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Report on a Reconnaissance Soil Survey of the LUNDU DISTRICT (WEST)

1st Division

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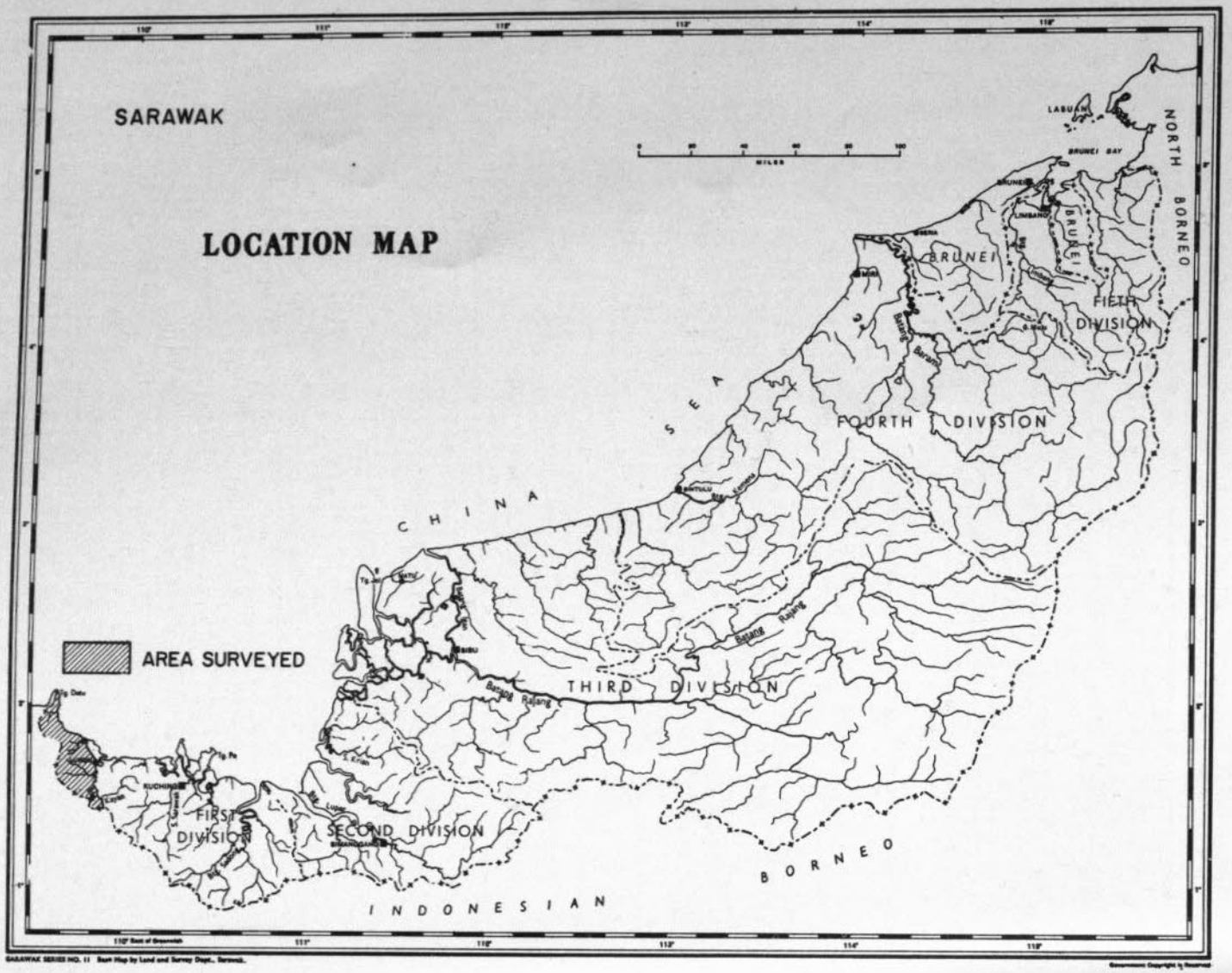
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KUCHING

REPORT ON THE RECONNAISSANCE SOIL SURVEY OF THE LUNDU DISTRICT (WEST)

by

J. P. ANDRIESSE.

INTRODUCTION

1. Definition of area

The area discussed in this report comprises the western part of the Lundu-District which is bounded in the west by the border with Indonesian Borneo, in the north by the South China Sea, in the east by a line drawn south from Sematan through Lundu town to where it crosses the Batang Kayan, the Batang Kayan up to its junction with Sungei Danian in the Rasau area and from there it follows an arbitrary line almost drawn northsouth to the Indonesian border. The southern boundary is formed by the border with Indonesian Borneo. The area is shown on the location map.

2. History of survey

Surveying on a reconnaissance basis started in the area in 1960 when the Serayan-Sematan Road area was surveyed (reference Survey Area Report 19). Further reconnaissance surveying was carried out during 1965 but owing to the security situation the border areas could not be covered. The boundary of the area then surveyed is shown on Map 1 (western boundary of survey area 25/2). During 1967 the border areas south of Sungei Jangkar comprising the Rasau, Selampit, Kandai, Biawak and Sungei Pasir areas were surveyed. Reporting was withheld until the full survey could be completed. This was accomplished during September-October, 1968.

Owing to adverse weather conditions the area in the Pueh - Samunsan Forest Reserve could not be surveyed in full. However, sufficient knowledge on the Samunsan area is available for a reliable (relative to the scale of mapping) air photo interpretation. The interpretation was greatly assisted by the information supplied by Forest Inventory Report on Gunung Pueh-Forest Reserve (Brunig, 1962). Subsequent development in the Sarawak Soil Classification system since 1966 has made it necessary to rename some of the soils in the area near Lundu which were reported upon in report 25/2. This area is therefore added to the soil map presented in this report. With the publishing of the present report, the report on survey area 19 (Lundu-Sematan Road area) has now become obselete particularly since the classification system used in 1960 has been totally revised; also the present map is more detailed and accurate which is due to better air photography being available now.

3. Method employed

Throughout the area full use was made of air photographs which were studied prior to field work. Landscape units and geological boundaries, which generally indicate changes in soils, were drawn. Thereafter the location of cutlines for soil observation and soil inventarisation was planned on the 1:50,000 scale topographic maps (series T735) in such a way that they crossed as many soil boundaries as could be expected (this in relation to landscape units and geology). During the field work soils were described and classified

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in these cutlines and along existing paths. The collected field information on the soil pattern and their characteristics was subsequently used to finalise boundaries on the air photographs after reinterpretation. The soil boundaries were then transferred from the 1:25,000 scale photographs onto the 1:50,000 scale topo maps using a Hilger and Watts Sketch master. Finally, the soil map drawn at a scale 1:50,000 was reduced photographically to the published scale of 1:100,000.

Throughout the surveying period the Surveyor was assisted by two Assistants and an average labour force of 15 persons.

Part I - GENERAL DESCRIPTION OF THE AREA

1. Administration and communications

The area forms the most western part of the First Division and is administered through the District Office at Lundu. The most southern part of the area surveyed, namely the Rasau area, has recently been joined with the Bau District area as far as responsibilities of the Department of Agriculture are concerned. This area is more easily accessible through the new Bau-Lundu road from the Bau end. With the completion of this road in October, 1968 the whole Lundu District has become much more easily accessible from Kuching and travelling time has been cut down from a day to about three hours. Road communication between the southern part of the area and Lundu has replaced river transport which until this year was the only means to get to this area. The Sematan area is now also joined with the First Division road net through the Sematan-Lundu road. However, although during the last years communications in the area have greatly improved, they still leave much to be desired. The utmost northern area between Pueh and Tanjong Dato is only accessible by sea which during the rainy season is risky. The Biawak area is still remote from Lundu in terms of time. The carrying of produce from Biawak to Lundu takes a full day. The completion of the Lundu-Biawak road at present under construction by the Malaysian Army will provide this much needed communication link. Not only from an administrative point of view is this road desirable but also economic development of this area in the agricultural sphere can only be brought about if easy access is available.

The main marketing place in the area is Lundu from which most of the rubber and pepper, the main agricultural produce in the area, is exported. Sematan has a secondary function in this respect and caters mainly for the northern part of the area. However, with the construction of the Lundu-Sematan road more people along this road perfer selling their produce at Lundu. Sematan is a centre for sea fish marketing which is sold subsequently to the Lundu market. Sea transport directly from Sematan to Kuching is probably cheaper than road transport although the latter would likely ensure fresher fish on the market in Kuching.

Population

No exact figures on the population in the area are available. As indicated by the 1960 Census, this may be in the region of 8,000.

The Dayak community is the dominant group followed by Malays and Chinese.

Although some intermixing has taken place in recent time the various population groups are still very much found in their own particular regions, the latter being largely dictated by history of settlement and land tenure regulations. Thus, the Malays are found mainly concentrated in the coastal area between Sematan and Tanjong Dato and along Sungei Sebat. Malays have also concentrated around marketing places such as Sematan and Lundu.

The Chinese population has mainly settled in the Mixed Zone area created along the Lundu-Sematan road, in the area surrounding Bukit Gading, and in the valleys of the numerous streams originating from this Mountain. To a minor extent this is also true for the valleys of rivers originating from the Pueh Massif (this applies only for rivers north of Sungei Jangkar) up to Sungei Sebat.

The Dayak population can be subdivided into three specific communities which are in order of numbers:

a. The Selakau Dayaks
b. Sebuyau Sea Dayaks
c. Jagoi Land Dayaks.

