE A7 (After Thomas, 1967a, p36)

Soil family	Mensuli
Location	Upper Taliwas valley
Surroundings	Hills
Site	Middle slope
Slope	22°
Site drainage	Shedding
Parent material	Chert
Vegetation	Primary forest
Soil drainage	Well drained

Horizon	Depth cm (in)		Description
Ah	0-3	(0-1)	Brown to dark brown (10YR 4/3); humic loam; strong fine crumb structure; very friable; many roots; abrupt smooth boundary
Ae	3-25	(1-10)	Reddish brown (5YR 4/3); clay loam; moderate very fine angular blocky structure; friable; few roots; clear smooth boundary
Blt	25-58	(10-23)	Yellowish red (5YR 4/6); sandy clay; strong very fine angular blocky structure; friable; few roots; gradual smooth boundary
B2	58-103	(23-41)	Yellowish red (5YR 4/6); sandy clay; strong very fine angular blocky structure; friable; few angular to subangular red and white chert fragments; few roots; gradual smooth boundary
BC	103-150	(41-60)	Yellowish red (5YR 4/6); sandy clay; moderate very fine angular blocky structure; firm; many chert fragements.

Depth cm	Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	Minerals of the clay fraction	
					Ca	Mg	K	Na			Kaolinite	Quartz
0-3	3.3	0.35	1	4.6	6.2	3.6	0.6	0.2	19.7	54	n.d.	n.d.
3-25	0.5	0.10	3	5.9	0.4	0.1	0.1	0.2	9.6	8	mod.	mod.
25-58	0.5	0.09	2	4.7	0.6	1.0	0.1	0.1	10.6	17	mod.	mod.
58-103	0.3	0.07	1	4.9	0.7	0.1	0.1	0.1	14.0	7	n.d.	n.d.
103-150	0.3	0.06	2	4.9	0.4	0.8	0.1	0.1	14.0	7	mod.	mod.

PROFILE Ao 8

Soil family	Kumansi
Location	Longmanis Virgin Jungle Reserve, Plot 244; about 400 m (¼ mi) E of Labuk Road at Mile 44 (grid ref. FX 504324)
Surroundings	Low hills; amplitude 30 m (100 ft)
Site	Upper middle slope
Slope	12°
Elevation	30 m (100 ft)
Site drainage	Shedding
Parent material	Mudstone
Vegetation	Lowland dipterocarp forest
Site drainage	Moderately well drained

Horizon	Depth cm (in)		Description
A	0-3	(0-1)	Dark brown (10YR 3/3); clay; strong medium granular structure; moist, friable; abrupt boundary
B1	3-10	(1-4)	Brown to dark brown (10YR 4/3); clay; moderate medium subangular blocky structure; moist, friable; thin continuous cutans; clear boundary
B2t	10-55	(4-22)	Yellowish brown (10YR 5/4); clay; strong fine and medium subangular blocky structure; moist, friable; few small soft black primary concretions; thick continuous cutans; gradual boundary
B3t	55-75	(22-30)	Light yellowish brown (10YR 6/4) with common fine distinct light grey (5YR 7/1) mottles; clay; moderate fine and medium subangular blocky structure; moist, friable; common gravel-sized mudstone fragments; thick continuous cutans; gradual boundary
BC	75-125	(30-50)	Very pale brown (10YR 7/4) with common fine distinct light grey (5YR 7/1) mottles; clay; moderate fine angular blocky structure; moist, firm; dominant weathered mudstone fragments; thick continuous cutans

Depth cm	Particle size distribution %				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na		
0-3	4	11	33	47	3.5	0.5	5.7	15.2	5.5	1.1	0.2	31.1	71
3-10	3	9	31	53	1.1	0.27	4.8	3.5	3.6	0.6	0.1	24.6	31
10-55	2	7	28	63	0.2	0.10	5.0	0.6	3.0	0.5	0.1	25.3	16
55-75	2	7	24	66	0.1	0.10	5.2	0.5	3.6	0.5	0.1	27.0	18
75-125	1	4	28	66	0.04	0.04	5.5	6.3	6.4	0.6	0.2	27.4	49

PROFILE Ao 9

Soil family	Kumansi
Location	Pangaraan Pensiangan (grid ref. LA 903222)
Surroundings	Mountains
Site	Convex slope
Slope	14°
Elevation	360 m (1 200 ft)
Site drainage	Shedding
Parent material	Shale
Land use	Shifting agriculture; tapioca plot
Soil drainage	Well drained

Horizon	Depth cm (in)		Description
A	0-5	(0-2)	Brown to dark brown (7.5YR 4/4); clay loam; strong fine and medium subangular blocky structure; moist, firm; common fine pores and root channels; common fine roots; diffuse boundary
B1t	5-25	(2-10)	Reddish brown (5YR 4/4); clay; strong fine and medium subangular blocky structure; moist, firm; thick broken cutans on ped faces; few fine roots; diffuse boundary
B2t	25-53	(10-21)	Yellowsih red (5YR 4/6); clay; strong medium and coarse angular to subangular blocky structure; moist, firm; thick continuous cutans on ped faces; few roots; diffuse boundary
B3t	53-120	(21-48)	Yellowish red (5YR 4/8); clay; structure, consistence and cutans as above; few to common gravel-sized fragments of weathering shale.

Depth cm	Particle size distribution %				Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay					Ca	Mg	K	Na		
0-5	–	–	–	–	5.4	0.48	8	4.9	6.6	3.4	0.4	0.1	30.8	34
5-25	4	16	30	47	1.1	0.18	1	4.4	0.2	0.3	0.2	–	21.3	4
25-53	2	13	26	55	0.2	0.09	1	4.8	0.1	0.1	0.2	–	22.9	2
53-120	2	12	25	59	0.4	0.08	tr.	4.6	0.2	0.1	0.2	–	21.8	2

Depth cm	Total				Minerals of the clay fraction	
	P ppm	K %	Mg %	Fe %	Vermiculite	Kaolinite
0-5	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
5-25	264	1.17	0.51	3.81	dom.	dom.
25-53	217	1.22	0.58	4.69	dom.	mod.
53-120	203	1.32	0.63	5.15	dom.	mod.

PROFILE Ao 10

Soil family	Kumansi
Location	Labuan (grid ref. FE 756844)
Surroundings	Hills
Site	Middle slope
Slope	23°
Elevation	30 m (100 ft)
Site drainage	Shedding
Parent material	Sandstone and shale
Land use	Rubber
Soil drainage	Well drained

Horizon	Depth cm (in)		Description
A	0-5	(0-2)	Brown (10YR 5/3); clay loam; strong fine subangular blocky structure; moist, friable; many fine roots; many wormcasts; gradual smooth boundary
EB	5-25	(2-10)	Yellowish brown (10YR 5/4); clay loam; moderate fine subangular blocky structure; moist, firm; thin patchy cutans; few roots; gradual smooth boundary
Bt	25-46	(10-18)	Strong brown (7.5YR 5/6) with few medium distinct pale brown (10YR 6/3) mottles; silty clay; structure and consistence as above; thin patchy cutans; few roots; gradual smooth boundary
BC	46-125	(18-50)	Yellowish brown (10YR 5/8) with common medium promintent light brownish grey (2.5Y 6/2) mottles; silty clay; structure, consistence and cutans as above

Depth cm	Particle size distribution %				Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay					Ca	Mg	K	Na		
0-5	4	32	28	31	2.2	0.27	3	4.3	1.8	1.1	0.3	0.2	11.9	29
5-25	12	29	26	33	1.0	0.13	1	4.2	0.3	0.7	0.3	0.1	11.8	12
25-46	5	17	29	46	0.5	0.12	1	4.1	0.3	0.6	0.1	0.1	14.5	8
46-125	3	17	29	45	0.5	0.11	tr.	4.2	0.2	0.5	0.2	0.2	14.4	8

PROFILE Ao 11

Soil family	Tanjong Lipat
Location	Near Luasong road bridge over the Sungai Mawing (grid ref. LC 273070)
Surroundings	Moderate hills; amplitude 45 m (150 ft)
Site	Lower slope
Slope	26°
Elevation	150 m (500 ft)
Site drainage	Receiving
Parent material	Sandstone and mudstone
Vegetation	Broken primary forest
Soil drainage	Moderately well drained

Horizon	Depth cm (in)		Description
A	0-3	(0-1)	Dark brown (10YR 3/3); humic loam; moderate fine and medium crumb structure; moist, very friable; abundant roots; abrupt smooth boundary
EB	3-35	(1-14)	Reddish yellow (7.5YR 6/8) with common fine distinct light yellowish brown (2.5Y 6/4), light grey (N7) and few fine distinct yellowish red (5YR 5/8) mottles; loam; moderate fine and medium subangular blocky structure; moist, friable; moderately thick broken cutans; common roots; common wormcasts; diffuse wavy boundary
Blt	35-65	(14-26)	Strong brown (7.5YR 5/8) with few fine distinct light grey (N7) and olive yellow (2.5Y 6/6) mottles; loam; moderate fine and medium subangular blocky structure; moist friable; few rotting sandstone fragments; moderately thick broken cutans few roots; diffuse wavy boundary

Horizon	Depth cm (in)	Description
B2t	65-100 (26-40)	Strong brown (7.5YR 5/8) with abundant fine distinct yellowish red (5YR 5/8) and few fine distinct light grey (N7) mottles; loam; moderate fine and medium subangular blocky structure; moist, friable; few rotting sandstone fragments; thick broken cutans; few roots; diffuse wavy boundary
B3t	100-125 (40-50)	Brownish yellow (10YR 6/6) with common fine distinct red (2.5YR 5/8) and light grey (N7) mottles; clay loam; moderate fine and medium subangular blocky structure; moist, firm; common rotting sandstone fragements; thick broken and continuous cutans

Depth cm	Particle size distribution %			Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	Total		
	Sand	Silt	Clay					Ca	Mg	K	Na			P ppm	K %	Mg %
0-3	56	31	13	3.1	0.48	10	4.2	0.7	1.4	0.3	0.1	14.2	18	264	0.56	0.16
3-35	39	31	30	0.4	0.07	tr.	4.8	tr.	0.4	0.1	0.1	10.2	6	150	0.70	0.19
35-65	39	26	35	0.3	0.07	tr.	5.1	0.1	0.4	0.1	0.1	10.7	7	166	0.76	0.23
65-100	41	24	35	0.3	0.08	tr.	5.1	0.1	0.5	0.1	0.1	11.2	7	110	0.83	0.24
100-125	34	26	40	0.3	0.08	tr.	5.3	0.1	0.7	0.1	0.1	10.3	10	138	0.83	0.25

PROFILE Ao 12

Soil family	Tanjong Lipat
Location	14 km (8 mi) S of Gunong Beeston
Surroundings	Low hills; amplitude 45 m (150 ft)
Site	Upper slope
Slope	2° convex
Site drainage	Shedding
Parent material	Slump formation with sandstone, mudstone and chert
Vegetation	Logged forest
Soil drainage	Well drained

Horizon	Depth cm (in)	Description
A	0-3 (0-1)	Very dark greyish brown (10YR 3/2); humic loam; moderate fine subangular blocky structure; moist, friable; abundant roots; clear smooth boundary
E	3-18 (1-7)	Yellowish brown (10YR 5/6); loam; moderate fine and medium subangular blocky structure; moist, firm; common roots; diffuse smooth boundary
Blt	18-53 (7-21)	Strong brown (7.5YR 5/6); clay loam; moderate medium subangular blocky structure; moist, firm; few chert gravels; moderately thick broken cutans; common roots; diffuse smooth boundary
B2t	53-85 (21-38)	Yellowish red (5YR 4/8); clay loam; moderate medium to coarse subangular blocky structure; most, firm; abundant chert stones and gravel; moderately thick broken cutans; few roots; diffuse wavy boundary

Depth cm	Particle size distribution %			Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Sand	Silt	Clay					Ca	Mg	K	Na		
0-3	53	29	18	6.2	0.52	7	4.4	1.0	1.6	0.5	tr.	11.5	27
3-18	41	34	25	1.0	0.12	2	4.5	0.1	0.2	0.2	–	10.8	5
18-53	36	29	35	0.4	0.06	1	4.2	0.1	0.2	0.1	–	11.5	3
53-85	43	22	35	0.2	0.04	1	4.3	tr.	0.1	0.1	–	11.0	2

PROFILE Ao 13

Soil family	Tanjong Lipat
Location	Tambunan Plain (grid ref. FW 082317)
Surroundings	High hills
Site	Footslope with terraces for crops
Slope	30°
Elevation	675 m (2 250 ft)
Site drainage	Normal
Parent material	Sandstone and shale
Land use	Rubber plantation
Soil drainage	Well drained

Horizon	Depth cm (in)		Description
O	2-0	(½-0)	Litter layer
A	0-15	(0-6)	Brown (7.5YR 5/4); clay loam; moderate fine subangular blocky structure; moist, friable to firm; thin patchy cutans; common fine pores and root channels; abundant fine and medium roots; diffuse boundary
EB	15-43	(6-17)	Reddish brown (5YR 4/4); clay; moderate fine angular blocky structure; moist, friable; moderately thick broken cutans; few fine pores; common fine and medium roots; diffuse boundary
Bt	43-75	(17-30)	Yellowish red (5YR 5/6); clay; strong fine and medium angular blocky structure; moist, firm; thick, continuous cutans; few fine pores; few fine roots; diffuse boundary
BC	75-120	(30-48)	Yellowish red (5YR 4/8); clay; strong fine and medium angular blocky structure; moist, firm; thick continuous cutans; few fine pores; few gravel-sized fragments of weathering sandstone and shale

Depth cm	Particle size distribution %				Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	Total		
	Coarse sand	Fine sand	Silt	Clay					Ca	Mg	K	Na			P ppm	K%	Mg%
0-15	–	47	21	32	1.6	0.15	8	4.6	–	tr.	0.1	tr.	12.8	1	230	1.10	0.24
15-43	–	47	21	32	1.0	0.10	4	4.6	–	–	0.1	tr.	11.7	1	200	1.16	0.31
43-75	–	41	21	37	0.4	0.06	2	4.7	–	–	0.1	tr.	10.6	1	170	1.28	0.34
75-120	–	37	17	47	0.3	0.06	4	4.9	–	–	0.1	–	12.6	1	180	1.46	0.39

PROFILE Ao 14

Soil family	Tanjong Lipat
Location	Headwaters of the Sungai Takala about 14 km (8½ mi) S of the Kinabatangan (grid ref. LC 827853)
Surroundings	Moderate to steep hills
Site	Middle slope
Slope	23°
Elevation	About 120 m (400 ft)
Site drainage	Shedding
Parent material	Sandstone
Vegetation	Recently logged dipterocarp forest
Soil drainage	Well drained

Horizon	Depth cm (in)		Description
A	0-3	(0-1)	Dark brown (2.5YR 3/2); sandy clay loam; moderate fine granular structure; moist, very friable; abrupt boundary

Horizon	Depth cm (in)		Description
E	3-8	(1-3)	Yellowish brown (10YR 5/4); sandy clay loam; weak fine to medium subangular blocky structure; moist, friable; common small sandstone fragments; clear boundary
EB	8-23	(3-9)	Yellowish brown (10YR 5/6); sandy clay loam; moderate fine subangular blocky structure; moist, friable; many small strongly weathered sandstone fragements; thin broken cutans; merging boundary
Bt	23-45	(9-18)	Yellowish brown (10YR 5/8); sandy clay loam; moderate fine and medium subangular blocky structure; moist, friable; many small to medium strongly weathered sandstone fragements; thin continuous cutans; merging boundary
BC	45-68	(18-22)	Yellowish brown (10YR 5/8); sandy clay; moderate fine and medium subangular blocky structure; moist, friable; dominant small to large angular weathered sandstone; thin continuous cutans; diffuse wavy boundary
C	68+	(22+)	Weathered sandstone

Depth cm	Particle size distribution %				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	Minerals of the clay fraction		
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na			Kaolinite	Illite	Vermiculite
0-3	13	52	14	22	1.9	0.31	4.2	0.6	1.9	0.5	0.2	13.7	23	n.d.	n.d.	n.d.
3-8	18	48	6	22	1.4	0.17	4.0	0.5	0.7	0.3	0.1	9.0	17	mod.	tr.	dom.
8-23	15	53	8	26	0.6	0.10	4.2	0.2	0.4	0.2	0.1	9.0	9	dom.	tr.	dom.
23-45	20	44	8	27	0.3	0.07	4.2	0.2	0.3	0.1	0.1	9.7	7	mod.	tr.	dom.
45-68	8	43	4	41	0.3	0.07	4.4	0.2	0.2	0.1	0.1	12.6	6	mod.	tr.	dom.

PROFILE Ao 15

Soil family	Kapilit
Location	Kalabakan valley (grid ref. LH 278842)
Surroundings	Moderate hills; amplitude 120 m (400 ft)
Site	Lower slope
Slope	39°
Elevation	90 m (300 ft)
Site drainage	Normal
Parent material	Sandstone
Vegetation	Dipterocarp forest
Soil drainage	Well drained

Horizon	Depth cm (in)		Description
A	0-5	(0-2)	Dark yellowish brown (10YR 3/4); humic sandy loam; moderate very fine to fine subangular blocky structure; wet, non-sticky and non-plastic; abundant roots; clear wavy boundary
El	5-28	(2-11)	Yellowish brown (10YR 5/6); sandy loam; weak very fine to fine subangular blocky structure; wet, non-sticky and non-plastic; few angular sandstone fragments; thin broken cutans; many roots; gradual wavy boundary
E2	28-38	(11-15)	Yellowish brown (10YR 5/6); sandy loam; weak very fine to fine subangular blocky structure; wet, non-sticky and non-plastic; many sandstone fragments; thin broken cutans; common roots; diffuse wavy boundary

Horizon	Depth cm (in)		Description
Bt	38-88	(15-35)	Yellowish brown (10YR 5/6); sandy clay loam; moderate very fine to fine subangular blocky structure; wet, slightly sticky and slightly plastic; many sandstone fragments; thick patchy cutans; common roots
R	88+	(35+)	Sandstone

Depth cm	Particle size distribution %			Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	Total		
	Sand	Silt	Clay					Ca	Mg	K	Na			P ppm	K%	Mg%
0-5	72	20	8	4.8	0.31	19	4.5	1.5	0.9	0.4	0.1	7.7	38	182	0.35	0.17
5-28	65	20	15	0.5	0.09	3	4.7	0.1	0.3	0.3	0.1	7.3	11	110	0.46	0.21
28-38	67	18	15	0.4	0.06	2	5.1	–	0.5	0.3	0.1	7.7	12	100	0.54	0.26
38-88	67	15	18	0.2	0.05	1	5.2	–	0.4	0.3	0.1	8.1	10	144	0.76	0.27

PROFILE Ao 16

Soil family	Kapilit
Location	Terikan (grid ref. LA 080484)
Surroundings	Low hills
Site	Footslope
Slope	15°
Elevation	14 m (45 ft)
Site drainage	Normal
Parent material	Sandstone
Land use	Rubber plantation
Soil drainage	Well drained

Horizon	Depth cm (in)		Description
O	3-0	(1-0)	Litter layer
A	0-18	(0-7)	Dark brown to brown (10YR 4/3) with few yellowish brown (10YR 5/6) mottles; fine sandy loam; weak medium to fine crumb structure; moist, friable; many roots; gradual wavy boundary
AB	18-45	(7-18)	Yellowish brown (10YR 5/8); loam; weak medium to fine crumb structure; moist, friable; thin patchy cutans; few small angular sandstone fragments; few roots; gradual smooth boundary
Bt	45-105	(18-42)	Reddish yellow (7.5YR 6/8); loam; moderate medium to coarse subangular blocky structure; moist, slightly firm; thin broken cutans; few small angular sandstone fragements; gradual smooth boundary
BC	105+	(42+)	Reddish yellow (7.5YR 6/8); sandy clay loam; common small reddish yellow (5YR 6/8) weathering sandstone fragements; moderate coarse angular blocky structure; moist, firm.

