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Report No.21

Report on a Reconnaissance Soil Survey
of the Miri-Berop Area

by

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REPORT ON A RECONNAISSANCE SOIL SURVEY OF THE MIRI - BEROP AREA

D. Wall, 1961.

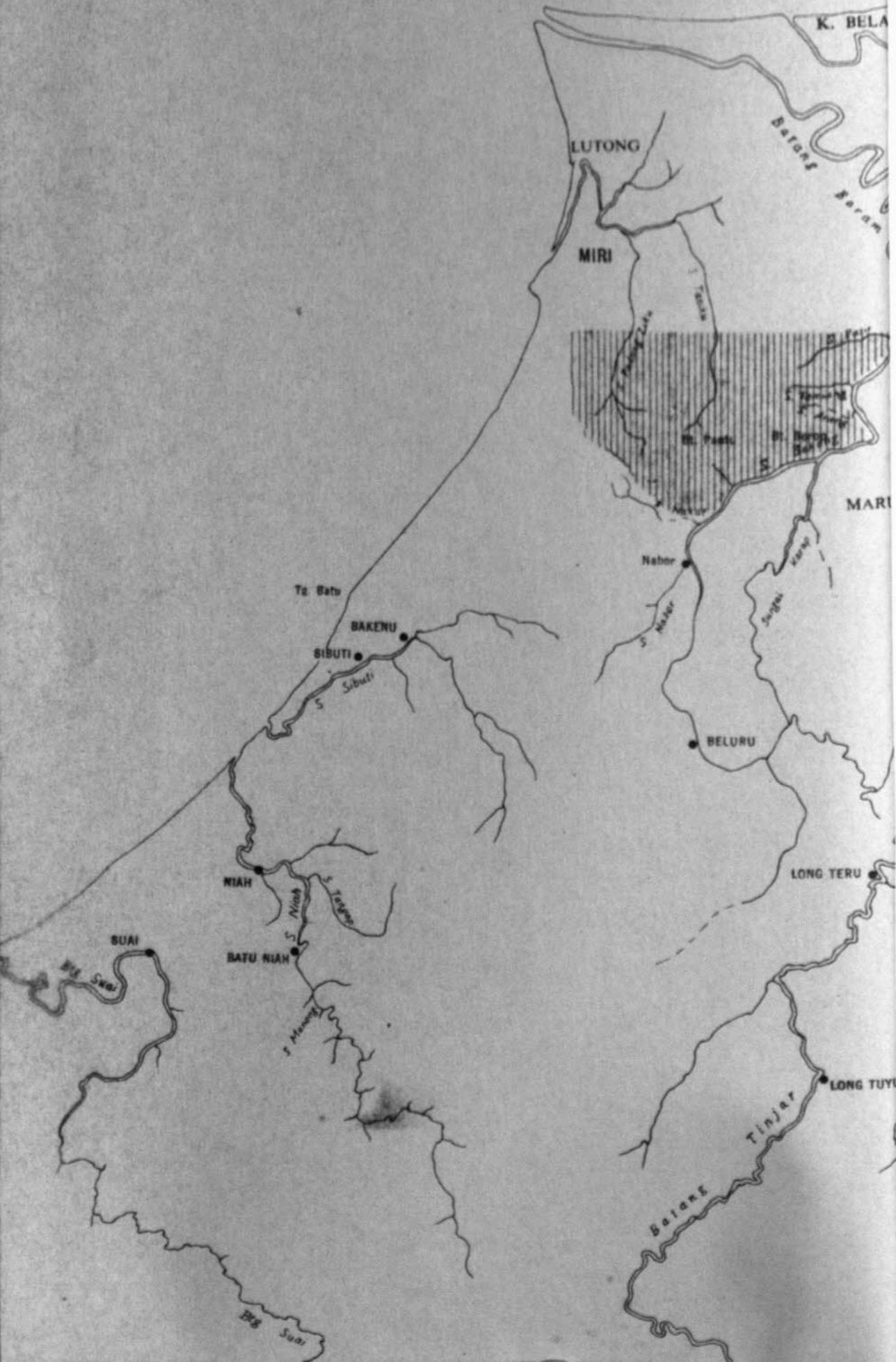
(location map facing page 1)

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Route Map facing page 17.

Soil Map enclosed (Soil Survey Drawing No.55)

LOCATION MAP
Bukit Berop Area
Scale 1:500,000



1. INTRODUCTION

1.1 1. The area surveyed lies in the fourth Division east and south of Miri and totals approximately 110,000 acres* It has been proposed that a road be built to feeder road standards between Miri and Bt. Berop where 2,000 acres of high-yielding, budded rubber has recently been planted. The Soil Survey had three objectives:

- a. to determine which of three proposed routes was the more feasible from a road construction point of view.
- b. which route passed through the most promising agricultural land.
- c. which route would be most beneficial to the general economy of the area.

These questions are discussed in the conclusions. The remainder of the report deals with the character of the area in general and the soils in detail.

1.2 2. Survey Methods. No maps were available at a scale larger than 1:250,000. The working maps were compiled in the Soils Laboratory from uncontrolled air photo mosaics, scale approximately 1:25,000. The enclosed Soil Map therefore, even though reduced to 1:50,000 contains planimetric errors and soil boundaries are only approximate. The work was made even more difficult by the generally poor quality of aerial photographs (R.A.F. 1947) and in some places a complete lack of air photo cover.

Before field work began the aerial photographs were used to delineate possible soil boundaries and pick out useful rentis lines. In the field these rentises were cut and auger descriptions taken at irregular significant intervals along them. According to methods of reconnaissance surveying the soil boundaries have been checked along rentises and where paths permit, elsewhere interpolation and extrapolation with the aid of aerial photographs is used.

1.3 3. Itinerary. Survey work was started on 26/10/60 and was completed by 22/11/60. The Survey team consisted of D. Wall (Soil Surveyor), A.A.'s Lim Chin Pang and Peter Kedit, and J.A.A.'s Wan Sulaiman and Maharip bin Sapong.

2. GENERAL CHARACTER OF THE AREA

2.1 1. Geology. Material from each of these three periods is present: the Miocene - Pliocene, Pleistocene and Recent or Holocene -

1. Miocene - Pliocene. Representing this period are three rather similar formations (the Lambir, Tukau and Miri Formations). The Lambir strata occur in the southern part of the map as high hills at the edge of the Bakong swamp. They consist mainly of hard sandstone and shales. The Miri material occurs in a very small area in the hills in the west and is also mainly sandstone with sandy shale and shales. Comprising the remaining bulk of the hills is lignite. Sandstone is therefore the dominant rock.