The Selakau Dayaks are exclusively found in the western part of the Lundu District. The Pueh Selakau have only recently settled in their area during the last 100 years. They are mainly living in small communities (with the exception of Kampongs Pueh and Biawak) in the numerous river valleys coming from the Pueh Mountains and settlements in the foothills of Bukits Pueh and Gading. They are typically Land Dayaks to whom river transport is traditionally unknown.

They engage in hill padi farming, cash crops are mainly rubber and pepper. Some large areas of 'Engkabang' cultivation can be found along the streams where they have settled. This must be a considerable source of income if the 'Engkabang' has a favourable season.

The Sebuyau Dayaks are found mainly along the Kayan river where they have penetrated from downstreams and the coastal areas. The boundary between the Sebuyau Dayaks and Jagoi's is just downstreams of Kampong Rasa. A large settlement of Ibans from Ulu Ai is found at Sebandi (right bank of the Kayan river and outside the area discussed). A large part of their farming land falls in the area discussed in this report.

The Sebuyau Sea Dayaks engage in hill padi farming and have recently taken to wet padi farming and coconut cultivation. Rubber is their main cash crop. Pepper is not much planted, mainly owing to adverse soil conditions in the area where they have settled.

The Jagoi Dayaks are found in the upper regions of the Kayan river. Kampong Rasa is a settlement of S.D.A. Jagoi Dayaks mainly from Selampit, Rasau and Stungkor origin. Further upstream, the large settlement of Selampit is found with people originating from Stungkor and Rasau. This settlement dates back to the Japanese occupation period. Rubber is the main source of income. In the southern part of the area, Rasau II (the name given to the original Rasau Mawang by the British Security Forces during the confrontation period) is the oldest Jagoi settlement in the area. Rasau I (original name Rasau Lallang) is a new R.C. settlement found lower downstream of Sungei Rasau. Both settlements have rubber as their main source of cash income but hill padi cultivation is practised yearly. In this area, there is no wet padi cultivation. During recent years much income was derived from the large supply of Belian available in this area. With the opening of the area by the Bau-Lundu road most of the Belian was sold as pepper poles and the supply is now nearly exhausted.

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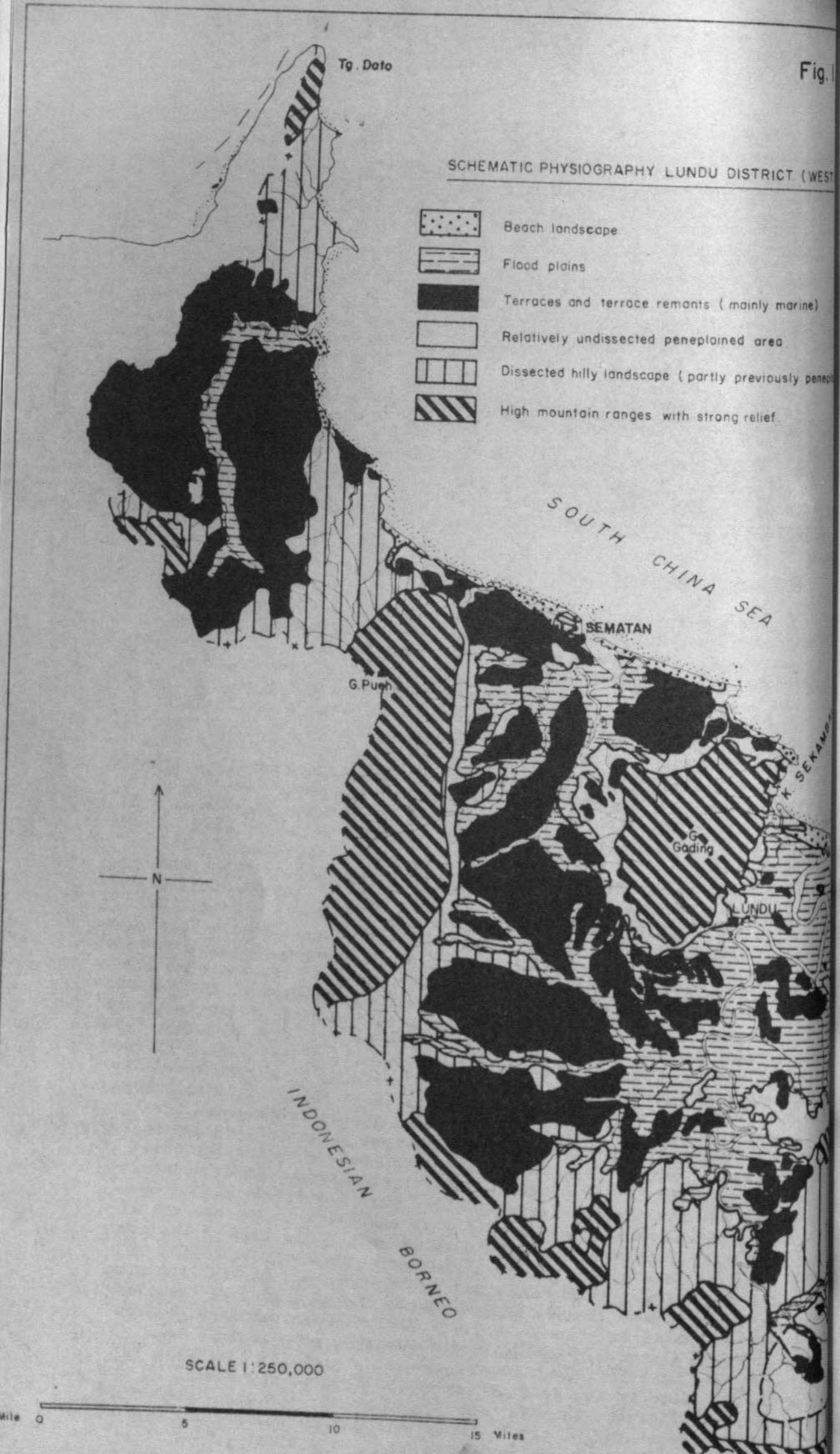
Fig. I



oil Survey Drawing No. 150

Compiled by J. P. Andriesse

Belian is prolific in sandstone areas where no podzols have formed, mainly on scarp slopes and in foothill area where the hill land merges into riverine plains. This species also occurs in riverine valleys with loamy to sandy recent alluvial deposits.

4. Physiography

Morphology of the terrain and the geology are intimately related to soil types occurring in the area. It is therefore necessary to describe these features in some detail so that the soil pattern is better understood.

The long coastline from Tanjong Dato to Sematan is formed by a great number of beach stretches which are either underbroken by rocky headlands or by river mouths, of the latter the largest is Kuala Samunsan.

At Tanjong Dato itself the granitic massif of Tanjong Dato rises steeply up from the coast and beach development is absent. All photographs show colluvial boulders and sand deposits on the coastal shelf. The coastline itself appears to be very unstable, between Samunsan and Sematan, particularly at the mouth of rivers where sandspits are formed and eroded within a number of years. This is very well illustrated by a comparison made between old and new air photography (years respectively 1948 and 1965). From the coast going land inwards several stranded beaches are found. Usually behind the present beach a number of moderately steep and high storm beaches are found at a level of 4 - 6 feet above high tide level (frequently 4 in the Pueh-Sematan section); this series is followed by a gently undulating subrecent beach landscape of varying width (level 6 - 10 feet). The greatest extent was found between Pueh and Siru. Behind this subrecent beach landscape normally a shallow narrow lagoon is found (often not more than a creek) behind which is a still older beach landscape at a slightly higher level (10 - 16 feet) in which several storm beaches can be recognised, these being best developed at the landward side of this landscape. This last old storm beach either slopes steeply down to an old lagoon (well developed between Pueh and Siru) or merges without any recognisable boundary into a much older marine terrace landscape which slopes up gently to the foothills of the Pueh Mountains (16 - 150 feet on average). Thus, in this coastal landscape 4 stages of deposition can be recognised, present level, subrecent level, old level and very old level. Some levels were taken along cutlines and the highest point in the old level corresponds with a 16 feet drop in sea level between the period in which the old beach landscape was formed and the period in which the present beach is formed. This drop in sea level appears to confirm the earlier findings by Wolfenden (1963) who reported a recent drop in sea level of approximately 10 to 20 feet. This process of beach development has been disrupted along the coast at some places by the numerous streams coming from the Pueh Massif and which sought an outlet to the sea. For this reason in some parts not all members of the sequence just described can be found. They have either been eroded by the vast moving waters of these mountain streams or where buried by fresh material as these mountain streams following the changes in sea levels as registered in the heights of the three beach landscapes extended their alluvial fans towards the sea.

Where rocky headlands occur near the sea frequently only the most recent beach landscape is present, or because of the steep inclination the sequence of beach deposits follow each other within such short distances, that they cannot be separated from each other.

This is particularly the case in the area between Kuala Samunsan and Tanjong Dato. The full sequence of beach landscapes is best preserved between S. Pueh and Sematan.

This beach landscape just described borders either onto gently undulating hilly terrain underlain by thick sandstone beds with a sequence of dip and scarp slopes with only a few protruding hills, or by the old marine terrace landscape. (likely Pleistocene in age) This is the fourth level of deposition referred to earlier. The latter deposits are very sandy in the top few feet and frequently overly sandstone beds in the Samunsan-Pueh area. This old terrace landscape is best preserved in the Samunsan basin which slopes very gently down from the upstream areas at the border with Indonesia towards the sea. This monotonous landscape is only underbroken by some hills formed by igneous extrusions. Again, in the Pueh-Sematan area because of the existence of a great number of very active streams this pattern is very much disturbed by erosion through which part of these terraces has been removed. In this area, as well as in the Samunsan basin the sedimentary materials are underlain by country rock, frequently at shallow depth, depending on elevation. This old marine terrace landscape extends deep into the country almost up to Biawak and along the Kayan river up to Kampong Rasa. Remnants of old terrace alluvium can still be found on the summits of hills there.