Depth cm	Particle size distribution %				Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay					Ca	Mg	K	Na		
0-18	1	76	9	10	1.6	0.13	4	4.3	0.2	0.1	0.1	tr.	6.7	6
18-45	3	77	12	5	1.0	0.09	tr.	4.6	0.2	0.1	–	tr.	4.6	7
45-105	8	68	11	12	0.5	0.03	1	4.8	0.2	–	–	–	3.1	7
105-110	5	67	9	17	0.1	–	tr.	4.6	0.3	tr.	–	–	2.6	12

Gleyic Luvisols (Lg)

PROFILE Lg 1

Soil family	Nangoh
Location	About 400 m (¼ mi) N of the Sungai Karamuak 800 m (½ mi) upstream from Kuala Pantagaluang (grid ref. LB 922936)
Surroundings	Broad valley floor with minor undulations
Site	Valley flat
Slope	Nil
Elevation	45 m (150 ft)
Site drainage	Receiving
Parent material	Medium-textured alluvium derived largely from basic and ultrabasic igneous rocks
Soil drainage	Poor; water table at 50 cm (20 in)

Horizon	Depth cm (in)		Description
A	0-3	(0-1)	Dark greyish brown (10YR 4/2); sandy clay loam; weak fine subangular blocky structure; moist, friable; abrupt boundary
EBg	3-13	(1-5)	Light brownish grey (2.5Y 6/2); clay loam; moderate fine and medium subangular blocky structure; moist, friable; few small hard black concretions; thin broken cutans; clear boundary
Btgcn	13-50	(5-20)	Light olive grey (5Y 6/2) with common medium distinct yellowish brown (10YR 5/8) mottles; clay loam; moderate fine subangular blocky structure; moist, friable; many small and common large round and nodular concretions; moderately thick broken cutans
BCgcn	50-75	(20-30)	Olive grey (5Y 5/2) with many fine and medium distinct light grey (7.5YR 7/0) and yellowish brown (10YR 5/8) mottles; gritty clay loam; weak coarse subangular blocky structure; wet, sticky, slightly plastic; many concretions, dominant in patches; thick continuous cutans

Depth cm	Particle size distribution %				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na		
3-13	12	30	21	33	1.6	0.18	5.6	0.5	5.6	0.1	–	8.6	73
13-50	7	24	26	39	0.3	0.07	6.9	0.3	5.9	0.1	–	6.5	95
50-75	10	28	24	38	0.4	0.07	6.8	0.5	10.2	0.1	0.1	11.5	95

PROFILE Lg 2

Soil family	Lungpatau
Location	Sungai Lungpatau about 800 m (½ mi) from the coast (grid ref. LE 261895)
Surroundings	Flat terrace with occasional crab mounds
Site	Terrace
Slope	Nil
Elevation	About 3 m (10 ft)
Site drainage	Receiving; freshwater flooding
Parent material	Fine-textured alluvium
Vegetation	Swamp forest lacking ground vegetation
Soil drainage	Poor; water table at 38 cm (15 in)

Horizon	Depth cm (in)		Description
O	8-0	(3-0)	Mixed leaf and root fragments; abrupt smooth boundary
A	0-15	(0-6)	Black (10YR 2/1); clay loam; strongly developed medium and fine granular structure; moist, firm; abrupt smooth boundary
AB	15-25	(6-10)	Brown to dark brown (10YR 4/3-5/3) with distinct yellowish brown mottles; clay; strong medium angular blocky structure; wet, very sticky and very plastic; few shell fragments; merging boundary
Btg	25-38	(10-15)	Dark grey (10YR 4/1) with faint yellowish brown mottles; clay; strong medium and fine angular blocky structure; wet, very plastic and very sticky; merging boundary
BCg	38-75	(15-30)	Greyish brown (2.5Y 5/2) with distinct reddish brown mottles; sandy clay; no orderly structural arrangement; wet, very plastic and very sticky; few coral fragments
IIC	75+	(30+)	Coral debris

Depth cm	Particle size distribution%				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	$CaCO_3$ equiv. %
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na			
0-15	n.d.	n.d.	n.d.	n.d.	8.8	0.68	7.4	60.8	8.6	0.5	5.8	58.9	sat.	n.d.
15-25	2	11	21	65	2.0	0.30	7.6	42.0	9.5	0.4	6.0	52.6	sat.	0.2
25-38	2	8	16	73	1.4	0.23	7.7	41.7	10.7	0.4	9.6	50.0	sat.	0.5
38-75	6	45	12	38	0.9	0.09	7.9	20.0	6.5	0.3	6.4	17.6	sat.	1.3

PROFILE Lg 3

Soil family	Buran
Location	Tanjong Batu (grid ref. FY 234185)
Surroundings	Kinabatangan floodplain
Site	Flat
Slope	Nil
Elevation	About 6 m (20 ft)
Site drainage	Receiving; freshwater flooding
Parent material	Fine-textured alluvium
Vegetation	Swamp forest
Soil drainage	Poor; water table at 23 cm (9 in)

Horizon	Depth cm (in)		Description
A	0-5	(0-2)	Greyish brown (2.5Y 5/2) with many distinct light grey (10YR 7/2) mottles; silty clay loam; moderate coarse granular structure; abrupt boundary
ABg	5-15	(2-6)	Light grey (10YR 7/2) with many distinct yellowish brown (10YR 5/8) mottles; silty clay loam; strong medium subangular blocky structure; moist, friable; abrupt boundary
B1g	15-30	(6-12)	Light grey (5Y 7/1) with many prominent yellowish brown (10YR 5/8) mottles; silty clay loam; moderate to strong medium angular blocky structure; wet, slightly sticky and plastic; moderately thick patchy cutans
B2tg	30-83	(12-33)	Light grey (7.5YR 7/1) with many prominent medium and coarse reddish yellow (7.5YR 6/8) mottles; clay; strong coarse prismatic structure; wet, sticky and plastic; thick continuous cutans; gradual boundary

Horizon	Depth cm (in)	Description
IIBCg	83-115 (33-46)	Brown to dark brown (7.5YR 4/2) with many medium brown to dark brown (7.5YR 4/4) mottles; clay loam; moderate coarse prismatic structure; wet, sticky and plastic; many leaf and wood fragments and manganese stains

Depth cm	Particle size distribution%				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	Minerals of the clay fraction		
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na			Kaolin-ite	Ill-ite	Vermic-ulite
0-5	–	17	40	31	2.8	0.7	4.5	3.2	2.6	0.5	0.2	24.4	27	n.d.	n.d.	n.d.
5-15	–	16	42	34	3.6	0.4	4.7	2.4	3.8	0.5	0.2	24.5	28	n.d.	n.d.	n.d.
15-30	–	17	43	36	1.2	0.17	5.1	4.1	5.3	0.3	0.3	18.2	55	dom.	mod.	tr.
30-83	–	13	32	51	0.6	0.1	5.1	4.1	5.3	0.4	0.3	17.5	58	dom.	mod.	mod.
83-115	1	32	31	30	3.8	0.15	2.5	3.2	5.0	–	0.2	23.4	36	mod.	dom.	tr.

PROFILE Lg 4

Soil family	Buran
Location	Floodplain of tributary of Sungai Juak
Surroundings	Floodplain
Site	Flat
Slope	Nil
Site drainage	Receiving; freshwater flooding
Parent material	Fine-textured alluvium
Vegetation	Primary forest
Soil drainage	Imperfect; water table at 115 cm (46 in)

Horizon	Depth cm (in)	Description
A	0-3 (0-1)	Very dark greyish brown (10YR 3/2); humic loam; moderate very fine and fine crumb structure; moist, friable; abundant roots; clear smooth boundary
E	3-25 (1-10)	Dark yellowish brown (10YR 4/4); clay loam; moderate medium subangular blocky structure; moist, firm; common roots; diffuse smooth boundary
B1t	25-53 (10-21)	Yellowish brown (10YR 5/4); clay; moderate coarse and medium subangular blocky structure; moist, firm; common fine black manganese concretations; moderately thick broken cutans; few roots; diffuse smooth boundary
B2t	53-85 (21-34)	Yellowish brown (10YR 5/4) with few fine distinct light greenish grey 5GY 7/1) and yellowish red (5YR 5/8) mottles; clay; moderate coarse and medium subangular blocky structure; wet, sticky and plastic; common fine black manganese concretions; thick broken cutans; few roots; diffuse smooth boundary
B3tg	85-125 (34-50)	Light grey (N7) with many fine distinct strong brown (7.5YR 5/8) mottles; clay; moderate coarse and medium subangular blocky structure; wet, sticky and plastic; common fine black manganese concretions; thick broken cutans; very few roots

Depth cm	Particle size distribution%			Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	Total			Avail. P ppm
	Sand	Silt	Clay				Ca	Mg	K	Na			K %	Mg %	P ppm	
0-3	62	20	18	8.8	0.51	5.8	15.6	8.7	0.2	0.1	36.7	67	0.03	0.96	254	10
3-25	57	7	36	1.1	0.14	5.9	8.2	10.3	0.1	0.1	29.2	64	0.04	1.46	144	tr.
25-53	29	28	43	0.5	0.05	6.5	5.9	9.8	0.1	0.1	22.5	71	0.02	1.48	40	tr.
53-85	37	25	38	0.4	0.05	6.6	5.3	9.5	0.1	0.1	21.6	69	0.02	1.18	40	10
85-125	27	25	48	0.3	0.03	6.9	7.3	14.4	0.1	0.1	27.6	79	0.03	1.28	28	tr.

PROFILE Lg 5

Soil family	Buran
Location	Mile 40 on the Penampang to Sinsuson Road (grid ref. FW066339)
Surroundings	Dissected terraces
Site	Terrace
Slope	8°
Elevation	750 m (2 500 ft)
Site drainage	Receiving
Parent material	Medium-textured stony alluvium
Land use	Wet rice
Soil drainage	Imperfect

Horizon	Depth cm (in)		Description
Apg	0-15	(0-6)	Greyish brown (2.5Y 5/2) with common fine prominent dark brown (10YR 3/3) mottles; sandy loam to loam; structureless, single grain; wet, slightly sticky, slightly plastic; common fine roots; clear smooth boundary
B1t	15-30	(6-12)	Strong brown (7.5YR 5/8); sandy clay loam; weak coarse subangular blocky structure; wet, sticky, plastic; few roots diffuse boundary
B2t	30-65	(12-26)	Yellowish red (5YR 5/8); sandy clay loam; moderate coarse subangular blocky structure; wet, very sticky, very plastic; thick continuous cutans; few fragments of sandstone gravel; few roots; diffuse boundary
BC	65+	(26+)	Yellowish red (5YR 5/8) with many medium prominent brownish yellow (10YR 6/6) mottles; clay loam to sandy clay; many weathered sandstone fragments

Depth cm	Particle size distribution%				Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	Total		
	Coarse sand	Fine sand	Silt	Clay					Ca	Mg	K	Na			P ppm	K %	Mg %
0-15	8	67	11	12	0.7	0.06	2	5.5	2.4	0.5	0.1	0.1	4.9	63	75	0.18	0.12
15-30	10	47	14	23	0.3	0.04	tr.	6.1	6.3	1.8	0.1	0.3	10.7	79	105	0.43	0.29
30-65	10	44	16	31	0.2	0.04	tr.	5.7	4.5	1.5	0.1	0.2	12.3	51	135	0.71	0.95

PROFILE Lg 6

Soil family	Lunparai
Location	About 9.5 (6 mi) N of Kuala Kawag
Surroundings	Rolling; amplitude 60 m (200 ft)
Site	Upper slope. Ridge top
Slope	12°, convex
Site drainage	Shedding
Parent material	Mudstone and minor basic tuff

Vegetation	Dipterocarp forest
Soil drainage	Poor

Horizon	**Depth cm (in)**		**Description**
A	0-4	(0-1½)	Very dark greyish brown (10YR 3/2); humic laom; moderate fine and medium crumb structure; moist, friable; abundant roots; clear smooth boundary
E	4-25	(1½-10)	Yellowish brown (10YR 5/4) with common brown to dark brown (10YR 4/3) humus stains; loam; moderate fine and medium subangular blocky structure; moist, friable; common roots; clear smooth boundary
B1tg	25-60	(10-24)	Light grey (5Y 7/1) with many fine distinct yellowish brown (10YR 5/6) mottles; clay loam; moderate coarse and medium subangular blocky structure; moist, firm; few gravels; thick broken cutans; common roots; diffuse smooth boundary
B2tg	60-88	(24-35)	Light grey (5Y 7/1); clay; weak coarse subangular blocky structure; moist, very firm; few gravels and stones; common soft rusty concretions; thick broken and continuous cutans; few roots; diffuse smooth boundary
B3tg	88-125	(35-50)	Light grey to grey (N 6) with many fine distinct yellowish brown (10YR 5/6) mottles; clay; structureless; moist, very firm; black fragments of decomposing tuff; thick broken and continuous cutans; very few roots

Depth cm	Particle size distribution%			Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	Total			Avail. P ppm
	Sand	Silt	Clay				Ca	Mg	K	Na			K %	Mg %	P ppm	
0-4	47	38	15	10.3	0.54	6.2	13.1	9.1	0.9	0.2	42.2	55	0.94	0.49	720	70
4-25	27	33	40	1.1	0.15	4.8	0.3	6.2	0.4	0.2	21.7	33	1.19	0.58	150	10
25-60	20	27	53	0.4	0.04	5.5	0.1	12.5	0.5	0.3	27.2	49	1.63	0.93	174	tr.
60-88	12	33	55	0.6	0.09	5.8	1.6	14.4	0.5	0.3	26.5	63	1.75	1.05	264	tr.
88-125	12	35	53	0.8	0.09	6.5	6.5	15.6	0.4	0.4	23.2	99	1.94	1.18	548	43

PROFILE Lg 7 (After Thomas, 1967a, p. 27)

Soil family	Lunparai
Location	East of the Sapagaya Bridge on the Silam road
Surroundings	Hilly
Site	Upper slope
Slope	5°
Elevation	30 m (100 ft)
Site drainage	Shedding
Parent material	Shale
Vegetation/Land use	Thicket regrowth after shifting cultivation
Soil drainage	Imperfect

Horizon	**Depth cm (in)**		**Description**
A	0-5	(0-2)	Very dark grey (10YR 3/1); humic loam; strong very fine subangular blocky structure; moist, very friable; very frequent roots
AE	5-12	(2-5)	Dark greyish brown (2.5Y 4/2); silty clay loam; strong very fine subangular blocky structure; moist, firm frequent roots
B1t	12-60	(5-24)	Yellowish brown (10YR 5/6); sandy clay; moderate fine subangular blocky structure; moist, firm; few roots

Horizon	Depth cm (in)	Description
B2tg	60-100 (24-40)	Greenish grey (5 BG 6/1) with many strong brown (7.5YR 5/6) mottles; clay loam; structureless, massive; sticky, plastic
B3tg	100-150 (40-60)	Greenish grey (5 BG 6/1) with common strong brown (7.5YR 5/8) mottles; sandy clay; structureless, massive; sticky, very plastic

Depth cm	Particle size distribution%				Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay					Ca	Mg	K	Na		
0-5	–	41	54	5	2.6	0.29	5	6.9	12.6	4.3	0.6	0.1	20.5	85
5-12	–	46	46	8	1.4	0.19	tr.	6.7	9.7	4.8	0.5	0.1	17.1	88
12-60	–	37	44	19	0.4	0.09	–	5.7	4.8	4.6	0.3	0.2	16.0	61
60-100	–	44	36	20	0.2	0.06	tr.	6.6	5.7	7.4	0,3	0.2	17.0	80
100-150	–	28	43	29	0.2	0.08	tr.	6.5	9.0	13.6	0.4	0.4	26.8	88

Calcic Luvisols (Lk)

PROFILE Lk 1 (After Thomas, 1968)

Soil family	Semporna
Location	Semporna Agricultural Station (grid ref. LJ 628925)
Surroundings	Terrace
Site	Gently undulating
Slope	Flat
Elevation	15 m (50 ft)
Site drainage	Receiving
Parent material	Coralline limestone
Land use	Rubber
Soil drainage	Well drained

Horizon	Depth cm (in.)		Description
A1	0-5	(0-2)	Very dark greyish brown (10YR 4/2); humic silty clay; moderate subangular blocky breaking into strong fine crumb structure; moist, friable; very frequent roots; clear smooth boundary
A2	5-20	(2-8)	Greyish brown (10YR 5/2); silty clay; moderate medium subangular blocky structure; moist, friable; few roots; clear smooth boundary
Blt	20-41	(8-16)	Brownish yellow to yellowish brown (10YR 6/8-5/8); clay; moderate fine subangular blocky structure; firm; thin patchy cutans; few roots; clear smooth boundary
B2t	41-66	(16-26)	Yellow (10YR 7/6); clay; strong fine subangular blocky structure; moist, friable; few roots; abrupt smooth boundary
BC	66-91	(26-36)	Yellow (10YR 7/8) with common medium distinct white (10YR 8/1) mottles; sandy clay; limestone rubble dominant; clear smooth boundary
R	91+	(36+)	Limestone rubble

Depth cm	Particle size distribution%				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na		
0-5	1	21	48	30	6.7	0.88	7.2	tr.	3.7	0.4	0.5	74.3	7
5-20	1	18	31	50	1.5	0.24	6.4	36.1	2.2	0.2	0.5	53.1	74
20-41	1	13	19	67	0.7	0.12	6.6	39.5	1.0	0.2	0.4	51.3	80
41-66	1	12	17	70	0.5	0.15	7.8	49.1	0.4	0.1	0.6	58.0	87
66-91	16	11	37	36	0.2	0.06	8.5	45.6	0.3	0.1	0.4	28.3	sat.

