Descriptions of Mapping Units

for

Detailed - Reconnaissance Soil Map of West - Sarawak

(Chapter 12 - Memoir 1. Soils of West - Sarawak)

by

J. P. Andriesse
(Soil Surveyor)

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Soil Survey Division
Research Branch

Dept of Agriculture
Sarawak

INTRODUCTION

The contents of this report have been extracted from Memoir 1, Soils of West Sarawak which is in preparation for printing but which will probably not be available until 1972.

In order not to unduly postpone release of important information on soil suitability and soil availability at District level, advanced copies of the Detailed-Reconnaissance Soil Map are distributed to agricultural staff on a Divisional and District level. Each District will receive one copy of that part of the map relevant to that District. The use of this map should be shared with other officers in the Divisional or District Development Committees because it is physically impossible to hand-paint more copies prior to the printing of the maps.

The descriptions of the mapping units found in this report will assist the map reading. It is thought that chapter 12 gives for the time being sufficient information to proceed with development planning. If more information is required prior to the publication of the full contents of Memoir I the Soils Division should be contacted. A complete copy of the Memoir is available for consultation if required.

J.P. Andriesse

March, 1971.

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Chapter 12. THE DETAILED RECONNAISSANCE SOIL MAP

Chapter 14 - THE DETAILED RECONNAISSANCE SOIL MAP

1. Compilation of the Map

The Detailed-Reconnaissance soil map was compilated following principles discussed under Chapter 2, section 6 (p. ....) and is issued in four sheets; three sheets show the soil pattern of the Region, while the fourth, containing the key to the mapping units, supplies information on the soil types depicted together with relevant information on parent materials and landforms.

In order to facilitate the use of these maps at district level, care has been taken that the map sheets as far as possible cover one or more districts. Sheet one covers the Lundu and Bau Districts, sheet two covers the Kuching Rural District, the Lower Sadong District and the Upper Sadong District, while sheet three covers the remaining part of the Region taken up by the western parts of the Simanggang and Lubok Antu Districts.

In order to avoid obscuring soil information by too much detailed topographic information and ensuing indicative lettering the topographic data has been kept as simple as possible. Since the topo-base was constructed by a simple photographic reduction process from the 1:50,000 scale topographic maps, detailed topographic information can be readily obtained from these and if necessary inserted, or a reduced version on film can be used as a transparent overlay.

2. Explanation of the Key to the Map

The Key sheet shows the colour scheme and symbols used for indicating soil types and combinations of soil types.

In the Key, the soil mapping units have been combined to form five main groups. These groups are related to topographic position and comprise:

a. Mountain and hill soils, which are soils occurring on high land, not affected by flooding and without a high water table. The soils are generally developed on parent rock in situ. The group contains a unit of soils developed on mixed materials in which residual soils and alluvial soils occur in complex.

b. Floodplain soils occur on flat land, generally liable to flooding of varying magnitude. The water table is commonly high. The soils are derived mainly from transported materials. As is the case with group a, a compound mapping unit comprising soils of mixed origin is used for areas where for cartographic reasons a separation of upland and lowland soils was impossible.

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c. Terrace and Fan soils occupy terrace sites and foothills. Although derived from transported materials, they are not [illegible]

d. [illegible]. As the name implies, these soils are found along the coast, where they have derived from transported materials. Most of the soil types in this group occupy flat areas and are liable to flooding; the water table is generally high.

e. Basin Swamp Soils are mainly formed by organic deposits which have accumulated in interfluvial basins swamps. A subgroup of mixed origin, comprising soils of mineral and organic derivation is found in areas where these soils occur in complex. All soils are liable to flooding and the watertable is high.

These five main groups of mapping units have each been divided into subgroups. Type of parent material appears to be the most logical choice for forming a basis for further subdivision because derivation plays next to topography an important role in soil formation.

The Mountain and Hill Soils therefore were divided under the subhead: 'formed on igneous rocks', 'on sedimentary rocks' and 'on miscellaneous rock types'. The subgroup formed 'on mixed materials' comprises soils from both residual and alluvial derivation.

The Floodplain Soils were divided into: 'on Recent Riverine Alluvium', 'on old Alluvium' and again under a subgroup 'on mixed materials', in which soils of alluvial and residual origin occur in complex.

The Terrace and Fan Soils have two subgroups namely those formed 'on Old Alluvium' and 'on Fan deposits'.

The Coastal Soils were divided into subgroups formed by soils 'on Recent Marine Alluvium' and those formed 'on Subrecent Marine Alluvium'. In this group the age of the parent material is indicative to maturation of the soil profile. A third subgroup is formed by soils developed 'on Recent Deltaic and Estuarine deposits'.

The principle of using type of parent material as a basis for subgrouping could not be followed for the Basin Swamp Soils. For these, depth has been used as criterion since in some way this property appears to be related to maturation.

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The choice of colours is generally based on these groups and subgroups. There are some exceptions, namely for certain alluvial soils colours are indicative to either derivation or soil forming process operating in these soils. Therefore, a close colour match may either indicate kinship in derivation or kinship in soil forming process; this would depend on which of the two is most strongly expressed in the morphology of the soil. In any case both factors are strongly related to each other.

It should be emphasized that great colour differences denote main soil differences, commonly of the magnitude used for a separation of soils at the Soil Group level. Undeveloped soils are uncoloured. The use of symbols in combination with colours made it possible to indicate specific characteristics of soils which may not be present in the whole mapping units. Letter symbols indicate specific families or series.

Small dots always indicate sandy soils and since both, light and heavy textured soils occur in most alluvial mapping units, this symbol is dominantly used in these mapping units. Likewise, steep land associated with shallow soils in most Mountain and Hill Soils is indicated by crosses.

It was, with a few exceptions, impossible to show on the map simple mapping units comprising one soil type only. Therefore, most mapping unite are compound units comprising closely allied soil types for which the predominance of some soils over others is indicated by the columns 'predominant' and 'subordinate'. Indications are further given on the specific type of parent material on which the mapping unit has formed and the specific landform in which it is found.

Names of soil classification units within the mapping units are indicated by capital letters for the Soil Groups; names of soil families are indicated by small lettering and specific soil series by italics. Commonly only soil families have been mapped, but areas in which specific soil series of a family could be embounderea are indicated by a two letter symbol. Therefore, areas of the same colour but without a two letter symbol belong to the soil family as indicated and may be formed by soils of various series within the family.

../Also

Also, if in a certain mapping unit a soil family dominantly occurs in some minor areas which cannot be indicated on the map, this soil family is indicated by a one letter symbol referring to the family involved. Occurrences of soil classification units indicated in the Key under the column 'subordinate' are not further indicated on the map.

3. Descriptions of the Soil Mapping Units

Most mapping units are associations of soil families. In some families specific series were mapped. Since the boundaries of the mapping units are mainly based on physiographic boundaries and/or boundaries between geological formations, the soils within one mapping unit are closely associated as far as topography and derivation is concerned. Because topography and parent materials strongly influence soil formation in the Region, other soil characteristics within the mapping unit are commonly also closely related.

The soil mapping units are of great practical importance somce land use or potential land use, is by and large the same for each individual mapping unit. In development planning of a scale related to the reconnaissance nature of the soil map, the soil mapping units can therefore be used for an assessment of the agricltural potential for a given area.

To this end, the main characteristics of the mapping units are described in general terms. The descriptions comprise notes on the occurrence, topography, landscape elements, parent materials, erosion and flooding risk, overall fertility aspects and agricultural potential. Reference is made to the specific soil classification units found within the mapping unit but apart from some general notes on the characteristics of these soils detailed descriptions have been omitted.

Instead constant reference is made to Chapter 11 (p. ....) in which the soil classification units are described in detail under the respective soil groups and readers requiring this detailed information are advised to consult these sections.

Table 25 shows the acreage of each mapping unit by district from which the relative importance of each soil mapping unit can be assessed. The area measurements were calculated by using a grid overlay according to the system of Dmitriyev (1965). The estimated error is not more than 5%. The relationship between the major soil

FIG. IV 6

SCHEMATIC RELATIONSHIP BETWEEN UPLAND SOIL MAPPING UNITS, TERRAIN AND PARENT MATERIAL

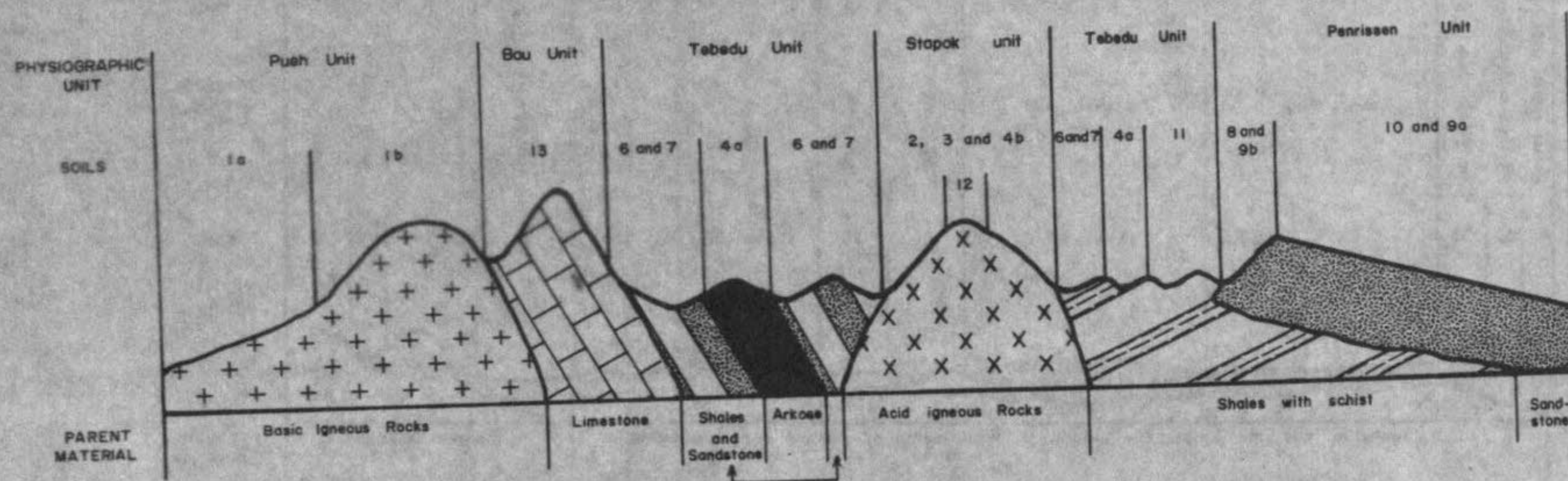

Fig. IV 7

SCHEMATIC RELATIONSHIP BETWEEN LOWLAND SOIL MAPPING UNITS, TERRAIN AND PARENT MATERIALS.

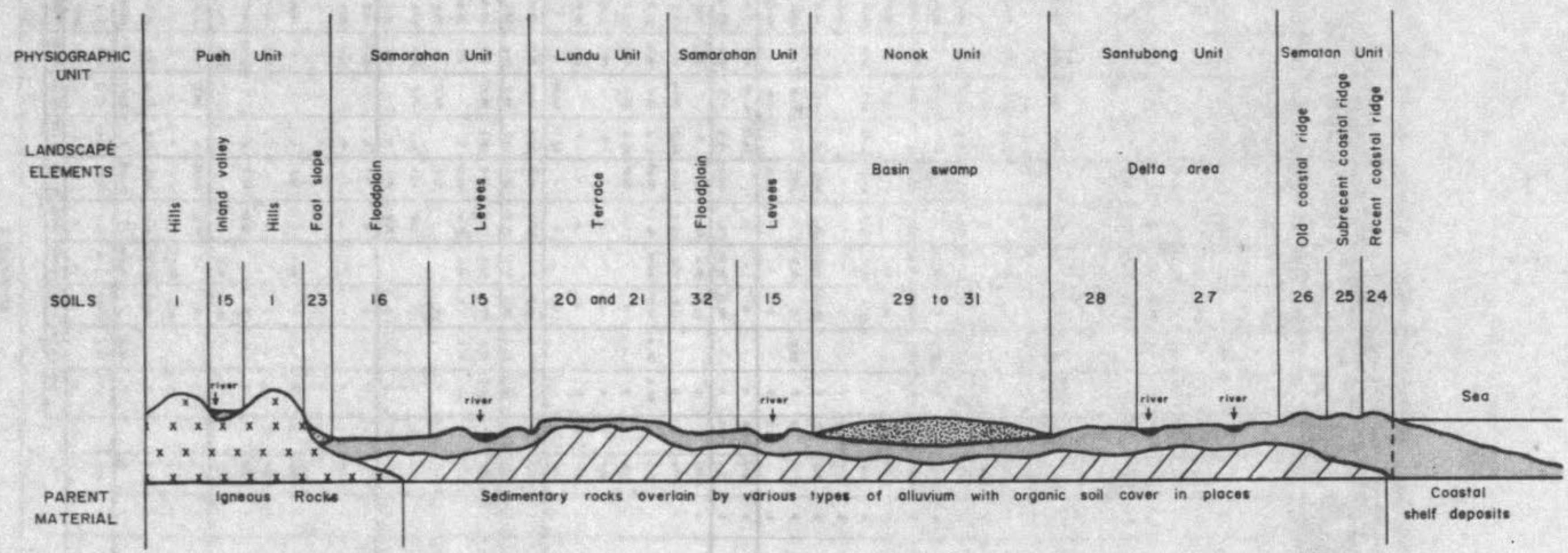

TABLE 25 AVAILABILITY OF ARABLE LAND BY DISTRICT AND ITS AGRICULTURAL SUITABILITY

A – total areal extent; B – calculated maximum area suitable to agriculture if improved