* All acreage figures have been taken from the soil map and approximated to the nearest 50 acres. Absolute acreages may vary from these figures depending on the accuracy of the base map.

These rocks underly the whole of the surveyed area but have been covered by material of later periods in the south, east and north. They comprise about 80% of the hilly land. The strata dip to the north over the whole area: fairly gently in the western parts (10° - 15°) but more steeply in the southern and eastern parts, near Sg. Bakong (20° - 30°). These hills are in effect the southern part of a large syncline: major faulting is not evident.

2. The Pleistocene. This period was one of considerable rising and lowering of sea levels. The results in this region can be seen on the northern margin of the hills where at one stage the sea remained at one level for a considerable time before 'abruptly' lowering. While the sea level remained static a wide flat coastal beach was formed, only penetrated by a few main rivers. The material that the sea eroded from the hills behind the beach plus that material transported by rivers and longshore drift was mainly sand, or occasionally in quieter water clay. This flat fossil coastal beach is still evident, especially so in the northwest. Elsewhere it has become dissected. Height above present sea level is approximately 20' - 40'.

3. Recent. At the end of the Pleistocene in this area there was a 'rapid' drop in sea level which left the Pleistocene beach as a fossil raised beach or so-called stranded coastline. The recent geological history appears to have been one in which the sea level has slowly risen or at least remained static resulting in steady accumulation of sediments and initiation of peat growth due to favourable habitat. The present situation is that the Recent material - alluvial clay, sands and peat, occurs in the north, east and south of this area and penetrating all the major valleys of the hills.

Geomorphology. 4 landscape units were distinguished: the dissected hills, the raised beaches, the alluvial land and the peat swamps.

1. The hills. Since the underlying strata are composed of fairly resistant sandstones and shales and dip to the north the land form is dominantly that of cuestas with scarp slopes facing south. The cuestas are lower and less well-defined in the west where strata dip is low, and correspondingly higher and well-formed in the south and east with steeper dips and apparently somewhat more resistant strata. Lending emphasis to the steepness of slopes is the very vigorous erosion by incised streams. In the south and east particularly the ridges are 'knife-edge'. It is due mainly to the plentiful rain that there are many minor streams which are actively dissecting both dip and scarp slopes. To sum up, the type of landform present is dissected, 'knife-edge' cuestas trending east west.

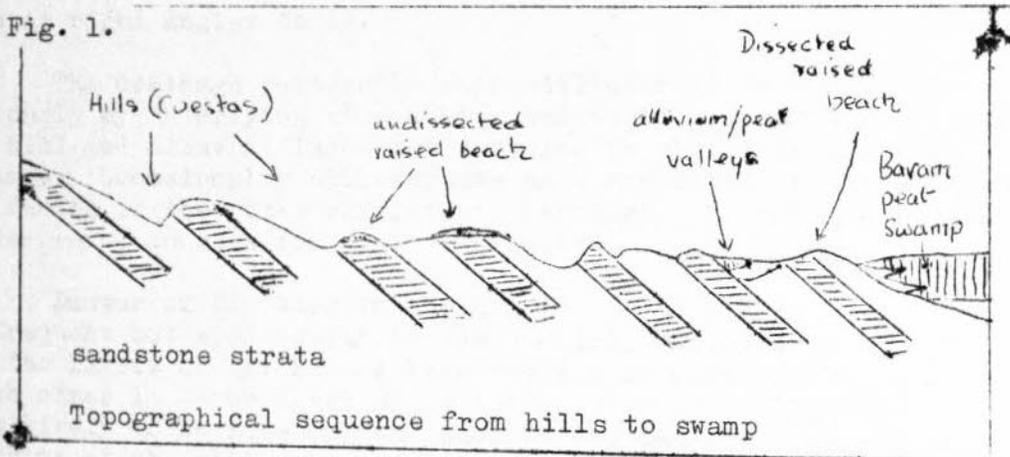
Gradient of scarp slopes may reach and exceed 90° locally where weathering has undercut a sandstone cliff; usually, however the steepness is more in the region of 30° - 50° : dipslopes are generally less than 35° . Within the hill region valleys are narrow and deep, but towards the fringes there are wide, flat, swampy valleys, particularly in the south and east, where possibly a depression of the land has resulted in the infilling of valleys by alluvium. In many cases this has been sufficient to leave isolated hill 'islands'. More recently conditions in such swampy areas have allowed deep peat accumulation.

2. Raised Beaches. Fringing the hills discontinuously in the north are remnants of an old coastal beach.

It is quite well preserved in the west but badly dissected in the east towards Sg. Bakong: at one time it must have stretched continuously around these foot hills as a fringe between one and three miles wide. It is the same raised beach that occurs along the coast south of Miri, around Marudi and in Brunei. The remnants are typically flat-topped and their height above the neighbouring swamp is about 20' - 40'. The old beach material is usually less than 15' thick and is exposed by incising streams.

The topographical sequence from swamp to hills is shown in section below.

Fig. 1.



3. Riverine land. These areas are very restricted within the hills and scarcely more extensive outside them. The hill valleys are narrow and alluvium is deposited in the form of terraces which may be quite high above a stream bed; they are usually discontinuous and confined to the less restricted parts of valleys. Such terraces frequently cause the partial blockage of tributary streams in such a manner that their drainage is impeded and peat swamps form. These are restricted in size by the nearby hill slopes but may be quite deep. Towards the swamp land where gradients are less steep much more material is deposited and the infilled valleys widen relatively rapidly. Here the terraces assume the character of levees behind which are the 'basin lands'. The levees of the Padang Liku are well developed and penetrate half a mile into the swamp before becoming inconspicuous.

The texture of the upper valley terrace material is coarse and ungraded: the alluvial material in blocked tributary valleys is usually finer. Levee textures are coarse while the basin lands behind are invariably fine. The alluvium fringing the Bakong foot hills is mainly material brought down by the many short hill streams and is consequently very variable texturally both within the profile and horizontally.

Gradients in all alluvial areas are negligible with the exceptions of certain upper stream courses.

4. Peat swamps. These occur on three sides of the area in addition to penetrating the larger valleys of the eastern half particularly. The Baram peat swamp in the north is deep to the edge of the hills. The Bakong peat swamp is less continuous, less deep and

interspersed with alluvial patches: in addition it frequently has a covering of **alluvium** which obscures the peat. The valley peat swamps are on the whole less deep but frequently exceed depths of 10'.

Without exception all peat areas are badly drained and gradients are flat, discounting the gentle biconvex structure in the Baram swamp.

3. Drainage. The two main river systems of this area are the Miri river tributaries in the west and the Sg. Bakong tributaries in the east. The watershed between the two bisects the region from north to south; it is not noticeable in the field as ridges run at right angles to it.