This terrace level varying between 150 feet in the upstream areas to approximately 20 feet near the coast may indicate that the old alluvial materials must be seen as a large coastal shelf deposit which has formed at the foot of the steeply rising Pueh and Gading massifs in times when the sea was approximately 120 to 150 feet higher than it is now. (likely during the Pleistocene) Mineralogical analyses confirm that the material, particularly in deeper layers is not well sorted and not water worn to any extent which may indicate deposition of colluvial material in shallow water rather than river transport. Only the top layers show sorting which is possibly due to the fact that after emerging of the shelf transport of material took place.

In this old terrace landscape present rivers have cut quite wide but steep valleys in which again recent material was deposited. The boundary between recent and old material is in places very abrupt and usually marked by a sudden break of slope in the landscape. Frequently at the edges of the terraces where the alluvial cover had been eroded away the country rock is outcropping.

In the Kandai-Selampit-Rasau area the same level of 150 feet can be found and indicates here an old peneplain level in which little old alluvium is found. Where present, it is mainly old riverine alluvium from present streams. Also in these areas the landscape is monotonous, with very few outstanding features. This is here mainly due to the nature of the underlying geology, it being mainly slightly dipping weakly consolidated sandstones. Throughout the area, the 150 feet level is usually marked by breaks in slope if underlain by hard rock.

The only riverine basin of any extent in the area is that of the Batang Kayan. In the present floodplain clay is deposited along the banks but some large peat deposits have formed between Sungei Pasir and the Batang Kayan possibly during the period in which the three beach landscapes were formed. The drop in sea level caused the Sungei Pasir and Batang Kayan to extend their levees into what was mainly a submerged inland sea basin. These high levees cut off parts of this basin in which peat could develop because of the very wet conditions caused by lack of drainage. The cutting off of numerous side valleys

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in the terrace landscape through an identical cause has also here given rise to the development of peat. It is worth noting that many of these valleys show an accumulation of more clayey materials on top of deep peat. This may indicate backflooding into these valleys during more recent times and may be caused either by a slow process of submerging of the land or to a rise in sea level. This process of accumulation of clay material on top of peat can be noticed in many places in the Lundu District (reference report 25/2).

The most outstanding topographic features in the area are the Pueh and Gading granitic Massifs which rise respectively to a height of over 4,000 feet and 2,000 feet often over a distance of less than 2 miles. On the foot of these massifs strongly dissected foothills are found which are partly built by metamorphosed rocktypes and at the debouching points of numerous streams partly by alluvial sand deposits.

The sudden checking of the high velocity of these stream waters when they arrive at the old marine terrace landscape has caused the depositing of large amounts of coarse debris at these points. Boulder fans with old river channels occur very frequently and meandering of stream channels in their own coarse deposits is still going on at the present.

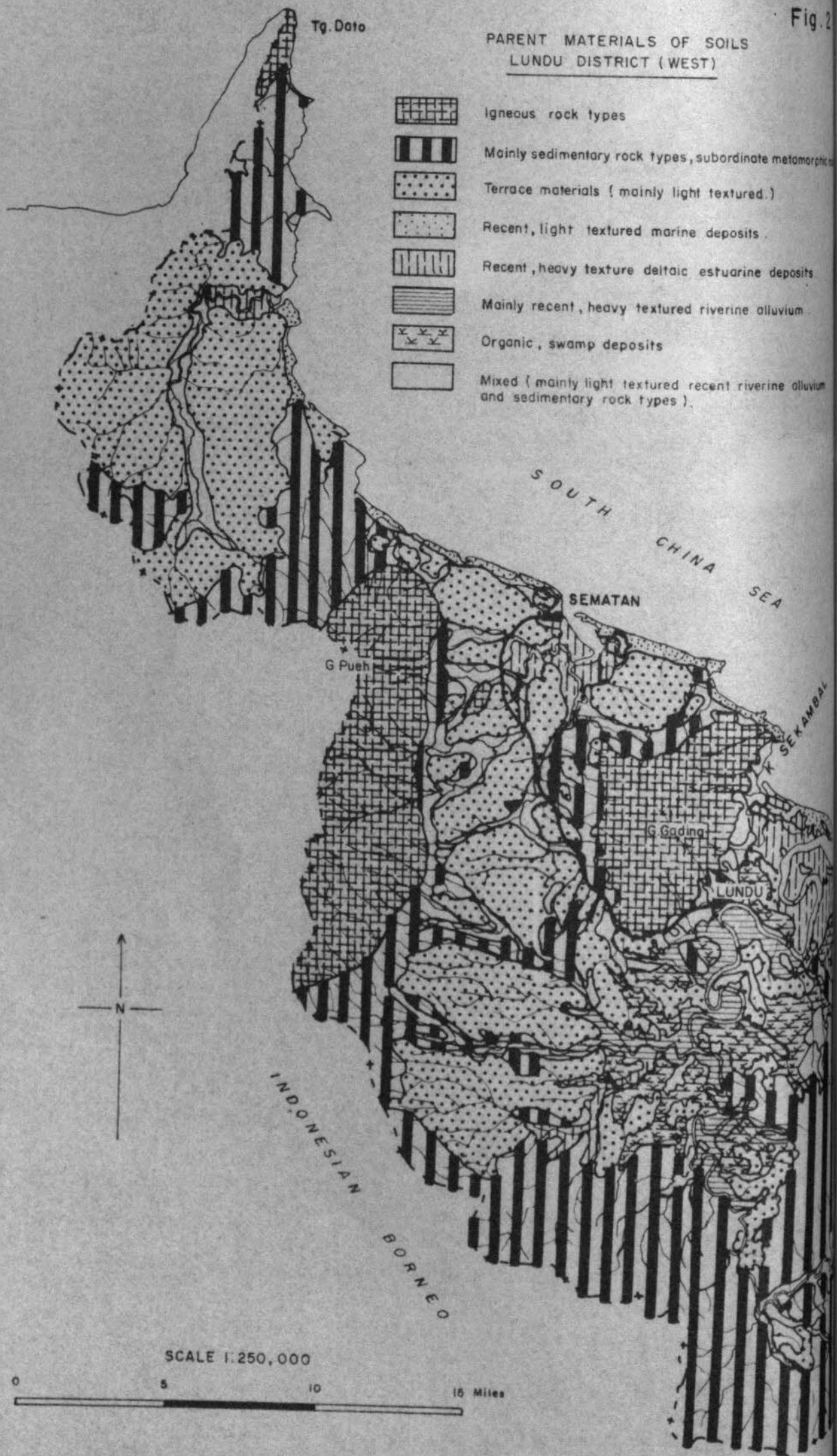
Summarising the following landscapes can be recognised:-

1. The granite massifs of the Pueh, Gading and Tanjong Dato Mountains.
2. The foothills of these mountains comprising many alluvial fans which are strongly dissected.
3. The old marine terrace lansscape, partially eroded and replaced by young river valleys together with monadnock type protruding hills. (G. Melaka, Serabang, Puting, Bedaun, Tamin Menari etc.)
4. The lowlying slightly dissected peneplain (same level as the marine terraces) of the Biawak, Kandai, Selampit, Rasau area formed by sandstone and Serabang formation rocktypes which is interrupted by some high ridges due to folding.
5. The present floodplain subdivided into:
   a. The numerous valleys in the old marine terrace landscape, frequently flooded but generally dry covered with recent riverine deposits.
   b. The wide floodplain of the Kayan river characterised by clay levees along its course, and which are occasionally flooded during high rainfall and the large basin peat swamp formed by the enclosing levees of the Sungei Pasir and Batang Kayan.
6. The Post-Pleistocene beach landscape with the three levels of stranded beaches each separated by lagoons.

The small floodplains at the mouths of the Samunsan and Sematan rivers fall under the same category as landscape 5 but because of the nearness to the sea depositing takes place in a brackish environment.

The various landscape units are shown in a schematic form on figure 1. (Physiography)

Fig. 2



Soil Survey Drawing No 150

Compiled by J. P. Andriesse

5. Parent Materials

Information on geology is mainly derived from Wolfenden (1963).

The complex soil pattern which is partly caused by the post Pleistocene history of the landscape is aggravated by a very complex geology.

This is not so much caused by the number of geological formations present in the area but by the great variety of rocktypes found in these formations.

The large massifs discussed under landscape unit 1 (see section Physiography) are formed by Biotite Adamellite which is granitic to granodioritic in composition, rather coarse in texture and characterised mainly by quartz, feldspars and biotite. Some hybridized materials due to contact with gabbroitic materials can be found in places but they do not influence the general soil pattern much. One large outcrop of gabbro found at Bukit Gebong was the only mappeable area at the scale used.

The variations in the adamellite are rather small and soils on these rocktypes are quite homogeneous, differences being mainly caused by slope aspect. The largest part of the area is formed by the Serabang formation which is of Upper Cretaceous to Triassic Age. The variety of rocktypes in this formation is great. They comprise phyllites, graywacke sandstone, and cherts mainly while a great number of extrusions of metamorphosed basaltic and andesitic lava's (greenstones) have cut through these sediments. They give rise to a great number of large and small hills resembling monadnocks, each of them having its own specific geology which makes interpretations of photographs without field knowledge very difficult. The chert frequently gives also rise to outstanding features such as at Kandai. Apart from these extrusions regional thermodynamic metamorphism has taken place in many localities. This has happened e.g. near the foothills of the granitic massifs and near the extrusions of greenstones. This has given rise to the formation of hornfels and associated rocktypes. Most of the Serabang formation rocks are more or less metamorphosed either dynamically or thermally. Most of the terrace landscape mentioned under 3 in the section on physiography is underlain by Serabang formation rocktypes while landscape unit 2 is made up partly by metamorphosed rocktypes or colluvial materials from the Biotite Adamellite.