PROFILE Lk 2

Soil family	Semporna
Location	About 400 m (¼ mi) S of the Sungai Kinabatangan 5¼ km (3 mi) downstream from Sukau (grid ref. FY 219110)
Surroundings	Steep narrow ridge with amplitude of about 75 m (250 ft)
Site	Narrow ledge
Slope	Level; slopes of 25° above and below
Elevation	About 75 m (250 ft)
Site drainage	Shedding
Parent material	Limestone
Vegetation	Dipterocarp forest with *Shorea multiflora, Dryobalanops lanceolate* and *Hopea nervosa*
Soil drainage	Well drained

Horizon	Depth cm (in)	Description
A	0-8 (0-3)	Very dark greyish brown (10YR 3/2); clay loam; strong medium and fine granular structure; moist, friable; clear smooth boundary
AB	8-15 (3-6)	Yellowish brown (10YR 5/4) with greyish brown organic matter inclusions; clay loam; strong medium and fine subangular blocky structure; moist, friable; merging boundary
B15	15-35 (6-14)	Yellowish brown (10YR 5/4-5/6); clay; strong medium and coarse subangular blocky structure; moist, very firm; thin patchy cutans; few large subangular limestone fragments; merging boundary
B2t	35-70 (14-28)	Yellowish brown (10YR 5/6); clay; strong medium subangular blocky structure; moist, firm; thick continuous cutans; few large subangular limestone fragments; abrupt irregular boundary
R	70+ (28+)	Limestone

Depth cm	Particle size distribution %				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na		
0-8	n.d.	n.d.	n.d.	n.d.	7.1	0.8	6.3	57.0	3.7	0.4	0.4	61.4	sat.
8-15	10	32	15	39	2.8	0.31	6.3	33.0	2.1	0.3	0.3	40.5	88
15-35	10	27	21	45	1.0	0.2	6.0	30.4	1.4	0.3	0.4	35.7	91
35-70	6	23	26	45	1.2	0.2	6.8	32.0	1.1	0.3	0.3	44.6	76

Ferric Luvisols (Lf)

PROFILE Lf 1

Soil family	Pantagaluang
Location	About 1¼ km (¾ mi) SW of the Sungai Karamuak at Liwatong Pau (grid ref. FW 809001)
Surroundings	Broad low terrace
Site	Terrace flat
Slope	Level
Elevation	90 m (300 ft)
Site drainage	Normal
Parent material	Medium-textured alluvium derived largely from ultrabasic and basic igneous rocks
Vegetation	Lowland dipterocarp forest
Soil drainage	Moderately well drained; water table at 113 cm (45 in)

Horizon	Depth cm (in)		Description
A	0-1	(0-½)	Very dark brown (10YR 2/2); sandy loam; moderate medium granular structure; moist, friable; abrupt boundary
AB1	1-10	(½-4)	Dark brown (10YR 3/3) with few coarse distinct dark yellowish brown (10YR 4/4) mottles; loamy sand; moderate fine subangular blocky structure; moist, friable; gradual boundary
AB2	10-40	(4-16)	Dark brown (10YR 3/3) with common medium distinct yellowish brown (10YR 5/8) mottles; loam; moderate fine and medium subangular blocky structure; moist, friable; gradual boundary
Blt	40-75	(16-30)	Dark yellowish brown (10YR 4/4) with black and dark greyish brown (10YR 4/2) mottles; clay loam; moderate fine subangular blocky structure; moist, friable; common small manganese concretions; thin broken cutans; clear boundary
B2cn	75-105	(30-42)	Dark yellowish brown (10YR 4/4) with common medium strong brown (7.5YR 5/6) mottles; loam; moderate medium subangular blocky structure; friable; many small hard round concretions; thin continuous cutans
BCcn	105-125	(42-50)	Brown to dark brown (7.5YR 4/4) with common coarse distinct yellowish brown (10YR 5/4) mottles; sandy clay loam; common concretions

Depth cm	Particle size distribution %				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na		
1-10	14	57	12	14	1.1	0.19	5.5	0.8	1.8	0.1	0.1	6.4	44
10-40	11	55	15	19	0.7	0.10	5.2	0.3	2.3	0.1	0.1	6.6	41
40-75	10	47	14	30	0.2	0.10	5.2	0.2	6.9	0.1	0.2	12.3	61
75-105	21	47	13	17	0.1	0.05	5.4	0.2	3.6	0.1	0.4	6.1	71

PROFILE Lf 2

Soil family	Pantagaluang
Location	About 400 m (¼ mi) N of the Sungai Karamuak 800 m (½ mi) upstream from the Sungai Pantagaluang (grid ref. LB 922937)
Surroundings	Broad valley floor with minor undulations

Site	Low terrace
Slope	Nil
Elevation	45 m (150 ft)
Site drainage	Receiving
Parent material	Medium-textured alluvium with concretions; concretionary boulders at surface
Vegetation	Swamp forest
Soil drainage	Moderately well drained

Horizon	Depth cm (in)		Description
Blcn	0-33	(0-13)	Dark yellowish brown (10YR 4/4); silt loam; strong medium and fine subangular blocky structure; moist, friable; common hard black round concretions; thin broken cutans; clear boundary
B2cn	33-63	(13-25)	Reddish brown (5YR 4/3); loam; moderate coarse subangular blocky breaking to fine subangular blocky structure; moist; friable; common hard black concretions; thin broken cutans; diffuse boundary
B3tcn	63-105	(25-42)	Reddish brown (5YR 4/4); silt loam; moderate fine subangular blocky structure; moist, very friable; common hard black concretions; thin broken cutans

Depth cm	Particle size distribution %				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na		
0-33	7	49	27	12	1.1	0.16	5.2	0.1	1.7	0.1	0.1	6.6	30
33-63	24	39	22	13	0.7	0.14	5.5	0.2	3.2	0.1	–	6.6	53
63-105	15	32	28	24	0.4	0.08	6.1	0.2	2.7	–	–	5.1	56

Depth cm	Total %						Minerals of the clay fraction		
	Fe	AL	Mn	Mg	Ni	Cr	Kaolinite	Illite	Vermiculite
33-63	41.1	6.1	0.2	0.8	0.3	1.7	mod.	mod.	dom.
63-105	37.7	5.2	0.5	1.1	0.4	1.5	dom.	mod.	mod.

PROFILE Lf 3

Soil family	Lumerau
Location	Lumerau Lowlands (grid ref. LD 970810)
Surroundings	Minor hillocks and alluvial flats
Site	Crest of small hillock; 5-10° slopes away from crest
Slope	Nil
Elevation	About 15 m (50 ft)
Site drainage	Shedding
Parental material	Mudstone
Vegetation	Lowland dipterocarp forest
Soil drainage	Moderately well drained

Horizon	Depth cm (in)		Description
A	0-3	(0-1)	Brown to dark brown (10YR 4/3); clay loam; strong medium granular structure; moist, friable; abrupt smooth boundary
B1t	3-38	(1-15)	Yellowish brown (10YR 5/6) with few faint grey mottles; silty clay; strong medium angular blocky structure; moist, firm; thick continuous cutans; merging boundary
B2t	38-60	(15-24)	Yellowish brown (10YR 5/8) with grey and reddish brown mottles; clay; strong medium and fine angular blocky structure; moist, firm; thick continuous cutans; merging boundary
B3t	60-85	(24-34)	Mixed light yellowish brown (10YR 6/4), strong brown (7.5YR 5/6) and yellowish red (5YR 5/8); clay; moderate medium angular and subangular blocky structure; moist, firm; thick patchy cutans; merging boundary
B4t	85-105	(34-42)	Light yellowish brown (10YR 6/4) with strong brown (7.5YR 5/6) and yellowish red (5YR 5/8) mottles; clay; moderate medium angular and subangular blocky structure; moist, firm; thin patchy cutans

Depth cm	Particle size distribution %				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na		
3-38	1	11	30	59	0.9	0.18	4.7	0.4	5.8	0.6	0.2	14.5	48
38-60	1	9	26	65	0.5	0.12	4.9	0.2	6.2	0.6	0.3	13.5	54
60-85	2	9	25	65	0.4	0.1	5.1	0.3	8.1	0.6	0.3	16.9	55
85-105	1	7	24	68	n.d.	n.d.	n.d.	n.d.	n.d	n.d.	n.d.	n.d.	n.d.

Chromic Luvisols (Lc)

PROFILE Lc 1

Soil family	Mangkap
Location	Headwaters of Sungai Binalik about 5 km (3 mi) N from Kuala Binalik (grid ref. LB 944972)
Surroundings	Broad valley floor
Site	Valley flat
Slope	Nil
Site drainage	Receiving
Parent material	Fine-textured alluvium derived largely from basic and ultrabasic igneous rocks
Vegetation	Lowland dipterocarp forest
Soil drainage	Well drained

Horizon	Depth cm (in)		Description
A	0-5	(0-2)	Dark brown (7.5YR 3/2); loam; strong fine angular and subangular blocky structure; moist, friable; clear boundary
B1	5-18	(2-7)	Brown to dark brown (7.5YR 4/2) with few distinct strong brown (7.5YR 5/6) mottles; clay loam; strong fine and medium subangular blocky structure; moist, friable; thin broken cutans; gradual boundary
B2tcn	18-48	(7-19)	Variegated strong brown (7.5YR 5/6) and brown to dark brown (7.5YR 4/2); clay; strong fine and medium subangular blocky structure; moist, friable; common small black soft manganese concretions; moderately thick continuous cutans; gradual boundary
B3tcn	48-105	(19-42)	Strong brown (7.5YR 5/6); clay; fine prismatic breaking to strong fine and medium subangular blocky structure; moist, friable; common small soft round black manganese concretions becoming hard below 90 cm (36 in); moderately thick continuous cutans

Depth cm	Particle size distribution %				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na		
0-5	7	37	24	23	2.8	0.31	5.9	1.3	0.4	0.3	0.1	17.7	12
5-18	7	38	26	26	0.9	0.15	5.8	0.1	5.9	0.1	–	16.9	36
18-48	6	28	23	40	0.5	0.10	5.7	0.1	10.2	0.1	–	15.5	67
48-105	9	20	18	50	0.2	0.10	5.9	0.1	14.0	0.2	–	17.8	80

PROFILE Lc 2

Soil family	Terang
Location	Sungai Lung Patau; about 1600 m (1 mi) from the coast (grid ref. LE 255894)
Surroundings	Terrace
Site	Flat
Slope	Nil
Elevation	About 3 m (10 ft)
Site drainage	Receiving; freshwater flooding rare
Parent material	Medium-textured alluvium
Vegetation	Dipterocarp forest; dominant
Soil drainage	Moderately well drained

Horizon	Depth cm (in)		Description
A	0-3	(0-1)	Very dark brown (10YR 2/2); loam; strong granular structure; moist, friable; abrupt smooth boundary
EB1	3-13	(1-5)	Very dark greyish brown (10YR 3/2); clay loam; strong medium and fine subangular blocky structure; moist, friable; clear smooth boundary
EB2	13-30	(5-12)	Brown to dark brown (7.5YR 4/4); clay loam; strong fine subangular blocky and granular structure; moist, very friable; few thin patchy cutans; gradual smooth boundary
B1	30-58	(12-23)	Yellowish red (5YR 5/6) with prominent light yellowish brown (2.5YR 6/4) mottles; clay loam; strong subangular blocky structure; few manganese concretions; few thin patchy cutans; gradual smooth boundary
B2t	58-105	(23-42)	Yellowish red (5YR 4/6) with prominent light yellowish brown (2.5Y structure; moist, firm; few manganese concretions; few thin patchy cutans

Depth cm	Particle size distribution %				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	Total %	
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na			Fe	A1
3-13	4	47	17	28	2.2	0.29	6.8	18.8	1.9	0.2	0.3	23.4	91	n.d.	n.d.
13-30	5	55	16	24	0.5	0.10	6.3	10.9	0.6	0.2	0.2	14.0	85	2.2	3.0
30-58	4	51	13	29	0.2	0.07	6.0	10.5	0.1	0.1	0.3	14.8	74	2.6	1.2
58-105	6	42	13	36	0.3	0.07	5.9	13.4	0.2	0.2	0.4	18.7	76	3.2	2.6

PROFILE Lc3 (After Belsham 1969, p. 43)

Soil family	Sabor
Location	Taritipon estate, Bandau
Surroundings	Floodplain
Site	Flat
Slope	Nil
Elevation	6 m (20 ft)
Site drainage	Receiving
Parent material	Fine-textured alluvium derived from basic and ultrabasic rocks
Land use	Rubber
Soil drainage	Well drained

Horizon	Depth cm (in)		Description
A	0-7	(0-3)	Dark brown (7.5YR 3/2); sandy loam; weak coarse crumb structure; very friable; many fine pores; abundant medium and fine roots; clear smooth boundary
E1	7-22	(3-9)	Dark reddish brown (4YR 3/3); silt loam; moderate medium subangular blocky structure; friable; common fine pores; abundant medium and fine roots; gradual smooth boundary
E2	22-35	(9-14)	Dark reddish brown (5YR 3/3); silt loam; moderate medium subangular blocky structure; firm; thick continuous cutans; common fine pores; abundant medium and fine roots; gradual smooth boundary

Horizon	Depth cm (in)	Description
Blt	35-58 (14-23)	Dark reddish brown (5YR 3/3); clay loam; strong medium prismatic and coarse angular blocky structure; very firm; thick continuous cutans; few fine pores; fine roots; merging boundary
B2t	58-83 (23-33)	Dark reddish brown (5YR 3/3); silty clay; moderate coarse prismatic and coarse angular blocky structure; very firm; thick continuous cutans; few fine pores; common fine roots; merging boundary
B3t	83-104 (33-41)	Dark reddish brown (5YR 3/3); silty clay; moderate coarse prismatic and coarse angular blocky structure; very firm; thick continuous cutans; few fine pores; very few fine roots; merging boundary
B4t	104-120 (41-48)	Dark reddish brown (5YR 3/3); silty clay loam; coarse prismatic and coarse angular blocky structure; very firm; thick continuous cutans on ped surfaces; few fine pores; very few fine roots

Depth cm	Particle size distribution %				Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	Total Fe%
	Coarse sand	Fine sand	Silt	Clay					Ca	Mg	K	Na			
0-7	n.d.	n.d.	n.d.	n.d.	2.3	0.31	2	6.5	8.0	4.3	0.4	0.2	15.9	81	n.d.
7-22	8	47	16	25	0.1	0.14	tr.	5.7	6.5	4.2	0.1	0.1	15.2	58	1.3
22-35	n.d.	n.d.	n.d.	n.d,	0.4	0.06	tr.	6.1	5.4	7.7	0.1	0.1	20.1	67	n.d.
35-58	5	45	20	30	0.2	0.07	tr.	6.5	7.1	10.6	0.2	0.2	23.4	77	2
58-83	8	39	20	30	0.3	0.07	1	6.5	5.5	10.3	0.1	0.2	10.7	85	n.d.
83-104	14	37	20	25	0.2	0.05	1	7.0	4.0	10.6	0.1	0.2	29.7	76	n.d.
104-120	20	39	12	25	0.1	0.05	1	6.9	4.6	10.0	0.1	0.2	22.4	66	1.5

PROFILE Lc 4

Soil family	Sabor
Location	About 60 m (200 ft) W of the Sungai Karamuak, 3¼ km (2 mi) downstream from site of Soriano mining camp (grid ref. LB 842987)
Surroundings	Floodplain of the Karamuak
Site	Flat
Slope	Nil
Elevation	67.5 m (225 ft)
Site drainage	Receiving; freshwater flooding
Parent material	Medium-textured alluvium
Vegetation	Secondary forest
Soil drainage	Moderately well drained

Horizon	Depth cm (in)	Description
C	0-3 (0-1)	Dark greyish brown (10YR 4/2) with layers of yellowish red silt loam (5YR 4/8) and leaves; weak medium subangular blocky structure; wet, slightly sticky, slightly plastic; abrupt boundary
AB	3-13 (1-5)	Brown (7.5YR 5/4) with common coarse distinct greyish brown (10YR 5/2) and fine reddish brown (5YR 4/3) mottles; clay loam; strong medium angular blocky structure; moist, firm; thin patchy cutans; clear boundary

Horizon	Depth cm (in)		Description
B1	13-28	(5-11)	Brown (7.5YR 5/4) with many fine distinct brown (10YR 5/3) and reddish brown (5YR 4/3) mottles; clay loam; strong medium prismatic breaking to medium subangular blocky structure; moist, firm; common black manganese stains; thin continuous cutans
B2	28-60	(11-24)	Brown to dark brown (10YR 4/3) with few fine faint brown (10YR 5/3) and strong brown (7.5YR 5/6) mottles; clay loam; strong medium prismatic structure; moist, friable; many black stains around root channels; thin continuous cutans; clear boundary
B3t	60-85	(24-34)	Strong brown (7.5YR 5/6) with many fine distinct yellowish red (5YR 5/8) mottles; clay loam; moderate coarse prismatic breaking to medium subangular blocky structure; moist, firm; many black stains around root channels; thick continuous cutans; gradual boundary
B4t	85-125	(34-50)	Strong brown (7.5YR 5/6) with few fine distinct yellowish red (5YR 5/8) and common greyish brown (10YR 5/2) mottles; clay loam; moderate medium prismatic breaking to medium subangular blocky structure; moist, friable; many black stains around roots channels; moderately thick broken clayskins

Depth cm	Particle size distribution %				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na		
0-3	n.d.	n.d.	n.d.	n.d.	4.8	0.37	6.4	17.4	9.2	0.6	0.3	30.8	89
3-13	1	34	37	28	2.0	0.25	6.3	12.9	7.6	0.3	0.5	22.6	94
13-28	1	36	36	28	1.3	0.18	6.4	14.7	7.0	0.2	0.3	21.7	sat.
28-60	–	30	38	32	0.9	0.15	6.6	9.9	8.6	0.2	0.3	21.5	88
60-85	–	25	41	34	0.7	0.11	6.6	10.2	8.5	0.2	0.4	22.3	86
85-125	–	28	41	33	0.6	0.12	6.7	10.3	9.2	0.2	0.2	21.8	96

PROFILE Lc 5

Soil	Malawali
location	Ulu Tingkayu
Surroundings	Mountains; amplitude 450 m (1500 ft)
Site	Middle slope
Slope	28°; convex
Site drainage	Normal
Parent material	Serpentinite
Vegetation	Primary forest
Soil drainage	Well drained

Horizon	Depth cm (in)		Description
A	0-3	(0-1)	Very dark greyish brown (10YR 3/2); loam; strong fine subangular blocky structure; friable; many roots; common serpentinite stones; abrupt smooth boundary
E	3-23	(1-9)	Very dark grey (5YR 3/1); clay loam; strong medium to coarse subangular blocky structure; firm; thin broken cutans; many roots; many serpentinite stones; diffuse smooth boundary

Horizon	Depth cm (in)		Description
Blt	23-68	(9-27)	Dark brown (7.5YR 3/2); silty clay; strong medium to coarse subangular blocky structure; firm; thick broken and continuous cutans; many serpentinite stones; common roots; diffuse smooth boundary
B2	68-125	(27-50)	Reddish brown (5YR 4/4); clay; strong medium to coarse subangular blocky structure; many serpentinite stones; few roots

Depth cm	Particle size distribution %				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	Avail. P ppm
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na			
0-3	21	21	23	35	1.47	0.20	6.4	10.2	29.0	0.2	0.2	43.3	91	1
3-23	22	24	21	32	1.5	0.19	6.5	11.6	30.7	0.1	0.2	46.9	91	1
23-68	10	20	18	55	0.33	0.09	6.5	9.0	46.6	0.1	0.1	60.6	92	1
68-125	16	24	19	43	0.35	0.07	6.9	7.3	49.8	0.02	0.1	59.3	96	1

PROFILE Lc 6

Soil family	Beeston
Location	3 km (2 mi) SW of Kuala Kawag
Surroundings	Steep hills; amplitude 300 m (1000 ft)
Site	Middle slope
Slope	25°
Elevation	240 m (800 ft)
Site drainage	Normal
Parent material	Gabbro
Vegetation	Dipterocarp forest
Soil drainage	Well drained

Horizon	Depth cm (in)		Description
A	0-3	(0-1)	Dark greyish brown (10YR 4/2); humic loam; moderate fine and medium crumb structure; moist, friable; abundant roots; clear smooth boundary
E	3-18	(1-7)	Yellowish brown (10YR 5/6); clay loam; moderate fine and medium subangular blocky structure; moist, friable; few gabbro fragments; common roots; diffuse smooth boundary
Blt	18-53	(7-21)	Strong brown (7.5YR 5/6); clay; moderate fine and medium subangular blocky structure; moist, friable; moderately thick broken cutans; few roots, diffuse smooth boundary
B2t	53-90	(21-36)	Strong brown (7.5YR 5/6) with few fine distinct light olive grey (5Y 6/2) mottles; clay; moderate fine subangular blocky structure; moist, friable; common gabbro gravels and fine hard black concretions; common roots; diffuse smooth boundary
B3t	90-125	(36-50)	Strong brown (7.5YR 5/6); clay; moderate fine subangular blocky structure; moist, friable; many gabbro gravels and fine hard black concretions; moderately thick broken cutans; few roots

Depth cm	Particle size distribution %			Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	Total			Avail. P ppm
	Sand	Silt	Clay				Ca	Mg	K	Na			Mg%	K %	P ppm	
0-3	52	24	24	5.6	0.42	5.1	11.6	8.4	0.3	0.3	38.5	54	0.75	0.03	110	10
3-18	32	24	44	1.2	0.12	5.5	9.4	7.1	0.1	0.4	29.6	57	0.73	0.01	64	10
18-53	17	19	64	0.9	0.08	5.8	11.6	8.2	tr.	0.4	31.0	65	0.71	0.01	52	tr.
53-90	17	21	62	0.6	0.05	6.0	13.1	9.0	tr.	0.4	30.6	74	0.70	0.01	40	tr.
90-125	24	22	54	0.2	0.03	6.6	15.6	12.5	tr.	0.4	34.2	83	0.93	0.02	28	tr.