The drainage pattern is subrectilinear influenced quite strongly by underlying strata with medium to high stream density in hill and alluvial land, but very low to absent in the peat swamps. Occasionally hill streams have exploited bedding planes or faults in the rocks sufficiently strongly to make themselves underground courses for short distances.

Danger of flooding in the higher hills will be infrequent but spectacular in the confined valleys. To judge by the levees of Sg. Padang Liku the floods must involve quite high rises in water level up to 15' - 20'. Serious floods are likely to be rare and confined to the Landas. Towards the margins of the hills where gradients are lower flooding may be more frequent but the water will spread over a considerably wider area and should be lower.

No hill streams are usable for transport due to steep gradients and rapids, and few streams on leaving the hill are sufficiently large for anything but local use. Sg. Bakong is the exception: it is used by small Chinese launches and is very slightly tidal at Bt. Berop (non-saline). Flooding of the adjacent land is quite common in the Landas, the floodwater spreading well inland up to 6' in depth in places.

4. Vegetation and Land Use. This section can be described most conveniently according to the four divisions used in section 2.2 Geomorphology.

1. The hills. The bulk of this land is under primary forest, either poor 'Lowland' Dipterocarp or 'Kerangas'. Undergrowth is sparse and quality of the forest appears to be rather poor though locally there are quite a number of large-girthed trees. The margins of the hill land are used only on the Bakong valley foot-hills and at Rh. Kabaloi, mainly for hill padi. In these localities there are of course scattered areas of 'jerami' and 'temuda'. At Bt. Berop, 2,000 acres have been cleared and planted to high yielding budded rubber.

2. Raised beaches. The forest on these areas is again mainly poor 'Lowland Dipterocarp' or 'Kerangas'. The 'Kerangas' type is more widespread however especially in the west. Forest quality is on the whole poor with a rather denser undergrowth of saplings. Land adjacent to the Riam road has been intermittently cultivated for a long time and little if any of the original forest remains. This part has been taken over by chinese cultivators whose main cash crop is pepper, sometimes rubber, on occasions tobacco. Towards Sg. Padang Liku there are a few scattered

Iban farmers practising shifting cultivation. Neighbouring Rh. Kabaloi many of the dissected old beaches are used for hill padi or rubber where the original residual soil is exposed, also the flanks of undissected beaches where similar residual soil occurs. In nearly all cases the podsollic old beaches are ignored and they remain under primary forest.

3. Riverine land. The original Riparian forest vegetation has practically vanished now except for the streams running through the Baram Forest Reserve. This is especially so in the Bakong valley where on this land padi, rubber and temuda are the dominant vegetation types. The same can be said at Kabaloi except that all available alluvial land there is prized for padi since such land is scarce. Regarding the cultivation of padi there, much alluvium is transported during the Landas season which is derived from the old beaches and is consequently sandy. This sand is said to prevent young padi growth by collecting between the leaf sheathes and damaging the young shoot.

4. Peat Areas. Only the shallower marginal peat has been used, the rest remains under swamp forest of varying types - Padang Paya, Alan forest, Mixed Swamp Forest and Freshwater Swamp Forest. All denote badly drained, permanently wet conditions. The margins have been used in the Bakong valley, also near Kabaloi and along the Riam Road.

THE SOILS.

1. Soil Classification. The survey was conducted on a reconnaissance basis and the mapping units are in effect Soil Associations. The Associations as used here are based on the distinguished landscape units as described in section 2.2. and in which the component basic soil series are regularly geographically associated. However, for mapping purposes the peat association has been subdivided into two units - see below.

In tabloid form:

<u>ORIGIN</u>	<u>ASSOCIATION</u>	<u>SOILS UNITS WITHIN MAPPING UNITS</u>
ORGANOCENE	PEAT	*1. 3-10' peat or muck over alluvium. *2. more than 10' peat or muck over alluvium.
	(PEAT *RIVERINE	3. mixed 1, 4, 5, sometimes 2.
	*RIVERINE	4. yellow sandy loam (levee) 5. Light grey silty clay with up to 3' peat or muck topsoil (basin-clay)
	*MARINE (Raised Beach)	6. White sand. 7. Light grey silty clay loam 8. Yellow sandy loam to loam 9. Pale yellow sandy clay loam 10. Valleys not mapped containing 3.
RESIDUAL	*HILL	11. Residual soils - exposed after dissection of marine deposits. 12. Yellow sandy loam to loam 13. Yellow sandy clay loam 14. Mixed colluvium 15. Valleys not mapped containing 3.
*mapping units.		

The soil units in the table are the dominant series found. There are many drainage and textural variations in the Riverine and Hill Associations in particular. The Reconnaissance map attached gives a reasonably accurate delimitation of Associations but should not be read too literally, bearing in mind the limitations of the base map and of the method of surveying used.

2. SOIL DESCRIPTIONS

Each Soil Association with their component units will be discussed separately.

3.2.1

1. PEAT ASSOCIATION. Distribution of peat in this area is widespread. The largest block forms the southern part of the extensive Baram swamp, but in addition there are the Bakong valley swamp areas and the valley peats which penetrate the hills of the eastern part in particular.

Peat depths especially in the north and east easily exceed 10 feet. Due to the woody nature of the material it is usually impossible to find the full depth using normal field equipment. Maximum depths reached were 18 - 20' in the Baram swamp, with no indication of the subjacent alluvium. In these areas too the peat often exceeds 10' in depth only a few yards from a foothill. The same applies to the valleys in the east which contain deep peat well into the hills.

A broad distinction according to original material can be made between valley peat and true swamp peat. The latter is invariably woody and only partially decomposed while valley peat can often be rather heterogeneous containing much interleaved inorganic material; in addition the organic matter itself may often be fine and more thoroughly decomposed due to the softer grassy flora which grows among the trees. In the Bakong valley the peat is frequently deep but contains interleaves of inorganic alluvium, especially near streams and the hills. The reverse occurs in the Riverine Association whose alluvium contains interleaves of peat. Only in areas well away from alluvial influence is the peat at all homogeneous. Such areas in the Bakong valley have been delimited on the map approximately; where the peat is interleaved with alluvium it has been mapped as soil unit 3.

Chemical analyses of a profile sampled near Bt. Berop under primary swamp forest, indicate an acid environment but with moderate levels of nutrients, except in calcium and potassium, in the upper layers. Fertility appears to decrease with depth. This profile is not necessarily typical of all the peat areas here but it conforms quite well to the normal inland peats. In all cases the peat is badly drained with the water table at or near the surface permanently.