In the southern part of the area and north of Gunung Pueh the landscape is formed by rocks of the Tertiary Plateau sandstone formation. These comprise mainly medium textured sandstones with in places thin beds of shales and mudstone. The latter are mainly of importance in the Selampit, Rasau area. Apart from this differences in texture, iron content of the sandstones gives rise to the formation of different soils.

These three geological formations form the main underlying geology of the area. However, in many places much of the geology is masked by a very deep cover of marine terrace alluvium. The underlying geology is only discernable at eroded terrace slopes and the normal sequence of parent materials at such a site is : old alluvium (sand) at the summit, Serabang formation rocktypes at the slope merging into recent alluvium in the present valley. The foothills of the Ademellite massifs display also a sequence: Adamellite at the steep slopes, metamorphosed rocktypes at the foothills merging either into old marine alluvium in undisturbed localities or recent coarse textured alluvial fan deposits near streams.

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The variations in the landscape underlain by the Tertiary sandstones is less but the elements are more difficult to recognise. There are no visible landscape features to recognise between iron rich and iron poor sandstone, mudstone does not always give steep dipslopes, although shales normally do. The general pattern however, is sandstone on the dipslopes, shale on the scarp slopes. Vegetation is generally a guide, but superior vegetation on scarp slopes is also caused by better drainage rather than a difference in parent material. Superior vegetation generally reflects the occurrence of igneous rocktypes in the Serabang formation but the difference in vegetation between terrace alluvium and sedimentary rocktypes in the Serabang formation is slight. Both give a sort of poor Dipterocarp forest merging into Kerangas. Only the graywacke sandstone generally gives a better vegetation.

In the valleys, recent alluvium of varying composition is deposited. Near the Pueh and Gading mountains the material is coarse to medium textured. Further away finer textured material is found. The same graduation is found in depth. The top layers are generally heavier textured than the deeper layers. Thus, even away from the mountains heavy loams frequently rest on sands. The same trend is found in the recent alluvium deposited in a wet environment. Thus, coarse and heavy textured soils follow each other in close succession depending on the local conditions of deposition.

In the most wet situation, the Batang Kayan floodplain and in some old lagoons, peat has formed.

Along the coast recent marine alluvium is found of which the characteristics vary with age. Thus, the oldest material is well weathered and leached the subrecent material is well weathered and partly leached while the most recent deposits are still relatively fresh. Most coastal deposits are sands, which can be expected since the source material is found nearby and is mainly granitic in origin or derived from sandstones.

It was generally observed that many differences in soil type are related either to differences in texture or chemical composition of the rocktypes. Of the latter, total iron and alluminium contents are of importance, the other elements (apart from in the recent alluvium) play a minor role since the climate tends to level out any differences such as feldspar content which may have existed. Thus, the content of ferromagnesium minerals in the rocks appears to be of major importance. For this reason strongly metamorphosed rocktypes at contact zone, such as occur in the foothills of Adamellite mountains give soils which are similar to those found on Adamellite and the boundary is erratic. Likewise sandstones poor in ferromagnesium minerals and irrespective of their Age give rise to the development of similar soils and these are often identical to those developed on sandy terrace alluvium.

Part 2 : SOILS

1. Classification

The classification used is that described in Technical Paper No.2 'A Classification of Sarawak Soils' issued by the Soils Division (1966). Since the publication of this paper certain amendments have been made in the family classification of the Gley Soils and Saline Gley Soils. These amendments concern only the Gley Soils as far as the present map is concerned and a note to that effect is made in the description of the units in the following section:

Classification at a series level(the lowest level of classification) has not yet been finalised and although in the mapping key certain soils have been classified at the series level, only those on which general agreement has been reached are actually shown on the map. New series within families are mentioned in the key and the text but are still mapped as the families to which they belong.

The description of soil units follows the order as shown on the key in the soil map. In the description, notes are given on the general characteristics of the classification unit, the overall fertility and capability for the major crop types in Sarawak. Limitations are also mentioned together with suggested measures to improve them.

A clear distinction should be made between classification unit and mapping unit. Classification units are soil groups, soil families or soil series. Such units are not always mappeable as single units and often they occur in association with other units. In case a classification unit is mapped as a single unit then the classification unit is a mapping unit. Associations are always mapping units which consist of several classification units and the characteristics of the mapping unit is therefore a combination of the characteristics of the comprising classification units.

2. Description of classification units

LATERITIC SOILS

Tarat Family

These are generally reddish brown to reddish yellow clays of a very good structure, angular blocky to crumbly; well-drained and having good water-holding capacities. Apart from a darker colour in the topsoil and red colours where the soil merges into the parent rock, the profiles do not show much variation. The parent rock may range from intermediate to basic igneous rocktypes.

In the area the soils belong mainly to one series in this family namely, the Tarat series which is characterised by weak angular blocky to crumbly structures and a strong reddish colour. The soils are friable and provide a good medium for plant growth. The Tarat series is regarded as one of the best upland soils in Sarawak, this mainly because of the excellent physical characteristics. The soils are generally poor in all plant nutrient and for sustained yields fertilisers must be used for almost any commercial crop. The soils have one limitation, which is topography. They generally occur on steep terrain and then tend to be shallow in nature. In such localities they often occur in association with the Skeletal Soils belonging to the Sedong Family. One other specific series has been separated from this family, namely the Jebong series which occurs on Bukit Jebong near

Sematan and which is derived from Gabbro. This series (for detailed description see the appendix) is characterised by a strong blocky structure in the subsoil and its compactness which is unusual for Tarat soils. Colour is like Tarat series. Most of the Jebong series is related to occurrences of bauxite and the compact nature of the soil may be related to the density of the aluminium oxides which have accumulated in this soil. The series is of little agricultural importance, the area is small and the series is found on steep terrain where it occurs mixed with much bouldery land unfit for cultivation unless very intensive farming such as pepper cultivation is carried out. Most of the Tarat series in the area is related to the outcrops of greenstone occurring in the Serabang formation. The areas are generally small in extend and apart from a relatively more extensive acreage in the Kandai area they are for the region as a whole of little agricultural importance.

RED-YELLOW PODSOLIC SOILS

Abok Family

The Abok Family comprises soils which have developed over acid igneous and metamorphic rocktypes. They are characterised by higher iron and aluminium contents than are found in the other families of this soil group. (more than 25% in the subsoil). The soils within this family, however, have a wide texture range and they differ also in structure and colour. To enable the grouping of soils of more or less common characteristics which are of agricultural significance, several series have been created within this family.

In this area, the Gading and Jagoi series are the most common ones. Because of the extensive areas they occupy, they could be mapped as such, while most other series although recognised in the field could not be mapped adequately as single unit and they have therefore been mapped together as Abok Family soils.

The Abok Family soils in the region not mapped as Gading or Jagoi series are commonly derived from metamorphic rocktypes which are found in the border areas of the Adamellite outcrops forming the Pueh and Gading mountains. The soils are of a reddish yellow colour and the texture ranges from a loamy sand to sandy clay loam. The parent material is probably metamorphosed sandstones. The structure of these soils is crumbly to weak angular blocky. The profile is homogeneous without much horizonation.

The occurrence of stonelines (quartz) is a common characteristic of these Abok soils.

Other Abok soils are found on metamorphosed igneous intrusions in the Serabang formation; these soils are generally more clayey and structure is more developed. They are commonly stronger coloured than those developed in the foothills of the Pueh and Gading mountains. They are transitional to the Tarat Family soils discussed under the Lateritic Soils and these probably occur mixed with the Abok soils. The areas are small and of little importance for overall development. The soils are, however, well suitable for pepper cultivation because of their good internal drainage, and the small areas of Abok soils found in any area could be best used for this crop since this would provide the highest income per acre. The fertility of all Abok soils is low; they are strongly leached, have no weatherable minerals and are deficient in all major nutrients than value lies in the good physical characteristics.

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The Gading series has all the characteristics of the Abok Family but has a strong red colour, while the texture is coarse sandy loam to coarse sandy clay in the subsoil. This series is derived from Adamellite granite in which the feldspars have weathered into clay while the coarse quartz of the granite forms the coarse to almost gritty sand fraction of the soils. The Gading series is if low chemical fertility, but is structurally a good soil. A main limitation is the steep slope on which they are normally found and they are, therefore, commonly associated with Skeletal soils mapped as Kapit Family.

A profile description of the Gading series can be found in the Appendix. It should be noted that in Report 25/2 on the eastern part of the Lundu area these soils are classified under the Tarat Family. Because of the sandy texture and too low iron content for Lateritic soils they are now classified as Red-Yellow Podsolic soils.

The Jagoi series occurs also on material derived from Adamellite. Main characteristics are the same as the Gading series. Jagoi series is, however, of a paler colour, and occurs mainly on footslope areas. Possibly Jagoi series has developed in colluvial materials and is more quartizitic than the Gading series. Two profile description are given in the Appendix. The soils are very sandy and extremely low in plant nutrients. They are recommended for rubber mainly.