PROFILE Lc 7

Soil family Libong
Location About 1600 m (1 mi) NW of Sungai Tabin 800 m (½ mi) NW of Quoin Hill (grid ref. LD 677872)
Surroundings Moderate hills
Site Middle slope of low hill
Slope 27°
Elevation About 90 m (300 ft)
Site drainage Shedding
Parent material Tuff
Vegetation Dipterocarp forest
Soil drainage Well drained

Horizon	Depth cm (in)	Description
A	0-5 (0-2)	Dark reddish brown (5YR 3/4); clay loam; moderate medium subangular blocky structure; moist, very friable; abrupt boundary
B1	5-20 (2-8)	Yellowish red (5YR 4/6); clay loam; strong medium angular blocky structure; moist, friable; thin broken cutans; clear boundary
B2t	20-48 (8-19)	Yellowish red (5YR 4/6); clay loam; moderate medium subangular blocky structure; moist, friable; many gravel-sized and few small- and medium-sized tuff fragments; thin continuous cutans; merging boundary
B3t	48-78 (19-31)	Red (2.5YR 4/6); clay loam; weak fine subangular blocky structure; moist, friable; few small and many gravel-sized light olive grey (5Y 6/2) tuff fragments; thin broken cutans; merging boundary
BC	78-115 (31-46)	Yellowish red (5YR 4/6); clay loam; moderate medium subangular blocky structure; moist, friable; thin continuous cutans; dominant small and gravel-sized tuff fragments

Depth cm	Particle size distribution %				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na		
0-5	22	25	17	34	2.7	0.54	4.8	9.9	16.8	1.3	0.7	44.1	65
5-20	21	27	17	34	1.1	0.18	4.7	1.8	12.9	0.3	0.2	41.1	37
20-48	10	23	24	42	0.5	0.12	5.0	1.3	18.4	0.3	0.2	42.2	49
48-78	9	24	22	43	0.2	0.07	5.1	1.0	29.9	0.2	0.2	44.9	70
78-115	10	27	25	43	0.1	0.05	5.2	2.4	33.4	0.2	0.2	37.7	76

Horizon	Depth cm (in)	Description
Bt	30-60 (12-24)	Yellowish brown (10YR 5/6); silty clay loam; moderate coarse breaking to fine and medium angular blocky structure; moist, firm; thick broken cutans; common fine pores; very few roots; diffuse boundary
BC	60-120 (24-48)	Brown to dark brown (7.5YR 4/4) with common fine faint pale brown (10YR 6/3) mottles; silty clay loam; strong coarse angular blocky structure; moist, firm; thin patchy cutans on ped faces above 75 cm

Depth cm	Particle size distribution %				Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay					Ca	Mg	K	Na		
0-13	2	41	27	24	2.1	0.27	21	5.6	9.3	4.3	0.4	0.2	19.0	75
13-30	1	42	29	24	0.5	0.12	tr.	5.7	5.8	3.0	0.2	0.1	13.2	69
30-60	1	35	32	29	0.6	0.11	1	5.5	5.1	3.2	0.2	0.1	14.7	58
60-120	1	35	32	30	0.4	0.09	tr.	5.6	4.6	3.6	0.2	0.0	14.8	57

Depth cm	Total			Minerals of the clay fraction		
	P ppm	K%	Mg%	Vermiculite	Kaolinite	Illite
0-13	515	1.12	0.59	dom.	dom.	mod.
13-30	291	1.33	0.66	mod.	mod.	tr.
30-60	324	1.15	0.67	mod.	mod.	tr.
60-120	304	1.18	0.68	mod.	mod.	mod.

PROFILE Lo 3

Soil family	Tingkayu
Location	About 4 km (2½ mi) N of Kuala Binalik (grid ref. LB 954962)
Surroundings	Moderate hills; amplitude 120 m (400 ft)
Site	Upper slope of steep ridge
Slope	25°
Elevation	150m (500 ft)
Site drainage	Shedding
Parent material	Serpentinite
Vegetation	Dipterocarp forest
Soil drainage	Well drained

Horizon	Depth cm (in)	Description
A	0-10 (0-4)	Dark greyish brown (10YR 4/2); loam; strong fine and medium subangular blocky structure; moist, friable; common gravel-sized serpentinite fragments; clear boundary
B1t	10-25 (4-10)	Yellowish brown (10YR 5/4); clay loam; strong fine subangular to angular blocky structure; moist, friable; many gravel-sized and small serpentinite fragments; moderately thick broken cutans; clear boundary
B2t	25-43 (10-17)	Yellowish brown (10YR 5/4-5/6); clay loam; strong fine subangular to angular blocky structure; moist, friable; many gravel-sized and small serpentinite fragments; moderately thick continuous cutans; gradual wavy boundary
BC	43-60 (17-24)	Many large weathered serpentinite fragments; matrix as B2t

Depth cm	Particle size distribution %				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	Minerals of the clay fraction	
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na			Montmor-illonite	Chlorite
0-10	14	25	33	19	3.7	0.31	6.5	2.8	12.3	0.1	0.1	17.4	88	tr.	dom.
10-25	17	21	25	34	0.9	0.15	6.7	0.9	20.3	–	–	23.1	92	mod.	dom.
25-43	13	27	16	35	0.6	0.12	7.1	0.4	33.5	–	–	39.0	87	n.d.	n.d.

PROFILE Lo 4

Soil family	Tingkayu
Location	Umas Umas (grid ref. LH 511091)
Surroundings	Hills; amplitude 150 m (500 ft)
Site	Middle slope
Slope	10°
Elevation	120 m (400 ft)
Site drainage	Normal
Parent material	Serpentinite with minor sandstone and mudstone
Vegetation	Recently logged forest
Soil drainage	Well drained

Horizon	Depth cm (in)	Description
A	0-3 (0-1)	Brown to dark brown (10YR 4/3); humic sandy loam; moderate very fine subangular blocky structure; moist, very friable; abundant roots; clear smooth boundary
E	3-45 (1-18)	Yellowish brown (10YR 5/4); sandy loam; moderate fine subangular blocky structure; moist, friable; many sandstone and mudstone fragments; common roots; diffuse wavy boundary
B1t	45-78 (18-31)	Brown (10YR 6/6); clay loam; moderate very fine and fine subangular blocky structure; wet, slightly sticky and plastic; many sandstone, mudstone and serpentinite fragments; thick broken cutans; very few roots; diffuse smooth boundary
B2t	78-108 (31-43)	Brownish yellow (10YR 6/6); clay; structureless; moist, firm; many serpentinite and sandstone fragments; very few roots; diffuse smooth boundary
BC	108-125 (43-50)	Light olive brown (2.5Y 5/4); clay; structureless; wet, sticky, plastic; many serpentinite fragments

Depth cm	Particle size distribution %			Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	Total			Avail. P ppm
	Sand	Silt	Clay				Ca	Mg	K	Na			K%	Mg%	P ppm	
0-3	45	42	13	4.1	0.27	4.7	2.9	4.8	0.2	0.1	19.4	41	0.34	0.49	360	10
3-45	50	30	20	0.7	0.06	5.1	0.4	4.3	0.1	0.1	11.6	42	0.60	0.78	238	10
45-78	27	28	45	0.3	0.05	5.9	0.2	16.6	0.4	0.2	22.9	76	0.85	1.75	230	tr.
78-108	25	17	58	0.3	0.05	5.9	0.8	23.8	0.5	0.2	30.6	82	0.74	1.56	76	tr.
108-125	40	17	43	0.4	0.04	7.0	4.8	43.4	0.5	0.3	44.6	sat.	0.54	7.06	28	10

PROFILE Lo 5

Soil family	Kobovan
Location	About 800 m (½ mi) W of the Sungai Karamuak 5 km (2¾ mi) upstream from Kuala Karamuak (grid ref. LB 979865)
Surroundings	Low hills; amplitude 30 m (100 ft)
Site	Lower middle slope
Slope	22°
Elevation	45 m (150 ft)
Site drainage	Shedding
Parent material	Basic igneous rocks
Vegetation	Dipterocarp forest
Soil drainage	Well drained

Horizon	Depth cm (in)	Description
A	0-3 (0-1)	Dark brown (10YR 3/3); sandy loam; moderate fine subangular blocky structure; moist, friable; common small subangular basic rock fragments; abrupt boundary
B1tcn	3-9 (1-3)	Brown to dark brown (10YR 4/3); clay loam; moderate to strong fine subangular blocky structure; moist, friable; common very small hard black concretions; moderately thick broken cutans; clear boundary
B2tcn	9-28 (3-11)	Dark brown (7.5YR 4/4); clay loam; moderate fine subangular blocky structure; moist, friable; common small concretions and small rock fragments; moderately thick continuous cutans; clear boundary
B3cn	28-50 (11-19)	Brown to dark brown (7.5YR 4/4); fine sandy clay loam; moderate fine subangular blocky structure; moist, friable; common small concretions and many small to large rock fragments; clear boundary
C	50+ (19+)	Strongly weathered basic rocks

Depth cm	Particle size distribution %				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	Minerals of the clay fraction	
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na			Kaolinite	Vermiculite
0-3	n.d.	n.d.	n.d.	n.d.	3.5	0.35	6.5	23.1	9.0	0.2	0.2	35.3	92	dom.	dom.
3-9	14	28	25	30	1.2	0.20	6.1	15.7	9.4	0.1	0.2	30.2	84	dom.	dom.
9-28	14	28	22	28	0.6	0.12	5.9	7.4	10.1	0.1	0.2	29.2	61	dom.	dom.
28-50	13	40	20	23	0.3	0.06	6.3	14.1	15.3	0.1	0.2	34.2	92	dom.	dom.
50-55	54	28	7	6	0.2	0.04	6.6	19.8	17.1	–	0.2	39.9	91	dom.	dom.

PROFILE Lo 6

Soil family	Kobovan
Location	Gunong Gunatong (grid ref. FW 756100)
Surroundings	Mountains; amplitude 900 m (3 000 ft)
Site	Upper slope below very narrow ridge crest
Slope	35°; uneven
Elevation	About 585 m (1 950 ft)
Site drainage	Shedding
Parent material	Stony colluvium derived from basic igneous rocks
Vegetation	Dipterocarp forest
Soil drainage	Well drained

Horizon	Depth cm (in)	Description
AB	0-15 (0-6)	Dark brown (10YR 3/2); clay loam; strong fine subangular blocky structure; moist, very friable; common small hard rock fragments; clear boundary
Bt	15-45 (6-18)	Dark yellowish brown (10YR 4/4); clay loam; strong medium and fine subangular blocky structure; moist, very friable; many small hard rock fragments; thin patchy cutans; gradual boundary
BC	45-90 (18-36)	Yellowish brown (10YR 5/4 and 5/6); clay loam; moderate medium subangular blocky structure; moist, friable; many weathered rock fragments; thin patchy cutans

Depth cm	Particle size distribution %				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	Minerals of the clay fraction	
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na			Kaolinite	Halloysite
0-15	n.d.	n.d.	n.d.	n.d.	3.2	0.46	6.1	9.9	6.5	0.1	0.2	23.8	71	dom.	tr.
15-45	13	25	27	33	1.1	0.14	6.2	6.7	8.2	0.1	0.3	20.4	75	dom.	tr.
45-90	11	26	22	39	0.6	0.05	6.2	9.5	13.8	0.1	0.4	29.5	80	dom.	tr.

PROFILE Lo 7

Soil family	Kobovan
Location	Ulu Karamuak; about 1 500 m (1 mi) W of Tanjong Kapok; (grid ref. FX 804056)
Surroundings	Moderate hills; amplitude about 75 m (250 ft)
Site	Middle slope of ridge
Slope	16°
Elevation	About 100 m (350 ft)
Site drainage	Normal
Parent material	Gabbro
Vegetation	Dipterocarp forest
Soil drainage	Well drained

Horizon	Depth cm (in)	Description
A	0-8 (0-3)	Dark greyish brown (10YR 4/2) with common coarse distinct pale yellow (2.5Y 7/4) mottles; clay loam; strong fine and medium subangular blocky structure; moist, friable; common large surface stones; clear boundary
B1cn	8-18 (3-7)	Brown to dark brown (10YR 4/3); organic matter washings in channels; sandy clay loam; strong medium subangular and angular blocky structure; moist, friable; few stones, many small round black concretions; common small felspar fragments; thick broken cutans; clear boundary
B2t	18-43 (7-17)	Olive yellow (2.5Y 6/6); gritty clay loam; moderate coarse angular blocky structure; moist, firm; common small concretions; many felspar fragments; clear wavy boundary
C	43+ (17+)	Rotten rock, felspars dominant; yellowish brown (10YR 5/4) sandy clay loam matrix

Depth cm	Particle size distribution %				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na		
0-8	10	26	25	34	4.2	0.42	6.1	27.2	5.7	0.2	0.3	38.1	88
8-18	31	23	23	24	1.4	0.20	5.8	16.1	4.9	0.1	0.4	29.3	73
18-43	17	24	23	39	0.7	0.11	6.7	18.2	9.3	0.1	0.4	32.4	86
43-60	31	32	16	23	0.1	0.05	6.7	9.2	7.5	0.1	0.5	24.5	72

PROFILE Lo 8

Soil family	Talid
Location	About 1 600 m (1 mi) S of the Sungai Tabin 800 m (½ mi) from railway crossing (grid ref. LD 720888)
Surroundings	Low isolated hill with steep slopes and narrow crest
Site	Upper slope
Slope	25°; stepped
Elevation	75 m (250 ft)
Site drainage	Shedding
Parent material	Tuffite
Vegetation	Dipterocarp forest
Soil drainage	Well drained

Horizon	Depth cm (in)	Description
A	0-3 (0-1)	Very dark greyish brown (10YR 3/2); silt loam; strong fine subangular blocky and medium granular structure; moist, friable; abrupt smooth boundary
Bt	3-43 (1-17)	Yellowish brown (10YR 5/4); clay; strong coarse subangular blocky structure; dry, hard; few small soft tuffite fragments; thin patchy cutans
C	43-80 (17-32)	Tuffite dominant with yellowish brown (10YR 5/4) sandy clay loam in interstices

Depth cm	Particle size distribution %				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	Minerals of the clay fraction	
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na			Illite	Vermiculite
0-3	n.d.	n.d.	n.d.	n.d.	5.9	0.68	6.5	30.0	11.5	1.5	0.3	49.6	87	n.d.	n.d.
3-43	2	12	36	52	0.7	0.11	5.1	16.8	11.4	1.4	0.4	45.5	66	tr.	dom.
43-80	20	35	27	21	0.1	0.10	5.5	27.5	12.9	1.4	1.2	59.9	72	–	dom.

PROFILE Lo 9

Soil family	Talid
Location	9½ km (6 mi) SW of Kuala Bole
Surroundings	Hills; amplitude 60 m (200 ft)
Site	Upper slope
Slope	15° convex
Site drainage	Shedding
Parent material	Tuffaceous sandstone and tuff
Vegetation	Dipterocarp forest
Soil drainage	Moderately well drained

Horizon	Depth cm (in)	Description
A	0-4 (0-1½)	Very dark greyish brown (10YR 3/2); humic loam; moderate medium crumb structure; moist, friable; abundant roots; clear wavy boundary
E	4-18 (1½-7)	Brown to dark brown (7.5YR 4/4); sandy clay loam; moderate medium subangular blocky structure; moist, friable; few sandstone fragments; common roots; diffuse smooth boundary
B1t	18-80 (7-32)	Brown (7.5YR 5/4); clay; moderate medium subangular blocky structure; moist, friable; common stones and boulders of soft tuff; moderately thick broken cutans; few roots; diffuse smooth boundary

Horizon	Depth cm (in)	Description
B2t	80-125 (32-50)	Brown (7.5YR 5/4) with few fine distinct light grey (N 7) mottles; clay; weak coarse and medium subangular blocky structure; moist, firm; abundant stones and boulders; moderately thick broken cutans; few roots

Depth cm	Particle size distribution %			Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	Total			Avail. P ppm
	Sand	Silt	Clay				Ca	Mg	K	Na			K%	Mg%	P ppm	
0-4	72	17	11	4.9	0.32	5.9	1.5	14.1	0.4	0.6	33.5	50	1.16	1.07	82	tr.
4-18	54	20	26	1.5	0.13	5.4	9.3	25.0	0.3	0.7	35.9	98	1.34	1.44	58	tr.
18-80	37	17	46	0.4	0.03	5.7	13.8	3.8	0.5	0.2	31.7	58	0.35	0.29	320	40
80-125	34	17	49	0.4	0.03	6.3	8.8	2.1	0.3	0.2	19.1	60	0.44	0.39	204	10

PROFILE Lo 10

Soil family	Lumpongon
Location	Lungmanis Timber Camp; about 400 m (¼ mi) E of railway at Mile 5½ (grid ref. FX 595227)
Surroundings	Low hills and alluvial flats
Site	Lower middle slope
Slope	15°
Elevation	30 m (100 ft)
Site drainage	Normal
Parent material	Mudstone
Vegetation	Lowland dipterocarp forest (regenerating; logged in 1957)
Soil drainage	Moderately well drained

Horizon	Depth cm (in)	Description
A	0-5 (0-2)	Dark greyish brown (10YR 4/2); clay loam; strong medium subangular blocky structure; moist, friable, abrupt boundary
B1t	5-25 (2-10)	Yellowish brown (10YR 5/4) with common fine distinct light grey (10YR 7/1) mottles; clay; moderate coarse subangular blocky structure; moist, firm; common small hard concretions; thin continuous cutans; clear boundary
B2t	25-75 (10-30)	Yellowish brown (10YR 5/6) with many fine distinct light grey (10YR 7/1) and light yellowish brown (10YR 6/4) mottles; clay; moderate medium subangular and angular blocky structure; moist, firm, common small concretions; thick continuous cutans; gradual boundary
BC	75-123 (30-49)	Very pale brown (10YR 7/4) with many medium prominent yellowish brown (10YR 5/6) and light grey (5Y 7/1) mottles; clay; moderate fine angular blocky structure; moist, firm; many very small concretions; many weathered mudstone fragments; thick continuous cutans; clear boundary
C	123+ (49+)	Weathered mudstone

Depth cm	Particle size distribution %				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na		
0-5	4	19	37	31	3.5	0.4	6.2	16.7	8.1	0.6	0.2	29.1	88
5-25	4	14	36	43	0.7	0.2	5.3	4.6	8.2	0.5	0.1	20.6	65
25-75	2	8	36	50	0.1	0.1	5.8	0.2	18.4	0.5	0.2	23.3	83
75-123	2	12	40	45	0.1	0.1	5.9	0.6	18.9	0.5	0.3	23.1	88

Gleyic Cambisols (Bg)

PROFILE Bg 1

Soil family	Sinsulod
Location	Upper Bole road traverse 400 m (¼ mi) to E of Sungai Bole
Surroundings	Sungai Bole floodplain
Site	Level
Slope	Nil
Site drainage	Receiving
Parent material	Medium-textured stony alluvium derived from basic and ultrabasic rocks
Vegetation	Poor forest
Soil drainage	Imperfect; water table at 93 cm (37 in)

Horizon	Depth cm (in)	Description
A	0-3 (0-1)	Very dark greyish brown (10YR 3/2); humic clay; strong fine crumb structure; moist, friable; abundant roots; diffuse boundary
B1	3-20 (1-8)	Dark brown (10YR 3/3); clay; moderate medium subangular blocky structure; moist, friable; common roots; diffuse smooth boundary
B2	20-57 (8-23)	Brown to dark brown (10YR 4/3); silty clay; moderate medium and coarse subangular blocky structure; moist, friable; thin patchy cutans; diffuse smooth boundary
C1g	57-83 (23-33)	Dark greyish brown (2.5Y 4/2); silty clay loam; structureless; wet, sticky and plastic; abundant gravels and rounded stones of basic rocks; few roots; diffuse smooth boundary
C2g	83-125 (33-50)	Yellowish brown (10YR 5/6); clay; structureless; wet, sticky and plastic; common rounded stones and gravels; few roots