[PAR]ENT MATERIAL	MAPPING UNIT	ESTIMATED PERCENTAGE SUITABLE	LUNDU A	LUNDU B	BAU A	BAU B	KUCHING RURAL A	KUCHING RURAL B	UPPER SADONG A	UPPER SADONG B	LOWER SADONG A	LOWER SADONG B	SIMANGGANG A	SIMANGGANG B	LUBOK ANTU A	LUBOK ANTU B	Limitations to Agriculture: TOPOGRAPHY	DRAINAGE	SURFACE EROSION RISK	FLOODING RISK	CHEMICAL FERTILITY STATUS	PHYSICAL STATUS	AGRICULTURAL SUITABILITY
ON IGNEOUS ROCKS	1a	75%	3.39	2.54	0.57	0.43	15.60	11.70	16.86	12.65	2.30	1.73	3.37	2.53	-	0	3	1	2	1	2	1	Very suitable to suitable, depending on slope.
	1b	30%	5.00	1.50	0.17	0.05	33.20	9.96	96.15	28.85	12.04	3.61	1.15	0.35	-	0	5/4	1	3	1	1	1	Marginally to moderately suitable depending on slope. Tree crops recommended.
	2a	20%	2.04	0.41	11.70	2.34	-	0	20.00	4.00	-	0	-	0	-	0	3	1	2	1	2	2	Marginally to moderately suitable depending on slope. Tree crops recommended.
	2b	10%	-	0	-	0	6.65	0.67	367	0.37	0.42	0.04	3.46	0.35	0.94	0.09	5/4	1	3	1	2	2	Marginally suitable to unsuitable.
	3a	50%	12.15	6.08	2.05	1.03	-	0	-	0	-	0	3.15	1.58	-	0	4/3	1	3	1	3	1	Suitable to moderately suitable depending on slope. Terraces needed for crops with open canopy.
	3b	5%	53.38	2.67	18.40	0.92	-	0	-	0	1.57	0.79	42.52	2.13	3.04	0.15	5/4	1	4	1	2	1	Marginally suitable to unsuitable.
	4a	60%	3.13	1.88	0.39	0.23	23.87	14.32	32.04	19.22	1.36	0.82	0.84	0.54	-	0	3/4	1/2	2	1	3	2	Suitable to moderately suitable depending on slope. Terraces needed for crops with open canopy.
	4b	60%	-	0	-	0	0.52	0.31	-	0	19.90	11.94	16.96	10.18	-	0	5/4	1/2	3	1	3	2	Marginally suitable to unsuitable.
	5a	60%	-	0	-	0	-	0	-	0	-	0	5.03	3.02	-	0	3	2/3	3	1	3	3	Moderately suitable, expensive to fertilize. Terraces needed for crops with open canopy.
	5b	0%	-	0	-	0	-	-	-	-	-	-	6.49	0	-	0	5/4	2	4	1	3	2	Unsuitable.
ON SEDIMENTARY ROCKS	6a	60%	26.81	16.09	161.00	96.60	126.09	75.65	141.81	85.09	17.28	10.37	70.77	42.46	14.14	8.48	4/3/2	1/2/3	2	1	2	1/2/3	Suitable to moderately suitable, depending on slope. Terraces needed for crops with open canopy.
	6b	20%	22.3	0.45	-	0	-	0	-	0	-	0	85.57	17.11	15.19	3.04	4	1/2/3	3	1	2	1/2/3	Marginally suitable to unsuitable
	7a	60%	15.45	9.27	7.83	4.70	10.15	6.09	28.28	16.97	-	0	3.36	2.02	-	0	4/3/2	1/2/3	2	1	2/3	1/2	Suitable to moderately suitable, depending on slope. Terraces needed for crops with open canopy.
	7b	20%	-	0	-	0	-	0	8.90	1.78	-	0	-	0	-	0	4	1/2/3	3	1	2/3	1/2	Marginally suitable to unsuitable.
	8a	60%	59.08	35.45	8.78	527	15.71	9.43	57.60	34.56	14.04	8.42	10.47	6.28	0.73	0.44	4/3	1/2	3	1	3/4	2	Moderately to marginally suitable, depending on slope. Tree crops recommended only.
	8b	0%	24.14	-	20.11	-	55.92	-	11.00	-	3.15	-	27.02	0	15.82	0	5/4	1/2	4	1	3/4	2	Unsuitable
	9a	30%	89.87	26.96	7.61	228	29.11	8.73	3498	10.49	46.50	13.95	54.67	16.40	5.23	1.57	4/3/2	1/2/3	3	1	3/4	2/3	Moderately to marginally suitable depending on slope. Tree crops recommended only.
	9b	0%	1.51	-	2.07	-	8.68	-	335	-	-	-	7.12	0	-	0	4/5	1/2	4	1	3/4	2/3	Unsuitable.
	10a	10%	67.40	6.74	15.38	1.54	7.64	0.76	053	0.05	14.04	1.40	17.18	1.72	-	0	2/3	3/4	2	-	4	3/4	Marginally suitable to unsuitable. Very expensive to fertilize
	10b	0%	-	0	-	-	12.99	-	-		-	-	-	0	-	0	4/3/2	2/3	3	1	4	3/4	Unsuitable.
	11	60%	49.81	29.88	-	0	0.85	0.51	18.01	10.81	0.84	0.50	20.53	12.32	-	0	3/4	2/3	3	-	2/3	2/3	Moderately suitable. Terraces needed for crops with open canopy
ON VARIOUS ROCKS	12	0%	4.02	-	3.47	-	0.85	-	8.27	-	8.69	-	3.98	0	0.52	0	5	1	4	1	-	-	Unsuitable for agriculture.
	13	0%	-	0	9.27	-	21.88	-	0.41	-	2.83	-	-	0	-	0	5	1	4	1	-	-	Unsuitable for agriculture.
[MI]XED UNIT	14a	70%	-	0	-	0	12.04	8.43	45.24	31.67	-	0	-	0	-	0	3/2/1	1-5	2	3	2/3	2/3/4	Moderately suitable. Needs drainage in places, expensive to fertilize, floodrisk in places.
	14b	70%	-	0	-	0	27.75	19.43	3.77	2.64	10.89	7.62	16.97	11.88	-	0	3/2/1	1-5	2	3	3	2/3/4	Marginally suitable. Needs drainage, expensive to fertilize, floodrisk in places.
RECENT RIVERINE ALLUVIUM	15a	75%	38.64	28.98	7.14	5.34	8.27	6.20	-	0	1.15	0.86	4.92	3.69	-	0	1	1/2/3	1	2	1/2	1/2	Very suitable. Floodrisk in places.
	15b	50%	-	0	-	0	2.30	1.15	40.95	20.48	0.42	0.21	0.21	0.11	-	0	1	1/2/3	1	2	3	2/3	Moderately suitable. Expensive to fertilize, floodrisk in places.
	16a	75%	15.93	11.95	3.12	2.34	37.28	27.96	0.21	0.16	23.25	17.44	25.34	19.01	4.40	3.30	1	2-5	1	4	1/2	3	Suitable. Needs drainage, floodrisk.
	16b	60%	3.54	2.12	-	0	0.83	0.50	6.29	3.77	0.52	0.31	-	0	-	0	1	2-5	1	4	3/4	3	Moderately suitable. Needs drainage, expensive to fertilize floodrisk.
	17	75%	-	0	7.11	5.33	10.05	7.54	-	0	-	0	-	0	-	0	1	4/5	1	3	1/2	3	Very suitable to suitable. Needs drainage in places, floodrisk in places.
OLD ALLUVIUM	18a	50%	0.72	0.36	-	0	5.66	2.83	-	0	-	0	-	0	-	0	1/2	4/5	1	3.	3/4	3/4	Marginally to moderately suitable. Needs drainage, expensive to fertilize, floodrisk in places.
	18b	50%	1.09	0.55	-	0	-	0	25.04	12.52	-	0	-	0	-	0	1/2	4/5	1	3	3/4	3/4	Marginally suitable. Needs drainage, expensive to fertilize, floodrisk in places.
[M]IXED UNIT	19a	75%	11.13	8.35	26.07	19.55	23.97	17.98	20.43	15.32	0.73	0.55	17.16	12.89	10.89	8.17	1/2/3	1/2/3	2	2	1/2/3	1/2/3	Very suitable to suitable. Floodrisk in places.
	19b	75%	3.78	2.84	8.41	6.31	1-25	0.93	5.97	4.48	4.93	3.70	7.33	5.50	0.52	0.39	1/2/3	1/2/3	2	2	2/3/4	1/2/3	Moderately suitable. Floodrisk in places.
TERRACES	20	10%	67.17	6.72	-	0	21.05	2.11	16.86	1.69	5.66	0.57	8.90	0.89	2.51	0.25	1/2	4/5	1	1	4	4	Marginally suitable to unsuitable, depending on locality. Very expensive to ferlize.
	21	50%	3.17	1.59	3.89	1.95	20.42	10.21	-	0	17.39	8.70	7.54	3.77	3.14	1.57	2/1	2/3	1	1	3/4	4	Marginally to moderately suitable depending on locality. Expensive to fertilize.
	22	0%	0.75	-	-	-	4.82	-	13.62	-	0.10	-	-	0	-	0	1/2/3	1	1	2/1	4	3	Unsuitable.
FANS	23a	80%	-	0	5.48	4.38	7.75	6.20	3.77	3.02	0.21	0.17	-	0	-	0	1/2/3	1	1	2/1	1/2	3	Very suitable.
	23b	25%	1.60	0.40	-	0	2.93	0.73	-	0	1.05	0.26	-	0	-	0	1/2	1/2/3	1	1/2	3/4	4	Marginally to moderately suitable depending on locality.
BEACH DEPOSITS	24	50%	3.39	1.70	-	0	2.51	1.25	-	0	-	0	-	0	-	0	1	1	1	1/2	2	1/2	Suitable. Fertilizer required, drought problem.
	25	80%	6.92	5.54	-	0	4.08	3.26	-	0	-	0	-	0	-	0	1	1/2	1	1	3	2/3	Moderately suitable. Expensive to fertilize, drought problem.
	26	0%	1.30	-	-	-	-	0	-	0	-	0	-	0	-	0	1	1	1	1	4	4	Marginally suitable. Very expensive to fertilize, drought problem.
DELTAIC DEPOSITS	27a	?	50.77	?	-	0	148.30	?	-	0	4.82	?	1.99	?	-	0	1	2/5	1	4	1	4/3	Under investigation needs drainage. Catclay and salinity problems. Floodrisk
	27b	20%	-	0	-	0	0.21	0.04	-	0	-	0	-	0	-	0	1	4/5	1	4	3	4	Marginally suitable. Needs drainage, expensive to fertilize.
	28a	75%	2.04	1.53	-	0	73.41	55.06	-	0	34.04	25.53	-	0	-	0	1	4/5	1	4	1	4/2	Suitable. Needs drainage, salinity and flood control.
	28b	20%	-	0	-	0	1.47	0.29	-	0	-	0	0.21	0.04	-	0	1	4/5	1	4	3	3/2	Marginally suitable. Needs drainage, expensive to fertilize.
PEATS	29a	75%	1.20	0.90	0.13	0.09	14.14	10.61	13.82	0	22.30	16.73	-	0	-	0	1	5	1	4	3	4	Moderately suitable. Needs drainage, subsidence problem.
	29b	75%	1.25	0.94	-	0	-	0	-	0	-	0	3.98	2.99	-	0	1	5	1	4	4	4	Marginally suitable. Needs drainage, subsidence problem, expensive to fertilize.
	30	75%	1.04	0.78	-	0	13.09	9.81	12.33	9.24	32.26	24.18	27.76	20.82	-	0	1	5	1	4	4	4	Moderately suitable. Needs drainage, subsidence problem.
	31	?	34.20	?	-	0	104.94	?	64.10	?	340.90	?	343.21	?	14.66	?	1	5	1	4	4	4	Probably suitable. At present not recommended because of severe subsidence problems.
[MIS]CELLANEOUS UNITS	32	50%	9.10	4.55	-	0	0.32	0.16	27.13	13.57	14.14	7.07	51.11	25.56	6.91	3.46	1	4/5	1	4	1-4	3/4	Suitable in part. Needs drainage.
	33	0%	0.64	0	-	0	7.96	0	-	0	-	0	-	0	-	0	-	-	-	-	-	-	Not to be used for agriculture.
Total			678.78	219.72	330.15	160.68	926.51	330.81	781.39	343.40	659.72	167.47	900.29	226.14	98.64	30.91							

EXPLANATION

TOPOGRAPHY	DRAINAGE	FLOODING RISK	SURFACE EROSION RISK	CHEMICAL FERTILITY STATUS	PHYSICAL STATUS	?
1. – Flat (< 2°)	1. – Well drained	1. – None	1. – None	1 – High	1. – Very good	depending on results of experimentation
2. – Gently sloping (2°–10°)	2. Moderately well drained	2. – Low (infrequent, short duration)	2. – Slight	2. – Moderate	2. – Good	
3. – Moderate steep (10°–20°)	3. Imperfectly drained.	3. – Moderate (infrequent)	3. – Moderate	3 – Low	3. – Poor	
4. – Steep (20°–35°)	4. Poorly drained.	4. – High (every year)	4. – High	4. – Very low	4 Very poor	At present difficult to assess.
5 – Very steep (> 35°)	5. Very poorly drained					

mapping units, the terrain in which they occur together with the parent materials on which they have formed, has been illustrated in a schematic from in Fig.IV. 6 and 7. (pp. ......)

a. Mountain and Hill Soils

Mapping unit 1

(i) Occurrence. As large areas forming steep moutainous terrain in the Upper Sadong District and as smaller areas forming steep mountainous terrain in the Kuching Rural and Lower Sadong Districts. Small areas of single hills occur throughout the Region but their total areal extent is of minor importance although locally their occurrence is of agricultural significance.

(ii) Topography. Most of the unit builds moderately steep to steep mountainous terrain, generally with slopes in the 15-30 degrees range. Footslopes are commonly the most gentle ones in this range, while upper slope areas may be steeper. Deeply incised gullies and valleys occur where large moutain complexes are involved. Minor areas are formed by single monadnock type hills with steep slopes. Erosion occurs generally as mass-movements of soil and rock debris along slopes; landslides are much in evidence. Commonly at the footslopes colluvial debris accumulates and is gradually removed by streams.

(iii) Parent Material. The unit is found exclusively on igneous rocks of basic to intermediate composition. The range is from gabbro-to andesite, the latter being the most common.