Merit Family

This Family has developed over heavy textured sedimentary rocks. They are mainly found on shales and mudstones in the Tertiary sediments where they occupy steep sloping areas. Only in the Rasau area they can be found on gentle slopes but they are there of small extend.

The Merit soils are generally deep clay loams overlying heavy clays which merge into weathered shale or mudstone. Colours range from brownish yellow in the surface horizons to reddish yellow in the sub-horizons. The weathered shale is frequently of a multi-coloured nature, mottled: yellow, brown, red and grey. Structure is macro-blocky but in moist soils, the usual field conditions, it is not very well developed. The Merit soils are chemically poor, often deficient in phosphate and nitrogen, potash is usually adequate at the natural level of P and N. The soils are well suitable for tree crops, they are frequently planted up with pepper but the internal drainage is in places inadequate for this crop. Imperfect drainage conditions are usually indicated by strong grey mottles within 18 inches from the surface. This is not always related to topography and such drainage conditions may also be found on steep slopes.

Apart from low chemical fertility and steep topography in places, this family has no other limitations to agriculture.

Bekenu Family

The Bekenu Family is very similar to the Merit Family but has a wider texture range. Bekenu soils are sandy in the surface horizons, frequently sandy loams while the subsoils are sandy clays to clays.

There is some variation in colour texture and structure in the Bekenu soils found in the area due to a difference in parent material. The soils developed in the Tertiary deposits are of the same colour range as the Merit soils, brownish yellow to reddish yellow. Structure is weak angular blocky to crumbly. The soils are not as massif as the Merit soils. A typical Bekenu soil is described in the Appendix.

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Bekenu Family soils developed over greywacke in the Serabang formation display a typical olive yellow colour; in places even an olive green colour was reported. The soils are quite blocky and massif. The texture is a sandy clay loam overlying sandy clays. The sand fraction is of medium size and consists of clear, transparent quartz grains. The soils are deep and occur on gently undulating terrain. This soil is provisionally called the Biawak series since it occurs most widespread in the Biawak-Sungei Pasir area.

A typical profile is described in the Appendix.

Bekenu soils are good agricultural soils, the limitations being mainly low fertility which can be rectified with fertilisers and in places steep topography. When occurring on the Tertiary deposits they are often found in association with Saratok Family soils discussed under the next Soil Group.

Nyalau Family

The Nyalau soils are genetically similar to the Merit and Bekenu soils but they are all light textured. The topsoils range from sand to sandy loam, while the subsoils are sandy clay loams to sandy clays (the latter are uncommon). The structure is usually weak subangular blocky to crumbly. The soils are commonly friable and very open. They are normally well-drained.

Nyalau soils occur most extensively in the Tertiary deposits (sandstones) where they are often associated with scarp slopes. In such areas podsols are usually developed on the dipslopes formed by sandstone beds, while on the scarpslopes, due to better drainage and rejuvenation through erosion, Nyalau soils have formed.

Near the Gading and Pueh mountains soils of Nyalau texture and colour usually occur. They are probably formed from sandstones in the Serabang formation, which are generally weakly to strongly metamorphosed in this area. Apart from a possible difference in parent material the profile characteristics are identical to normal Nyalau soils and no separation has, therefore, been attempted.

A typical Nyalau soil on Tertiary sandstone is described in the Appendix. Nyalau soils are very poor chemically, drainage is good to excessive. Because of the sandy nature fertilisation must be expensive for demanding crops and for this reason pepper is usually not planted on this soil type. They are typical rubber soils and particularly in the Selampit area are used for this purpose.

Other tree crops could be planted on this soil provide the economics of fertilisation is studied in advance.

Malang Family

The Malang soils are heavy textured subrecent alluvial soils which occupy levee or floodplain sites which are slightly above normal flood level. For this reason, some profile development is noticeable, although commonly this is very weakly expressed. The soils are in the heavy loam range and around Bukit Gading a considerable amount of the fine sand to silt fraction is made up of micaceous material, which gives a smeary character to these soils. The colour is commonly brownish yellow to reddish yellow in the deeper layers. Structure is commonly absent or weak subangular blocky to crumbly. Internal drainage varies with location. Low lying places are characterised by a gley horizon and a watertable within the profile depth (4 feet) but always

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below 20 inches. Chemical fertility is moderate for Sarawak standards. The soils are well suitable for agriculture, particularly for annual crops and perennials such as Rambutan, Durian and Citrus which can stand moderately wet conditions.

The limitations of this family is low fertility for the more demanding crops, sporadic flooding and high watertable in some localities.

The normal series in the Malang Family as occurring around Bukit Gading is the Sekati series which has been discussed in Report 25/2. (description added to Appendix).

Malang soils which have developed in alluvium coming from sources which are not mica bearing are of somewhat lower fertility but in the area they are of small extend.

GREY WHITE PODSOLIC SOILS

Saratok Family

The Saratok Family soils occur widespread on the Tertiary sandstones in the Rasau and Selampit areas. The texture range is from loamy sands to heavy loams. Texture is commonly very similar to that of Nyalau soils and the only difference between Saratok and Nyalau soils is frequently the colour, the former being characterised by grey to pale yellow colours. This is indicative to low iron content of the parent material, which probably is of little significance agriculturally. For this reason, Saratok soils and Nyalau soils can be regarded as of similar agricultural importance. The crop range is the same as given for the Nyalau soils. In some localities Saratok soils appear to be bisequent in nature. Here quartz sand overlies quite abruptly heavy textured horizons. This is possibly due to the interbedding of heavy textured sediments in sandstone beds, the stratification being preserved in the profiles. Such profiles may display bad internal drainage conditions since the heavy textured subhorizons are less well permeable than the top horizons. Sensative crops may suffer from this. The occurrence of such profiles can, however, not be predicted nor can it be recognised by surface observations. Quite likely this is the reason why Saratok do not behave as well as Nyalau soils when cropped. The iron content, which appears to be the only chemical difference cannot be responsible for this variation and physical characteristics are likely to play a major role in this. The Saratok soils are of limited agricultural value and apart from rubber no other crops are recommended for these soils. Near markets vegetables could be grown if this is done with the incorporation of organic fertilisers.

Kerait Family

This Family occurs widespread on phyllite in the Serabang formation. Frequently the surface horizon is sandy (sandy loam) while the subhorizons are sandy clays, massif and compact. When occurring on phyllite the colours are of an unusual blue colour and the soils have been mapped as Rukam series, of which a profile description can be found in the Appendix. This series occupies commonly terrace sites where the underlying geology is outcropping. Where this is overlain by terrace sands podsols have developed. Thus, on the flanks of the terraces and in dissected terrace areas the Rukam series occurs dominantly. The soils are badly structured and internal drainage is poor, which is probably caused by the strong texture variations between top- and subsoil. The Rukam series is a poor soil by any standard, chemically as well as physically. However, because of the dominant occu-

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rrence of podsols on the terraces the local inhabitants have endeavoured to use them since they are frequently the best soils available. Rubber could be planted with adequate fertilisation but the growth is retarded if compared with rubber grown on better soils.

Another series in this family is of pinkish colour, the type profile was found on a terrace edge near Serayan, hence the name Serayan series. A profile description is added to the Appendix. Apart from the colour and less abrupt texture changes in the profile, the series is very similar to the Rukam series; the parent material is probably chert. Pepper is cultivated on this soil with apparent good success. This is thought to be due to the mounding practise and the pepper is rooting mainly in sandy loam topsoil, the heavy compact subhorizons being not reached by the root system. It is suggested that heavy application of fertilisers are needed to cultivate this soil type. If other better soils are available it could better be left untouched.

Triboh Family

This Family is of small extent in the area. It is very similar to the Saratok Family but occurs on terrace sites and has developed on old high level alluvium. As far as agriculture is concerned the soils could be rated as being of equal value. Rubber is the most logical crop choice if the soils must be used. With proper management citrus appears to be doing well on these soils but much fertiliser is needed.

PODSOLS

Silantek Family

The Silantek Family is characterised by white sandy topsoils if the primary vegetation has been removed. Under virgin forest, a peaty organic horizon of up to one foot in depth forms the topsoil which then overlies white sand. Underneath the sand a soft humus horizon is found overlying pale yellow sandy clay loam to in places a sandy clay. The Silantek Family occurs typically on the dipslopes of Tertiary sandstone areas.

The soils are of very low fertility and are not recommended for agriculture. They are widespread in the Rasau-Selampit area, and in the Belinsah and Bakuching areas.

Buso Family and Miri Family

Both Families occur commonly in association on the old marine deposits found in the terrace landscape between Biawak and Pueh. The Buso Family is very much alike the Silantek Family but the parent material of the former is old alluvium. The Buso soils display also a weak developed humus pan in the profile. The depth of the humus pan depends on the thickness of the coarser textured old alluvium. In some localities e.g. near the foot of the Pueh mountain, the alluvial cover is very thin and the humus pan occurs at shallow depth while the sand cover consists of very coarse sand. Towards the sea the alluvial cover becomes thicker but the material becomes finer. If the alluvial cover is thin the humus pan rests on top of residual material which is either phyllite or greywacke from the Serabang formation on which, when exposed, Rukam series or Bekenu soils have developed. If the humus pan is hard and not penetrable by auger the soils belong to the Miri Family. Such places are commonly marked by very wet conditions after rain because the rain water cannot percolate through the soil and semi-

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swampy conditions are created by stagnant water. Miri and Buso soils occur in a complex pattern and the two families cannot be separated on a reconnaissance survey. The impression is that Buso is more common than Miri, but the latter may become dominant towards the sea where the material in which these soils develop is finer.

Both families are unsuitable for agriculture.