Depth cm	Particle size distribution%			Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Sand	Silt	Clay					Ca	Mg	K	Na		
0-3	19	13	68	5.8	0.41	1	5.6	4.1	8.8	0.2	0.3	30.4	44
3-20	42	15	43	1.8	0.17	tr.	5.9	0.8	10.1	0.1	0.1	20.1	55
20-57	29	30	41	0.8	0.09	tr.	6.5	0.8	15.6	tr.	tr.	26.2	63
57-83	39	33	28	0.4	0.05	tr.	6.6	0.5	8.8	tr.	tr.	14.8	63
83-125	59	8	33	0.3	0.04	tr.	6.9	1.1	9.8	tr.	tr.	16.7	65

PROFILE Bg 2

Soil family	Luba
Location	2.4 km (1½ mi) N of Brumas Camp on River Umas (grid ref. LC 583143)
Surroundings	Terraces and velley floors; amplitude 8 m (25 ft)
Site	Valley floor
Slope	Nil
Elevation	135 m (450 ft)
Site drainage	Receiving; frequent flooding
Parent material	Medium-textured alluvium
Vegetation	Dipterocarp forest
Soil drainage	Imperfect

Horizon	Depth cm (in)	Description
A	0-3 (0-1)	Dark yellowish brown (10YR 3/4); humic sandy loam; moderate very fine subangular blocky structure; moist, very friable; abundant roots; clear smooth boundary
B1	3-38 (1-15)	Yellowish brown (10YR 5/8) with few coarse distinct light grey (5Y 7/1) mottles; loam; moderate medium subangular blocky structure; moist, very friable; common roots; diffuse smooth boundary
B2	38-60 (15-24)	Yellowish brown (10YR 5/6) with few fine faint light grey (5Y 7/2) mottles; loam, moderate medium subangular blocky structure; moist, very friable; few roots; diffuse smooth boundary
B3	60-105 (24-42)	Yellowish brown (10YR 5/6) with many fine and medium distinct light grey (5Y 7/2) mottles; sandy loam; moderate fine to coarse subangular blocky structure; moist, friable; few fine soft manganese concretions; few roots; diffuse smooth boundary
B4g	105-125 (42-50)	Light grey (5Y 7/2) with many fine distinct strong brown (7.5YR 5/8) mottles; loam; moderate fine and medium subangular blocky structure; wet, non-sticky and non-plastic; many fine soft manganese concretions; very few roots

Depth cm	Particle size distribution%			Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Sand	Silt	Clay					Ca	Mg	K	Na		
0-3	77	17	6	4.3	0.32	12	4.6	0.3	0.6	0.3	0.1	7.5	17
3-38	62	17	21	0.4	0.05	1	4.6	–	0.2	0.1	0.1	n.d.	n.d.
38-60	60	17	23	0.3	0.03	2	4.8	–	0.1	0.1	0.1	8.4	4
60-105	70	10	20	0.2	0.03	tr.	5.2	–	0.1	0.1	0.1	6.5	5
105-125	67	10	23	0.3	0.03	tr.	5.3	–	0.4	0.1	0.1	6.6	9

Chromic Cambisols (Bc)

PROFILE Bc 1

Soil family	Mankawagu
Location	About 90 m (100 yd) W of the Sungai Mankawagu (grid ref. LB 514809)
Surroundings	Floodplain of the Mankawagu
Site	Valley flat
Slope	Level
Elevation	75 m (250 ft)
Site drainage	Freshwater flooding
Parent material	Coarse-textured alluvium
Vegetation	Regrowth following cultivation
Soil drainage	Moderately well drained; water table at 85 cm (34 in)

Horizon	Depth cm (in)	Description
A	0-3 (0-1)	Dark brown (7.5YR 3/2); loam; weak fine subangular blocky structure; moist, friable; abrupt boundary
B	3-30 (1-12)	Reddish brown (5YR 4/4); loam; strong medium and fine subangular blocky structure; moist, friable; thin continuous cutans; clear boundary
BC	30-125 (12-50)	Reddish brown (5YR 4/4); loamy sand; weak coarse subangular blocky structure; moist, very friable

Depth cm	Particle size distribution%				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na		
0-3	1	60	14	17	2.5	0.28	6.9	11.3	3.1	0.4	0.1	14.2	sat.
3-30	1	62	16	18	0.6	0.10	5.9	5.4	1.3	0.1	0.1	8.6	80
30-125	3	77	10	10	0.2	0.04	6.0	1.6	0.8	0.1	0.1	5.3	49

PROFILE Bc 2

Soil family	Mankawagu
Location	Bukit Garam (grid ref. FX 696056)
Surroundings	Low dissected hills; amplitude 45 m (150 ft)
Site	Narrow crest
Slope	5° with 30° slope to the NE and cliff to the SW
Elevation	About 60 m (200 ft)
Site drainage	Shedding
Parent material	Quartz and sandstone pebble deposit
Vegetation	Secondary forest
Soil drainage	Excessive

Horizon	Depth cm (in)	Description
A	0-3 (0-1)	Brown to dark brown (10YR 4/3); sand; many small quartz pebbles; clear smooth boundary
E	3-13 (1-5)	Dominant quartz and sandstone pebbles up to 10 cm (4 in) in diameter; matrix of dark yellowish brown (10YR 3/4); loamy sand; weak fine and medium granular structure
B1	13-50 (5-20)	Dominant quartz and sandstone pebbles; matrix of brown to strong brown (7.5YR 5/4-5/6); sandy loam; weak very fine subangular blocky structure; moist, friable; merging boundary

Horizon	Depth cm (in)	Description
B2	50-125 (20-50)	Dominant quartz and sandstone pebbles; matrix of strong brown (7.5YR 5/8); sandy loam; weak very fine subangular blocky structure; moist, friable

Depth cm	Particle size distribution%				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na		
0-13	40	36	9	13	2.7	0.22	4.4	1.3	0.1	0.2	0.1	7.9	21
13-50	32	39	11	19	1.1	0.12	4.1	0.1	0.2	0.1	0.1	6.0	9
50-125	37	33	12	20	0.6	0.06	4.3	0.2	0.2	0.1	0.1	4.8	10

PROFILE Bc 3 (After Hooper and Ives, 1964, p128)

Soil family	Silad
Location	Bukit Melawali; Labuk valley
Surroundings	Steep hills
Site	Valley side
Slope	25°
Site drainage	Shedding
Parent material	Ultrabasic igneous rocks
Vegetation	Forest
Soil drainage	Well drained

Horizon	Depth cm (in)	Description
O	2.5-0 (1-0)	Surface litter or decaying twigs and leaves
A	0-4 (0-1½)	Brown to dark brown (7.5YR 4/4); silt loam; moderate fine blocky and medium to fine crumb structure; very friable; abundant fine fibrous and common small woody roots; merging boundary
AB	4-15 (1½-6)	Brown to dark brown (7.5YR 4/4); silty clay loam; moderate fine to medium blocky and fine crumb structure; common fine fibrous and small woody roots; merging boundary
B	15-53 (6-21)	Dark reddish brown (5YR 3/4) with common faint medium to coarse reddish brown (5YR 4/4) mottles; silty clay loam; weak medium blocky structure; few fine fibrous and small woody roots; wavy boundary
C	53+ (21+)	Rock dominant; boulders of weathering serpentinite

Depth cm	Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
					Ca	Mg	K	Na		
4-15	2.4	0.26	2	5.9	0.9	0.9	tr.	0.1	13.3	14
15-53	0.6	0.05	1	6.0	0.9	1.4	tr.	0.1	9.7	25

PROFILE Bc 4

Soil family	Kawa
Location	Headwaters of Sungai Lamag; 16 km (9 mi) S of Kuala Lamag (grid ref. LC 645839)
Surroundings	Moderate hills with steep slopes

Site	Upper slope
Slope	30°
Elevation	About 150 m (500 ft)
Site drainage	Shedding
Parent material	Amygdaloidal basalt
Vegetation	Dipterocarp forest
Soil drainage	Well drained

Horizon	Depth cm (in)		Description
AB	0-8	(0-3)	Dark reddish grey (5YR 4/2); sandy loam; strong medium angular blocky structure; moist, friable; common gravel and few small stones; moderately thick continuous cutans; gradual boundary
B1	8-25	(3-10)	Dark reddish grey (5YR 4/2); sandy clay loam; moderate medium angular blocky structure; moist, friable; many gravel-sized stones; moderately thick cutans; gradual boundary
B2	25-65	(10-26)	Reddish brown (5YR 4/3); sandy clay loam; moderate coarse subangular blocky structure; moist, friable; many gravel-sized and few small stones; thin cutans; gradual boundary
BC	65-90	(26-36)	Reddish brown (5YR 4/4); sandy clay loam; weak medium subangular blocky structure; moist, firm; many gravel-sized and small to medium stones; patchy cutans

Depth cm	Particle size distribution%				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	Total %		Minerals of the clay fraction	
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na			Fe	A1	Vermic-ulite	Montmorill-onite
0-8	16	34	27	20	1.6	0.53	5.5	43.1	6.7	0.8	0.5	49.7	80	8.8	3.3	n.d.	n.d.
8-25	15	32	27	25	0.7	0.17	5.3	27.0	5.7	0.7	0.2	51.8	65	8.8	3.3	dom.	dom.
25-65	20	33	20	23	0.4	0.16	5.6	33.7	4.4	0.4	0.3	52.3	76	8.0	4.0	tr.	dom.
65-90	27	36	13	24	0.1	0.02	6.0	40.2	7.7	0.4	2.0	54.3	92	6.2	3.6	tr.	dom.

PROFILE Bc 5 (After Wilson, 1969a, p59)

Soil family	Sadok
Location	Gudong Sadok Sadok, Kota Belud District
Surroundings	Mountains
Site	Middle slope
Slope	33°
Elevation	1 035 m (3 450 ft)
Site drainage	Shedding
Parent material	Granite
Soil drainage	Well drained

Horizon	Depth cm (in)		Description
O	5-0	(2-0)	Organic debris; abrupt smooth boundary
A	0-4	(0-1½)	Dark reddish brown (5YR 3/2); loam; weak fine granular structure; friable; clear smooth boundary
B	4-30	(1½-12)	Brown to dark brown (7.5YR 4/4) with weak dark reddish brown (5YR 3/3) stains; loam; weak fine to coarse granular structure; friable; few quartz grains and granite pebbles; diffuse smooth boundary

Horizon	Depth cm (in)		Description
BC	30-60	(12-24)	Strong brown (7.5YR 5/6); loam; weak fine granular structure friable; granite fragments
C	60+	(24+)	Weathering granite

Depth cm	Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
					Ca	Mg	K	Na		
5-0	40.1	1.66	95	3.6	0.9	2.4	1.3	0.3	105.6	5
0-4	15.2	1.06	9	4.3	0.3	0.6	0.4	0.1	36.5	4
4-30	4.5	0.29	1	5.0	0.3	0.2	0.1	0.2	13.0	6
30-60	1.4	0.07	5	5.0	0.3	0.1	0.1	0.1	7.4	8

PROFILE Bc 6

Soil family Juak
Location Headwaters of Sungai Imbak about 18 km (11 mi) SE of its confluence with Sungai Kuamut (grid ref. LC 232269)
Surroundings Mountains with amplitude of about 900 m (3 000 ft)
Site Knoll on ridge with very steep slopes
Slope 25°
Elevation 750 m (2 500 ft)
Site drainage Shedding
Parent material Chert
Vegetation Dipterocarp forest
Soil drainage Well drained

Horizon	Depth cm (in)		Description
A	0-3	(0-1)	Dark reddish brown (5YR 3/2); clay loam; strong fine subangular blocky structure
B	3-75	(1-30)	Reddish brown (5YR 4/3); silty clay loam; strong medium subangular blocky structure; moist, friable; many large red angular chert boulders
C	75+	(30+)	Red chert

Depth cm	Particle size distribution%				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na		
3-75	15	26	29	29	0.21	9	4.8	2.3	14.3	0.2	0.3	25.6	67

PROFILE Bc 7

Soil family Luasong
Location 3 km (2 mi) SE of Beaufort (grid ref. FY 397877)
Surroundings Moderate hills
Site Valleyside
Slope 27°
Elevation 70 m (200 ft)
Site drainage Shedding
Parent material Sandstone and shale
Land use Rubber
Soil drainage Well drained

Horizon	Depth cm (in)		Description
A	0-8	(0-3½)	Dark brown (10YR 4/3); loam; strong coarse granular structure; friable; many roots; clear irregular boundary
AB	8-18	(3½-7)	Yellowish brown (10YR 5/6) and dark greyish brown (10YR 5/2); sandy clay loam; moderate medium subangular blocky structure; friable; common roots; gradual wavy boundary
B	18-40	(7-16)	Strong brown (7.5YR 5/6); sandy clay loam; moderate medium subangular blocky structure; friable; common roots; gradual irregular boundary
BC	40-80	(16-24)	Yellowish brown (7.5YR 5/8) with common pale yellow mottles; sand clay loam; moderate fine subangular blocky structure; friable; many sandstone fragments; irregular boundary
C	80+	24+	Predominantly sandstone with shale

Depth cm	Particle size distribution%				Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay					Ca	Mg	K	Na		
0-8	7	56	17	19	2.1	0.18	4	5.6	1.6	2.1	0.5	0.1	10.1	42
8-18	6	56	16	24	0.9	0.12	2	5.1	0.3	1.1	0.2	0.1	7.6	22
18-40	7	56	17	24	0.4	0.07	2	5.0	0.1	0.3	0.1	tr.	6.0	10
40-80	9	53	16	27	0.2	0.06	2	5.2	0.1	0.1	0.1	tr.	5.5	5

Dystric Cambisols (Bd)

PROFILE Bd 1

Soil family	Kelawat
Location	Kampong Bankuan, Tomani, Tenom (grid ref. LA 548377)
Surroundings	River terrace
Site	Flat
Slope	Nil
Elevation	225 m (750 ft)
Site drainage	Normal
Parent material	Medium-textured alluvium
Land use	Old rubber plantation
Soil drainage	Moderately well drained

Horizon	Depth cm	(in)	Description
A	0-8	(0-3)	Brown to dark brown (10YR 4/3); loam; moderate to strong medium and fine angular blocky structure; moist, friable; common fine pores; common fine and medium roots; diffuse boundary
B1	8-45	(3-18)	Dark yellowish brown (10YR 4/4); loam; structure and consistence as above; thin cutans on ped faces and in pores; common fine pores; common roots; gradual smooth boundary
B2	45-90	(18-36)	Yellowish brown (10YR 5/4) with common medium and coarse distinct strong brown (7.5YR 5/6) mottles; loam; moderate medium and coarse subangular blocky structure; moist, friable, thin broken cutans on ped faces; common fine pores; very few small soft iron nodules; common roots; diffuse boundary
C	90-120	(36-48)	Yellowish brown (10YR 5/4); loam

Depth cm	Particle size distribution%				Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	Total		
	Coarse sand	Fine sand	Silt	Clay					Ca	Mg	K	Na			P ppm	K %	Mg %
0-8	2	33	39	22	2.1	0.22	12	5.7	9.7	4.1	0.4	0.1	16.9	84	422	1.65	0.77
8-45	1	35	37	21	0.7	0.12	1	5.7	0.8	3.4	0.3	0.1	13.8	33	344	1.62	0.77
45-90	–	39	42	21	0.4	0.09	1	5.9	0.7	4.1	0.3	0.1	13.3	39	316	1.73	0.77
90-120	–	35	42	24	0.5	0.10	–	6.0	0.7	4.8	0.3	0.1	10.5	56	293	1.73	0.77

PROFILE Bd 2 (After Wilson, 1969a, p34)

Soil family	Meliau
Location	Kota Belud District
Surroundings	Mountains
Site	Steep slope
Site drainage	Shedding
Parent material	Ultrabasic igneous rocks
Soil drainage	Well drained

Horizon	Depth cm	(in)	Description
A	0-5	(0-2)	Dark greyish brown (10YR 4/2); sandy loam; weak fine granular structure; friable; many stones; gradual boundary
B	5-35	(2-14)	Yellowish brown (10YR 5/7); fine sandy loam; weak fine granular structure; friable; many stones
C	35+	(14+)	Rock dominant

Depth cm	Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
					Ca	Mg	K	Na		
0-5	2.0	0.44	5	5.0	1.6	8.1	0.2	0.1	18.8	53
5-35	1.0	0.13	1	5.3	0.3	2.6	0.1	0.1	7.2	43

PROFILE Bd 3 (After Hooper and Ives, 1964, p109)

Soil family	Nerelud
Location	East of Bukit Minau, Lubuk valley
Surroundings	Ridges
Site	Ridge side
Slope	12°
Site drainage	Shedding
Parent material	Basic igneous rocks
Vegetation	Primary forest
Soil drainage	Well drained

Horizon	Depth cm (in)		Description
A1	0-4	(0-1½)	Brown to dark brown (10YR 4/3); loam; very small amounts of incorporated humus; strong fine to medium blocky and weak fine granular structure; dry, slightly hard; many roots; merging boundary
A2	4-9	(1½-3½)	Dark yellowish brown (10YR 4/4); clay loam; small amounts of incorporated humus; strong medium to fine angular and weak fine granular structure; firm; common roots; merging boundary
B1	9-25	(3½-10)	Yellowish brown (10YR 5/6); clay loam; humus along old root channels; moderate medium to fine angular blocky structure; friable to firm; few roots; diffuse boundary
B2	25-77	(10-31)	Yellowish brown (10YR 5/6); clay loam; moderate medium to fine blocky structure; friable to very friable; diffuse smooth boundary
BC	77-127	(31-51)	Yellowish brown (10YR 5/8); clay loam, slightly stony with gravel-sized subangular basic rock fragments; moderate to weak medium to fine blocky structure; friable

Depth cm	Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
					Ca	Mg	K	Na		
0-4	5.3	0.62	10	5.3	10.4	7.4	0.4	0.2	29.7	62
4-9	1.9	0.31	6	5.9	0.3	3.5	0.2	0.2	15.5	27
9-25	2.0	0.28	5	4.6	0.3	2.5	0.1	0.1	14.6	21
25-77	0.6	0.10	1	4.9	0.7	1.7	tr.	0.1	10.6	24
77-122	0.4	0.07	1	5.1	0.5	tr.	0.1	0.5	9.0	12

PROFILE Bd 4

Soil family	Tenggara
Location	About 1 500 m (1 mi) N of Sungai Segama 1 500 m upstream from Kuala Tagas Tagas (grid ref. LD 500912)
Surroundings	Moderate hills
Site	Middle slope
Slope	35°

Elevation	About 90 m (300 ft)
Site drainage	Shedding
Parent material	Tuffite
Vegetation	Recently felled dipterocarp forest
Soil drainage	Well drained

Horizon	Depth cm (in)		Description
A	0-5	(0-2)	Dark brown (10YR 3/3); loam; strong granular and medium subangular blocky structure; moist friable; few angular tuffite fragments; clear smooth boundary
B	5-20	(2-8)	Yellowish brown (10YR 5/4); gritty clay loam; strong medium and fine subangular blocky structure; moist, friable; common tuffite fragments; gradual irregular boundary
C	20-125	(8-50)	Rotten tuffite; variegated yellowish brown to strong brown with grey, black and yellowish red mottles

Depth cm	Org. C%	Total N%	pH H_2O	Exch cations meq%				CEC meq%	Base satn. %
				Ca	Mg	K	Na		
0-5	5.4	0.45	5.2	14.5	7.6	0.7	0.2	33.9	68
5-20	1.0	0.16	4.4	1.6	4.3	0.4	0.2	27.9	23