(iv) Soils. Soils, comprising SKELETAL SOILS of the Sedong Family (p. ....) are usually associated with steep land. Shallow soils occur in complex with bouldery and rocky land, the latter being dominant where recent landslides have removed much of the original soil mantle. This steep land is indicated as mapping unit 1b. On more gentle sloping land the soils are deeper and belong to the LATERITIC Soils in which the Tarat series is dominant (p. ....). Small areas belong to the Antayan series (p. ....) which is separated from the Tarat series on account of a more blocky structure and more yellowish colouration. The areas are indicated on the map by the symbol At. Although the Tarat Family soils are generally well developed, shallow and deep phases occur in complex in most areas. This is caused by mass-movements of soils along slopes through which in some places the normal soil has been truncated, while in others it may be found buried. The latter phase is commonly found at lower slopes where much colluvial material accumulates. The soils,

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although prone to erosion through mass-movements are generally stable to surface-wash. Even at exposed sites surface wash is not much in evidence although some gullying is taking place. Flooding does not occur in the soils of the mapping unit.

(v) Fertility Aspects. By Sarawak standards, the soils are among the best upland soils to be found in Sarawak. This is not so much caused by the nutrient content which is generally low, but by the favourable physical conditions. If sufficient nutrients are added, roots develop freely in these soils and are not hampered by excessive water or impenetrable horizons. When exposed, the surface soils may dry out during long spells of dry weather and sensitive crops may suffer from drought. The most shallow, immature soils in this unit, the Suka series, are the most fertile ones in the range, because they are relatively young. However, because they occur on the most difficult terrain, the steep slopes, they are at present mainly used for shifting cultivation. Tree crops are difficult to establish because of the shallowness of the soil. The soils generally respond to fertilizers although the phosphate retention is moderately high.

(vi) Agricultural Potential. The areas are not suitable for large scale development based on intensive land-use. Parts of the unit, particularly those formed by footslopes can be used for crops with a high income per surface areas. Pepper is particularly suited to such land use and since also the soil types are of particular value for pepper cultivation this crop is the best choice for this type of land. The shallow soils on steep slopes which should be kept under permanent cover could be used for fruit trees if planted in holes. Although in this mapping unit the topography forms the greatest limitation to agriculture every endeavour should be made to find means of using this land, because of all the upland soils it comprises the most fertile soils. The most appropriate system to make use of this land would be to have small farm units on selected sites with crops giving a high income per surface area planted. Although the steepness of the slope may normally carry a high risk of erosion, the author is of the opinion that with proper management involving permanent coverage of the soil, the slope factor is off-set by the relative high agricultural potential and the low erodability of these soils. The necessity to make use of this land is further emphasized by the low potential of other available upland soils in the areas surrounding this mapping unit and the large population concentrations usually found in close proximity.

Mapping unit 2

(i) Occurrence. As many small areas forming monadnock type hills in the Bau District, some larger areas of mountainour terrain in the Upper Sadong District and to a minor extent in the Kuching Rural District. Some single small areas in the Simanggang District.

(ii) Topography. The mapping unit is characterised by single hills and mountains rising steeply from surrounding plains and low hilly country. An exception is the large area found in the Upper Sadong District where in the Sungei Roban drainage basin, the mapping unit builds strongly dissected hilly terrain merging into mountainous terrain. Large streams are generally absent, the areas being drained by small gullies fed by springs which are often tapped by the local population for domestic use. The slopes are commonly in the 20-35 degrees range or over. Erosion occurs as mass-movement through landslides. At the foot of steep hills, a pediment of boulders overlying a buried soil is commonly found.

(iii) Parent Material. The unit is found on acid igneous, intrusive and extrusive rock types of fine texture. The range of rock types is large and includes decite, rhyolite, microgranodiorite and associated porphyritic rocks and tuffs.

(iv) Soils. The soils comprise SKELETAL SOILS found on steep slopes where the soil mantle has been removed by erosion. The soils are therefore commonly associated with rocky and bouldery land. Although this is indicated by mapping unit 2b, it does not mean that the remaining portion of the unit, formed by 2a does not contain skeletal and shallow soils. Unit 2a comprises mainly RED-YELLOW PODZOLIC SOILS of the Abok Family, the Gumbang series being dominant (p. .....). This series is characterised by shallow, undeveloped soils and therefore most of the mapping unit can be regarded as having generally shallow soils, in which boulders and rock outcrops occur in abundance. It should be mentioned that the extent of the mapping unit has probably been exaggerated. This is caused by the fact that the acid intrusions are commonly only outcropping near the summit of the hills. Although bouldery material may have spread over the slopes, it frequently overlies soils which belong to neighbouring mapping units. The exact boundary is very difficult to indicate and the topography has generally served as an indication. Typical examples of the Gumbang series are therefore difficult to fine.

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(v) Fertilty Aspects. The soils are commonly of moderate fertility and can as far as the nutrient status is concerned, be compared with the RED-YELLOW PODZOLIC SOILS derived from shales. Structurally, they are often better than the shale derived soils and the internal drainage is superior. Since very little permanent agriculture is practised on these soils, it is difficult to give indications on their crop performance. The local inhabitants, however, regard them as better padi soils than the ones derived from sedimentary rocks, occupying much of the surrounding areas. Probably the vegetation is able to regenerate faster because of the nutrients obtained from weathering rock found at shallow depth.

(vi) Agricultural Potential. Because of shallowness of soil, the occurrence of bouldery and rock land, combined with the general steep terrain the agricultural potential of this mapping unit is low. The areas are small and locally they can be used for the cultivation of fruit trees and some pepper. Old native fruit plantations indicating old settlements are often found on these hills. (Bukit Gumbang is a good example). This usage could be encouraged. Only in the larger areas in the Upper Sadong District permanent cultivation would be possible on moderately steep land. Pepper and fruit crops are the most obvious crops. Areas still under primary forest should be kept as Communal Reserves, as this use is probably of more economic value for the local inhabitants than agricultural exploitation.

Mapping unit 3

(i) Occurrence. This unit is found in four major areas. The first two are found in the Lundu District where they comprise the Pueh and Gading massifs. The third one is found in the Bau District comprising the Jagoi-Kisam massif and the fourth is found in the Simanggang District where it forms the Tabong-Telaga mountains in the Ulu Strap area. The mapping unit is further forming monor, single hills mainly in the Lower Sadong and Simanggang Districts.

(ii) Topography. The mapping unit is commonly found on moderately to steep mountainous terrain with deeply incised valleys and gullies. Those areas forming the Pueh and Gading massifs are the most steep one, and reach heights of 5,000 feet in places. Erosion under natural cover is generally by mass-movement along slopes. Particularly the Jagoi-Kisam area is prone to many landslides leaving steep rocky cliffs at the mountain sides. Without a natural soil cover sheet erosion occurs.

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(iii) Parent Material. These comprise coarse grained acid igneous rock types, mainly coarse grained granites and granodiorites of varying chemical composition. Those in the Lundu District contain large amounts of biotite and the rocks are commonly referred to as adamellite. In the Bau District, granodiorite of very acid nature is found while areas in the Simanggang District are mainly built by very acid granites with few ferro-magnesium minerals.

(iv) Soils. The mapping unit is dominantly formed by SKELETAL SOILS of the Kapit Family (Buri series) (p. ....) indicated by subunit 3b. This series occurs on steep land where landslides constantly rejuvenate the soil mantle. The series is commonly found in complex with bouldery and rocky land. On the less steep slopes and on the footslopes where colluvial material may accumulate, the soils are deeper and belong to the RED-YELLOW PODZOLIC SOILS, Abok Family. In this mapping unit two main series are separated within the Abok Family, namely the Gading series (p. ....) found generally on granodiorite and the Jagoi series (p. ....) found generally on granites. The Jagoi series is indicated as such on the map (Jg), the remainder belongs to the Gading series. Both series have in common a granitic texture in which coarse sand with clay dominates over silty. They differ in colour, the Gading being stronger coloured. Generally the Jagoi is deeper and found at lower slopes and one cannot escape from the impression that probably the Jagoi series is more related to colluvial material while the Gading series is its residual counterpart on the steeper slopes.

(v) Fertility Aspects. The soils are physically of favourable condition but they are chemically very poor. The latter is caused by the highly acidic nature of the parent materials. The primary forest shows generally a good stand but this is probably more related to the surface area of the root system than to inherent high fertility of soils. The favourable physical conditions result in a well developed root system which is able to extract the necessary nutrients over a large area. The soils are generally not used for permanent agriculture but where this has been attempted, as for instance in the Simanggang District, pepper has been a failure while also rubber did not very well. Although this must be attributed to the low amounts of fertilizers used by the local population, it confirms the conclusion reached from soil analyses that the soils are deficient in all nutrients and need to be heavily fertilized. With proper fertilization, mostcrops chould do well on these soils since the physical conditions are good.

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(vi) Agricultural Potential. For most areas the agricultural potential must be regarded as being very low. The steepness of the terrain combined with the low fertility of the soils do not favour agricultural exploitation. Moreover, the sandy soils when not kept under permanent cover are prone to sheet erosion, and therefore on the steep slopes the soils could best be left under primary forest. In the Pueh and Gading areas, this is still the case but the result of shifting cultivation in the Jagoi-Kisam and Tabong-Telaga areas has been devastating. Sheet erosion, land slides and lallang infestation (the latter particularly in the Tabong area) are much in evidence. This may prove the desirability to keep these areas under a permanent cover. The generally more undulating terrain in the Tabong region may be used for crops such as rubber and oil palm if the soils are properly fertilized and sufficient attention is given to conservation measures. (Andriesse, 1968a).

Mapping unit 4

(i) Occurrence. This mapping unit is found in two major areas. The first one is found as an almost continuous area in the Upper Sadong District, west of Serian and transgresses into the Kuching Rural District. The second area is found in the border area of the Lower Sadong and Simanggang Districts. Small areas of only local importance are further found mainly in the Upper Sadong District along the Serian-Simanggang road.

(ii) Topography. The topography is very varied. In the first mentioned locality where the mapping unit is found on arkose the landscape is formed by moderately dissected hilly terrain, showing deeply incised valleys. The amplitude in relief is generally about a 100 feet and where the small streams have reached local base level small inland valleys have formed. In the interior where the downcutting process still proceeds, the landscape is cut up into a multitude of hills by many small streams. The slopes are commonly in the 15-25 degrees range. Locally this may be less or more. Erosion is caused mainly by slipping or sliding. Sheet erosion is not much in evidence.

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In the border area of the First and Second Divisions the mapping unit forms steep, high, mountainous terrain in which small streams have cut deeply incised valleys. Slopes are generally well over 20 degrees. This landscape can be compared with that of mapping unit 3. Other areas of minor importance have a topography which can be compared with that of the first mentioned locality.

(iii) Parent Material. This mapping unit is composed of soils developed on parent materials which can be regarded as being chemically intermediate between the basic igneous rocks forming mapping unit 1 and those of the acid igneous rocks forming mapping unit 3. In some areas specific parent materials could be differentiated such as arkose in the area west of Serian and schist in minor areas east of Serian, while the large area at the border of the First and Second Divisions is formed by a range of rock types in which diorite is dominant. Granite and granodiorite may also occur. Very small areas in the Lower Sadong District are formed by silicified volcanic rocks.

(iv) Soils. On account of terrain, a main subdivision is made between SKELETAL SOILS and RED-YELLOW PODZOLIC SOILS. The steeply sloping mountainous terrain in the border area of First and Second Divisions is dominantly covered by SKELETAL SOILS of the Kapit Family (p. ....). Well-developed soils are rare and usually occur only at some moderately sloping land or on colluvial footslopes. These developed soils belong to the Abok Family (p. ....) and since the complex geology makes it impossible to establish with some certainty the parent material no differentiation into series has been made. In other areas, this has been possible and most soils are mapped there as RED-YELLOW PODZOLIC SOILS, also belonging to the Abok Family but comprising specific series related to the kind of parent material on which they have formed. So is the Serin series (p. ....) related to arkose, the Bayur series (p. ...) to schist and the Keladan series (p. ....) to silicified volcanic rocks. These series have been indicated as such on the map, respectively in, By and Kl. Where this has not been done, the soils belong to the undifferentiated Abok Family.

(v) Fertility Aspects. The SKELETAL SOILS and the undifferentiated Abok Family soils occurring in subunit 4b are the best supplied with nutrients. This statement is based by inference from the parent materials because very little analytical information is available.

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The soils have received very little attention because the terrain is not suited to agriculture and most areas are still under primary forest and uninhabited. Where used in fringe areas, pepper cultivation is carried out with success. This is probably more related to the good physical properties of the soils than to nutrient status.

The Serin series is intensively used for pepper, rubber and various other crops, as is the Bayur series and both give excellent results if intensive farming methods are used and sufficient fertilizers are supplied. The soil analyses reveal a deficiency in all major nutrients, potassium being least deficient. The structure of the Serin series is inferior to that of the Bayur and root development in the latter is commonly better. For this reason, the latter soils are much favoured for pepper cultivation along the Serian-Balai Ringin Road. The soils appear to respond favourable to fertilization although phosphate is liable to be highly fixed in the Serin series.

(vi) Agricultural Potential. The areas at the border of the First and Second Divisions have a low agricultural potential because of bad topography. Fringe areas may be used by the local inhabitants if slopes are not too steep. But this is only of local significance. The Serin series can be used for intensive agriculture although soil conservation measures and fertilization need constant attention. The steepest areas (mainly those along the Padawan road) are topographically the least suitable. Rubber is an excellent crop for this soil type, particularly since it provides an excellent permanent soil cover. Pepper can be grown with proper fertilization but erosion should be controlled by terracing. The latter, although preventing sheet erosion may not be able to control mass-movement such as slips and landslides which are natural phenomena in this area. They may be particularly dangerous if houses are built on unstable sites.

The Bayur series is an excellent soil for pepper. The areas, being small in extent, are admirably suited to intensify farming in an area in which soils suitable for intensive agriculture are rare.

The Keladan series, although suitable for intensive farming is too small in areal extent to be of any agricultural significance beyond the local level.

../unit 5

Mapping unit 5

(i) Occurrence. This mapping unit occurs exclusively in the Lingga Subdistrict in the east of the Region. Its largest extent is found on Bukit Lingga or Bukit Lesong (as it is called by the immediate surroundings of the first mentioned location. (Bukit Apeng and Bukit Krepok).