Total acreage mapped of peat exceeding 3 feet in depth is 31,500 acres. The great majority of this exceeds 10' in depth, there being only a limited narrow strip of shallower peat (3 - 10 feet) fringing hills and streams, that is not mappable at this scale. The peat-alluvium association (mapping unit 3) also includes roughly 3,800 acres of peat of all depths, mainly of a heterogeneous character.

3.2.2.

2. PEAT-RIVERINE ASSOCIATION. This mapping unit includes heterogeneous alluvial/peat soils that occur mainly in the Bakong valley, also small strips of peat and alluvium in the small valleys particularly that cannot be mapped separately. Total acreage mapped is 7,700 acres.

3.2.3 3. RIVERINE ASSOCIATION. Basically there are two main types of soil: those of the terraces and levees, and those of the basins behind. The terrace and levee soils are typified by yellow sandy loams, the basins by light gray silty clays.

3.2.3.1 1. Levee and terrace soils. These soils are distributed along the banks of every sizeable stream in the area. The Padang Liku has discontinuous terraces backing hills upstream which may be up to 200' wide. These gradually grade downstream into lower levees varying from 0' to 200' - 300' wide depending whether the river is eroding laterally at that particular point or not. Generally the levees diminish in size with increasing distance from the hills.

Variations are few: texture tends to become finer downstream, definitely so at right angles from the river bank. Textures within a profile however, may vary considerably - more often due to variations in grade of sediments than to leaching, though this does have an effect on the less frequently flooded terraces. Drainage is free, occasionally imperfect* the water table generally being at least 24" deep. Structure is usually weak which allows easy root penetration and good aeration and drainage. The levees slope gently down towards the basins. The levees of Sg. Bakong are low and heavy textured being relatively far from the source of the material - as such they can be regarded as better drained basin clays.

Chemical analyses of a profile in the upper Padang Liku indicate a poor nutrient status, in nitrogen and magnesium in particular. The exchange capacity is low due to the dominance of sand but despite this base saturation is still low to medium. The topsoil is not particularly enriched. A description of this profile is summarised below.

Location : upper Padang Liku, true left bank, 150' from river.
 Parent material: alluvium - terrace sand.
 Vegetation: poor Lowland Dipterocarp, fairly thin undergrowth.
 Topography: flat; microrelief undulating.
 Drainage : internal-free, external-normal.
 Water table not encountered.

2 - 0 " coarse, undecomposed leaves with thin discontinuous bottom layer of humus.
 0 - 17" yellowish brown sandy loam. Weak, fine - medium granular structure; moist, friable consistence. Clear, wavy change to:
 17 - 32" Brownish yellow sandy loam with many medium - coarse distinct pale yellow mottles. Single grain structure; moist, loose-friable consistence. Few medium - coarse roots. Clear, smooth change to:

/32 - 37"

* Drainage sequence according to mottling and gleying is free - imperfect - poor - very poor.

32 -37+" Pale yellow medium sand with many, coarse, distinct brownish yellow and few, fine, faint strong brown mottles. Single grain structure; consistence moist and firm. Few medium roots.

3.2.3.2 2. Basin soils. The distribution of these soils is scattered over the whole area except in the very central hill mass. They are confined mainly to strips between the levees and the deep peat soils and only attain any appreciable width in the Bakong valley. Within the hills are small embayments of basin soils drained by tributaries of the larger streams such as the Padang Liku. They vary in quality mainly with distance from banks of streams. True basin soils lie far from both the materials source and from streams: they are generally grey to white silty clays, impervious, waterlogged, thoroughly gleyed and have a topsoil of peat. (Peat is included as part of an alluvial soil up to 3 feet in depth but beyond this limit it is classified as a peat soil). Nearer to rivers and hills the soils are transitional to levees and colluvium: they become yellower, lighter textured, more mottled and better drained with little or no peat above.

Chemical analyses indicate that this basin clay is slightly more fertile than the levee soils as regards phosphate, carbon, nitrogen and bases though the absolute nutrient level is low with the exception of sodium: the exchange capacity is higher than the levee soil reflecting the presence of clay while base saturation is low. The soil is acid and one test for sulphates gave a reading of 0.4%, which indicates poor growing conditions. The acidity is not necessarily present wherever basin clay occurs. Due to the more or less permanently waterlogged condition, normal leaching by rainfall is not encountered hence the higher level of nutrients relative to the levee soils. A condensed auger soil description is given below:

Location: roughly 1 mile due north of Rh. Nakat.
 Parent material: riverine alluvium - silty clay.
 Vegetation: swamp padi
 Topography: flat
 Drainage: internal - very poor, external - receiving.
 Water table at surface.

0 - 6" Dark brown organic loam containing numerous fine roots and decomposing leaves.

6 - 13" Soil from above horizon mixed patchily with subjacent light grey clay - effect of cultivation.

13 - 30" Light gray plastic silty clay.

30 - 40" Light olive grey plastic silty clay.

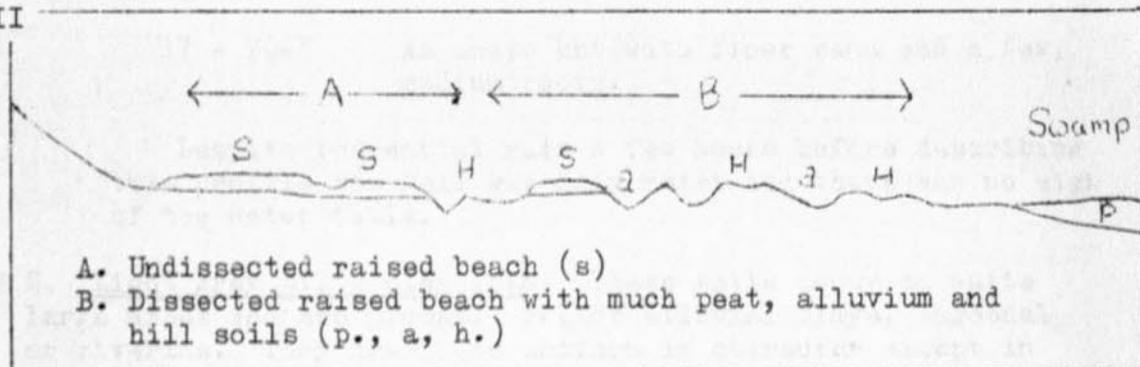
Total acreage of Riverine alluvium mapped is 4,350 acres, of which the levee soils can be expected to be in the minority.

3.2.4. 4. MARINE-RAISED BEACH ASSOCIATION. Within this Association there are three types of soil belonging to the raised beach proper: a white sand, a light gray clay loam and a yellow sandy loam to loam, each of which having variations in drainage, texture etc. in addition there are residual soils exposed where the beach material has been eroded. Only one, a pale yellow sandy clay loam which has been affected by the old beach conditions, will be described in this section. The other three types are described under 3.2.5.