PROFILE Bd 5 (After Thomas, 1967a, p26)

Soil family	Durikong
Location	Mile 11 on the main road from Bakapit Camp, Lahad Datu District
Surroundings	Mountains
Site	Terrace
Slope	5^0
Site drainage	Normal
Parent material	Conglomerate
Vegetation	Regenerating forest after logging
Soil drainage	Well drained

Horizon	Depth cm (in)		Description
A	0-3	(0-1)	Brown (10YR 5/3); humic sandy clay loam; moderate very fine subangular blocky structure; friable; common roots
AB	3-45	(1-18)	Yellowish brown (10YR 5/8); silty clay; moderate subangular blocky structure; firm; few roots
B	45-90	(18-36)	Brown (7.5YR 5/4) with many light olive brown (2.5YR 5/4) mottles; silty clay; moderate medium subangular blocky structure; firm; few fine fragments of white chert; few roots
C	90-105	(36-42)	Brown (7.5YR 5/4) with many light olive brown (2.5YR 5/4) mottles; silty clay; moderate medium subangular blocky structure; firm; dominant subangular chert fragments

Depth cm	Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
					Ca	Mg	K	Na		
0-3	4.5	0.19	tr.	4.7	0.8	0.9	0.2	0.2	12.6	17
3-45	1.4	0.11	–	4.6	0.4	0.3	0.1	0.2	14.5	7
45-90	0.8	0.08	–	5.2	0.2	0.7	0.1	0.1	17.2	6
90-105	0.5	0.06	–	5.3	0.2	0.2	0.1	0.1	10.1	6

PROFILE Bd 6

Soil family	Laab
Location	5 km (3 mi) SW of Luasong (grid ref. LC 166056)
Surroundings	Steep ridge; amplitude 90 m (300 ft)
Site	Upper slope
Slope	27°
Elevation	210 m (700 ft)
Site drainage	Shedding
Parent material	Mudstone and sandstone
Vegetation	Dipterocarp forest
Soil drainage	Well drained

Horizon	Depth cm (in)		Description
A	0-3	(0-1)	Dark yellowish brown (10YR 4/4); humic loam; strong very fine subangular blocky structure; moist, very friable; abundant roots; abrupt smooth boundary
B	3-50	(1-20)	Brownish yellow (10YR 6/6); loam; moderate fine and medium subangular blocky structure; moist friable; common mudstone fragments; common roots; diffuse irregular boundary
C	50-70	(20-28)	Brownish yellow (10YR 6/6); sandy clay loam; weak fine subangular blocky structure; moist, friable; many mudstone fragments; few roots
R	70+	(28+)	Mudstone and sandstone

Depth cm	Particle size distribution%			Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn %
	Sand	Silt	Clay					Ca	Mg	K	Na		
0-3	45	37	18	4.1	0.29	7	4.2	0.7	2.6	0.4	0.1	11.1	34
3-50	42	65	23	1.0	0.13	2	4.6	–	1.6	0.2	0.2	11.5	17

PROFILE Bd 7

Soil family	Antulai
Location	6.4 km (4 mi) E of Kampong Pangaraan, Pensiangan (grid ref. LA 947 225)
Surroundings	Mountains
Site	Saddle on ridge
Slope	10°
Elevation	1 080 m (3 600 ft)
Site drainage	Receiving
Parent material	Sandstone colluvium
Vegetation	Montane forest
Soil drainage	Well drained

Horizon	Depth cm (in)		Description
O	2-0	(½-0)	Litter and mor
A	0-4	(0-1½)	Dark brown (7.5YR 3/2); sandy loam; weak fine subangular blocky structure; moist, very friable; common fine pores; abundant roots; clear smooth boundary
B1	4-28	(1½-11)	Yellowish brown (10YR 5/8); loam; weak fine and medium subangular blocky structure; moist, friable; common fine pores; common roots; diffuse boundary

Horizon	Depth cm (in)		Description
B2	28-80	(11-24)	Brownish yellow (10YR 6/8); loam; weak fine and medium subangular blocky structure; moist, friable; few roots; diffuse boundary
C	80+	(24+)	Weathering sandstone with coarse sandy loam matrix

Depth cm	Particle size distribution%				Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay					Ca	Mg	K	Na		
0-4	–	–	–	–	8.4	0.53	9	4.0	0.3	0.4	0.3	tr.	27.4	4
4-28	12	53	14	19	0.9	0.07	2	4.6	0.1	0.1	0.1	–	10.2	4
28-80	9	58	12	19	0.5	0.03	1	4.8	0.1	0.1	tr.	–	6.0	4

Eutric Cambisols (Be)

PROFILE Be 1

Soil family	Bulanat
Location	Mile 4 on the Tenom to Melalap road (grid ref. LA 611709)
Surroundings	River terrace
Site	Terrace flat
Slope	1°
Elevation	210 m (700 ft)
Site drainage	Normal
Parent material	Medium-textured alluvium
Lane use	Cocoa and banana plantation
Soil drainage	Well drained

Horizon	Depth cm (in)	Description
A	0-13 (0-5)	Brown to dark brown (10YR 4/3); sandy loam; strong medium crumb to fine subangular blocky structure; moist, friable; many fine pores; many fine and medium roots; gradual smooth boundary
B1	13-35 (5-14)	Yellowish brown (10YR 5/4); sandy loam to sandy clay loam; strong medium and fine angular blocky structure; moist, firm; thin continuous cutans on ped faces and in pores; many fine pores; common roots; diffuse boundary
B2	35-63 (14-25)	Dark yellowish brown (10YR 4/4); sandy loam; moderate medium subangular blocky structure; moist, friable; moderately thick continuous cutans on ped faces and in pores; common fine pores; fewgravel-sized fragments of weathering sandstone; few small soft irregular black iron-manganese nodules; few roots; diffuse boundary
BC	63-120 (25-48)	Yellowish brown (10YR 5/4); sandy loam; moderate to strong medium and coarse subangular blocky structure; moist, firm; thin broken cutans on ped faces above 90 cm; common fine pores; few gravel-sized fragments of weathering sandstone; few roots

Depth cm	Particle size distribution%				Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch, cations meq%				CEC meq%	Base satn. %	Total		
	Coarse sand	Fine sand	Silt	Clay					Ca	Mg	K	Na			P ppm	K %	Mg %
0-13	9	46	20	21	1.7	0.21	22	5.6	4.9	2.3	0.6	0.1	13.6	58	459	1.28	0.37
13-35	9	48	20	22	0.6	0.11	3	5.2	3.1	2.1	0.3	0.1	10.4	54	299	0.11	0.42
35-63	10	54	17	18	0.2	0.05	tr.	6.2	3.8	2.6	0.2	0.1	8.5	78	180	0.92	0.41
63-120	14	50	17	19	0.1	0.05	tr.	6.3	4.2	3.2	0.1	0.2	9.1	84	176	1.48	0.46

Depth cm	Minerals of the clay fraction			
	Illite	Vermi-culite	Kaolin-ite	Quartz
0-13	n.d.	n.d.	n.d.	n.d.
13-35	mod.	mod.	tr.	tr.
35-63	mod.	mod.	tr.	tr.
63-120	n.d.	n.d.	n.d.	n.d.

PROFILE Be 2

Soil family	Binuang
Location	Headwaters of Sungai Takala about 11 km (7mi) S of confluence with the Kinabatangan (grid ref. LC 824855)
Surroundings	Moderate hills; amplitude 60 m (200 ft)
Site	Crest of steep hill
Slope	Convex crest with 20-40° slopes below
Elevation	About 150 m (500 ft)
Site drainage	Shedding
Parent material	Serpentinite
Vegetation	Forest rich in *Tristania grandifolia*
Soil drainage	Well drained

Horizon	Depth cm (in)		Description
A	0-1	(0-½)	Black (10YR 2/1); clay loam
B	1-30	(½-12)	Very dark greyish brown (10YR 3/2); silty clay; strong coarse granular structure; moist, firm; common small to large weathered serpentinite fragments; merging boundary
BC	30-48	(12-19)	Very dark greyish brown (10YR 3/2); clay; moderate medium granular structure; moist, friable; many serpentinite fragments; clear boundary
C	48+	(19+)	Dominant strongly weathered serpentinite

Depth cm	Particle size distribution%				Org. C%	Total N%	pH		Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay			H_2O	KCL	Ca	Mg	K	Na		
1-30	5	17	39	40	2.1	0.42	5.8	5.5	0.2	52.9	0.3	0.2	51.9	sat.
30-48	11	23	25	44	0.8	0.20	6.3	6.1	–	60.4	0.1	0.1	62.3	98

PROFILE Be 3

Soil family	Hatton
Location	3.2 km (2 mi) E of Kuala Danum
Surroundings	Steep hills; amplitude 300 m (1 000 ft)
Site	Middle slope
Slope	15°
Site drainage	Normal
Parent material	Tuff
Vegetation	Dipterocarp forest
Soil drainage	Well drained

Horizon	Depth cm (in)		Description
A	0-3	(0-1)	Very dark greyish brown (10YR 3/2); humic loam; moderate very fine to fine subangular blocky structure; moist, friable; frequent roots; clear smooth boundary
E	3-23	(1-9)	Brown to dark brown (10YR 4/3); loam; moderate fine and medium subangular blocky structure; moist, friable; common roots; diffuse smooth boundary
B1	23-67	(9-23)	Dark yellowish brown (10YR 4/4); loam; moderate fine and medium subangular blocky structure; moist, friable; common gravels and stones of tuff; moderately thick patchy cutans; few roots; diffuse smooth boundary

Horizon	Depth cm (in)		Description
B2	67-97	(23-39)	Yellowish brown to dark yellowish brown (10YR 5/4-4/4); clay loam; moderate coarse subangular blocky structure; moist, firm; many stones; thick continuous cutans; few roots; diffuse smooth boundary
C	97+	(39+)	Rotting tuff

Depth cm	Particle size distribution%			Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Sand	Silt	Clay					Ca	Mg	K	Na		
0-3	62	25	33	4.8	0.36	1	5.9	8.5	25.9	0.1	0.3	47.0	74
3-23	35	32	33	1.2	0.10	tr.	5.7	1.2	27.1	0.2	0.1	40.5	71
23-67	52	30	18	0.4	0.10	tr.	5.9	3.0	28.8	0.3	0.1	44.2	73
67-97	70	12	18	0.3	0.04	tr.	6.3	10.0	34.7	0.3	0.1	46.4	97

Albic Arenosols (Qa)

PROFILE Qa 1

Soil family	Serai
Location	1.6 km (1 mi) W of Kampong Labok (grid ref. LA 190686)
Surroundings	Terrace
Site	Terrace flat
Slope	Nil
Elevation	40 m (130 ft)
Site drainage	Receiving
Parent material	Siliceous sand
Vegetation	Sparse heath forest with many ferns
Soil drainage	Imperfect; water seepage at 60 cm (24 in)

Horizon	Depth cm (in)		Description
A	0-13	(0-5)	Black (5YR 2/1); humic sand; structureless, single grain; dry, very friable; many charcoal fragments; abundant roots; clear wavy boundary
E1	13-45	(5-18)	Pinkish grey (7.5YR 7/2); sand; structureless, single grain; moist, firm; few charcoal fragments; few roots; gradual smooth boundary
E2	45-120	(18-48)	White (10YR 8/1); sand; structureless, massive breaking to single grain; moist to wet, very firm becoming increasingly compacted with depth.

Depth cm	Particle size distribution%				Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay					Ca	Mg	K	Na		
0-13	28	52	3	2	3.9	0.15	5	2.1	0.2	0.1	0.3	0.3	18.1	4
13-45	31	64	–	1	0.2	0.02	tr.	3.4	0.2	–	tr.	0.2	0.6	67
45-120	29	62	2	3	–	–	–	5.3	0.2	–	–	0.2	0.3	sat.

PROFILE Qa 2

Soil family	Serai
Location	Labuan; Mile 2 on the Victoria to Layang road (grid ref. PE 820842)
Surroundings	Undulating terrace
Site	Terrace flat
Slope	Nil
Elevation	12 m (40 ft)
Site drainage	Normal
Parent material	Siliceous sand
Vegetation	Sparse grasses and bushes
Soil drainage	Excessive

Horizon	Depth cm (in)		Description
A	0-13	(0-5)	Grey (2.5Y 5/1); fine sand; structureless, single grain; moist, loose; frequent fine roots; clear smooth boundary
E1	13-61	(5-24)	Light grey (2.5Y 7/2); sand; structureless, single grain; moist loose; few fine roots; gradual smooth boundary
E2	61-236	(24-93)	White (2.5Y 8/2); sand; structureless, single grain; moist, loose; very few fine roots

Depth cm	Particle size distribution%				Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay					Ca	Mg	K	Na		
0-13	6	90	3	1	0.6	0.04	8	5.0	0.6	–	tr.	0.2	2.5	32
13-61	5	92	3	1	0.1	0.04	–	5.6	0.2	0.1	–	0.1	0.5	80
61-236	5	92	2	1	0.0	0.01	–	5.7	0.2	0.1	–	0.1	0.9	44

Cambic Arenosols (Qc)

PROFILE Qc 1

Soil family	Pisau
Location	Pulau Berhala (grid ref. FY 033495)
Surroundings	Beach
Site	Beach flat
Slope	Nil
Elevation	1.5-3 m (10-15 ft)
Site drainage	Normal
Parent material	Coral sand
Land use	Coconut plantation
Profile drainage	Well drained

Horizon	Depth cm (in)	Description
Ap	0-10 (0-4)	Dark brown (7.5YR 3/2); loamy sand; moderate granular structure; dry, slightly hard; common coral fragments; abrupt boundary
B	10-45 (4-18)	Strong brown (7.5YR 5/6); dominant gravel-sized coral fragments; loamy sand; weak subangular blocky structure; diffuse boundary
C	45-125 (18-50)	Pinkish grey (7.5YR 7/2); dominant gravel-sized coral fragments; weak subangular blocky structure; dry, soft

Depth cm	Particle size distribution%				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %	Total Fe %	$CaCO_3$ equiv. %
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na				
0-10	42	29	11	12	4.2	0.46	7.4	46.7	0.6	0.2	0.8	18.2	sat.	n.d.	n.d..
10-45	51	29	9	9	1.0	0.25	7.7	30.6	0.3	0.1	0.7	7.0	sat.	2.5	63.0
45-125	73	12	7	6	0.6	0.09	8.0	32.5	0.3	0.1	0.7	2.5	sat.	1.4	84.0

PROFILE Qc 2

Soil family	Kabili
Location	Sepilok Forest Reserve; Forest Plot No 16 (grid ref. FX 781421)
Surroundings	Alluvial flats and low hills
Site	Flat between 2 small rivers
Slope	Level
Elevation	15 m (50 ft)
Site drainage	Freshwater flooding; infrequent flash floods
Parent material	Coarse-textured alluvium
Vegetation	Lowland dipterocarp forest
Soil drainage	Imperfect

Horizon	Depth cm (in)	Description
A	0-18 (0-7)	Dark yellowish brown (10YR 4/4) with many bleached sand grains; loamy sand; strong granular structure; moist, very friable; abrupt boundary
B	18-55 (7-22)	Brownish yellow (10YR 6/6); loamy sand; weak coarse subangular blocky structure; moist, very friable; gradual boundary
C1	55-80 (22-32)	Brownish yellow (10YR 6/8) with many coarse distinct pale yellow (2.5Y 7/4) mottles; sand; structureless, but coherent; moist, very friable; clear boundary

Horizon	Depth cm (in)		Description
C2g	80-108	(32-43)	Brownish yellow (10YR 6/8) and light grey (2.5Y 7/2) with common distinct fine yellowish red (5YR 5/6) mottles; sand; structureless, but coherent; moist, very friable; clear boundary
C3g	108-125	(43-50)	Pale yellow (2.5Y 7/4) and light grey (2.5Y 7/2) with common distinct fine strong brown (7.5YR 5/8) mottles; loamy sand; structureless, but coherent; moist, very friable

Depth cm	Particle size distribution%				Org. C%	Total N%	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay				Ca	Mg	K	Na		
0-18	3	77	6	14	1.5	0.16	4.1	0.2	0.8	0.1	0.1	7.6	16
18-55	4	81	6	12	0.4	0.08	4.5	0.1	0.3	0.1	0.1	5.7	10
55-80	14	81	2	4	0.04	0.02	4.7	0.1	0.1	0.1	0.1	2.2	19
80-108	14	76	4	7	0.1	0.05	4.4	0.1	0.1	0.1	0.1	3.4	12
108-125	4	82	7	9	0.1	0.03	4.4	0.1	0.1	0.1	0.2	3.7	16

PROFILE Qc 3

Soil family	Pangarangan
Location	Ulu Sipitang (grid ref. LA 206617)
Surroundings	Low hills
Site	Middle slope
Slope	35°
Elevation	30 m (100 ft)
Site drainage	Shedding
Parent material	Sandstone
Land use	Overgrown rubber plantation
Soil drainage	Well drained

Horizon	Depth cm (in)		Description
O	3-0	(1-0)	Organic litter layer
A	0-15	(0-6)	Dark brown (10YR 3/3); loamy coarse sand; weak fine crumb structure; dry, friable to loose; abundant roots; clear smooth boundary
B1	15-45	(6-18)	Strong brown (7.5YR 5/6); sandy loam; weak medium to fine crumb structure; moist, very friable; many roots; gradual smooth boundary
B2	45-75	(18-30)	Strong brown (7.5YR 5/8); sandy loam; weak medium to coarse angular blocky structure; moist, very friable; few large sandstone fragments; few roots; gradual smooth boundary
C	75+	(30+)	Weathering sandstone

Depth cm	Particle size distribution%				Org. C%	Total N%	Avail. P ppm	pH H_2O	Exch. cations meq%				CEC meq%	Base satn. %
	Coarse sand	Fine sand	Silt	Clay					Ca	Mg	K	Na		
0-15	26	55	5	8	2.2	0.18	2	4.0	0.2	0.1	tr.	0.1	7.2	6
15-45	30	53	6	8	1.1	0.08	tr.	4.5	0.2	tr.	tr.	0.1	3.6	8
45-75	28	55	6	7	0.7	0.06	1	4.9	0.2	—	—	0.1	2.9	10

Appendix 2

Profile description: Horizon nomenclature and definitions of diagnostic horizons

HORIZON NOMENCLATURE

Terms used in the description of individual soil horizons follow Section 4 of the FAO Guidelines (Food and Agriculture Organization, 1965). Horizon nomenclature, however, is based on that proposed by the International Soil Science Society (Bramao *et al*, 1967) with one major departure. The G horizon has been omitted and the suffix 'g' refers only to strong gleying.

Master horizons

O — An horizon forming the upper part of the soil, consisting of fresh and/or partly decomposed organic matter accumulated under predominantly aerobic conditions, and having a minimum organic matter content of 30% if the mineral fraction contains more than 50% of clay, or 20% organic matter if the mineral fraction has no clay. For intermediate clay contents, proportional organic matter contents are required

A — An horizon formed or forming at or adjacent to the surface, consisting of an accumulation of humified organic matter intimately associated with the mineral fraction, and having an organic matter content of less than 30% if the mineral fraction contains more than 50% of clay, or less than 20% organic matter if the mineral fraction has no clay. For intermediate clay contents, proportional organic matter contents are required

E — An horizon underlying the O or A horizon (if present), having a lower content of organic matter and/or sesquioxides and/or clay than the immediately underlying horizon, and usually indicated by a pale colour and a relative accumulation of quartz and/or other resistant minerals of sand or silt sizes

B — An horizon lying between the A or E horizons (if present) and the C or R horizons (if present), in which rock structure is obliterated or is faintly evident, and characterised by a concentration of silicate clay (by illuviation or alteration), sesquioxides (by illuviation or residual accumulation), or organic matter (by illuviation), alone or in combination.(The B horizon may show accumulations of calcium or magnesium carbonate, gypsum or other more soluble salts)

C — An horizon consisting of unconsolidated material which does not show properties diagnostic of the other master horizons. (The C horizon may show accumulations of calcium or magnesium carbonate, gypsum or other more soluble salts)

R — Consolidated bedrock

Transitional horizons

Horizons which are transitional between two master horizons are indicated by both capital letters of the master horizons concerned (for instance AE, EB, BE, BC), the first letter marking the master horizon to which the transitional horizon is more alike i.e. the order of the letters indicates the dominant properties of the transitional horizon (for instance AB or BA). Mixed horizons are indicated by both capital letters of the master horizons concerned but separated by a diagonal stroke (for instance E/B, B/C). It is to be noted that transitional horizons are no longer marked by figures as has been done in the past.