(ii) Topography. The unit builds generally mountainous terrain; a minor area north of Bukit Lingga is formed by low hilly terrain. The mountainous areas comprise two single mountains, namely Bukit Lingga and to the west Bukit Apeng. They rise steeply up from the surrounding plains and hilly terrain of low elevation. The footslopes are moderately steep to gently sloping. Upper slopes areas are very steep, usually more than 30 degrees. The mountains are drained on all sides by small deeply incised streams forming a radial pattern. The hilly terrain in the small area north of Bukit Lingga comprises moderately sloping land but where it borders into the surrounding peat swamps slopes are steep. On the mountains where the surface is exposed, erosion is severe. Footslope areas are covered with large boulders and other colluvial material of smaller size. Landslides are common but because of the absence of youthful streams at the foot of the mountains the scree material formed at the footslopes is not very rapidly removed and long concave slopes are therefore most common.

(iii) Parent Material. This consists of microgranite with exveptional small amounts of ferro-magnesium minerals. Accessory minerals are dominated by monazite.

(iv) Soils. The Lingga series (p. ....) is commonly found on moderately steep to gently sloping terrain, thus the footslopes. This series is classified as a GREY-WHITE PODZOLIC SOILS because of its very pale colouration which is related to the low iron content of the parent rock. On account of derivation, it should have been placed in the Abok Family, RED-YELLOW PODZOLIC SOIL GROUP. The Lingga series is, therefore, anomalous and is difficult to place in the present classification system.

The soils are characterised by a silty texture. This, and its pale colour makes it easy to distinguish them from other soils, particularly as they occur in such a localised area. The heavy mineral monazite is another diagnostic characteristic since it occurs doninantly in the heavy mineral fraction.

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On the steep slopes, the Lingga series occurs in complex with SKELETAL SOILS and bouldery and rocky land.

(v) Fertility Aspects. The soils are chemically very poor. When occurring in footslope areas, the soils are also generally imperfectly drained. Much surface run-off water tends to collect there and infiltrates into the porous soils. The local people have indicated that on the steep slopes good hill padi yields can be obtained, particularly on Bukit Apeng. This must be attributed to the shallow nature of the soil and constant rejuvenation so that the forest is able to regenerate rapidly. This is not the case at the more gentle footslopes, where older soil material tends to accumulate.

(vi) Agricultural potential. Because of the small total area involved, the unit is of very minor importance for the Region. Locally, the soils can be used for rubber and fruit crops. Citrus appears to do well on the lower footslopes if adequate attention is given to drainage. The steep slopes with more fertile soils are not suited to agriculture and are better left under primary forest and if they must be used, fruit crops should be planted in selected places with easier or more manageable slopes.

Mapping units 6 and 7

These two units are best described together because they have many characteristics in common.

(i) Occurrence. The units occur throughout the region and comprise the dominant upland soils in the Bau, Kuching Rural, Upper Sadong and Simanggang Districts. Unit 6 is most common, while unit 7 is of local importance only in some areas of the Upper Sadong District.

(ii) Topography. The units generally built moderately dissected to strongly dissected terrain of which the height varies between 50 and 350 feet. The terrain is described in detail under Chapter 4 (p. .... and p. ....). The hill summits in this landscape indicate the existence of former floodplains and their height increases gradually from about 50 feet near the coast or present floodplain level to about 350 feet in the interior. The slopes are of surprisingly equal magnitude throughout the Region, regardless the amplitude of relief. There is, however, a tendency to more rounded hills towards the present floodplains, which may in some localities

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possibly be caused by the presence of less hard parent materials in which present floodplains have formed, the rivers seeking their way to the sea through the most easily erodable materials. Slopes are complex and generally within a range of 15 to 25 degrees, they rarely exceed it. Upper slopes and footslopes may be steeper than the mid-slope areas, but the reverse also happens. No general rules can be given. Land slips and slides are very common, because the underlying rock formations are formed by generally folded stratified materials. Slips and slides create an undulating slope surface.

Sheet erosion is not much in evidence in this landscape, particularly if the soil is under permanent vegetative cover.

Subunits 6b and 7b occur on higher land than subunits 6a and 7a and because the amplitude of relief is greater mass removal of soil-rock debris is of a greater magnitude than that occurring on short slopes. Examples of the landscape of subunit 6b are found in the Undup area in the extreme east of the Region.

Although sheet-wash is commonly not of significance, in unit 7 one generally finds a thin veneer of sand on native paths if these are located along slopes. Since the topsoils in unit 7 are more sandy than in unit 6 this may indicate that some sheet-wash is taking place in the more sandy soils. These native paths induce gullying as run-off water tends to concentrate in the small indents the paths make on the surface. The coarse particles settle on these paths while the clay particles are carried away along the slope in suspension. Soil observations along such paths may over-emphasized the sandy texture of these soils.

(iii) Parent material. Unit 6 comprises soils on argillaceous rocks while those in unit 7 are derived from arenaceous rock types or a mixture of argillaceous and arenaceous types. Commonly thin or thick sandstone beds occurs within sedimentary rocks composed mainly of shales; the reverse also happens. It is therefore possible that on one slope soils of unit 6 and 7 occur in succession although as a rule the materials derived from beds of different texture is completely mixed through mass-movement along the slope. It is also possible that soils develop through various beds of sedimentary rocks, giving rise to the occurrence of bisequent soils.

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(iv) Soils. The soils in both mapping units belong all to the RED-YELLOW PODZOLIC GROUP. While in unit 6 the Merit Family (p. ....) is dominant and the Bekenu Family (p. ....) occurs subordinate, the reverse is the case in unit 7. This is caused by the complex manner in which arenaceous and argillaceous rocks usually occur. Where argillaceous rocks are dominant the Merit Family is the common soil type, locally the Bekenu Family may be present if beds of sandstone influence the shale. Where fine sandstone is dominant, the Bekenu Family is the normal occurring soil type, while the Merit Family may be of local importance where shale outcrops. Again, both families occur as deep and shallow phases, depending on the steepness of the terrain. The dominance of shallow phases is indicated by subunits b. mapped on steep land.

The Merit and Bekenu Families cover a wide range of soils with great variations in characteristics such as drainage, permeability, porosity and content of iron concretions. The main distination between the families is based on texture, the Merit being more clayey. Other characteristics have not yet been used officially for a further differentiation of the families into series. Chemical characteristics often relate to type of parent material and this was used as a criteria for the separation of some series (see Chapter 11, p. ....) but on the map only two are indicated, namely the Padawan series (Pw) which has a lighter colour than is usually the case for the Merit Family and which is transitional to the GREY-WHITE PODZOLIC SOILS, and the Begunan series (Bg) which has strong red colours and is related to the occurrence of red mudstone. General indications relevant to all soils involved in these mapping units cannot be given, and the reader is referred to Chapter 11 for detailed information.

(v) Fertility Aspects. The soils in both mapping units are of moderate fertility. The overall fertility rating may be influenced by physical characteristics such as drainage. The better drained members of the unit give a better crop growth than the imperfectly drained ones. Particularly pepper is very sensitive to this soil property. Rubber, also tends to do better on the better drained soils. Most soils respond well to fertilizers although phosphate fixation is a problem in some series. This factor is discussed in detailed in Chapter 14 (p. ....). Trace element deficiencies pose other problems, particularly in the cultivation of pepper.

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Generally, with adequate fertilizers and in places with control of drainage (depending on the crop), the soils can support many crops but because of the difficult terrain perennial crops are best suited to them.

(vi) Agricultural Potential. Because of the dominance of mapping units 6 and 7 in the uplands the use of this land is of great economic importance. The main limitation is topography, which apart from the danger of erosion makes farming difficult and expensive. It would be impossible to condemn agriculture in this large area for reasons of topography only because a very large portion of the rural population is already making use of this land and depends on it. Therefore, ways and means have to be found to make optimum use of this land.

Firstly, it is imparative that the generally moderately steep land should be used for perennial crops mainly. Some more gently sloping land, such as occurring along the Bau-Lundu road (Andriesse, 1967) and along the Serian-Simanggang road (Andriesse, 1965a) may probably be used for some annuals. Present choices are rubber and oilpalm of which the latter is also restricted by slope limits and transportation difficulties. Pepper could be grown in selected areas, but does not bring a solution for the use of the largest part of the area. Suggestions have been made to introduce the taunya system from Burma into these areas (Dutch University Team, 1970). This system is based on shifting cultivation in which use is made of commercial trees during the forest regeneration period.

The Semongok Agricultural Research Station has been located on land of mapping unit 6 to carry out research with crops and management practises on this type of topography. Crops being tested include also coffee and tea and any firm recommendation, with the exception of rubber and pepper, must await results of these investigations.

Mapping unit 8

(i) Occurrence. The largest expanse of this unit is found in the Lundu District where it is almost exclusively confined to the Sampadi and Pueh Forest Reserves.

Another large area is formed by the Matang-Bukit Raya range along the Bau-Lundu District border and within the Kuching Rural District.

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A large area of this unit is also found in the Penrissen-Bungoh mountain complex at the border with Indonesia and comprises the upper catchment areas of the Sarawak and Sadong rivers.

The unit is found widespread in the Upper Sadong and Lower Sadong Districts towards the border with Indonesia as is the case in the Simanggang District. Smaller isolated areas of this unit are found throughout the Region.

(ii) Topography. The unit is usually found in terrain displaying cuesta features. Because of uplift and easily erodable parent materials, very deeply incised rivers have cut up the landscape into very steep high ranges. This is enhanced by strong folding. A typical example is the Penrissen-Bungoh complex. Where the sandstones are more or less horizontally bedded the landscape is much more subdued. Sequences of scarp and dipslopes are common, as are mesas, hogbacks and other such mountain types. The mapping unit is mainly confined to the scarpslopes. Where the unit is formed by low undulating hilly terrain, small differences between these two slope types do not give rise to the formation of different soil types. The unit builds also conspicuous mountain ranges such as the Matang, Bungoh-Penrissen, Klingkang and Narup Ranges.

Steep scarp slopes are indicated on the map by subunit 8b while the more moderately sloping terrain is indicated by subunit 8a. Erosion in the form of landslides is very much in evidence on scarpslopes where well developed pediments are commonly found at the foot. In more undulating terrain mass-movement of soils are less common but gully and sheet erosion are more in evidence, particularly when the soils are exposed.

(iii) Parent Material. These are invariably poorly consolidated coarse-grained sandstones. The sandstones are generally highly quartzitic and poor in weatherable minerals.

(iv) Soils. On steeply sloping land such as scarp slopes the Kapit Family (p. ....) is very common. This family belongs to the group of SKELETAL SOILS. On moderately steep terrain and gently sloping land Nyalau Family soils (p. ....) are found. This family belongs to the RED-YELLOW PODZOLIC SOILS. The latter family is characterised by light textures related to the coarseness of the parent materisls. Deep and shallow phases both occur, but the latter are more common on steep terrain where they occur in association with SKELETAL SOILS. Although some soils in the Nyalau Family are

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imperfectly drained, the well drained phase is usually dominant. Because of their light texture and porosity they are easily eroded, particularly where thin beds of shale occur within the sandstone and provide a slipping surface. During periods of intensive rainfall the soils become saturated and if the slopes are disturbed by cutting or even the fall of a single tree large landslides may occur. Crests of mountain spurs may have a very thin soil cover or are formed by almost bare rock. Where beds of fine textured sandstone or argillaceous rocks occur mixed with coarse sandstone the Bekenu Family is dominant, indicated by the symbol B. Likewise the Nyalau Family occurs as small areas within mapping units 6 and 7. This is indicated on the map by the symbol N.

(v) Fertility Aspects. The soils are very poor in nutrients. This is to be expected from the siliceous nature of the parent material. The Nyalau soils, however, have moderately good physical properties. Given sufficient fertilizers most crop will grow on the Nyalau Family soils. Rapid leaching may necessitate the giving of split fertilizer applications. Rubber is an excellent crop for this soil type. This is probably mainly caused by the favourable physical conditions which promotes free development of the rooting system. Indications in Land Development Schemes are that with the same fertilizer applications rubber grows better on the Nyalau soils than on the more clayey soils in units 6 and 7. Whether this holds for oil palm can only be assessed by experimentation. For more nutrient demanding crops than rubber, the soils are probably too deficient in nutrients to make fertilization economical. This is much dependent on the economic value of the crop and the locality. It would not be advisable to use these soils for pepper cultivation, unless the market price justifies the expenses.

(vi) Agricultural Potential. The overall agricultural potential is low. Large areas are too steep for cultivation and should be left under primary forest. In areas with slopes of less than 15 degrees, the land could be used profitable for tree crops if market prices are high. Terracing is not recommended, even on steep slopes, since this would probably aggravate the erosion problem. Trees should be planted in holes.

Mapping units 9 and 10

These two units are described together because of their close relationship in landscape and in parent materials.

(i) Occurrence. The largest single area of these combined units is found in the Sampadi Forest Reserve in the Lundu District. Another area is found in the Bungoh-Penrissen mountain complex. Unit 9 occurs singly in a large area in the Lower Sadong District near the Indonesian border, while unit 10 is found widespread throughout the Region where flat mountain tops are formed by horizontally bedded sandstone.

(ii) Topography. The units are found generally on dipslopes of cuesta's and on the summits of mesas. With the same type of parent material there is a strong relationship between the degree of slope and the mapping unit present. With slopes of less than 5 degrees, mapping unit 10 is dominant while on land with slopes of more than 5 degrees mapping unit 9 commonly occurs. Mapping unit 10, therefore, may however occur on slopes of more than 5 degrees if the parent material is coarse enough to allow sufficient rapid percolation of rainwater. There is generally very little slump along these slopes, but sheet erosion may occur if the soil is bared of vegetation. Gullying occurs at the edges of dipslopes and may extend into these, forming deeply incised valleys. Undulations in the commonly long dipslopes are caused by outcropping sandstone beds which may form small scarps. Unit 9 is also found on colluvial footslopes of mountains built by unit 8 but the areas are too small to show in detail on the map.

(iii) Parent Material. Parent materials are formed by poorly consolidated, coarse grained quartitic sandstones. In some localities unit 9 is derived from colluvial wash from mountains built also by coarse sandstones.