As a whole this Association has a topography which is dissected except for a large block in the northeast of the map and scattered smaller patches elsewhere. Where the topography is undissected the incidence of raised beach soils is high but where dissection is

advanced and has proceeded more intensively the incidence of raised beach soils will be low i.e. this mapping unit in the last case especially may contain an appreciable area of soils of the other Associations, namely the Hill and Peat/Alluvium Associations. A sectional diagram will explain this:

fig. II



With reconnaissance mapping methods it has proved impossible to map separately the detailed hill soils, alluvium and peat that occur within this Association. The undissected areas have been indicated on the map:

1. White sand. The areas where this soil is known to occur have been indicated on the map, likewise the light gray silty clay loam described next. Depth of the sand may exceed 15 feet but more usually it is less than 10' in depth. Variation in soil properties are limited to degree of podsolization. In places a compact indurated dark brown humus pan is present while in other places it is absent. This feature is associated with conditions of internal drainage: the true podsol pan is thought to occur where drainage is impeded, i.e. in the central parts of these sandy areas, and not near the edge. Initially leaching conditions in this soil were ideal.

As a result, the soil is chemically very poor with the exception of the top few inches which are enriched by humus. Exchange capacity even at 6" depth is only 1.0 m.e.%. There is only a trace of phosphate and nitrogen below 3" and very little magnesium and potassium. The soil is acid but pH levels are higher than the hill soils for example especially in the B horizon.

A pit description of a profile without pan is given below:

Location : near Sg. Taniku, see map (3805/08)
 Parent material: alluvial - beach sand (old)
 Vegetation : 'Kerangas' with thin undergrowth
 Topography : flat.
 Drainage : internal - free to excessive,
 external - no surface run off.

Water table not encountered.

$\frac{1}{2}$ - 0" - Decomposing leaves, in places absent.
 0 - 3" - Light brownish gray, medium to coarse single grain sand with common, distinct, dark brown patches of humus. Loose, moist consistence. Abundant medium - coarse roots. Clear, wavy change to:
 3 - 6" - White medium to coarse sand with few mottles as above. Single grain structure; moist, loose consistence. Many medium - fine roots. Clear wavy change to:

- 6 - 17" White medium - coarse sand with few, faint, brown mottles and many medium roots. Structure and consistence as above. Faint, wavy change to:
- 17 - 70+" As above but with finer sand and a few, medium roots.

Despite torrential rain a few hours before describing this profile the soil was only moist and there was no sign of the water table.

- 3.2.4.2 2. Light grey silty clay loam. These soils occur in quite large areas and are probably relict alluvial clays, lagoonal or riverine. They are quite uniform in character except in transitional areas near the white sands or the soil described next.

It is an acid, not badly leached soil that has been enriched in the top few inches by humus. On the whole the base status is low but higher than the residual hill soils. Nitrogen and phosphate levels are satisfactory in the top-soil particularly. Exchange capacity is medium as is base saturation.

An auger description is given below:

Location: 1 mile approx. due east of Sg. Padang Liku/Riam Road junction: see map (3820/23)

Parent mater- alluvium-riverine or lagoonal clay (Old) ial:

Vegetation: 'Kerangas' type with fairly thick undergrowth.

Topography: flat

Drainage: internal - imperfect to poor, external - receiving.
Water table not encountered.

$\frac{1}{2}$ - 0 decomposing leaves and fine roots.

0 - 1" Dark brown loam with many fine - medium roots. Moderate fine - medium crumbly structure; moist, friable consistence.

1 - 6" Dark greyish brown loam - silty clay loam with many diffused bluish black mottles from pieces of charcoal. Roots common and medium sized: structure moderate fine - medium crumbly: consistence moist, and firm.

6 - 12" White silty clay loam with common, faint, diffused yellow mottles: consistence moist and firm. Some distinct diffused mottles penetrating from above horizon.

12 - 30"+ White silty clay loam with common, distinct diffused yellow mottles.

- 3.2.4.3. 3. Yellow sandy loam to loam. This soil is not widespread and is found in discontinuous strips near the edge of the raised beach where formerly a river cut its way through to the coast. The soil is in fact old river terrace material derived from the hills behind. Variations in colour and texture are likely to be wide.

Chemically the soil is probably acid and will certainly be no richer in nutrients than the ordinary levee soil.

The above are soils occurring as associated members on old alluvial material. As explained before this mapping unit also contains considerable dissected areas where beach material has been eroded to expose the residual soils beneath (again sandstone and shale derived). These are mainly young soils and very similar to the soils described in section 3.2.5., the only exception being a pale yellow sandy clay loam which will be described next;

- 3.2.4.4. 4. Pale yellow sandy clay loam. This soil has been 'bleached' or subject to marine influences and can be found usually on exposed places from which beach material has been eroded. Its appearance is that of a poorly drained soil but position on slope and texture indicate imperfectly-drained conditions only. Colours are generally pale, textures vary according to whether sandstone or shale is the parent material: it is probable that part of the soil material consists of remnants of old beach material.

Chemical analysis of one profile (see below) indicates that the soil is acid but slightly richer than the normal residual soils in phosphate and nitrogen in particular. Bases, except sodium, however are low.

An auger description is summarised below:

Location - 5th mile Riam Road

Parent material - Tukau formation (probably shale here)

Vegetation - Temuda

Topography - slightly convex, 10° gradient near top of slope.

Drainage - external - normal; internal-imperfect.

0 - 3" - Light brownish grey loam containing decaying leaves.

3 - 30" Pale yellow sandy clay loam containing few fine roots. Few faint diffused yellow and grey mottles.

30 - 40"+ Light grey sandy clay loam, no mottling.

3.2.5. 5. HILL ASSOCIATION.

Three fairly distinct types of soil were found on the hills, a yellow sandy loam to loam, a yellow sandy clay loam and a brownish yellow sandy loam to sandy clay loam associated broadly with sandstone and with shale parent material and with colluvium respectively, but associated in particular with position on slope. The sandstone if outcropping near the top of a ridge will give the yellow sandy loam to loam soil. The shale, if outcropping anywhere on the slope will probably give a heavier yellow sandy clay loam: the bottoms of most slopes however have received colluvial material from higher up and are mainly heavy textured soils, though if all upslope parent material is sandstone it will of course be a lighter soil.

- 3.2.5.1 1. Yellow sandy loam to loam. Being associated with sandstone parent material it occurs over a large part of this Hill

Association, especially on ridges, structural terraces or steep slopes. Colours may vary in the topsoil from a yellowish brown to brownish yellow: textures may be loamy sands to sandy clay loams. Depths are also variable but usually rather shallow, especially on ridges and the steeper slopes. In general the steeper a slope the shallower its soil. Occasionally a layer of very hard iron coated sandstone may be exposed by streams on steep slopes but such material is rarely encountered during augering - more often a gritty layer of iron concretions or iron coated sandstone at some depth.