Undifferentiated podsols

Soils in this mapping unit occur in the Samunsan area from which little field information is available. From the vegetation (air photograph interpretation) and some notes on soils found in the Forest Inventory Report on this area (Brunig, 1963) it can be deducted that Podsols are involved. With the available information, it is, however, not possible to separate out the families involved. They belong to Silantek, Buso and Miri Families. Probably soils in this unit are dominantly Buso and Miri Family soils. In any case, the whole unit should be regarded as unsuitable for agriculture.

Jerijeh Family

This Family occurs in the beach landscape in the coastal area between S. Samunsan and Sematan. Small areas may be found between Kuala Samunsan and Tj. Dato. The soils are found on the oldest post Pleistocene stranded beaches up to a height of 16 feet above present high tide level. The soils are characterised by their topography, deep medium sand topsoil of white colour which overly an incipient humus pan at varying depth. This may be from 10 inches to over 3 feet. Below the incipient humus pan commonly humus iron concretions (soft) are found embedded in a strong brown to reddish yellow medium sand. The watertable is commonly found within 5 feet. The Jerijeh Family is regarded as the oldest member of the sequence recent beach sand (unweathered) - subrecent beach sand (partially weathered) to old beach sands (strongly weathered). The soils are extremely poor and contain no plant food. If the reddish yellow coloured sand is found near the surface (say within 2 feet) coconut could possibly be planted if fertilisers are applied liberally in the initial growing years so that the roots may reach the more fertile sand underneath. Tobacco may be another alternative.

The Jerijeh soils as occurring in the area have been given the series name Pueh series. A description is given in the Appendix.

Kilong Series

The Kilong series consists of very deep homogeneous white coloured quartz sands in which no profile development has occurred within a depth of five feet. Only the topsoil may be a dark coloured organic horizon consisting of peat like organic debris from the original vegetation. This is rapidly oxidised after cultivation. Below four feet the white quartz sand may either appear to overly a humus pan in which case they are related to the Miri soils or a soft incipient humus pan may be found overlying strong brown to reddish yellow coloured sand in which case a very deep Jerijeh soil is involved.

In some instances it is possible to make this separation if the old beach landscape borders an old lagoon. In other places, such as at Kilong the old beach landscape merges into the old marine terraces without much trace and the boundary cannot be drawn. Apart from the fact that soil characteristics which are present below a depth of four feet are not diagnostic according to the Sarawak classification, the agricultural significance of such features is also very low, particularly when they are found in soils which in any case are not agricultural soils. For this reason the name Kilong series is suggested for all these deep sands without profile development and which are Regosolic in nature. The soils were only mapped near Sematan, but occur also elsewhere in Sarawak.

GLEY SOILS

Bijat Family

These soils have developed in floodplains where heavy textured alluvium has been deposited. They are characterised by clay loam to clay textured throughout the profile. In some localities, however, topsoils may be light textured due to colluvial deposits from neighbouring hills. These areas are, however, of small extent. The colours range from brownish yellow to brownish grey in the topsoil while the subsoil below 20 inches is always coloured grey, white or greenish blue, frequently with brown mottles which decrease in intensity with depth. These colours are due to lack of aeration and the soils are commonly wet throughout the year with the watertable normally within a depth of 20 inches. In the dry season the watertable may fall slightly below this level. The soils are normally flooded during the wet season. Organic top horizons have in many places formed on this family due to wet conditions but following wet padi cultivation and artificial drainage the mucky or peaty topsoil are frequently absent. Where the organic topsoils are still found the soils are mapped as Sebandi Family. Due to the complex pattern in which these two families occur Bijat Family is normally mapped in association with Sebandi Family soils.

Bijat soils are good wet padi soils and if drain-off properly during the dry-season off-season crops can be planted with success. Due to the frequent floods the soils are not recommended for perennial crops which cannot stand wet conditions of any duration. If proper drainage can be provided the soils are excellent coconut soils. The fertility depends much on the location. If the source material of the deposits is rich in plant nutrients then commonly the Bijat soils derived from them are richer than if the parent rock is poor. The natural fertility is normally sufficient for a good rice crop once in three or four years. Good annual yields can only be expected if fertilisers are used. Probably the nutrient value of flood water is maintaining much of the fertility of many of these wet padi areas. The soils analyses do not prove great fertility at all.

Generally speaking, Bijat soils are good agricultural soils which with proper drainage can be cultivated intensively.

Flooding, however, will remain a permanent risk.

Tatau Family

Tatau Family soils are similar to Bijat soils, the difference being the texture range. Tatau soils are all light textured. Normally, the topsoils are of medium texture, light loams to clay loams which overly at shallow depth loamy sand to sand. Two series are distinguished: The Plan series has formed in recent floodplains. In the area Plan series occurs mainly around Bukits Pueh and Gading and the source material of the coarse deposits is formed by the coarse textured Adamellite forming these mountains. The Plan series occupies normally small interior valleys through which the many streams from the Pueh and Gading mountains find their way to either the sea or major rivers. The fertility of these soils depends on the thickness of the more heavy textured top layer. Frequently in these top layers a considerable amount of organic material has aacumulated which is responsible for maintaining the fertility of these areas. Although drainage of these wet floodplains is normally advocated for intensive agriculture, this may be not so advantageous for the Plan series since after drainage the organic matter is destroyed and the fertility lost. What remains is often poor quartz sand. Without large amounts of fertilisers no good yields can be expected from such soils. Possibly grazing would be a good alternative to wet padi cultivation. Any recommendation must be made on the merits of each site and no general statement can be made.

Another series in this family is the Gong series which is almost identical to the Plan series, the difference being that the Gong series is developed over old alluvium which has eroded from the terraces which often surround the low lying valleys where the Gong series is found. The parent material, being extremely poor, cannot give any rich soils and Gong soils are, therefore, very poor. Wet padi cultivation on a rotation system is carried out but yields are poor. No recommendation for Gong series can be given. If they have to be used, the same statement as made for the Plan series applies here. Prevent the organic matter which frequently has accumulated in the topsoil from oxidising. The result would otherwise be a very poor quartz sand on which little will grow.

Sebandi Family

This Family commonly occurs in association with Bijat Family soils. The topsoil from 0-10 inches may be a muck or peat overlying grey to greenish grey coloured clay loam to clay. The watertable is always high and flooding occurs regularly in the wet season.

The soil occurs often mixed with Bijat soils due to the disappearance of the organic top through cultivation. It is found singularly at mapping is dependant on the site of the area in which they occur. The fertility of the Sebandi soils is as good as that of the Bijat soils found in the same locality. Agricultural use depends on drainage possibilities. In their natural state they cannot be used for any other crop than wet rice. For good yields however the fields need draining-off in the dry season and off-season crops can then also be planted. The soils are suitable for coconut if they are drained. Oilpalm could be planted as is the case with the Bijat soils but drainage is essential. For this crop, however, flooding will remain a permanent risk.

Semado Family

This Family is the only upland gley soil mapped in the area. They occur on the lower slopes of gentle sloping hills underlain by Tertiary shales and mudstones. The only area mapped as Semado is found in the Rasau area. This family occurs, however, also in other areas where shales and mudstone from long dipslopes where much surface water accumulates and where lateral and vertical drainage is slow. The soils are all heavy textured in the subsoil, topsoils are normally also heavy textured but frequently due to colluviation medium textured material has been washed down the long slopes and has accumulated on the lower slopes thus giving the Semado frequently a medium textured topsoil. Bisequent profiles are very common in such localities. Colours are generally pale yellow in the topsoil frequently mottled grey or brown overlying a light grey coloured subsoil normally intensively mottled pale yellow. The soils appear to be all poor in iron and therefore resemble Kerait Family soils discussed under the GREY-WHITE PODSOLICS. At the lowlying localities where the Semado occurs it cannot be decided whether bad drainage conditions have been responsible for the gley-like appearance of the subsoil or whether the material was poor in iron from the start. Possibly both factors are playing a role. The watertable in Semado soils is normally not found within a depth of four feet, but water standing in soil pits after rain indicate that water moves very slowly in these soils and although no watertable may be found during the wet season the subsoils are almost permanently in saturated condition. Due to the bad structure, (very blocky when dry), poor internal drainage, and generally very low chemical fertility Semado soils are not good agricultural soils. The topography, however, is favourable for agriculture. Grazing would be a good alternative to doing nothing with these soils. The establishment of grasses on these soils can, however, not be achieved without the use of artificial fertilisers. The economics of this is unknown to the author. For the present no other recommendations for this soil can be given.

SALINE-GLEY SOILS

Rajang Family and Belat Family

This Family is found in estuarine and deltaic areas where riverine and marine alluvium has accumulated in a brackish water environment. The Rajang Family soils are characterised by their natural vegetation which is Mangrove or Nipah, heavy texture (mainly clays throughout the profile) and very wet conditions. The watertable is found at shallow depth frequently within a depth of 20 inches. During the wet season the soils may be flooded daily. It is known from other localities in Sarawak where this family is found (Sungei Sarawak, ref. Survey Report 125) that commonly the occurrence of catclays (Acid-Sulphate clays) is associated with this family. Although the chemical fertility of these soils is normally better than any other alluvial soils in Sarawak the danger of the formation of catclays must be considered in any agricultural development in these areas. Practical experience shows that after drainage coconut is doing reasonably well on these soils. There is little information on the behaviour of wet rice on these soils although in the Santubong area rice is planted (upland variety) on similar soil. The yields are, according to local information, low. The Rajang Family in the area is only of importance at Kuala Sematan where it occurs extensively. There it is associated with soils belonging to the Belat Family, which has almost similar characteristics as the Rajang, the difference being texture, the Belat Family being light textured. The occurrence of Belat Family soils is related to the nearby location of marine terraces formed by quartz sand from which much material has been eroded and which has been redeposited at relatively short distance from these terraces in the present floodplain.