(iv) Soils. Soils in unit 9 belong to the Sarawak Family (p. ...), GREY-WHITE PODZOLIC SOIL group. This family is characterised by a light texture and very pale colours. Soils in unit 10 belong to Silantek Family (p. ....) in the group of PODZOLS. This family is also light textured and pale coloured but an illuviated humus accumulation layer is present in the B horizon. Both soils of unit 9 and unit 10 are strongly related and the difference is probably caused by more intense leaching in the PODZOLS than in the GREY-WHITE PODZOLIC SOILS. Both soils are derived from the same parent material but the difference in slope is probably sufficient to bring about this change. The PODZOLS are considered to be the most mature soils found in the Region. They occur on very

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stable slopes where little rejuvenation and truncation take place. The leaching process enhanced by the porosity of the soils has, therefore, reached a climax in which all bases have been washed out and only humus is transported downwards. On steeper land SKELETAL SOILS are found. These belong to the Kapit Family (p. . ....). The total area of this steep land is small. In the Bako Peninsula very shallow soils of unit 10 are found. Probably most of this land was stripped of its soil cover since the Mid-Pleistocene. Wave-cut platforms are to be found at several levels. For this reason, soils occur identical to those generally found on steep slopes.

(v) Fertility Aspects. The soils in both units are poor in nutrients, those in unit 10 being the poorest. Due to the prolonged leaching most of the nutrients originally present have been removed and what has remained is stored in the vegetation and the humus. The latter is also of very poor composition. The fertility of the soils in unit 9 is almost similar to that of the Nyalau soils of unit 8, the difference being mainly in iron content. The soils of units 9 and 10 lack structure and when exposed become quickly degraded.

(vi) Agricultural Potential. Both units offer very little prospect for agriculture. Where they occur near large markets, small areas may be made use of for the cultivation of vegetables. This would entail the application of most nutrients needed and since the soils are almost pure sands, the cultivation would be a form of hydroponics. In such localities, the planting of fruit trees in combination with the rearing of pigs may also be an economic proposition. Generally, the land occurs in remote areas and although the topography may be suitable for farming, the soils are too poor to grow crops economically. The better soils of the Saratok Family (unit 9) can be used for rubber where not other land is available. Most of the land is at present still under primary forest, an indication that it did not offer much prospect for the shifting cultivator either, They could best be left under this type of land use, oriif possible be used for tree plantations with commercial species.

../Mapping

Mapping unit 11

(i) Occurrence. The mapping units occur as two major areas, one in the Lundu District and the other in the Upper Sadong District, and as small scattered areas in these two districts.

(ii) Topography. The unit generally builds dissected hilly terrain of low elevation, mainly below the 250 feet level. In the Lundu area the topography is subdued and only moderately dissected with large tracts of smooth relief. The unit commonly forms edges of terraces where overlying old alluvium was removed by erosion. In the Upper Sadong District, north and south of the Serian-Balai-Ringin Road, the topography shows strong relief in the south but becomes gently undulating towards the north.

The steepest parts have slopes within the 20-25 range but slopes of 10-15 degrees are more common, particularly in the areas with more smooth topography. Generally, the unit has more rounded hills than found in units 6 and 7 with which it is closely associated. It is not clear whether this is caused by softer parent materials or is due to the occurrence of the mapping units in locations with another morphological history (below the 150 feet). Slipping and sliding of soil-rock material along slopes is not very serious.

(iii) Parent material. In the Lundu area they are formed by phyllites, and cherts while in the Upper Sadong District they comprise carbonaceous shales locally of schistose nature. They all have in common a very low iron content. The presence of many small pyrites, particularly in the carbonaceous shales, may indicate that the material was originally deposited in deltaic conditions, to which also the high carbon content must be attributed.

The cherts in the Lundu area are of a pinkish and bluish colouration which persists in the soils making identification easy. Greywacke sandstone occurring mixed with cherts and phyllites in the Lundu area gives rise to soils with an olive green colour.

(iv) Soils. The soils belong to the GREY-WHITE PODZOLIC SOILS which is separated from the RED-YELLOW PODZOLIC SOILS on account of the pale colours. In the mapping unit they belong to one family, the Kerait Family (p. ....) which is separated into two series, the Rukam series (Rk) fonnd in the Lundu area and the Kerait series (Kt) occurring in the Upper Sadong District. A series of minor

../importance

importance, the Serayan series, on pink chert, is also found in the Lundu area but is not indicated on the map. The soils have in common medium textured topsoils overlying massive, blocky clay subsoils. In the series on chert quartzitic nodules may be present in the subsoils. The soils are all pale coloured, the Rukam series having a faint bluish hue, while the Serayan series is slightly pinkish. The Kerait series is grey-white to white. In the Lundu area beds of greywacke sandstone give rise to a subordinate occurrence of more sandy soils of the Bekenu Family (p. ....), which on account of a typical olive-green colour are mapped as Biawak series. They are however not shown on the map as such.

(v) Fertility Aspects. The very pale colouration gives the impression that the soils are inferior to the more strongly coloured ones classified as RED-YELLOW PODZOLIC SOILS. There is, however, no analytical evidence to support this. Analyses show differences only in the iron content. Chemically, therefore, the soils can be compared with the Merit and Bekenu Families which are regarded as chemically of moderate low fertility, meaning that fertilizers are needed for most crops.

The soils are physically somewhat inferior to the RED-YELLOW PODZOLIC SOILS and are commonly imperfectly drained. This may be due to the gentle topography. Because of the lack of iron, gley features are only weakly expressed. In the Serian area the Kerait series is used for pepper with moderately good success, but heavy fertilization is needed. The Rukam and Serayan series are probably inferior to the Kerait series but have not been sufficiently studied to substantiate this. All soils can be used for rubber cultivation.

(vi) Agricultural Potential. This must be rated as moderate to low. The topography is generally suitable for agriculture but the chemical fertility and structure of soils are limitations, particularly where demanding crops are concerned. In the Lundu area, where good soils are rare, use can be made of the unit for rubber cultivation. Nothing is known of the behaviour of oilpalm on these soils but it is thought that the dense massive subsoil is not a very good rooting medium. Although oilpalm has a great adapting capacity, the soils are not the most obvious ones to select if better soils are available, but it is probably right to say that particularly in the Lundu area where there is need for agricultural expension on this type of soil, experimental work with some crops may be justified.

../ Mapping

Mapping units 12 and 13

(i) Occurrence. The units are found on steep mountain ranges throughout the Region. Mapping unit 13 which is the largest in area of the two units occurs exclusively in the middle part of the Region, namely the Bau District and in border areas of the Kuching Rural and Upper Sadong Districts.

(ii) Topography. Unit 12 is found on very steep mountain tops or crests where erosion has laid bare the underlying rock formations. Unit 13 forms very steep haystack shaped hills and mountains in which karst features commonly occur.

Erosion is here caused by solution of limestone along cracks through which large boulders are separated from the rock mass causing colluviation with accumulation of angular limestone blocks at the footslopes.

Streams are usually absent in both units; in unit 13 subterranean streams have formed an intricate pattern of caves with outlets at various levels which may indicate former erosion base levels.

(iii) Parent Material. Unit 12 is formed mainly by igneous rocks, particularly granite. Sandstones form the parent material in some localities such as the Penrissen-Bungoh range and the Klingkang range. The parent material of unit 13 is exclusively formed by limestone in which locally intrusive veins of acid to intermediate igneous rocks are found.

(iv) Soils. Unit 12 comprises weakly developed SKELETAL SOILS. They belong to the Meluan Family (p. ....). This family is associated with bouldery and rockly land. The unit is dominated by bare rock with a very thin veneer of soil and rock rubble. Unit 13 commonly has no soil cover; in places some soil material has collected in hollows and cracks. This material is mainly derived from igneous intrusions or from alien rocks and alluvium which formerly overlay the limestone.

The latter soils are classified as BROWN-FOREST SOILS, Kabuloh Family. The soils are of no importance for agriculture in this Region and further details are therefore omitted.

(v) Agricultural Potential. Both mapping units have no agricultural potential. The terrain is too steep and the soil cover if present too thin to be of any agricultural significance. Both units should be left under primary forest.

../Mapping

Mapping unit 14

(i) Occurrence. This mapping unit is of a very heterogeneous nature and occurs in three localities. The first locality is found west and south of Kuching Town between the deltaic deposits and peat swamps in the east and the uplands in the west. The second locality is found in the eastern part of the Upper Sadong District where it trangresses into the Lower Sadong District. These two areas comprise mainly subunit b. A third area is found in the Simanggang District along and north of the Serian-Simanggang road from approximately 85th mile to 105th mile. The latter area is formed by subunit a. Areas of minor importance, mainly belonging to subunit b. occur throughout the Region and are confined to areas where uplands merge into peat swamps.

(ii) Topography. The landscape is characterised by very low rounded hills which merge into interspersed valleys. The amplitude of relief is very small and commonly not over 20 feet. Under vegetation cover the distinction between valleys and hill land is very difficult on air photographs. Valley formation has come to a halt in these areas and sediments are actively accumulating. The valleys are frequently flooded during times of high rainfall. The slopes of the hilly terrain are gentle and for the majority less than 10 degrees. Little erosion is taking place. Most of the uplands in this unit is degraded by overfarming in the past. Probably the excellent topography made the land very suitable to hill padi farming but too intensive use has destroyed much of its original value.

(iii) Parent materials. These are varied. In subunit a. the hilly land is commonly underlain by argillaceous rock types, mainly mudstones and shales. The hills in subunit b. are formed by more arenaceous rocks such as feldspathic grit, cherts and sandstones with thin beds of phyllites. The valleys are filled by organic deposits of variable depths or by mineral deposits, the latter of varying composition. In subunit a. they are generally more clayey than in subunit b. The organic deposits vary in depth. Old alluvial deposits may be found overlying low hills or may occur at lower footslopes where hilly land merges into recent valleys.

../(iv)

(iv) Soils. In subunit a. the upland soils belong to the GREY-WHITE PODZOLIC and RED-YELLOW PODZOLIC SOILS in which respectively the Kerait Family (p. ....) and the Merit Family (p. ....) are respresented. Some Bekenu Family (p. ....) soils may occur in places. The classification of soils in these areas causes some difficulty because the pale colouration of soils may be relict gley features caused by high groundwater tables in the past. Therefore, GREY-WHITE PODZOLIC SOILS with topsoils resembling RED-YELLOW PODZOLIC SOILS are found in some localities, notably in the Simanggang District and the subsoils may be fossil gleyed horizons. This needs further study. In subunit b. soils of the same groups are found but since the textures are generally lighter they belong respectively to the Saratok Family (p. ....) and Nyalau Family (p. ....). For the Saratok soils, the gley horizons may be fossil features. In the terrace deposits commonly the Triboh Family (p. ....) has formed. This family belongs to the group of GREY-WHITE PODZOLIC SOILS, but PODZOLS of the lowland type also occur. In the valleys strongly gleyed sediments are found. They belong to the group of GLEY SOILS in which the Bijat Family (p. ....) is represented in subunit a. while soils of lighter texture the Tatau Family (p. ....), is commonly found in subunit b. Small areas of dry RECENT ALLUVIAL SOILS may occupy levee positions along small streams. Drowned valleys are commonly occupied by PEAT SOILS of varying depth.

This mapping unit requires semi-detailed surveying at a large scale for a proper delineation of soil types. Because of the heterogenity of the soils, the fertility aspects cannot be discussed. Indications can be obtained from the descriptions of the soil classification units in Chapter 11.

(v) Agricultural Potential. The topography of this mapping unit offers prospects for permanent agricultural use. The slopes are gentle and the erosion hazard is not great. Many of the small valleys offer opportunities for the cultivation of wet padi, but the flooding hazard is a limitation. Because of the heterogenity of soils the areas should be studied in detail to delineate the more suitable ones. A disadvantage is that large tracts of uplands have suffered from overfarming in the past and the soils are degraded. The area in the Simanggang District probably has the greatest potential for intensive farming but a solution to the problem of reusing degraded soils should first be found.

../Experimentation

Experimentation with crops and fertilizers should assess the economic prospects on the various soil types. The flooding in the valleys should be controlled for the cultivation of wet padi. The latter is however of not great significance as only minor areas will appear to be suitable for that crop. Oilpalm, particularly in the Simanggang area, could offer some prospects. (Andriesse, 1965a).

b. Floodplain Soils

Mapping unit 15

(i) Occurrence. This unit occurs as long stretched areas in the narrow upper and middle reaches of riverine valleys. Although most of this mapping unit occurs in the Lundu-Bau and Kuching Rural Districts, it should be noted that the mapping unit forms also part of mapping unit 19. The latter is a heterogeneous unit in which unit 15 could not be shown separately because of lack of detailed information or cartographic limitations. For this reason, the description of mapping unit 15 includes also parts of unit 19. (p. ....).

(ii) Topography. The unit forms generally flat terrain, commonly above normal flood level of the river. Microrelief may be hummocky, particularly where it borders the river course. Small river banks may be present. The rivers usually have steep embankments and meander in their own deposits. Flooding is in most localities an annual occurrence, but it is usually of short duration, 2 to 3 days. However, several floods may occur in one wet season, but flooding may be totally absent for a number of years.

Erosion is confined to the river banks where flush floods may cause lateral erosion of river banks through slumping.

(iii) Parent Material. The parent materials comprise recent riverine deposits of varying texture and origin. Generally, the alluvium from basic igneous to intermediate igneous rocks, shales and mudstones is heavy textured while that from acid igneous rocks and sandstones is light textured. The heavy textured alluvials are in the clay loam of clay range, those of light texture are commonly sandy loams to sandy clay loams. Sends occur only in some localities where the source rock is composed of coarse textured

../sandstone

sandstone or granite. Although the parent materials are of recent origin they may contain large amounts of material derived from strongly weathered and eroded soils in the uplands.

(iv) Soils. Characteristics of the soils vary in texture, drainage and parent material. They are all grouped as RECENT ALLUVIAL SOILS of which the heavy textured members - subunit a. are mapped as Seduau Family (p. ....) while the light textured members - subunit b. are mapped as the Kayan Family (p. ....). Both families can be subdivided into series on account of colour, drainage, and source material but on the map only one series is shown separately, namely the Sebat series (St), which occurs extensively in the Lundu District and is derived from adamellite. All series are described in Chapter 11, section 9 (p. ....). The symbol Mx has been used to indicate those areas where heavy and light textured soils occur together and where a separation into subunits a. and b. was impossible because of cartographic limitations.