Structure is usually weakly coherent with friable consistency in the top horizons. At greater depths texture increases, the structure becomes more blocky and the consistency firm. As a result the erosion hazard of the topsoil is great should the vegetation be removed, especially so on steeper slopes.

Chemical analyses show the soil to be acid and poor in all nutrients with the exception of sodium throughout the profile and phosphate in the top few inches. There are signs of leaching beneath the topsoil of the more soluble elements but this tends to be obscured by the humus enrichment from above.

The residual sandstone soil in the Raised Beach Association is younger, probably less well drained and slightly more fertile than the older soils. It is also likely to be more shallow.

A profile description of the old sandstone soil is summarised below.

- Location: upper Padang Liku - see map, profile no. 3769/73
- Parent material: Tukau formation, mainly sandstone.
- Vegetation: Lowland Dipterocarp (poor): undergrowth thin.
- Topography: brow of ridge, facing regular slope of 20°.
- Drainage: external - shedding; internal - imperfect. Water table not encountered.
- 3 - 0" decomposing leaf and root litter.
- 0 - 2" Dark brown loam containing many coarse - fine roots. Moderate subangular structure; moist, friable consistence.
- 2 - 10" Yellowish brown loam containing few coarse roots. Structure moderate, sub angular; consistence moist, friable - firm.
- 10 - 18" Yellowish brown sandy clay loam containing few medium - coarse roots. Structure in profile massive; consistence moist and firm.
- 18 - 27" Yellowish brown sandy clay loam. Structure in profile massive; consistence moist and firm.
- 27 - 40"+ Reddish yellow sandy clay loam to sandy clay.

3.2.5.2. 2. Yellow sandy clay loam. As explained above this soil is residual from shale outcrops. It varies in colours from yellowish brown to brownish yellow, in topsoil texture from loam to sandy clay and in drainage from imperfect to poor. Since textures are heavier than soil 1 of this Association the soils are less susceptible to erosion but since the topsoil is the only part of the profile that is comparatively rich the erosion factor may still be an important feature in considering cultivation.

Chemically the soil resembles the soil unit 1 above. There are few available nutrients below the top few inches with the exception of sodium. Again the younger soils from shales in the Raised Beach mapping unit are rather shallower, heavier textured, more mottled and probably less leached than the ones above.

An auger description of the older shale soil is given below.

Location: Padang Liku valley, rentis XII, 5,600.

Parent material: Tukau formation (shale)

Vegetation: Lowland Dipterocarp (poor) thin undergrowth.

Topography: lightly concave, approx. 15°.

Drainage: external - receiving, internal - imperfect to poor. Water table not encountered. Scattered leaves lying on surface.

0 - 1" Light yellowish brown sandy loam with common fine roots.

1 - 6" Colour as above, clay loam with few distinct reddish brown mottles and few medium roots.

6 - 20" Brownish yellow sandy clay loam to sandy clay with common mottles as above plus few faint grey mottles (gleying)

20 - 33"+ As above with common grey gleying.

The top horizons of this soil are possibly colluvial in origin.

3.2.5.3. 3. Colluvial soils. This is really of alluvial origin being material washed down slopes during rainstorms. Distribution is not necessarily at every foothill, though at the foot of steeper hill slopes it is unusual not to find this material. It grades into the alluvial fans of tiny rills with which it is often associated. The material is very variable though the profile is generally deep and textures light. The topsoil is mainly well-drained and the subsoil gleyed to a greater or less extent. Fertility is also likely to be variable

but will rarely if at all be high.

Where this soil occurs with the Raised Beach mapping unit it will also be variable but on the whole a little richer than within the Hill Association.

Total acreage mapped of this Association is 43,900 acres.

4. AGRICULTURAL SUITABILITY

Comments in this section are generalised and are based on field notes plus chemical analyses of soils. Regarding the latter it is not likely that the analyses of two or three profiles for one association are typical of the whole of that Association which may total 40,000 acres or more: comments on fertility should therefore be used as a guide or indication only.

4.1

PEAT ASSOCIATION. Chemically the peat appears to be reasonably suitable for certain types of agriculture despite the acidity, which may be reduced by draining and addition of lime. Limitations for agriculture are therefore mainly physical. Peat greater than 6 feet in depth should not be drained unless levels are taken beforehand to ensure that river flooding will not occur after peat shrinkage. The bulk of the peat swamp is woody and may present drainage difficulties and produce an uneven surface. The peat of the Bakong valley and certain hill valleys is less woody on the whole, however, and is also mixed with mineral matter which adds to the agricultural possibilities. In those places where a skin of inorganic alluvium overlies peat, or where thick lenses of peat occur within alluvium, effective drainage may be difficult.

Crops suitable are padi on the lightly drained shallower peat (3 feet deep) with annuals on the deeper peat such as pineapples, bananas, keladi and other garden produce. This land is not extensive on the whole and as usual in circumstances of land shortage has mostly been used. Since padi land is likely to be scarcer still over the whole area in the future due to pressure of population the shallower peat should be kept for this purpose wherever possible.

Regular manuring especially with lime is important to maintain fertility.

2. PEAT - RIVERINE ASSOCIATION. For this mixed Association refer to relevant units.

3. RIVERINE ASSOCIATION

4.3.1

1. Levee soils. These are well-drained and aerated soils with a weak structure and therefore physically favourable for crops, but unfortunately poor chemically since they are derived from the equally poor sandstones of the hills. As such and being immediately available from the waterways they are suitable for garden and fruit produce, especially near kampongs where adventitious fertilizing is likely. Coconuts in particular are likely to do well. Far more use could be made of these soils in the Bakong valley, also at Kabaloi where little but bamboo grows on them at present. If used intensively a general fertilizer applied little and often is essential.

2. Basin soils. These are badly drained and generally impervious except where peat lenses occur. Chemically they are not rich but on the other hand they have not been leached like the soils above. Again, since padi land is likely to become scarce these soils are the only ones really suitable for that purpose and should be reserved for it, and not planted over to rubber as has been

attempted in places. Occasionally it appears that a weak type of 'catclay' occurs (acid and sulphurous) which does not favour crop growth of any kind. Poor padi growth in patches and yellowing of dried soil clods together indicate its presence. If possible such areas should be well-drained, leached with freshwater and limed heavily but should this prove economically impossible they are better left alone.

Soils intermediate between 1 and 2 above which have a reasonably low watertable should be suitable for rubber or fruit and garden produce. These will be yellow heavy clays found behind the levees.