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The Rajang and Belat Families are also found in small lagoons and along the borders of small estuarines (S. Belinsah and S. Samunsan) at the coast between Sematan and Batang Samunsan. Apart from coconut development in selected areas of Rajang Family soils no recommendations are given for the agricultural use of these families.

PEAT SOILS

Mukah Family

Mukah Family soils are found in riverine floodplains where basin peat has formed and in some small lagoons in the coastal stretch between Sematan and Samunsan. The largest expense of this family occurs in the middle Batang Kayan floodplain. Mukah soils are formed by organic material ranging in depth from 10 to 40 inches and which overly heavy textured mineral soils. Commonly the peat is coarse woody material and the watertable is normally high. Mukah soils can be used for wet padi and other crops such as coconut, and perhaps coffee and oilpalm provided they are properly drained. Drainage is the most difficult limitation to remedy in the locations where Mukah soils have developed. It is expected that after the initial drainage shrinkage will occur which will enhance the risk of flooding. For this reason annuals and only perennials which can stand wet conditions for some duration are recommended for this family.

The chemical fertility of the soils is varied but generally low, the peats being acid and devoid of plant nutrients. The admixture of a certain amount of mineral soil with the peat does greatly higher than the fertility status of this soil type.

Igan Family

The Igan Family soils occur in association with the old marine terraces. They have developed in undulations presents in these terraces surfaces and water tends to accumulate there. In one locality (at Pueh) it has formed in a lagoon. As far as the top organic layer is concerned, the Igan Family soils are similar to Mukah soils. The organic material however rests on sand which is infertile. For this reason, the Igan soils are agriculturally of little significance since when the peat cover has disappeared following drainage (oxidation of organic material) one is left with poor infertile quartz sand. If the top muck or peat layers can be maintained some cropping can be done using shifting cultivation methods. For agricultural development where permanency of cropping and increase in yields is the aim they are of no importance.

Anderson Family

Anderson Family comprises deep woody peat deposits (deeper than 40 inches). The areas are all badly drained and have high watertable. A subdivision is made on depth, thus Anderson 1 40-80 inches, Anderson 2 80-120 inches, Anderson 3 deeper than 120 inches. The deposits either rest on clay or sand, the former being dominant. Because of the difficulty to drain, then deep peat, Anderson 2 and 3 are not recommended for cropping. Anderson 1 can be recommended for annuals or bush type crops if the areas can be drained.

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RECENT ALLUVIAL SOILS

Seduau Family

Recent alluvial soils are soils which are undeveloped and which do not show any horizonation except for a weakly developed A horizon (humus accumulation in the topsoil).

The Seduau Family soils have developed in recent riverine deposits of a heavy loam to clay texture which have accumulated in river valleys. The Seduau soils occur either in middle or upper valley stretches where the watertable is low because of the steep gradient of the river, or they are found on levee sites at lower stretches of river valleys. In general the material is stratified and layers of varying texture may alternate in the profile. For the Seduau Family, however, the average texture should be heavier than loam. In the area the Seduau soils are mainly found along the many streams coming from the Pueh and Gading mountains, particularly along S. Biawak, S. Pasir and S. Jangkar. Most of the material is micaceous because of the source rock which is biotite bearing granite. For these soils the name Sebat series has been chosen. A typical profile is given in the Appendix. The profiles show a brownish yellow to brown loamy soil which normally overlies a sandy layer at three to four feet of depth. Near the foot of the mountains, the sandy sublayers may occur at shallow depth and when the average texture becomes lighter than a loam the soil is classified as Kayan Family (for the micaceous material Bajo series). A boundary is difficult to draw. A watertable is normally absent in these soils but may be present at a depth of four feet or so during the wet season. The Sebat series may show red mottles at a depth of two feet and over and frequently brownish black manganese staining or small concretions may be found. The Sebat series is an excellent soil for annual crops and fruit trees. Large areas have been planted up with Illipe nut in the S. Pasir and S. Jangkar areas. Near Bukit Gading pepper is planted by the Chinese. The main limitation in this soil is flooding which occasionally may occur during the wet season. This is not harmful for normal fruit trees, since the floods are of short duration but the pepper may suffer badly. It is suggested that Illipe nut planting is uneconomic since these can only be harvested once in many years (commonly seven years). These excellent soils should be put to some better agricultural use, from which a higher and yearly income can be obtained.

Kayan Family

Kayan soils occur in similar localities as the Seduau series. They are mainly found in the upper sections of river valleys where the riverine alluvium tends to be light textured. When the parent rock in itself is mainly sand (sandstone) than most of the dry riverine alluvium along the river courses is Kayan Family soil. Such is the case along the Batang Kayan which catchment is mainly formed by poor sandstones. Kayan soils apart from being very sandy are also poor when compared with the Seduau Family soils. Their use is therefore more restricted to fruit crops mainly. Annuals would need to heavy fertiliser applications for economic returns. The Bajo series is the light textured counterpart of the Sebat series, the parent material being Adamellite.

Both Seduau and Kayan would support oilpalm but the areas of these soils are of too small extent for this crop.

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Kabong Family

The Kabong Family is formed by recent beach deposits. They are sandy throughout, of a yellow to pale brown colour. Apart from a very weak mottling in the lower subsoil no horizonation is present. Even the organic matter accumulation in the topsoils is very weakly expressed. In the area the recent beach deposits are mainly of a micaceous nature. Also they contain a considerable amount of ferro-magnesium minerals which upon weathering may give rise to red coloured sands. For this reason the Siru series has been split off from the rest of the Kabong Family which is non-micaceous and mainly quartz sand. The Siru series of which a description is given in the Appendix occurs all along the coastline from Sematan to Tj. Dato. The colour is pale brown and in the profile often weak blotches of manganese oxides are visible in the subsoil.

The watertable is low and there are no signs of reduction or gleying in the profile. The Rambungan series is a good soil for coconut planting and if organic matter is incorporated in the soil would possibly grow good vegetables and water melons. Grasses could be established with sufficient initial fertilisation. Not much experience is available with the cultivation of fodder grasses.

Sematan Family

This Family occurs between Sematan and Tj. Dato on the sub-recent stranded beaches. It is suggested that the origin of the Sematan Family is the Kabong Family which upon weathering of minerals which released iron oxides has been coated a reddish yellow colour. The colour is the most striking characteristic of the Sematan Family. Although the Sematan Family has been placed in the group of Recent Alluvial Soils a weak horizonation is present. Frequently a band of manganese oxides has accumulated at a certain depth in the profile. These concern the soils which are intermediate between Kabong and Sematan soils proper. They are always located just behind Kabong soils. These soils have been given the name of Rambungan series of which a description is given in the Appendix. The Sematan series does not show distinct horizon of manganese accumulation but manganese blotches or soft concretions may be present throughout the lower subsoil. Also the colour of the Sematan series is reddish yellow while that of the Rambungan is a brown colour. Sematan series is most likely the oldest member in the sequence Siru series - Rambungan series - Sematan series. The Rambungan series is suitable for coconut and some annuals such as melons, while the Sematan is too strongly leached to contain sufficient plant nutrients for an economic crop. It is suggested that coconut could be grown on the Sematan soils if fertilisers are used for the first year to enable the roots to reach richer layers which are present below a depth of three to four feet where the sand resembles the Rambungan series.

Rough grazing may be another possibility to use the Sematan Family but not much information is available on this possible land use.

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SKELETAL SOILS

Sedong Family

Skeletal soils are soils in which the parent rock is found within a depth of ten inches from the surface. This may be weathered or hard bed rock. In the case of the Sedong Family the parent material is basic to intermediate basic to metamorphic rocktypes, normally parent materials which give rise to the occurrence of the Lateritic soils. For this reason Sedong Family soils are often mapped in association with Tarat soils when occurring on steep slopes. The Sedong series normally shows a dark brown to brownish yellow clay in which within ten inches from the surface weathered parent rock is present. The parent material increases in volume with depth and the hard bed rock is normally reached within three feet. The slopes are always steep. The Sedong soils are fertile by Sarawak standards since they are young soils and relatively little leached. Excellent hill padi can be obtained from these soils. The slopes are normally not suitable for annual crops (erosion hazard) while for tree crops the bouldery terrain forms an obstacle. Cocoa could be planted, also pisang and coffee if plant holes can be made. Gardens will, however, be small, since the relatively good areas with more or less suitable slopes are small. Sedong soils are therefore best used by the individual farmer who may know from experience where best results can be achieved. Organised development should be ruled out. In the area Sedong soils are rare, they mainly occur on the greenstones in the Serabang formation. The largest extend is found near Tanjong Serabang and at G. Puting which is at present not accessible.

Kapit Family

These soils are similar to Sedong Family soils, the difference being the parent material. Kapit soils occur on acid parent materials which are poor in ferro-magnesium minerals. In the area the largest expense is formed by the steep sloping Pueh and Gading mountains which are built by Adamellite granite. Kapit soils occurring on granites are mapped as Buri series. The soils are normally reddish yellow coloured and quite sandy. Granite is found at shallow depth within a depth of ten inches. The slopes on which the Buri series is found are very steep, frequently over 35 degrees and no agriculture is recommended for the areas. Other Kapit soils have formed over shales and sandstones in the Rasau area. There they are often association with shallow podsols and Merit soils. Also here the terrain prevents agricultural development.