(v) Fertility Aspects. Because of the heterogenity of the soil parent materials and texture, the fertility of the soils varies widely. Those whose parent materials include limestone and basic igneous rocks are among the most fertile soils in the Region. Those derived solely from quartzitic sandstones are among the poorest. This difference is brought but by the series to which the particular soil belongs.

Generally, the Seduau Family soils are of higher fertility than the Kayan Family soils. The former are capable of supporting a wide variety of crops, annuals as well as perennials. Fertilization is necessary for the annuals, perennials need fertilization for sustained high yields.

(vi) Agricultural Potential. The unit is of great potential value, particularly subunit 15a. Although the total area is not great, the local importance is emphasized by the fact that over large tracts of land it contains the only soils which can support intensive agriculture. Existing permanent agriculture is usually found concentrated in this unit. Unfortunately much of the unit is occupied by old rubber gardens which at present is not the most economic way to make use of these valuable soils. Fruit trees, coffee, high yielding rubber and annuals would probably give a better income per surface unit, and land use for these crops should be encouraged. The only limitation in subunit 15a is posed by the flooding risk,

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which may be severe in some localities. The main limitation for subunit 15b is the sandy nature of the soils. Imperfectly drainage conditions may be present throughout the unit, but this is not difficult to remedy. The areas are generally too small to be of value for development schemes and the like. Development of this unit should be realised through intensive extension work.

Mapping unit 16

(i) Occurrence. The unit occurs concentrated in the lower floodplains of main rivers basins as a continuous belt on either side of a river stretching from the middle reaches to the coast. Of minor importance are floodplains of small rivers which could not be separately shown on the map and which from part of mapping unit 32 (p. ....).

(ii) Topography. The unit is characterised by flat terrain, commonly waterlogged or with a high watertable. The land usually slopes away from the river where an incipient levee is commonly present, and merges into basin peat swamps. River embankments are usually concave. Tidal influence, particularly during the wet season when flooding may occur, causes lateral erosion of levees. Prolonged wet conditions may occur but high floods are rare.

(iii) Parent Material. Parent materials of the unit are formed by clay to silty clay deposits from heterogeneous sources but mainly from shale. Deposits along the Samarahan and Sadong rivers are partly derived from basic to intermediate igneous rocks. In other river basins this is of minor importance and only of local significance.

Light textured parent materials are rare and are commonly found only in close proximity of sandstones and granites. Near the coast marine sand deposits form some incipient ridges which have high watertables.

(iv) Soils. The dominant soil types in this unit belong to the GLEY SOILS which are characterised by reduced conditions below a depth of 20 inches. The heavy textured soils, mapped as subunit 16a, belong to the Bijat Family (p. ....). The light textured soils subunit 16b belong to the Tatau Family (p. ....). Series within these families and occurring in the unit are not shown on the map. This appeared to be impossible because of the generally small areal extent of these series. For details at the series level, reference

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is made to Chapter 11, section 6 (p. ....). One series is shown separately as unit 17 (p. ....) RECENT ALLUVIAL SOILS described under mapping 15 are subordinat in unit 16. Commonly, the Seduau Family (p. ....) occurs in association with the Bijat Family (p. ....) while the Kayan Family (p. ....) is found together with the Tatau Family. (p. ....).

(v) Fertility Aspects. The Bijat Family is one of the most fertile soils found in the Region and is suitable for wet padi cultivation and if drained could be used for a variety of other crops such as coconut, coffee, cocoa and oilpalm. Those soils along the Samarahan river and the Sadong river are probably of the best quality. This is related to the nature of the parent material. However, for sustained high yields, fertilization is necessary. The greatest limitation for agriculture is the poor drainage. The light textured soils in this unit, the Tatau Family, are not well supplied with nutrients and must be rated as poor soils. If they are overlain by a thin layer of muck, wet rice can be grown, but heavy fertilization is necessary. Drainage would increase the crop range but the Tatau Family soils would be more expensive to use than the Bijat Family soils.

(vi) Agricultural Potential. Only the heavy textured soils, the Bijat Family, (p. ....) are of interest for agricultural development. They are potentially suitable for intensive cultivation but efforts are required to improve the drainage and to reduce the flood hazard. Large areas are still used in rotation for wet rice cultivation without fertilizers. Intensification is recommended. This Family, although of considerable total extent, is difficult to develop since the soils commonly occur as narrow belts along rivers where measures to control flooding and drainage are expensive and difficult. However, as an alternative, much could be done by a proper location of crops e.g. coconut on the higher ground near the river, while wet rice could be planted on the lower ground which is not so well drained. By such means, expenses on drainage could be curtailed. Schemes should preferably encompass a whole floodplain or an important part of it, because any measure aimed to limit the flooding risk will affect the drainage either in upstream areas or downstream. Straightening of river courses by indiscriminate cutting of meanders can adversely affect the drainage conditions downstream. Small inland valleys should if possible be treated as one drainage parcel; piece meal development would

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make it difficult to improve the conditions in the whole valley at a later stage.

Mapping unit 17

(i) Occurrence. The unit occurs in association with mapping unit 13 (p. ....) and is only found in valleys surrounding limestone outcrops. For this reason, it is only found in the Bau, Kuching Rural and Upper Sadong Districts.

(ii) Topography. The unit occupies valley bottoms underlain by limestone. Small limestone outcrops commonly occur. Low lying places are commonly waterlogged or have a high watertable. On somewhat higher ground a low watertable is found and terrace remnants may occur intermixed with Recent Alluvials. On air photographs the unit looks flat but in reality it is micro-hummocky.

(iii) Parent Material. This is mainly recent alluvium derived from shales but it may contain small pieces of limestone. Terrace remnants are formed by old light textured alluvium commonly derived from sandstone. Old alluvium may occur at levels where commonly recent deposits are found. This is caused by a general lowering of the land surface by solution of the underlying limestone and results in preservation of old alluvium at local base level or even below that. In the latter case, recent alluvium overlies the old alluvium. Where possible such areas have been mapped separately as mapping unit 18 (p. ....).

(iv) Soils. These are very varied but the majority of the soils belong to the GLEY SOILS, Bijat Family, Paya Megok series (p. ....). RECENT ALLUVIAL SOILS in the unit mainly belong to the Paku series (p. ....). Paya Megok series is separated from other series in the Bijat Family on account of its occurrence on limestone; it is usually better supplied with calcium than other soils in the Bijat Family, but otherwise the characteristics are much the same is those of the other soils in the Family. Paku series is characterised by a high content of rounded oolitic iron concretions, and as the formation of these concretions is not yet well understood (they may form in situ or are derived from other sources) no attempt has been made to place the series into a family. Such oolitic iron concretions are also found in some localities in the Paya Megok series, notably in the Bau area but no separate series has been created for such occurrences. Soil developed on old alluvium

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of low lying sites with a high calcium content indicating influence from limestone outcropping nearby are classified as the Mundai series in the Tatau Family (p. ....). Also here oolitic iron concretions are found in places and because the concretions generally occur concentrated in layers, an alluvial origin is suggested in these soils.

(v) Fertility Aspects. The Paya Megok series is generally well supplied with nutrients, that is, for Sarawak standards. Calcium in particular is high. Apart from the drainage, which is poor, the soils are well suitable for agriculture. With drainage improvement they could support a wide range of crops. Experiments with this series in the former Paya Megok Padi Station have shown that a variety of off-season crops can be grown with success, particularly if rotated. The Paku series is also capable to support many crops of which pepper may be mentioned as the most important one. Drainage may be too imperfect for this crop in places, but this can be remedied. Citrus is another crop doing well on these soils. The Mundai series is poor in nutrients, except for calcium. However, the sandy texture and the proximity to markets make soils of the Mundai series particularly favourable for vegetable growing provided the soils are well fertilized.

(vi) Agricultural Potential. This unit comprises some of the most valuable land in the Region and every effort should be made to make optimum use of it. The unit as a whole is suitable for intensive farming. In the Bau area, a large part is still reserved for mining, leaving little land available for farming. This situation needs to be reviewed, when the need for land becomes pressing. Because of their location and the favourable topography, the areas are particularly suited for cattle farming in rotation with vegetables, food crops and cattle fodder. Some areas, particularly Paya Megok, have a high flooding hazard and this should be taken into account in planning the use of these soils. To obtain maximum use of these areas annual crops are recommended during the dry seasons. Some areas may be used for wet padi under a small irrigation scheme but sources of water may be difficult to find.

Mapping unit 18

(i) Occurrence. The total area of this unit is small and of very little importance for the Region. It is found in the Lundu District as some valley bottoms and in the Kuching Rural District as small

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areas near the coast where it generally backs recent deltaic deposits, or it occupies limestone flats. In the Upper Sadong District, it covers an old floodplain near Muara Mongkos.

(ii) Topography. This is varied, and is formed by flat valley bottoms often including footslopes of surrounding hills. Near the coast the areas resemble slightly raised terraces. The relief is generally very subdued, being gently undulating to flat.

(iii) Parent Material. These are mainly old alluvial deposits of heavy texture for subunit a. and of light texture for subunit b. They are highly quartzitic. Near the coast they are very silty while in the interior sandy materials prevail. The deposits in the area near Muara Mongkos in the Upper Sadong District are probably the oldest in age, their level being at 200 feet less or more. Although being old alluvials deposits, they generally do not occupy terrace positions but are still found at local base level, probably because dissection has not yet reached these comparatively remote areas.

(iv) Soils. Most soils belong to the group of GLEY SOILS which is characterised by a high watertable. The heavy textured soils belong to the Semadoh Family Embang series, (p. ....), while the light textured ones belong to the Tatau Family, Gong series, (p. ....). Both Embang and Gong series are separated within their respective families because of their old alluvial nature. They have very pale colours which is probably due to the age of the soils and they may be caused by strong leaching if not gleying. The absence of iron makes it difficult to decide which of the two factors has caused the light colour. Iron pans do, however, occur in Gong series soils at Muara Mongkos so that in that locality leaching cannot be ruled out. The old alluvial derivation is again difficult to prove if the soils occur at local base level which is the case in areas where they rest on subsiding limestone or where they occur in old not yet dissected floodplains.

Some of the soils, notably in the Lundu District, have derived from old terrace alluvium which accumulated in valley bottom through colluviation.

(v) Fertility Aspects. The soils are all highly leached and are of a quartzitic nature. The chemical fertility therefore is extremely low. Physically they are also of poor quality. The heavy textured soils are massive and poorly drained, the light textured ones are poorly drained also. They do not offer much prospect for

../agriculture

agriculture unless occurring near large markets. In that case, they can be used for market gardening and pig rearing. If drained, the light textured soils can be used for citrus if heavily fertilized.

(vi) Agricultural Potential. This is very low. Agricultural development should not be considered unless the locality justifies the expenses required for improvement.

Mapping unit 19

This mapping unit occurs widespread in the middle and upper riverine valleys of most Districts. It is a very heterogeneous unit comprising RECENT ALLUVIAL SOILS found in units 15 (p. ....) and 16 (p. ....) and residual soils found in mapping units 6 and 7 (p. ...) mainly. This interior valley association is complex in topography and consequently in soils. The landscape is formed by generally small levees, with local floodplains or valley bottoms also of small extent, together with low gently undulating hills mantled by residual soils. The scale of mapping did not allow a separation of all the soil classification units found in this mapping unit. Semi-detailed or detailed surveys are needed to adequately delineate the great variety of soils which occurs. For this reason, no adequate description can be given for the mapping unit as a whole and reference must be made to the descriptions of the mapping units making up this association.

The mapping unit is agriculturally of great importance. Much of the existing permanent agriculture in the interior areas is found concentrated in this unit. Probably the locality along rivers has influenced this land use, but the fertility of the soils, particularly the recent alluvial ones, and the gentle topography must have played a role as well.

Subunit b. is least fertile since the soils are of a light textured character and terrace alluvium forms part of the subunit. Subunit a. which is characterised by generally heavy textured soils has the greatest agricultural potential, not only because this unit is topographically suitable for intensive farming but also because it contains the relatively most fertile soils.

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c. Terrace and Fan Soils

Mapping unit 20

(i) Occurrence. This unit occurs throughout the area but the largest acreage is found in the Lundu District followed by the Kuching Rural District. In these Districts the unit is commonly found near the coast. Minor areas occur in other Districts but more in the interior. The mapping unit is similar to the Lundu physiographic unit described in Chapter 4, section 3 f (p. ....). The unit also occurs as small areas within other mapping units which are indicated by the letter symbol P.

(ii) Topography. The unit is found on flat to very gently sloping preserved terrace summits or on terrace remnants. The external drainage is poor and is partly caused by the micro-hummocky surface of the terraces which induces ponding in shallow depressions. The internal drainage is also very poor because of the presence of hard pans which induces the formation of a perched watertable during periods of high rainfall. The areas are not liable to flooding but waterlogging as a result of poor internal drainage commonly occurs.

(iii) Parent Material. The parent materials are formed by light textured old alluvium. This alluvium is stratified and the various layers may be formed by deposits with strong textural contrast. Gravel and clay may alternate with sandy loam and sandy deposits, the latter two being dominant. The deposits are all highly quartzitic and have derived mainly from Tertiary sandstones and conglomerates. In the Lundu District, the deposits originate largely from the adamellite of Bukits Pueh and Gading.

(iv) Soils. The soils belong dominantly to the PODZOL group of which two families, the Miri Family (p. ....) and the Buso Family (p. ....) commonly occur in complex. Both families are characterised by a humus accumulation horizon in the subsoil but in the Miri Family this forms a hardpan while in the Buso Family the horizon is soft and penetrable by auger. All soils are highly permeable to water but the hardpan of the Miri Family does not allow penetration to greater depth and gives rise to the formation of a perched watertable. The surface textures in both soils are very sandy, but commonly at the depth of the humus accumulation horizon or just below it a distinct textural change occurs, and sandy clay loam to heavy clay may form the subsoil. A pebble or bouldery layer in which the humus accumulation horizon has formed is commonly found

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at the footslopes of the Matang mountain massif in the Kuching Rural District.