Subhorizons

This subdivision of master and transitional horizons is indicated by numerals in continuous sequence. These numerals merely indicate differences which can be observed and recorded in a profile description (for instance A1, A2, A3, EB1, EB2, B1, B2, BC1, BC2).

In addition to the numerical subdivision, an interpretative suffix letter, having a genetic implication, may be added to the horizon designation. The suffix letters should be used only if there is sufficient evidence for the implied interpretation. The suffix follows the numerical notation (for instance, A1a, A2a, B1t, B2t, B3t, C1, C2ca); if the horizon is not subdivided by numerals, the suffix letter may be used immediately following the capital letter (for instance, Aa, Bt, Cca).

Lithological discontinuities

When it is necessary to number layers of contrasting materials, Roman numerals are pre-fixed to the horizon designations concerned (for instance, when the C horizon is different from the material in which the soil is presumed to have formed, the following soil sequence could be given: A, B, IIC). The same notation can be applied when different materials are recognised within the C horizon (for instance, IC, IIC, IIIC).

Proposed suffixes

a Well decomposed organic matter accumulated under hydromorphic conditions; used with the A horizon (for instance Aa)

b Buried horizon

cn Accumulation of concretions or hard non-concretionary nodules enriched in sesquioxides (for instance, B2ox, cn)

f Fermented, partly decomposed organic matter; applied to the O horizon (for instance Of)

fe Illuvial accumulation of iron; applied to the B horizon of Podzols (for instance B2fe)

g Strong gleying

h Humified, well decomposed organic matter; applied to:

1. The lower part of the O horizon (for instance, Oh)
2. An undisturbed A horizon (for instance, Ah)
3. The illuvial accumulation of organic matter in the B horizon of Podzols (for instance B1h) or in B horizons formed in peat

l Litter; applied to the upper part of the O horizon (for instance Ol)

o Poorly decomposed organic material accumulated under hydromorphic conditions; applied to peats (for instance, Co)

ox Residual accumulation of sesquioxides; applied to the B horizon of Ferralsols (for instance, B1 ox)

p Disturbed by ploughing or other tillage practices; applied to the A horizon (for instance, A1p)

t Illuvial accumulation of clay; applied to B horizons (for instance Bt)

DEFINITIONS OF DIAGNOSTIC HORIZONS

The definitions of the diagnostic horizons used by the FAO have been drawn largely from those adopted in Soil Classification, a Comprehensive System (USDA, 1960) and subsequent supplements (USDA, 1967 and 1973).

Mollic A horizon

The mollic A horizon is a surface layer which, after the surface 18 cm (7 in) are mixed, as by ploughing, has the following properties:

1. Soil structure is sufficiently strong that the horizon is not both massive and hard, or very hard when dry

2. Both broken and rubbed soils have colours with a chroma of less than 3.5 when moist, a value darker than 3.5 when moist, and 5.5 when dry, and at least one unit darker than the C (both moist and dry). If only hard rock is present, comparison should be made with the next underlying horizon

3. The base saturation is more than 50% (by the ammonium acetate method)

4. The organic matter content is at least 1% (0.58% organic carbon) throughout. If the dark surface horizon is less than 18 cm (7 in) thick in a virgin soil with a solum of less than 45 cm (18 in.), the organic matter content must be sufficient to give an average of 1% to a plough layer that is 18 cm (7 in) thick. The upper limit of organic carbon content of the mollic A horizon is the lower limit of the peaty A horizon

5. The thickness is more than 10 cm (4 in) if resting directly on hard rock. If the soil contains an argillic, natric, spodic or cambic B horizon or a fragipan or duripan, the thickness of the A must be more than one-third of the thickness of the solum, where the solum is less than 75 cm (30 in) thick, and must be more than 25 cm where the solum is more than 75 cm (30 in)thick

6. The mollic A horizon has less than 250 parts per million of P_2O_5 soluble in citric acid, or has increasing amounts of P_2O_5 soluble in citric acid below the A horizon

Umbric A horizon

The umbric A horizon is comparable to the mollic A horizon in its colour, organic carbon and thickness requirements. It includes those thick dark surface horizons that have a base saturation less than 50% (by amonium acetate method) or that are both hard and massive when dry.

Histic A horizon

The histic A horizon is a horizon at or near the surface, saturated with water at some season (unless artificially drained) and containing 30% or more organic matter (17.4%

organic carbon) if the mineral fraction has more than 50% clay, or 20% or more organic matter (11.6% organic carbon) if the mineral fraction has no clay. For intermediate textures the required organic matter content is proportional to the clay content. If the A horizon is less than 20 cm (8 in) thick or has been ploughed, it is sufficient, after the upper 20 cm (8 in) have been mixed, that the organic matter content be 28% (16.2% organic carbon) and 14% (8.1% organic carbon) respectively. Where a histic horizon is buried it is diagnostic if its upper boundary occurs within 50 cm (20 in) of the surface.

Ochric A horizon

The ochric A horizon is too light in colour, too low in organic carbon, or too thin to be mollic umbric or histic.

Albic E horizon

The albic E horizon is an E horizon from which clay and free iron oxides have been removed, or in which the oxides have been segregated to the extent that the colour of the horizon is determined primarily by the colour of the primary sand and silt particles, rather than by coatings on these particles. The dominant colours in the matrix of at least a part of the E horizon have moist and dry chromas of two or less.

Argillic B horizon

The argillic B horizon is one that contains illuvial layer-lattice clays. This horizon forms below an eluvial horizon, but it may be at the surface if the soil has been partially truncated. It has the following properties that may be used for identification in the field:

1. If an E horizon remains, the argillic B horizon contains more total and more fine clay than does the eluvial horizon, exclusive of differences which may result from a lithological discontinuity, in accordance with the following specifications:

    i. If any part of the E horizon has less than 15% total clay in the fine earth (less than 2 mm) fraction, the B horizon must contain at least 3% more clay

    ii. If the E horizon has more than 15% and less than 40% total clay in the fine earth fraction, the ratio of the clay in the B horizon to that in the E horizon must be 1.2 or more

    iii. If the E horizon has more than 40% total clay in the fine earth fraction, the B horizon must contain at least 8% more clay

2. An argillic B horizon should be at least one-tenth the thickness of the sum of all overlying horizons, or more than 15 cm (6 in) thick if the E and B horizons are thicker than 150 cm (60 in). The clay increases required under item 1 must be reached within a vertical distance of 30 cm (12 in) or less

3. In soils with massive or single grained structure, the argillic B horizon should have oriented clays bridging the sand grains and in some pores

4. If peds are present, an argillic B horizon has the following properties: (a) there are clay skins on some of the vertical and horizontal ped surfaces and in fine pores, or oriented clays in 1% or more of the cross section; (b) if the horizon is clayey with kaolinitic clay and the surface horizon has more than 40% clay, there are some clay skins on peds and in pores in the lower part of of that horizon having blocky or prismatic structure; (c) if the B horizon is clayey with two to one lattice clay, clay skins may be lacking, provided there are evidences of pressure caused by swelling, the evidence of pressure may be occasional slickensides or wavy horizon boundaries in the illuvial horizon, accompanied by uncoated sand or silt grains in the overlying horizon

5. If a soil shows a lithologic discontinuity between the E horizon and the argillic B horizon, or if only a plough layer overlies the argillic B horizon, the horizon need show only clay skins in some part, either in some fine pores, or if peds exist, on some vertical and horizontal ped surfaces. Thin sections should show that some part of the horizon has about 1% or more of oriented clay bodies

Cambric B horizon

The cambric B horizon is an altered horizon reaching to at least 25 cm (10 in) below the soil surface that lacks the dark colours and organic matter that are characteristic of mollic, umbric or histic A horizons and it has:

1. Textures of loamy very fine sand or finer in the fine earth (less than 2 mm) fraction
2. Soil structure rather than rock structure
3. Some weatherable minerals
4. Evidence of alteration reflected by stronger chromas or redder hues than the underlying horizons* and/or evidences of removal of carbonates
5. Too few evidences of illuviation to meet the requirements of an argillic or a spodic B horizon
6. No cementation or induration and lacks a brittle consistence when moist

Spodic B horizon

The spodic B horizon is characterised by the following properties:

1. If there is a strongly bleached eluvial horizon (continuous or intermittent) thicker than 18 cm (7 in.) underlying an A horizon, the spodic B horizon has:

   i. so much amorphous material that
   $$\frac{\text{\% extractable C + Fe + Al}}{\text{\% clay}} > 0.15^{**}$$

   ii. A thickness of 1 cm or more, either as a continuous horizon or as a sum of lamellae within 100 cm (40 in)

   iii. Extractable C + Fe + Al > 1.0% or moist colour hues which are 7.5YR or redder; and moist values of 3 or less in some continuous part of the horizon or in any other subhorizon that is at least 1 cm thick; and hues which are as red or redder than the underlying horizon

   iv. No clay skins on ped faces or in pores

2. In an A horizon rests on the spodic B horizon the spodic B horizon meets the requirements listed under 1, and in addition has:

   i. A 15-bar water content of less than 20% or, if it is higher, a pH (H_2O) which is less than 5.0 but at least 0.5 higher than pH (KCl)

* If soils are poorly drained (in the case of the gleyic soils) the hues should not be bluer than 10Y and should change on exposure to the air; if there is mottling, chromas are two or less; if there is no mottling chromas are less than one if values are less than four, otherwise chromas are one or less.

** Elemental weight % by pyrophosphate-dithionite extraction.

ii. Enough depth that the horizon is not obliterated by ploughing (to 18 cm (7 in)) or enough degree of expression that the horizon after mixing to 18 cm (7 in) has:

a. More than 3% organic matter (1.7% organic carbon)

b. $\frac{\text{\% extractable C + Fe + Al}}{\text{\% clay}} > 0.20^{**}$

c. Fragments of amorphous coatings or pellets can be clearly identified

d. A hue redder than 10YR with a moist value of less than three, or a chroma of three or more in hues of 10YR or redder

Oxic B horizon

The oxic B horizon is a horizon which lacks the characteristics mentioned for the argillic B horizon and:

1. Is at least 30 cm (12 in)thick

2. Has a fine earth fraction that retains 10 meq or less of ammonium ions per 100 g clay from a 1*N* NH_4 Cl solution:

$$\frac{\text{meq bases retained} \times 100}{\text{\% clay}} \leqslant 10$$

or has less than 10 meq of bases extractable with NH_4 OAc and aluminium extractable with 1 *N* KCl per 100 g clay

3. Has an apparent cation exchange capacity of the fine earth of 16 meq or less per 100 g clay by the ammonium acetate method thus:

$$\frac{\text{meq CEC} \times 100}{\text{\% clay}} \leqslant 16$$

4. Has no more than traces of primary aluminosilicates such as felspars, micas, glass and ferro-magnesian minerals

5. Has no more than traces of water-dispersible clay in some subhorizons

6. Has texture of sandy loam or finer (in the fine earth fraction) and more than 15% clay

7. Has mostly gradual or diffuse boundaries between its subhorizons

8. Has less than 5% by volume that shows rock structure

Gleyic horizon

The gleyic horizon is indicative of pronounced wetness. In the absence of a precise definition of the gleyic horizon by FAO the definition of strong gleying (USDA 1960) has been adopted.

'In aggregated material, ped faces in horizons with strong gleying generally have chromas of two or less as a continuous phase, and commonly have few of faint mottles. Interiors

** See previous page.

of peds may have prominent and many mottles but commonly have a network of threads or bands of low chroma surrounding the mottles. In soils that are not aggregated, a base chroma of one or less, with or without mottles, is indicative of strong gleying'.

Horizons 'in which portions have mottles with chromas of 2 or less and moist values of four or more, whether or not that portion is dominant in volume or whether or not it is a continuous phase surrounding spots of higher chroma' (USDA 1973) are not considered to be gleyic horizons. However the phrase 'mottles with chromas of two or less' includes the meaning that the horizons that have such mottles are saturated with water at some time of the year or are artificially drained.

Thionic horizon

The thionic horizon contains an amount of sulphides and/or elemental sulphur which is sufficiently high to cause acidification of the soil upon oxidation to pH (KCl) of less than 3.5 within 100 cm (40 in) of the surface.

Appendix 3

Profile description: terms used

Information on the site sampled is based on the FAO Guidelines (Food and Agriculture Organization, 1965). Slope categories are those which have been in regular use in Sabah, namely level (<5°), rolling (5-15°), hilly (15-25°) and steep (>25°).

SITE DRAINAGE CATEGORIES

Site drainage categories are based on the Field Handbook (Great Britain, Soil Survey Staff, 1960).

Shedding sites Slopes with runoff exceeding the amount of water reaching the site from higher slopes. Most convex slopes and the upper slopes of hills would belong to this class.

Normal sites Slopes on which runoff might be expected to equal approximately the amount of water running onto the site. This clas includes regular slopes and possibly also flat areas excepting basin sites.

Receiving sites Sites receiving more water from the slopes above than is lost by runoff. This type should be subdivided into those with some runoff and those with no runoff.

Freshwater flooding sites Soils liable to flooding from a water course. These include sites with regular seasonal flooding, sites with occasional flooding, springs and flush sites.

Saltwater flooding sites

Irrigated sites

SOIL DRAINAGE

The following classes of soil drainage are recognised

Very poorly drained Water is removed from the soil so slowly that the watertable remains at or on the surface the greater part of the time. Soils of this drainage class usually occupy level or depressed sites and are frequently ponded.

Poorly drained Water is removed so slowly that the soil remains wet for a large part of the time. The watertable is commonly at or near the surface during a considerable part of the year. Poorly drained conditions are due to a high watertable, to a slowly permeable layer within the profile, to seepage, or to some combination of these conditions.

Imperfectly drained Water is removed from the soil slowly enough to keep it wet for significant periods, but not all of the time. Imperfectly drained soils commonly have a

slowly permeable layer within the profile, a high watertable, additions through seepage, or a combination of these conditions.

Moderately well drained Water is removed from the soil somewhat slowly, so that the profile is wet for a small, but significant, part of the time. Moderately well drained soils commonly have a slowly permeable layer within or immediately beneath the solum, a relatively high watertable, additions of water through seepage, or some combination of these conditions.

Well drained Water is removed from the soil readily, but not rapidly. Well drained soils commonly retain optimum amounts of moisture for plant growth.

Somewhat excessively drained Water is removed from the soil rapidly.

Excessively drained Water is removed from the soil very rapidly.

In an attempt to relate the depths of gleyic horizons and gleying to particular drainage classes the following depth criteria have been used during the survey in Sabah.

1. Very poorly drained profiles have gleyic or histic horizons at the surface
2. Poorly drained profiles have gleyic horizons within 50 cm (20 in) of the surface
3. Imperfectly drained profiles have gleyic horizons below 50 cm (20 in)
4. Moderately well drained profiles may have base colours with chromas of more than two and mottles with chromas of two or less, but lack gleyic horizons

Having established the drainage class of the soil it is then necessary to decide whether a drainage defect is due to 'surface water' or 'soil groundwater' or to a combination. If due to surface water the word 'impeded' should be used; it should not be used for soils with gleying caused by groundwater. Soils are thus considered to have impeded drainage when the permeability of one horizon or more in the solum is too low to transmit, without waterlogging, the water entering the soil from above. The profile may be freely drained below the impeding horizon which might be an iron, clay or humus pan. A soil might, however, possess a high absolute permeability, but under very high rainfall may show drainage impedence.

HORIZON BOUNDARIES

The depths to horizon boundaries are measured from the surface or from the base of the O horizon if present; both width and topography are described.

Width of boundary

Abrupt	Boundary less than 2 cm (0.8 in) wide
Clear	Boundary 2-5 cm (0.8-2 in)
Gradual	Boundary 5-12 cm (2-4.8 in)
Diffuse	Boundary more than 12 cm (4.8 in)

Topography of boundary

Smooth	Boundary is nearly a plane surface
Wavy	Pockets are wider than their depths
Irregular	Pockets are deeper than their width
Broken	Horizon boundary is not continuous (occurs when horizons are developed in separated cracks or pockets)

COLOUR

Munsell Soil Colour Charts were used.

Abundance of mottles

Few	Mottles occupy less than about 2% of the exposed surface
Common	Mottles occupy about 2% to 20% of the exposed surface
Many	Mottles occupy more than 20% of the exposed surface

Size of mottles (approximate diameters of individual mottles)

Fine	Mottles less than 5 mm along greatest dimension
Medium	Mottles range between 5 and 15 mm along greatest dimension
Coarse	Mottles are greater than 15 mm along greatest dimension

Contrast between mottles

Faint	Indistinct mottles are evident and recognisable only with close examination. Soil colours in both matrix and mottles have closely related hues and chromas
Distinct	Although not striking, the mottles are readily seen. The hue, value, and chroma of the matrix are easily distinguished from those of the mottles. They may vary as much as one or two hues or several units in chroma or value. The pattern may be a continuous matrix with mottles, or mixtures of two or more colours
Prominent	The conspicuous mottles are obvious and mottling is one of the outstanding features of the horizon. Hue, chroma, and value may be several units apart. The pattern may be a continuous matrix with contrasting mottles, or mixtures of two or more colours

TEXTURE

Twelve basic texture classes are recognised and these are grouped into five categories for purposes of soil family separation (See Appendix 5 for particle size analyses).

Coarse	Sand and loamy sand
Moderately coarse	Sandy loam
Medium	Loam, silt loam and silt
Moderately fine	Sandy clay loam, clay loam and silty clay loam
Fine	Sandy clay, silty clay and clay

STRUCTURE

Structure is defined in terms of type, class and degree of development.