Regular manuring to maintain fertility is important. A little lime in particular should be useful in decreasing the acidity.

4. RAISED BEACH ASSOCIATION

- 4.4.1 1. White sand. This soil is totally unsuitable for any kind of agriculture practised in Sarawak at present, unless a great deal of money were spent. It should be left under forest and perhaps cropped selectively for timber.
- 4.4.2 2. Light grey silty clay loam. The old alluvium is acid but under the present vegetation not badly leached. The topsoil appears to be moderately rich and should repay cultivation. Nitrogen content in particular is unusually high. Topography is flat and drainage imperfect to poor but rubber should grow well, possibly citrus and other moderately heavy feeders not requiring very well-drained soil.

Limitations are drainage allied to flat topography. Regular manuring must be carried out especially with lime to improve acidity, structure and drainage.

5. HILL ASSOCIATION

- 4.5.1 1. Yellow sandy loam to loam. The topsoil is light textured and has a good structure for plant growth. The nutrient status is however poor or very poor with the exception of the top few inches enriched by organic matter. Slopes are steep on the whole and as a result erosion hazard is high after removal of natural vegetation, as seen at Bt. Berop.

These soils are agriculturally poor and it is felt that they should be left under natural vegetation wherever possible. If cultivation is decided on however, well built permanent terraces are essential to avoid erosion of the topsoil plus adequate manuring on the 'plenty and regular' basis: slopes exceeding 30° should be avoided. In other words much money, time and labour must be spent to conserve and if possible improve the soil. Under no circumstances should shifting cultivation be allowed.

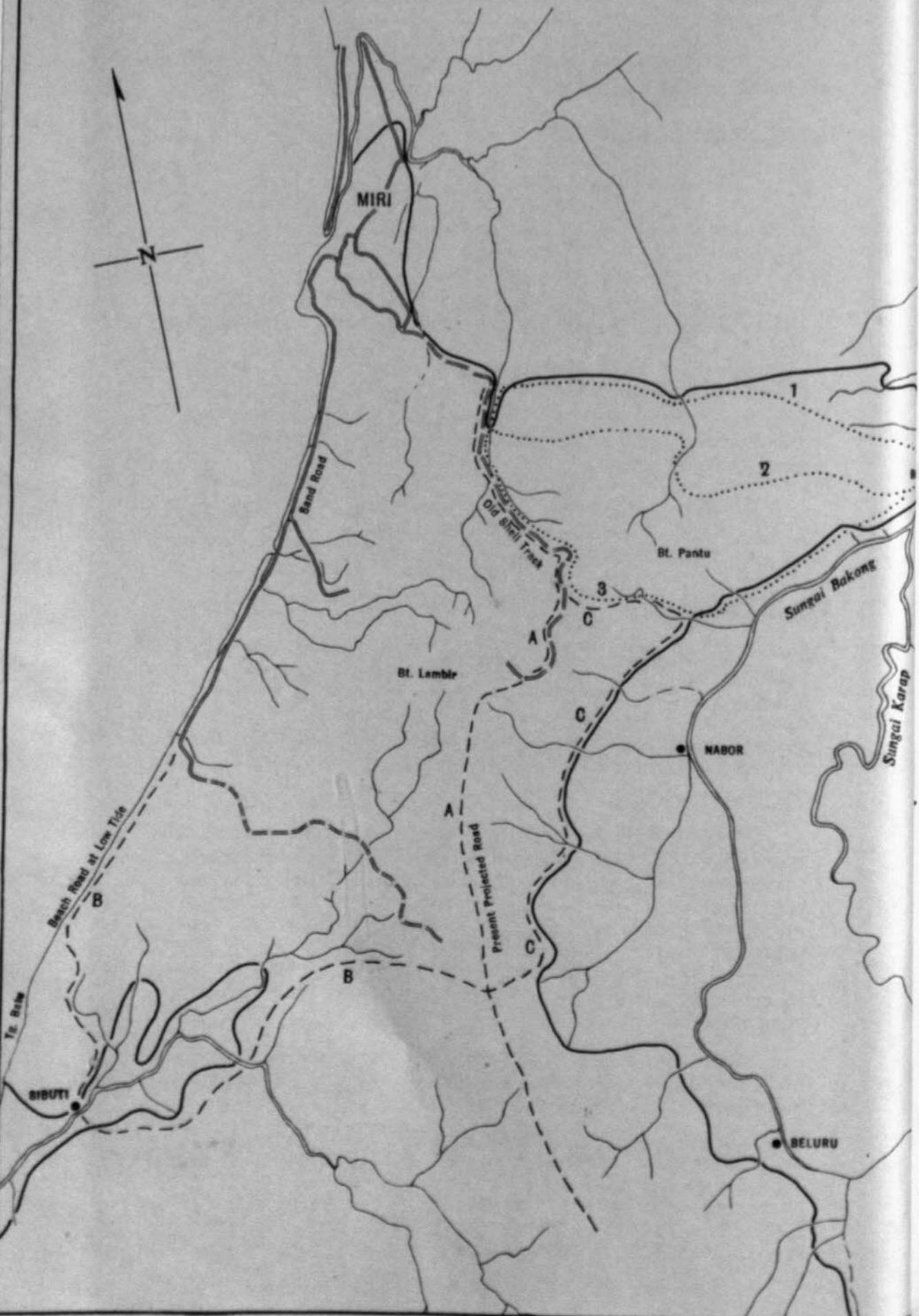
Manuring in quantity and regularly will be important to improve the nutrient status. Nitrogen, phosphate and all bases are deficient.

- 4.5.2 2. Yellow sandy clay loam to clay. The texture of this soil is heavier than 1 above and develops under less steep topography and therefore the erosion hazard is diminished though still present. These soils are not large in acreage and mainly occur near the foothills. Nutrient status is low excepting the topsoil. Rubber growing

SKETCH MAP SHOWING PROPOSED ROUTES

Scale 1 : 250,000

- Feeder Roads (1, 2 & 3)
- - - - - Trunk Roads (A, B & C)
- Existing Roads
- - - - - Existing Tracks
- Approximate boundary of flat alluvial land



would be possible but again terracing and regular manuring are necessary since the soils are poor and slopes quite steep.

3. Brownish yellow sandy loam to sandy clay loam.

This variable colluvial soil is usually imperfectly drained and occurs on slopes less than 20°. Depending on texture and slope it can be treated as for 1 and 2 above.

5. CONCLUSIONS

1. Soils. Broadly there are three genetic kinds of soil which require three different cultivation practices: i.e. the organogene peat, the alluvial and the residual soils.