The Triboh Family (p. ....) in the GREY-WHITE PODZOLIC SOILS is subordinate in the unit. It is strongly related to the Buso Family but has no humus accumulation horizon in the subsoil. This difference may be caused either by age or by topography, the Triboh Family being younger in development and occurring on more steeply sloping terrain so that lateral drainage and leaching dominates over vertical drainage and leaching.

(iv) Fertility Aspects. All soils in this unit are characterised by light surface textures in which sand to sandy loam dominates. The sands are highly quartzitic. A low base exchange capacity caupled with a very low nutrient content makes these soils extremely poor chemically. The physical properties of the Miri Family are very poor, because of the hardpan; those of the Buso Family are somewhat better since the internal drainage is not hampered by the existence of a hardpan. Of all the soils in unit 20, the Triboh Family soils are rated as the best physically. The Miri Family must be rated as having a very low suitability for agriculture, the Buso Family is somewhat better but must still be rated as a poor soil while the Triboh Family although again of better quality than the Buso Family must still be regarded as of low quality even for Sarawak conditions.

The fertility level of the Buso and Triboh Families can be raised by heavy fertilizer applications. Since their physical properties are somewhat better than those of the Miri Family they can be used for some form of agriculture. The latter soils are of very little use since even with fertilizer applications the unfavourable physical conditions will make farming a very poor proposition.

(vi) Agricultural Potential. The Miri Family soils have a very low development potential and can best be left untouched, particularly if they occur in remote areas. The same can be said of the Buso Family soils, although the latter offer some prospects if sufficient fertilizers are applied. Where they occur near markets, the Buso soils can be used for citrus and vegetable gardening in combination with pig or cattle rearing. With sufficient fertilizers, the Buso Family and Triboh Family soils can also be used for rough grazing. This potential is, however, only present if the location justifies the high expenses for amelioration. This may be the case near Kuching Town where some of these soils are presently used for such agricultural enterprises.

Mapping unit 21

(i) Occurrence. This unit, although present in all districts, is only of importance in the Kuching Rural and Upper Sadong Districts. In the latter, they occupy some large continuous areas while in the other districts occurrences are scattered and of small areal extent. A considerable area in the Upper Sadong District occurs in complex with peat soils. This is indicated by the letter symbol As.

(ii) Topography. The unit occurs on summits and slopes of old terraces and on gently sloping colluvial foot hills or pediments of mountain massifs built mainly by sandstones or granite. Some very small colluvial footslopes may occur in minor valleys where the country-rock is dominantly sandstone. The unit is characterised by a, for agriculture, favourable topography, the slopes generally being less than 10 degrees. Dissection has not progressed very much yet and is mainly confined to the edges of terraces. Flooding does not occur, the exception being areas occurring in the Upper Sadong District where they are low lying and form a complex with peat soils.

(iii) Parent Materials. The parent materials mainly comprise old, light textured terrace deposits and light textured colluvium on colluvial footslopes. The materials are highly quartzitic and have mainly derived from quartzitic sandstones of Tertiary age or from granite. If occurring on terraces the material may be stratified with interlayering of coarse and heavy textured deposits. The former are, however, dominant.

(iv) Soils. These belong mainly to the GREY-WHITE PODZOLIC SOILS which are represented in this unit by the Triboh Family (p.....). The Miri (p. ....) and Buso Families (p. ....) dominantly occurring in mapping unit 20 are found in this unit as subordinate members. The Triboh Family soils have light textured topsoils and medium to heavy textured subsoils. This distinct textural contrast may either be a result of soil forming processes or be caused by the bisequent nature of the old alluvial deposits.

../(v)

(v) Fertility Aspects. The Triboh Family soils are chemically poor to very poor. The nutrient content is very low. Because of the sandy nature of these soils fertilizer responses are good since interactions between nutrients and soils will not occur. Particularly phosphate fixation is low for Sarawak standards.

(vi) Agricultural Potential. The development potential is not very great but depending on location the unit offers prospects for citrus cultivation, pineapple, market-gardening and cattle rearing with rough grazing. The fertilizer requirements are high and for this reason the introduction of cattle for incorporating much needed organic manures into the soils would be advisable. Since the areas of this unit are generally small and other soil types usually occur mixed with this unit, it will be difficult to develop these areas with the use of organised farming methods. Where better soils are available the unit will be the last one to select for agriculture. However, with strict adherence to the advice given above, the unit may have some potential where sited close to population centres, but the economics of any farming enterprise on this unit should be subjected to thorough studies before it is recommended for development.

Mapping unit 22

(i) Occurrence. This unit is of very small extent and occurs almost exclusively around Kuching Town. A small area is found near Sematan in the Lundu District. Other minor occurrences are of no significance for the Region.

(ii) Topography. In the Kuching Rural District the unit occupies mainly terrace summits and terrace escarpments. The summits have a smooth topography but are micro-hummocky with incipient dissection. The terrace escarpments are dissected and gullies are common on steep slopes. In some places, notably in the Semobah area the unit is formed probably by old river beds. The terrace topography is absent and the unit is found in valley locations. In the Sematan area, the unit forms old beach ridges which slope gently towards the coast. The watertable in all areas is low. Flooding is not known to occur although in the Kuching Rural District where parts of the unit occupy old valley positions a flooding risk may exist.

../(iii)

(iii) Parent Materials. They consist of old terrace and coarse riverine deposits. Pebbles and coarse sand dominate. These materials are mainly composed of quartz and are probably related to conglomerates in the Tertiary deposits found in the interior in the Bungo-Penrissen mountain complex. The old marine ridges are composed of quartz sand derived mainly from the adamellite of Bukits Pueh and Gading.

(iv) Soils. The soils on the river terraces and those found in old river beds are classified as REGOSOLS and belong to the Gaya Family (p. ....). This family is characterised by an impenetrable layer of boulders or gravels at a depth of less than 10 inches. The depth of this very coarse textured material varies and in some localities the depth is more than 10 inches. In such localities, the soils are classed in the Triboh Family (p. ....) discussed under mapping unit 21 (p. ....). In the Lundu District, the soils formed on the old marine ridges also belong to the REGOSOLS but are classified there as the Kilong series (p. ....) and are indicated on the map by the symbol Kg. This series is characterised by coarse to medium-grained sand deposits which may have a humus accumulation horizon at a depth greater than 4 feet. These soils belong to the so-called Giant PODZOLS. Since diagnostic horizons occurring below a depth of 4 feet are not considered in the Sarawak classification the soils cannot be classified as PODZOLS, although genetically they belong to this group. No separate family has yet been defined for these soils. All soils in this unit are highly quartzitic, light textured, have high water infiltration rate and are subject to excessive drying out during dry periods.

(v) Fertility Aspects. The soils are chemically extremely poor. They have little or no base exchange capacity and the nutrient content is extremely low. Moreover, the high infiltration rate and excessive internal drainage make these soils prone to drought conditions in the short dry periods which are particularly common in the Sematan area.

Any form of agriculture would amount to a hydroponic culture which is extremely costly.

(vi) Agricultural Potential. The development potential for agriculture is extremely low. This unit can best be used for residential or industrial sites.

../Mapping

Mapping unit 23

(i) Occurrence. The unit occurs widespread throughout the Region but is mainly confined to the Lundu, Bau, Kuching Rural and Upper Sadong Districts. Subunit a. is found in the upper valleys of minor rivers draining igneous massifs while subunit b. is generally located at the foottof such massifs or in alluvial fans.

(ii) Topography. The topography is varied. Subunit a. is generally found in valley bottoms with a flat to gently undulating topography. A typical example of subunit a. is to be found in the Tarat Agricultural Satation. Flooding may locally occur but is generally of short duration. Subunit b. is formed by typical cone-shaped alluvial fan deposits with a more undulating topography merging onto hilly terrain. The slopes are gentle and rarely exceed 10 degrees, gullying is however much in evidence. Flooding does not occur in subunit b. This subunit is further characterised by the existence of many small streams with boulder beds. These rivers frequently change their courses when their outlets are blocked by coarse debris, and the terrain is therefore marked by many fossil stream beds which may in a later stage in development of the alluvial cones again be reused by the same river originally responsible for its formation.

(iii) Parent Materials. The parent materials consist of coarse to heavy textured alluvial and colluvial material. The heavy textured materials are mainly derived from basic to intermediate igneous rocks. In subunit a. much of the material comprises eroded soil from areas forming mapping unit 1 (p. ....). Subunit b. is formed mainly by light and coarse-textured material derived from granite and associated rock types and sandstone. Much of it is colluvial wash related to areas forming mapping unit 3 (p. ....).

(iv) Soils. The soils are very varied in texture, colour and chemical composition. Those in subunit a. all belong to the group of RECENT ALLUVIAL SOILS represented by the Ramun Family (p. ....). This family is mainly derived from basic to intermediate igneous rocks. A further subdivision into series is based on texture. The gravelly clays or clays at shallow depth underlain by gravel are classified as the Ramun series (p. ....), while the clays, or loams with or without gravel at a depth below 2 feet are classified as Terbat series (p. ....). The Ramun series is commonly found near the debouching point of streams where the sudden change in

../stream

stream velocity causes the coarse material to be deposited. Further downstream the Terbat series is dominant; this soil is strongly related to the Tarat Family described under mapping unit 1 (p. ....).

The Ramun Family soils are weakly developed. It should, however, be noted that a large part of the alluvial deposits comprises eroded material from well developed upland soils. This has greatly affected the chemical composition of the colluvial and alluvial deposits and although being classified as RECENT ALLUVIAL SOILS, the material is generally well weathered, the Terbat series more so than the Ramun series.

Subunit b. comprises light textured soils in which sandy loam mixed with boulders or with boulders at depth is dominant. These soils have been classified as the Lundu series (p. ....). The series is not yet well defined since it comprises material of varying sources, granite and sandstone, while the amount and depth of bouldery material may vary considerably.

In the Lundu series, an incipient A2 horizon may sometimes be found in places indicating that leaching is present. Detailed mapping would be necessary to describe the variations within this series.

(v) Fertility Aspects. The Ramun series soils are chemically fertile by Sarawak standards. Because of the large amounts of relatively unweathered or weakly weathered basic to intermediate igneous rock fragments, they are relatively well supplied with nutrients and they have a high nutrient reserve. The Terbat series although of good quality, is less well supplied with nutrients and also the nutrient reserve is much lower because most of its material is derived from eroded weathered upland soils. The Ramun and Terbat series have well-developed structures. The main limitation in the Ramun series is the gravelly layer which in some places may be impenetrable for roots, while also because of the high infiltration rate drought conditions may occur in dry periods.

The Ramun Family is highly suitable for tree crops such as rambutan, bananas, citrus and coffee. The Terbat series in this family can also be used for a wide variety of annual crops. They need fertilizers in some degree depending on the crops grown. Phosphate fixation is moderately high but the overall fertility of these soils must be rated as one of the best for Sarawak standards.

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Because the Lundu series is derived from acid igneous rocks and quartzitic sandstone, it is less fertile than the Ramun or Terbat series. Physically, the Lundu series is well drained as the Ramun Family but this depends much on locality. In places, the coarse fraction of the soil may attain the nature of boulder beds and would hinder root development. The bouldery subsoils make the growing of annual crops very difficult since ploughing will be impossible. [illegible]

(vi) Agricultural Potential. The development potential for the Ramun Family soils is high. One limitation is the small size of areas but every effort should be made to intensify agriculture on these soils, particularly in interior areas where the population is presently depending much on shifting cultivation. A large range of crops can be grown on these soils, although those sensitive to flooding or wet conditions for short periods should be omitted. The Lundu series has only a very moderate agricultural potential. Only perennial crops can be grown. Coconut has been attempted in the area along the Serikin River but does not prove to be a success. Coffee can be grown if the soils are well fertilised. Rubber is probably the only crop which can be recommended without reservation. The development of this series will depend very much on the local population and the situation at each locality since the soil conditions vary from place to place and the owner needs to be critical in the selection of crops for each particular area.

d. Coastal Soils

Mapping units 24, 25 and 26

These units are intimately related and occur in sequence. For this reason, they are described together.

(i) Occurrence. The units are confined only to the Kuching Rural and Lundu Districts and are exclusively found in the coastal area between the Santubong Peninsula and Tanjong Dato.

(ii) Topography. The units build a coastal ridge landscape in which unit 24 forms the most recent beach. It rises to only a few feet above normal high tide level and is commonly separated from unit 25 by a slightly higher, small storm beach where a very low incipient dune has formed. Unit 25 is backing the present beach and consists of a series of low lying ridges separated by swales.

The watertable in the latter may be high in the wet period. Small tidal creeks usually originate in these swales. Commonly the ridge furthest away from the coast is the most extensive one and slopes gently away from the coast to a creek commonly forming its boundary with unit 26. The latter unit rises quite steeply from this creek towards the landside to a height of approximately 14 foot above sea level whereafter the surface is more gently sloping. Unit 26 is characterised by a series of small ridges at the extreme landward side probably representing incipient dunes. The watertable in unit 26 is moderately high and can usually be found within a depth of 6 feet.

(ii) Parent Materials. The units are respectively built by recent to subrecent, medium to fine-textured marine sands. Most of the material originates from the adamellite building the Gading and Pueh massifs but between Lundu and the Santubong Peninsula material from Tertiary sandstones and metamorphosed sedimentary rocks of Early Cretacious age form important admixtures. The amount of weatherable minerals in the deposits is low but in some localities, notably near Santubong, the content of hornblende is moderately high. This may indicate an influence from intermediate igneous rocks at Pulau Salak.

(iv) Soils. The soils form a weathering sequence in which the most recent undeveloped deposits on the present beach form unit 24, weakly developed soils on the ridges of intermediate age form unit 25, while well developed iron/humus podzols on the oldest deposits form unit 26. The soils in unit 24 and 25 are classified as RECENT ALLUVIAL SOILS but are probably better placed in the group of REGOSOLS, particularly unit 24. This unit is formed by the Siru series (p. ....) of the Kabong Family. The Siru series is separated from other series in the Kabong Family because of its high content of micas and manganese, which bears relation to specific source materials of the deposits. Shells commonly occur in this series but they tend to concentrate in layers.