TABLE 1 Types and classes of soil structure

Class	Type (shape and arrangement of peds)						
	Platelike with one dimension (the vertical) limited and greatly less than the other two; arranged around a horizontal plane; faces mostly horizontal	Prismlike with two dimensions (the horizontal) limited and considerably less than the vertical; arranged around a vertical line; vertical faces well defined; vertices angular		Blocklike; polyhedronlike, or spheroidal, with three dimensions of the same order of magnitude, arranged around a point			
				Blocklike; blocks or polyhedrons having plane or curved surfaces that are casts of the moulds formed by the faces of the surrounding peds		Spheroids or polyhedrons having plane or curved surfaces which have slight or no accommodation to the faces of surrounding peds	
		Without rounded caps	With rounded caps	Faces flattened; most vertices sharply angular	Mixed rounded and flattened faces with many rounded vertices	Relatively non-porous peds	Porous peds
	Platy	Prismatic	Columnar	(Angular) Blocky	Subangular blocky	Granular	Crumb
Very fine or very thin	Very thin platy; <1 mm	Very fine prismatic; <10 mm	Very fine columnar; <10 mm	Very fine angular blocky; <5 mm	Very fine subangular blocky; <5 mm	Very fine granular; <1 mm	Very fine crumb; <1mm
Fine or thin	Thin platy; 1 to 2 mm	Fine prismatic; 10 to 20 mm	Fine columnar; 10 to 20 mm	Fine angular blocky; 5 to 10 mm	Fine subangular blocky; 5 to 10 mm	Fine granular; 1 to 2 mm	Fine crumb; 1 to 2 mm
Medium	Medium platy; 2-5 mm	Medium prismatic; 20 to 50 mm	Medium columnar; 20 to 50 mm	Medium angular blocky; 10 to 20 mm	Medium subangular blocky; 10 to 20 mm	Medium granular; 2 to 5 mm	Medium crumb; 2 to 5 mm
Coarse or thick	Thick platy; 5 to 10 mm	Coarse prismatic; 50 to 100 mm	Coarse columnar; 50 to 100 mm	Coarse angular blocky; 20 to 50 mm	Coarse subangular blocky; 20 to 50 mm	Coarse granular; 5 to 10 mm	
Very coarse or very thick	Very thick platy; >10 mm	Very coarse prismatic; >100 mm	Very coarse columnar; >100 mm	Very coarse angular blocky; >50 mm	Very coarse sub angular blocky; >50 mm	Very coarse granular; >10 mm	

The degree of structural development is estimated in the field by noting the distinctness of the structural units and the extent to which they are broken or destroyed when the soil mass is displaced or gently crushed. The following terms are used:

Structureless	No planes of weakness or observable aggregation in either the moist or dry condition; massive if coherent; single grain if incoherent
Weak	Poorly formed, indistinct units which break easily on displacement, yielding much unaggregated or fragmental material
Moderate	Well formed distinct units that are moderately resistant to disruption on disturbance
Strong	Well formed units, distinct in undisturbed moist soil, which adhere only weakly to one another, and can be separated without disruption when the soil is disturbed

CONSISTENCE

Soil consistence comprises those attributes of soil material, commonly described by such terms as 'heavy' and 'light', that are expressed by the degree and kind of cohesion and adhesion or by the resistance offered to deformation or rupture. Consistence is closely related to both texture and structure.

As consistence varies with moisture conditions, terms are necessary for each significant moisture state: thus a ped may be pard when dry, friable when moist (referring specifically to a moisture content roughly mid-way between air-dry and field capacity) and plastic when wet (referring specifically to a moisture content at or slightly above field capacity).

The range of moisture content in which it is friable is an important characteristic affecting the workability of the soil. The following terms are used to describe consistence:

Consistence when wet

Consistence when wet is determined when the soil is at, or slightly above, field capacity.

1. Stickiness

Stickiness is the quality of adhesion of the soil material to other objects and is determined by noting the adherence of soil material when it is pressed between thumb and finger.

Non-sticky	After release of pressure, practically no soil material adheres to thumb or finger
Slightly sticky	After pressure, soil material adheres to both thumb and finger but comes off one or the other rather cleanly; it is not appreciably stretched when the digits are separated
Sticky	After pressure, soil material adheres to both thumb and finger and tends to stretch somewhat and pull apart rather than pulling free from either digit
Very sticky	After pressure, soil material adheres strongly to both thumb and forefinger and is decidedly stretched when they are separated

2. Plasticity

Plasticity is the ability of soil material to change shape continuously under the influence of an applied stress and to retain the impressed shape on removal of the stress. Determined by rolling the soil material between thumb and forefinger.

Non-plastic	No wire is formable
Slightly plastic	Wire formable, but soil mass easily deformable
Plastic	Wire formable and moderate pressure required for deformation of the soil mass
Very plastic	Wire formable and much pressure required for deformation of the soil mass

Consistence when moist

Determined at a moisture content approximately midway between air-dry and field capacity, by attempting to crush in the hand a mass of soil material that appears slightly moist.

Loose	Non-coherent
Very friable	Soil material crushes under very gentle pressure but coheres when pressed together
Friable	Soil material crushes easily under gentle to moderate pressure between thumb and forefinger

Firm	Soil material crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable
Very firm	Soil material crushes under strong pressure; barely crushable between thumb and forefinger
Extremely firm	Soil material crushes only under very strong pressure; cannot be crushed between thumb and forefinger and must be broken apart bit by bit

Consistence when dry

Determined by attempting to break an air-dry mass between thumb and forefinger or in the hand

Loose	Noncoherent
Soft	Soil mass is very weakly coherent and friable; breaks to powder or individual grains under very slight pressure
Slightly hard	Weakly resistant to pressure; easily broken between thumb and forefinger
Hard	Moderately resistant to pressure; can be broken in the hands without difficulty, but is barely breakable between thumb and forefinger
Very hard	Very resistant to pressure; can be broken in the hands only with difficulty; not breakable between thumb and forefinger
Extremely hard	Extremely resistant to pressure; cannot be broken in the hands

CUTANS (PED COATINGS), PRESSURE FACES, SLICKENSIDES, ETC.

Under this item any detectable surface phenomena on ped faces and within cracks, pores and channels should be described, whatever their possible origin. Thus cutans (ped coatings), pressure faces, slickensides, etc, are all included in this item and are described in the following terms:

Quantity

Patchy	Small scattered patches of cutan on ped faces or as linings in pores, etc.
Broken	Cutans cover much but not all of ped faces or line most, but not all pores, etc.
Continuous	Cutans cover peds entirely or completely line pores, channels, etc.

Thickness

Thin	Fine sand grains are readily apparent in the cutan; bridges between grains are weak; thickness microscopic
Moderately thick	Fine sand grains are enveloped in the cutan and their outlines are indistinct
Thick	Surface of cutan is smooth; showing no outlines of fine sand grains; strong bridges between larger grains

CEMENTATION

Descriptions of cementation imply that the condition alters little, if any, with changes in the moisture content of the soil.

Weakly cemented	Cemented mass is brittle and hard, but can be broken in the the hands
Strongly cemented	Cemented mass is brittle and harder than can be broken in the hands, but is easily broken with a hammer
Indurated	Very strongly cemented: brittle, does not soften under prolonged wetting, and is so extremely hard that for breakage a sharp blow with a hammer is required; hammer generally rings as a result of the blow

STONES

Abundance

An indication of the relative abundance of particles in different size groups is given together with their shape and nature where identifiable.

Very few	less than 5% by volume
Few	5-15% by volume
Many	15-40% by volume
Very many	40-80% by volume

When rock or mineral fragments occupy a horizon to the virtual exclusion of fine earth, their abundance may be described as 'dominant'.

Size

Size ranges for large particles are defined as follows:

Gravel	0.2-7.5 cm (0.08-3 in)
Stones	7.5-25 cm (3-10 in)
Boulders	More than 25 cm (10 in)

The simple terms 'angular', 'rounded' and 'flat' are usually adequate to describe the shape of fragments and require no definition.

The nature of the rock or mineral fragments should be described as accurately as possible, but where the nature is indeterminate, 'rock' or 'mineral' fragments can be used.

The state of weathering of the fragments (other than quartz) should also be described and the following qualifying adjectives are suggested

Fresh	Fragments showing little or no signs of weathering
Weathered	Partial weathering is indicated by discoloration and loss of crystal form in the outer parts of the fragments, but the centres remain relatively fresh and the fragments have lost little of their original strength.

Strongly weathered	All but the most resistant minerals are strongly discoloured and altered throughout the fragments, which tend to disintegrate under only moderate pressure.

MINERAL NODULES

The term 'nodule' carries no implication of mode of formation and is therefore preferred when the mode of formation is uncertain. Description of nodular material includes information on abundance, size, hardness, shape, colour and nature of the nodules.

Abundance

Very few	Less than 5% by volume
Few	5-15% by volume
Many	15-40% by volume
Very many	40-80% by volume
Dominant	Over 80% by volume

Size

Small	Less than 1 cm (0.4 in) diameter
Large	More than 1 cm (0.4 in) diameter

The average size can be indicated in brackets; this is desirable if the nodules are exceptionally small (< 0.5 cm) (< 0.2 in) or large (> 2 cm) (> 0.8 in).

Hardness

Soft	Nodules can be broken between forefinger and thumbnail
Hard	Nodule cannot be broken in the fingers

CONTENT OF CARBONATES

Profiles derived from, or suspected of including, calcium carbonate are tested with dilute hydrochloric acid and described in the following terms:

Non-calcareous	No detectable effervescence
Slightly calcareous	Very feeble effervescence; scarcely visible, but detectable to the ear
Calcareous	Visible effervescence
Strongly calcareous	Strong effervescence; particles of carbonate usually clearly visible

Other features such as pores, artefacts, insect nests, wormcasts or burrows and roots are described only where their presence is noteworthy.

PEAT

Peat deposits are described under the following headings (Great Britain Soil Survey Staff, 1960)

1. Thickness, clarity, moisture, colour

2. Botanical composition of peat-forming remains

3. Structural properties

Fibrous	Plant remains easily recognisable, original structure and some of the mechanical strength of plant materials maintained
Pseudo-fibrous	Plant remains recognisable, but fibrous in appearance only; when moist, peat is soft and plastic in character
Amorphous	Absence of recognisable plant remains, and may be sub-aquatic sediments or humified layers

4. Degree of humification

Slightly humified

H_1	Completely non-humified and free of dy*; yields only colourless water when squeezed.
H_2	More or less unhumified and free of dy; yields yellowish brown water when squeezed.
H_3	Very slightly humified with a small amount of dy ; yields muddy water when squeezed, but the peat substance itself does not pass through the fingers.
H_4	Slightly humified peat and weakly dy-charged; yields very muddy water when squeezed. Residue slightly pastic.
H_5	Humified peat with a considerable amount of dy; plant structure quite evident; yields very muddy water when squeezed and some of the peat substance escapes through the fingers; residue quite plastic.

Medium humified

H_{6-7}	Well humified peat and strongly dy-charged; visible plant structure insignificant; up to two-thirds of mass passes through the fingers on squeezing, residue consists chiefly of root fibres and wood, etc, and is strongly plastic.

Strongly humified

H_{8-10}	Very strongly humified and almost completely dy-charged; no vegetable structure visible (in field); almost the whole of the mass squeezes through the fingers.

* Dy; brown or yellow-brown flocculent material that can be squeezed out with the water from coherent peats.

Appendix 4

Profile description: Guide to the interpretation of soil analyses

The ratings suggested for pH, organic carbon, total nitrogen, cation exchange capacity, easily soluble phosphorus, base saturation and exchangeable cations are based on Metson (1956) with adaptations to suit Sabah conditions; they are intended as guides only. Salinity classes are taken from the Soil Survey Manual (USDA, 1951). Particle size distribution and minerals of the clay fraction are explained in Appendix 5.

Soil pH (H_2O)		Carbon and nitrogen		
Rating	Range	Organic C%	Total N%	Rating
Strongly alkaline	>8.4	>20	>1.0	Very high
Alkaline	7.5 - 8.3	10 - 20	0.5 - 1.0	High
Near neutral	6.6 - 7.4	4 - 10	0.2 - 0.5	Medium
Acid	5.3 - 6.5	2 - 4	0.1 - 0.2	Low
Strongly acid	4.1 - 5.2	< 2	<0.1	Very low
Extremely acid	<4.0			

Cation exchange capacity, base saturation and easily soluble phosphorus			
Cation exch. capacity meq%	Base satn. %	Avail. P ppm	Rating
>40	75 - 100	>20	Very high
25 - 40	50 - 75	15 - 20	High
15 - 25	35 - 50	5 - 15	Medium
5 - 15	20 - 35	1 - 5	Low
< 5	0 - 20	< 1	Very low

Exch. cations meq%					Salinity	
Ca	Mg	K	Na	Rating	Class	Conductivity mmhos/cm
>20	>8	>1.2	>2	Very high	Non-saline	0 - 4
10 - 20	3 - 8	0.6 - 1.2	0.7 - 2	High	Slightly saline	4 - 8
5 - 10	1 - 3	0.3 - 0.6	0.3 - 0.7	Medium	Moderately saline	8 - 15
2 - 5	0.3 - 1	0.2 - 0.3	0.1 - 0.3	Low	Strongly saline	>15
<2	<0.3	<0.2	<0.1	Very low		

Appendix 5

Methods of soil analysis

Soil samples collected from the field were initially air dried and lightly ground to pass a 2 mm (0.08 in) sieve. For determinations of total nitrogen, organic carbon, easily soluble phosphorus and total elements, a portion of each sample was ground to pass a 60 mesh (0.25 mm) (0.1 in) sieve.

Moisture Factor (Metson, 1956) The moisture factor was calculated from the ratio of the weight of a sample of air dried soil to the weight of the same sample following oven drying at 105°C for 8 to 24 hours.

pH (Metson, 1956) pH in water and in 1*N* potassium chloride was determined on a 1:2.5 suspension of soil in both liquids.

Total nitrogen Total nitrogen was determined by the semi-micro Kjeldahl method (Metson, 1956).

Organic carbon Organic carbon was determined by the wet digestion method (Walkley and Black, 1934).

Available phosphorus The phosphorus extractable in a solution of 100 ml 1*N* hydrochloric acid + 30 ml 1*N* ammonium fluoride diluted to 1 litre was determined by the Bray and Kurts method (Jackson 1958). It is sometimes referred to as 'easily soluble phosphorus'.

Cation exchange capacity and exchangeable cations CEC was determined by leaching with 1*N* ammonium acetate at pH 7 (Metson, 1956). Exchangeable sodium and potassium were determined by flame photometry (Metson, 1956). Exchangeable calcium and magnesium were determined by atomic absorption spectrophotometry (Remakrishna et al., 1966).

Determination of chloride Chloride was determined by the Kohr titration method (Metson, 1956).

Calcium carbonate Calcium carbonate was determined by the Tinsley, Taylor and Moore method (Metson, 1956).

Total phosphorus Until December 1971 total phosphorus was determined spectrophotometrically on a nitric acid/hydrofluoric digest using ammonium molydate and ammonium vanadate (Jackson, 1958). From January 1972 a method employing perchloric acid (60%)/concentrated sulphuric acid digestion has been used. Total phosphorus was estimated by the ammonium molybdate/ascorbic acid method (Fogg and Wilkinson, 1958).

Total calcium, magnesium, potassium, sodium, iron, aluminium, manganese and some trace metals. A perchloric acid/hydrofluoric acid digestion was used (Jackson, 1958). Elements were determined as follows

K, Na	Flame photometry
Fe, Mn, Cr, Ni, Cu, Zn	Atomic absorption (some by X-ray fluorescence without acid digestion)
Ca, Mg	Atomic absorption with strontium chloride to suppress Fe, Al and P interference
Al	colorimetric by Aluminon

Extractable aluminium, iron magnese and some trace metals Metals were extracted with 1*N* ammonium acetate (Jackson, 1958). The pH of the extracting solution was varied according to the element of interest. For aluminium and some trace metals the pH of the extracting solution was 4.8; for iron the pH was 3.0 and for manganese the pH was 7.0. For samples from a few spodic horizons of podzols the extractable iron and aluminium were determined either with sodium pyrophosphate ($Na_4P_2O_7$) at pH 8.0 or with sodium dithionite and sodium citrate (USDA, 1967a).

pH after oxidation Soils suspected of high acid sulphate potential were oxidised with hydrogen peroxide. Following oxidation, the pH was measured in the normal way in water.

Conductivity Conductivity was measured on the soil water suspension used for pH determination (Metson, 1956). A Mullard conductivity bridge was used.

Total sulphur The sodium carbonate fusion/ammonium acetate extraction method was used (Jackson, 1958).

Particle size distribution Samples were oxidised with 15% alkaline hydrogen peroxide to remove organic matter, and then dispersed with a rotary stirrer using a 5% Calgon solution as the dispersing agent (Black *et al*., 1965). Estimation of particle size classes was according to the International Particle Size Classification (clay < 0.002 mm; silt 0.02-0.002 mm; fine sand 0.2-0.02 mm; coarse sand 2-0.2 mm) and was done by the pipette method (Black *et al.*, 1965) and sieving of the sand fraction.

On samples sent to Hunting Technical Services (see Volume 3), a hydrometer method was used to determine silt and clay. Total sand was calculated by difference.

Water-dispersible clay The samples were oxidised with hydrogen peroxide, then shaken in water overnight in a rotary shaker; the dispersible clay was then determined by the pipette method noted above (USDA, 1967a).

Determination of the minerals of the clay fraction by X-ray diffraction Samples were prepared by removing organic matter with sodium hypochlorite, dispersing clay with sodium hydroxide, removing iron oxides with sodium bicarbonate/citrate/dithionite and saturating the exchange complex with Mg^{2+} and K^{+}. X-ray diffraction was performed on a Philips PW 1050 diffractometer using a CuK (Ni) target for non-Fe minerals and a FeK (Mn) target for Fe-minerals. Details of the methods used are given in Black (1965), Cullity (1956) and Grim (1968). The minerals determined are expressed as follows:

Dominant	(dom.)	> 40%
Moderate	(mod.)	20-40%
Present	(pres.)	5-20%
Trace	(tr.)	< 5%

Determination of the minerals of the sand fraction Heavy minerals (specific gravity > 3.95) were examined by mineralogical microscopy.

Appendix 6

Correlation of the soil families with the provisional families described in draft reports

Draft reports of this study were submitted to the Sabah Government in 1972/73. These contained a provisional classification of soil families. Modifications have since been made particularly in soil units on alluvium where considerable merging of families has been necessary.

Soil unit	Family	Provisional families included
Dystric Histosol	Kaintano Klias Arang	Tawai, Kolopis Mansalak Simindalan
Thionic Fluvisol	Weston Kalibong	Padas, Peras Peras
Eutric Fluvisol	Pegalan	Sumilad
Humic Gleysol	Guan Kidukarok	Anam, Malabau, Mesapol Tudan
Calcaric Gleysol	Lari	Kinau, Timbang, Pandasan, Putatan
Dystric Gleysol	Koyah	Rhododendron, Padang, Kuamut
Eutric Gleysol	Bangawat	Laya, Kaya, Kinasaraban, Bandau
Gleyic Podzol	Baiayo Pa Sia	Benoni, Kiansom, Lanas, Tabalin Manjang, Kundasang
Orthic Podzol	Silimpopon Sibuga	Balambangan, Tinosan Maligan
Rhodic Ferralsol	Apas	Bakapit

APPENDIX 6 (continued)

Soil unit	Family	Provisional families included
Gleyic Acrisol	Inanam	Buloh, Kasigui, Mengkadait, Penawan, Beatrice
	Gunong Alab	Tiga, Kapuron
Ferric Acrisol	Lumisir	Tamu Darat, Sebyte, Lucia, Gading
	Beruang	Membalua
Orthic Acrisol	Katai	Tongkabira, Telupid, Limbuak
	Paliu	Ruku Ruku, Mesalau, Miau
	Kinabutan	Lividoi, Danum
Gleyic Luvisol	Nangoh	Boutu
	Buran	Balung
	Lunparai	Malambabula
Chromic Luvisol	Mangkap	Ensuon
	Sabor	Nyamok
	Kalawali	Naping
	Libong	Kayan, Dumundong
Orthic Luvisol	Darau	Segaliud, Saga
	Kobovan	Tamanong, Segama
	Talid	Banggi
Gleyic Cambisol	Luba	Hitam
Chromic Cambisol	Mankawagu	Sebangan
	Silad	Tambuyukon
Dystric Cambisol	Kelawat	Masakum, Tamparuli, Dompoi
	Antulai	Laab
Eutric Cambisol	Bulanat	Tomisan
	Bombalai	Tinagat, Sinon, Mantri
Cambric Arenosol	Kabili	Bungon

Appendix 7

Glossary of Malay terms

Balai raya	village rest house
Batu	rock
Besar	large
Bukit	hill
Darat	mainland
Garam	salt
Gunong	mountain
Hitam	black
Hutan	forest
Kampong	village
Kechil	small
Kuala	river mouth
Ladang	estate
Laut	sea
Padang	sports field
Pantai	beach
Parit	ditch
Pasir	sand
Pengkalan	wharf
Palau	island
Puteh	white
Ranchangan	scheme
Sekolah	school
Sungai	river
Tanjong	cape
Telok	bay
Trusan	channel
Ulu	headwaters

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