The peat is comparatively fertile but acid and needs controlled draining plus liming for cultivation.

The alluvium if used for swamp padi needs controlled drainage plus regular manuring.

The hills as a whole are poor and liable to erosion if the vegetation is removed. Cultivation should not be allowed unless stringent measures are made to conserve the topsoil and improve the general soil fertility by manuring. Shifting cultivation should not be allowed under any circumstances.

The bulk of the shallow peat and alluvial soils have already been used by inhabitants of Rh. Nakat and Rh. Burit in the Bakong valley; by Rh. Kabaloi inhabitants in Ulu Sg. Kabaloi and scattered Dayaks and Chinese along the Riam Road. There is little scope for expanding agriculture on these soils except in the Padang Liku and other lesser valleys in scattered embayments.

The hills can be regarded as a block of country as yet untouched by cultivation except on the extremities. It is felt that they should be left under forest cover to avoid losing the comparatively rich few inches of topsoil. If there is a need for more land due to population pressure it should be farmers with capital as at Bt. Berop, who should be persuaded to come in. Even at Bt. Berop however there are instances where rubber has been planted on excessively steep slopes and it is apparent that cultivation of these hills must be more selective as regards slope.

2. Roads. Three routes had been proposed at the beginning of the Survey marked on the map facing this page as routes 1, 2 and 3. All routes followed the Riam road as far as Sg. Padang Liku.

Route 1 follows an easy route topographically but also cuts through many swamps, which would increase route distance substantially were they to be circumnavigated. This route would aid Rh. Kabaloi and open up a certain amount of low hill land but little alluvium in the east.

Route 2 follows hilly land most of the way direct to Bt. Berop and would be expensive as regards earth moving and bridge building. This hills made available would be steep and unprepossessing for agriculture. Soil for road building would be suitable.

Route 3 follows Sg. Padang Liku to the headwaters. The whole of this stretch was followed at one time by a 'Shell' track and was also used by Japanese. The old track follows

the levee of terrace soils all the way and in many places is still in quite good condition though overgrown. The soil is sandy and not ideal for roadbuilding and about one dozen bridges will be needed, some large. Gradients however, are very low. Between the place where the road leaves Padang Liku and the Bakong valley is a bad stretch with steep gradients and narrow ridges. From the Bakong valley to Bt. Berop the proposed route would follow foothills where gradients are low though many streams must be crossed and the soil will not in all places be suitable. This route is long but would open up scattered patches for cultivation in Sg. Padang Liku for swamp padi; the hills again are steep and of little merit for cultivation. Therefore as far as soils and opening up new agricultural land are concerned there is little to choose between the routes since the land is either of medium quality and used or unused and very poor in quality.

The last route is felt to be more worthwhile, however, despite its length, as explained in the next section.

- 5.3 3. General Economy. Rubber sheet will have to be transported from Bt. Berop in the near future and it is a moot point as to whether it will be cheaper to use small chinese launches in Sg. Bakong and take a long time, or build a new road over virgin land that could not be intensively developed and take a comparatively short time.

Of the routes suggested the last would benefit the general economy most since it is the only one that would aid the settlements along the Bakong foothills. On the other hand the inhabitants there seem perfectly satisfied to market their rubber in Nabor as at present. Whether they would use a new road or not to Miri for marketing produce is in question.

Regarding the economy of a wider area and the question of trunk routes the sketch map included refers. Trunk route A follows watersheds as far as the Padang Liku thence to Miri. Assuming the hill soils to be the same on this watershed section as the watershed soils in the present area (similar geology) this route will be difficult to build and further will not be suitable for agricultural development. On the other hand either B or C would aid present communities. B connects up with the Miri coast road after a short distance and would be relatively cheap to build, in addition connecting Sibuti with Miri. C follows the Bakong foothills and would fit in well with the present proposed feeder road route over the water shed to Miri.

Both B and C could be built by choosing one for the trunk route and building the other to feeder road standards.

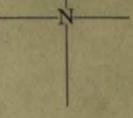
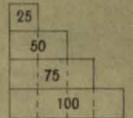
RECONNAISSANCE SOIL MAP

MIRI - BEROP AREA

SCALE 1 : 50,000 approx.

Map derived from air photo mosaics scale approx. 1 : 25,000

Area Scale (acres)



LEGEND

- Soil sample location
- 3828/30 Laboratory ref. numbers of sample
- XVII Rents
- - - Soil boundary uncertain
- - - Route taken by soil survey party
- Main watershed
- Longhouse
- - - Boundary of survey area
- Main stream
- Minor stream
- Marine (Raised Beach) Association :
 - U - undisected
 - D - dissected
 - C - areas known to be clay
 - S - areas known to be sand

KEY TO SOILS

ORIGIN	SOIL ASSOCIATION	COMPONENT SOIL UNITS	CHARACTERISTICS AND CAPABILITY
ORGANOGENE	PEAT	1. 3 - 10' peat or muck	Acid and permanently waterlogged. Shallow margins suitable for swamp padi if drained. Danger of flooding if drain deep peat beyond say 6 feet.
		2. more than 10' peat or muck	
	PEAT - RIVERINE	3. mixed 1, 4 and 5 sometimes 2	Refer to individual units
ALLUVIAL	RIVERINE	4. yellow sandy loam (levee)	Levee terrace soil. Well drained, coarse textured, poor in nutrients. Suitable for fruit gardens, coconuts
		5. light gray silty clay (basin soil) with up to 3' peat or muck	Impervious and usually easily irrigated. Badly drained, poor to moderate nutrient level. Suitable for swamp padi except patches of 'catclay'.
	MARINE (RAISED BEACH)	6. white sand	Old beach sand, often humus podsol, poorly drained subsoil, leached. Unsuitable for agriculture.
		7. light gray silty clay loam	Old alluvium imperfectly drained, moderate nutrient level; suitable for rubber, possibly citrus.
		8. yellow sandy loam - loam	As for 4.
		9. pale yellow sandy clay loam	As for 11.
		Also small valleys containing 3	Refer to individual units
		Also soils of hill association in dissected parts	Refer to individual units
RESIDUAL	HILL	10. yellow sandy loam - loam	Associated with sandstone. Free - imperfect drainage, steep slopes, erosion hazard high. Nutrient level low except topsoil. Not suitable for cultivation unless stringent precautions taken against erosion.
		11. yellow sandy clay loam	Associated with shales. Imperfect - poor drainage, moderately steep slopes. Nutrient level low except topsoil. Possibly suitable for rubber cultivation if erosion control measures taken.
		12. colluvial soils	Variable qualities. Often light textured but on low - med. slopes. Nutrient level probably low - medium. Cultivation as for 11.
		Also small valleys containing 3	Refer to individual units