Unit 25 is formed by two series both belonging to the Sematan Family. The latter is characterised by a distinct reddish-yellow to yellowish-red colouration. The Sematan series (p. ....) is dominant in this family and has incipient soft iron concretions in the lower horizons. These may be absent in some localities. They are probably caused by an intermittent ground watertable and for this reason, the iron accumulations are more common near swales than on the crest of ridges. The Rambungan series (p. ....) in the

../Sematan

Sematan Family is of very small extent and is transitional between the Kabong Family and the Sematan Family; and it is always found between the Siru series and the Sematan series. Progressive leaching has, however, moved most of the calcium, while iron is liberated from weatherable minerals and coats the quartz grains brown. Manganese may accumulate in the B horizon, but its presence depends on the original manganese content of the deposits and is not always present.

Unit 26 is formed by PODZOLS, and is represented by the Jerijeh Family (p. ....). This family is characterised by a well developed white A2 horizon overlying a well developed humus-iron accumulation horizon formed on the unaltered reddish coloured material found in the Sematan Family. It thus represents a further stage in leaching and podzolization. Several series make up this family but none have been mapped separately. They are differentiated on account of the depth of the A2 which in this soil type reflects the rate of podzolization. The ultimate stage is reached in the Kilong series (p. ....), mapped as a REGOSOLS and which is described under mapping unit 22 (p. ....). In this soil type, which occurs subordinately in mapping unit 26, the A2 reaches to below a depth of 4 feet.

(v) Fertility Aspects. The chemical fertility of the soils declines from unit 24 to unit 26. Thus, the Siru series is potentially the most fertile one, followed by the Rambungan series, Sematan series and Pueh series. The latter is extremely poor. The Sematan is poor while the Rambungan is probably the best soil in this range since most nutrients are here liberated and in solution. In the Siru series a high pH prevents much leaching. By world standards, however, all soils are quite poor, the only element in sufficient supply is calcium, and this is present only in the Siru series. Crops, particularly coconut and water melons do well on the Siru and Rambungan series. Coconut is also planted on the Sematan series but without fertilizers the palms do not grow well. The Pueh series only supports a low shrub or lallang, once the original forest cover has been removed.

(vi) Agricultural Potential. The area is small but is of local importance since most of the local population on this land depends on agriculture to supplement their income from fishing. The Siru series and the Rambungan series can best be planted up with coconut and annual crops such as water-melons. Additional fertilization would improve yields. The Sematan series can be used for coconut

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if properly fertilized. The use of this land for rough grazing under coconut should be investigated. Most of this soil type is at present only sparcely used. The use of the Puch series forms a difficult problem. Probably the application of fertilizers will be uneconomic on this soil but little information on this is available. The series is, however, of small extent and only of importance near Kpg. Siru and Kpg. Puch. Rough grazing and coconut would be the only possibilities since the soils need an initial organic topsoil to prevent loss by leaching of fertilizers applied later on. If the topsoils can be improved probably other crops can be grown as well.

Mapping units 27 and 28

(i) Occurrence. These units occur in deltaic and estuarine areas and are found most widespread in the Kuching Rural and Lower Sadong Districts where they occupy the Sarawak River Delta and the Nonok Peninsula.

Smaller areas are formed by the Sematan and Lundu river deltas, and are found at the margins of the Sadong Lupar estuaries.

(ii) Topography. The units are characterised by a flat, low-lying landscape situated a few feet above normal high tide level. Unit 27 is generally somewhat lower than unit 28 (see Santubong unit, Chapter 4, section 3b; p. ....). A great many tidal creeks intersect this low lying land, particularly in the delta's. In the estuaries where the units are found as small ribbons on incipient levees along the river channel, tidal creeks drain basins swamps backing the levees. The ground watertable is high and commonly occurs within one foot from the surface; in unit 28 the watertable is somewhat lower depending on artificial drainage. During peak high tides, unit 27 is frequently flooded by brackish water and affects the groundwater to varying degree. The groundwater in unit 28 may be brackish during the less wet season but may be fresh during the wet season. Flooding in unit 28 is less frequent than in unit 27. This depends, however, on locality. Thus, in the Nonok Peninsula freshwater flooding may occur during the wet season. Most of this water originates from the large basin swamps found to the south of this area. Areas of unit 28, flanking river channels may be flooded with fresh water during the wet season when the rivers are at peak level. In some localities, unit 27 has a micro-hummocky surface, caused by the presence of mud lobster mounds. This is notably so in the Sarawak

../River

River delta. Unit 28 is affected as well but only to a minor extent.

(iii) Parent Material. The parent materials are formed by recent, heavy textured deltaic and estuarine deposits; but in a few minor localities, the deposits are light textured. The heavy textured materials are silty clays which were deposited in a saline to brackish water environment. The deposited material originates from the interior areas of West Sarawak and were carried down to the sea mainly by the Lundu, Sarawak, Sadong and Lupar rivers. These deposits were enriched by the sea with magnesium and potassium but calcium is however extremely low. Some layers of shell debris may be found within the deposits but these are rare.

(iv) Soils. All soils have been grouped under the SALINE-GLEY soils. These are characterised by strong gleying caused by a high watertable and saline or brackish conditions in part of the profile during parts of the year.

In the formal Sarawak classification units 27 and 28 are separated on account of degree of salinity. The soils in unit 27 are moderately to strongly saline throughout the year while the soils in unit 27 may have only brackish conditions during part of the year. Soils of unit 27 dominately belong to the Rajang Family (p. ....), while soils of unit 28 for the majority belong to the Pendam Family (p. ....). The salinity factor is difficult to use in the field as a diagnostic feature, particularly where changes occur throughout the year. For this reason, natural vegetation is normally used to differentiate between the Rajang and Pendam Families. The Rajang soils support a mangrove/nipah vegetation and all areas with this type of vegetation have been mapped as such. Where the natural vegatation has been removed areas were mapped as Pendam Family soils, since the salinity decreased with cultivation and drainage improvement. Nevertheless, it is safe to infer that areas mapped as Pendam Family contain soils belonging to the Rajang Family, particularly in areas where no artificial drainage was provided. For this reason, the Rajang Family is mapped as a subordinate member in unit 28. The light textured and strongly saline members of the SALINE-GLEY soils are mapped as subunit 27b of Belat Family (p. ....), while the light textured but weakly saline soils are mapped as subunit 28b. of the Nonok Family (p. ....). But subunits are of very minor importance.

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depth of 80 to 120 inches as Anderson 2 Family (p. ....), while peats with a depth of more than 120 inches belong to the Anderson 3 Family (p. ....). Anderson 1 is individually mapped as unit 30 because it still has some agricultural value. Anderson 2 and 3 Families are mapped in combination to form unit 31 because peats exceeding a depth of 80 inches are usually not recommended for agriculture. A small area in the Lundu District is mapped as the Limbang Family (p. ....), indicated by the letter symbol L. In this area, saltwater has infiltrated a peat swamp causing a change in the environmental conditions from a freshwater peat swamp to a saltwater peat swamp.

(v) Fertility Aspects. The peats are inherently very poor in plant nutrients. The shallow peats in unit 29a are probably the most fertile of all the peat soils in these units. Commonly there is a flush of liberated nitrogen during the first two years of cultivation on peats, particularly if they have been burned and drained. After that the initial fertility declines rapidly and many deficiencies occur. Trace elements particularly iron and copper are usually deficient. After drainage, a favourable granular structure may develop in the surface horizon, but if allowed to dry out the surface becomes very compact due to irreversible drying. Exchangeable nutrients calculated on a oven dry basis usually give high values. Since the bulk density of the peats is very low, these values when extrapolated to the field condition should be reduced by as much as 90 percent. The fertility of peats particularly that of the shallow phases, varies greatly with locality. Those peats in the Sadong River basin are generally more fertile than elsewhere. This may be caused by the influence of the underlying mineral deposits, since the mineral deposits in that area are also richer in plant nutrients than riverine deposits elsewhere.

The drainage problem is probably the most difficult one to solve. For this reason, deep peat soils are commonly not recommended for agricultural use.

(vi) Agricultural Potential. The shallow peat soils of unit 29 can be used for agriculture if properly drained. An allowance of up to 2 feet for shrinkage and subsidence following the first few years of reclamation should be made. After the first few years, the subsidence rate decreases to less than an inch or so per year.

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To keep pace with the subsidence, drainage channels will have to be deepened periodically. It is estimated that if the drainage is sufficiently maintained, 40 inches of peat may take roughly 30 years to disappear altogether. If drainage is not maintained then the areas would probably become waterlogged again and the subsidence will be halted. Drainage should therefore be carefully controlled and initial deep drainage is not recommended. If properly drained, most suitable crops are probably pineapple, coffee and oilpalm. Coconut may be grown in shallow peats if they can root in the mineral subsoil because the peat itself does not provide sufficient anchorage for top heavy tree crops. No doubt many crops, annuals and bush-type perennials can be grown, as shown in the Peat Research Station at Batu Kawa Road, near Kuching. The economics of the use of peat for agriculture should be thoroughly studied before appropriate recommendations can be given. Subunit 29b is not very suitable for agriculture because of the very poor mineral soils found below the peat. If the peat upon drainage has subsided or disappeared altogether the sandy subsoil would not form a good medium for plant growth. Wet padi can be grown if the water can be properly controlled but yields are not very good unless fertilizers are applied. Fertilizing peat soils, however, is still in the experimental stages. Unit 30 can also be used for agriculture, but the drainage and ensuing subsidence present even greater problems in this unit than in unit 29. If the peat is allowed to subside too much than the level may become lower than the major drainage channel, the river, and flooding will occur unless water is removed by pumping. For this reason, deep peat soils, mapped as unit 31, are not recommended for agriculture.

The development of peat soils is a risky venture, and the long term influence of continued drainage is not yet known. A special section on this subject deals with this problem and the reader is referred to this section for further details. (Chapter 13, section 2, p. ....).

Mapping unit 32

This is a compound unit and comprises soils commonly found in unit 16, 29, 30 and 31. The soils within these units range from GLEY SOILS to PEAT SOILS. The composing soil units can not be separated, either, because of the complexity of the soils and the impossibility to show all boundaries on the employed scale or,

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because insufficient field information is available on the areas to differentiate between the various component units. Most of the areas would need semi-detailed surveying techniques on at least a scale of 1:25,000 to show all soil types present. Part of this unit is made up of GLEY SOILS mainly belonging to the Bijat Family (p. ....). These are excellent soils for wet padi and when drained a variety of other crops can also be grown (see under mapping unit 16, p. ....). The reainder of the unit is mainly peat of varying depth. (see under mapping units 29 to 31, p. ....).

The agricultural potential of the areas justifies further investigations at a semi-detailed level if such information is not yet available. Many small wet padi improvement schemes could be accommodated in this unit.

Mapping unit 33

This unit comprises disturbed soils and includes areas occupied by mining or town land. It has no agricultural significance and is therefore not further discussed.

Letter Symbol T

Finally, the symbol T, inserted in some mapping units on the soil maps indicates the existence of terrace deposits belonging to the Sabangang (p. ....) and Lupar Families (p. ....). These families have not yet been described since they have not been mapped separately and do not form a common part of other mapping units.

These terrace deposits are mainly found in the Sarawak Kiri, Sarawak Kanan and Batang Lupar drainage basins. The Sabangang Family is characterised by yellow to reddish-yellow colours, and the texture range is the same as that of the Nyalau Family, (mapping unit 8, p. ....), commonly sandy loam over sandy clay loam. The soils are, however, differentiated from Nyalau soils by a distinct layer of rounded gravels occurring at depth which indicates its alluvial nature. The Sabangang soils may have partly derived from colluvial material of neighbouring hills. The Lupar Family is heavy textured and the soils are comparable to Merit Family soils, (mapping unit 6, p. ....) but also contains a layer of rounded gravels at depth which indicates its alluvial origin and for this reason, it is separated from the Merit Family.

Agriculturally, the Sabangang and Lupar Families can be compared with the Nyalau Family and the Merit Family respectively but they differ in topography. Since the gravel deposits commonly occur at great depth many other localities with Sabangang and Lupar soils may have been overlooked. Diagnostic features occurring at such depth are in any case not of agricultural significance and can therefore be ignored.

4. Summary.

Table 25 summarizes in an easily available form the most important features of all soil mapping units described in this chapter.

This Table shows the total area of each mapping unit by District (column A). Since the areal extent of a mapping unit does not give any indication to its agricultural potential each mapping unit has been assigned a certain use percentage. This figure represents the maximum percentage of arable land within the unit if properly used, and is based on the survey experience of the author. Column B therefore indicates, although subjectively so, the amount of land actually suitable for agriculture at maximum use level for each mapping unit.

The limitations for agriculture for each unit are furthermore listed in accordance with their degree of severity. The coding used to indicate the severity of the limitations is explained at the bottom of Table 25. Finally, the agricultural development potential of each unit is given in the last column, together with the most important limitations to agriculture.

From Table 25 it is possible to calculate for each district the total amount of land available for agriculture. In Table 26, an attempt has been made to use these calculated figures to indicate in what district land is most scarce in relation to the present population. Quite probably in this Table the number of farming families for each district is exaggerated because they are calculated over the whole rural population. In fact, a certain percentage of this population is not engaged in agriculture at all. Therefore, the arrived at figures shown in the last column of Table 26 and indicating the land available for each family at present is on the pessimistic side. However, the Table illustrates adequately that it

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Table 26

Estimated availability of arable land per family by District (First Division) (1970 population).

District	estimated rural population 1970 [1]	average size household 1960 [2]	estimated farming families 1970	estimated total arable land needed if fully developed	% of total land area	estimated total available arable land if fully developed [3]	land available at present per family
Lundu	18,087	5.4	3,294	32,940 ac.	32.9	140,800 ac.	± 43 ac.
Bau	31,187	5.7	5,471	54,710 ac.	48.7	102,835 ac.	± 19 ac.
Kuching (Rural)	133,384	5.9	22,607	220,070 ac.	35.6	211,718 ac.	± 9 ac.
Upper Sadong	50,422	6	8,403	84,030 ac.	44.0	220,896 ac.	± 26 ac.
Lower Sadong	33,176	5.5	6,032	60,320 ac.	25.4	107,190 ac.	± 17 ac.

1) Ref. Development Plan, Dutch University Team, 1970.

2) Ref. Sarawak Population Census, 1960, Jones, L. W., 1962.

3) Calculations based on detailed-reconnaissance soil map, West Sarawak (table 25), this memoir.