Meluan Family

Finally, Meluan soils are formed by patches of almost bare rock. The soil cover is very shallow and hard bedrock is found within a depth of ten inches. Such soils have developed over hard chert in the Kandai area and over granite Adamellite in the Pueh mountains mainly. Here they occupy shoulders of high and steep ridges from which the soil mantle has been totally eroded. The very poor vegetation which is visible on air-photographs gives evidence of this. Meluan soils are unsuitable for agriculture.

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Miscellaneous units

Certain units only occurring in the area previously reported upon in report 25/2 have been omitted from this report. Their description can be found in report 25/2.

In one area near Kuala Samunsan a soil type was found containing large amounts of iron concretions at shallow depth. This soil needs further study before it can be properly classified. The area is small and has been indicated by a question mark on the map.

PART 3 : LAND POTENTIAL

1. Land Classification

In this section an attempt is made to interpret information of a pedological nature presented in foregoing sections in terms of agricultural usefulness of land with particular reference to the immediate requirements for agricultural development as is at present envisaged in Sarawak.

Any method which aims to classify land in terms of suitability for agriculture must be based on experience with the soils to be classified and crops to be grown. Commonly such experience is gained by long term studies of crop behaviour on specific and selected soil types and if such studies are to be of practical value calculations of management costs should form part of this research. While such information may be readily available in developed countries with a permanent settled agricultural society in less developed countries such as Sarawak this is not the case. It is only during recent years that such studies have been started and results will only become available after some years.

The Soil Surveyor can therefore only base his classification on experience which may either be available from other countries or which has to be obtained from personal field knowledge in Sarawak. In both cases a certain amount of subjective judgement is involved which cannot be avoided.

Apart from the immediate soils problems with which the agriculturist is confronted and which must be taken into consideration in a classification system, the improvement of certain soil conditions such as drainage, fertilisation, etc. must be taken into account as well.

The cost if improvement of bad land is dependent on a number of economic factors such as labour costs, capital costs of materials, and transport which may range widely depending on accessibility. Also the location of the area is of importance and it may for instance pay better to improve bad land near a port or market than to develop good land which is remote from such facilities.

For these reasons it is impossible to indicate for a given area what soil types are suitable, marginal or unsuitable for agriculture.

Even in case this was possible such a rating of land should take into account the crops to be grown and the world market prices.

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Given the unlikely situation that pineapple would become a highly priced crop, soils which are normally not recommended for agricultural use would suddenly become very suitable since pineapple may be the only profitable crop to grow on such a soil type.

Every land rating therefore is only of value for the present day and may need revision from time to time.

The large majority of the soils in the area at present under study need improvement, improvement which although technically possible may be very expensive.

These costs cannot be estimated by reporter but they are nevertheless for a large part of the area the deciding factor whether a soil should be used for agriculture or not, and they should therefore be taken into account in a development programme.

If reporter were to classify the land in this area in terms of suitability for agriculture the classification would be very much subjective and if he were to state that a soil is unsuitable for agriculture on account of high costs for reclamation he would be biased in his judgement since he cannot foresee what amount of money would be the limit for improvement of bad land.

To avoid such difficulties a system of land rating outlined in Table 1 was employed which classifies land into four categories in which the amount of effort, time and expense needed to remove main limitations increases from category one to four. The nature of the limitation which needs improvement is used to subdivide the four categories into three sub-categories a, b and c. In the first sub-category the limitation is drainage and improvement involves drainage works to an increasing extent and with increasing expenses in the category range one to four.

In the second sub-category the main limitation is the soil itself which may need an increasing amount of fertilisers and special soil management practises in the category range one to four.

In the third sub-category the main limitation is topography on which it is increasingly difficult to farm in the range category one to four.

By this method the soils most easy to cultivate are classified in category one while the soils which are most difficult to farm and those with highest costs in improvement would be classified as category four.

This system avoids interpretive terms such as marginally suitable and unsuitable for agriculture and rightly so since this suitability depends so much on local conditions.

The only subjective factor in this system is the placement of the soil mapping units (families and associations of families) in the various categories but since this is based on relative values which can be compared in the field it is not unduly biased in nature.

It can be stated that the Department does not at present normally recommend the agricultural use of soils placed in category IV although it should be recognised that in abnormal cases, there may be no other alternative than to use them.

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This system further allows the compilation of an easily understandable land potential map (map 3) which shows the relative value of all the land in this area together with the limitations which were responsible for this rating.

From this map it can be deduced where the best land is and where land can be cultivated at the lowest costs.

Table 1

LAND RATING

Categories			Sub-categories (limiting factors)		
red	-	Category I	a	-	drainage
yellow	-	Category II	b	-	soil
green	-	Category III	c	-	topography
white	-	Category IV			

THE RATING OF LAND INTO CATEGORIES IS BASED ON THE INCREASING AMOUNT OF EFFORT, TIME AND EXPENSE NEEDED TO REMOVE MAIN LIMITATIONS FOR AGRICULTURAL USE AS INDICATED BY THE SUBCATEGORIES.
CATEGORY IV REPRESENTS LAND OF THE LOWEST VALUE IN SARAWAK.

In the case of two major limitations being present, one is shown with line-shading on the map, the second is indicated with the symbols a, b and c.

2. Summary of Conclusions and Recommendations

Areas in Cagegory 1 land occur mainly along the foothills of Bukit Pueh and Gading and in the valleys formed by streams flowing from these mountains. These areas concern mainly dry soils, either hill soils or dry alluvials in which the watertable is generally low throughout the year. In some areas, however, Category 1 land has been indicated to have a drainage problem (marked 'a' on the map). In these valleys this drainage problem is mainly caused by the flooding risk which occurs and which is therefore restricting the crop range on such soils.

Category 1 land occurs furthermore along the Batang Kayan and Sungei Pasir, for both only the lower river stretches are involved. This Category 1 land concerns wet soils which are in need for drainage improvement to tap their potential. Main crops in such areas will be mainly wet rice with off-season crops. Tree crops are not recommended because of the risk of flooding in such areas.

Category 1 land along these rivers thus indicate potential wet padi areas which could be improved upon.

Large tracks of land belong to Category II land which is particularly present in the Rasau, and Selampit areas. The main limitation in these soils is fertility which is generally low and crops demanding in plant nutrients can only be grown if fertilisers are used liberally.

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Category II land in the foothills of Gunung Pueh and Gunung Gading have a slope problem which is indicated by 'c' on the map. Soils are generally better than those in Category II marked with 'b' (low fertility), the steep topography being the reason why these soils were placed in Category II. In this type of terrain farmers have to search for the best slopes to cultivate. The land is too steep for annual crops and perennials should be used to off set the risk of erosion.

Category III land is land generally of very low fertility on which agriculture is restricted. Its use is not recommended if other soils are available. For regional planning, particularly for the siting of roads. Category 1 and II should be looked for. Category III could at present be classed as marginally suitable. The crop range is restricted and limitations due to bad drainage (a), very low fertility (b) and steep topography (c) are severe.

Category IV land should not be used for agriculture. This is land with very difficult drainage problems, extremely low fertility or excessively steep. These areas are regarded as being permanently unsuitable for agriculture.

From this outline and the Land Potentiality map it follows that good wet padi land is limited in the area, and only occurring along the lower stretches of the Batang Kayan and Sungei Pasir. Small drainage schemes are recommended. The areas are in general too small for large schemes and development will be on an A.P.P.S. scale.

The large areas of Category 1 land in the river valleys (dry alluvials) are for the greatest part covered with Engkabang. It is suggested that the growing of annuals and fruit crops which bear fruit yearly would be much more economical. Particularly since this land is almost the only good land available in these areas a gradual change over to other cash crops is advocated. Apart from rubber there is little prospect in agriculture in the surrounding areas. Near Kampong Ulu Pasir, there appears to be an area well suitable for irrigated padi but at present under sheet lallang. This is probably caused by over farming in the past. The soils are good and the development of this land is strongly recommended.

An area south of Sungei Pasir still under primary forest and classified as Category 1 land should be opened up for farming. This could possibly be realised after the completion of the Biawak road.

Most of the land settled by Chinese belongs to Category 1 land and is already cultivated intensively.

The Samunsan river basin does not contain much good land and apart from a narrow stretch of land along the river agriculture in this area would not be enonomic. Development of the Category 1 and II areas north of Samunsan river should be enhanced. This land is rather steep but it contains excellent soils for pepper growing and could bear a much larger population than it has at present. Communications with this area are however non-existent.

The development of the coastal sands in Category I and II would have to be based mainly on the cultivation of coconuts and the possibility of the establishment of rough grazing on the Category II land there would need investigation.

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Tarat Family : Jebong series S7454/57

Location: R.38A, pole 14 (350 meter) Sematan area. Ref. S.A. 103.

Topography: On high hill (Bukit Jebong). Steep slope. Many rocks sticking out.

Vegetation: Primary Forest.

Parent Material: Gabbro.

0 - ½ inch		litter of decayed leaves and roots.
½ - 3 inches	A1	Brown (10YR 5/3) loam, well rooted (mainly fine to medium roots), crumbly, moist. Gradual regular change to
3 - 7 "	B1	Strong brown (7.5YR 5/6) clay loam, crumbly to subangular blocky. Moist. Diffuse change to
7 - 18 "	B2	Reddish yellow (7.5YR 6/6) clay loam to clay. Compact, firm. Blocky structure. Few fine roots. Diffuse wavy change to
18 - 25 "	B/C	Reddish yellow (7.5YR 6/6) clay with hard weathered rock outcropping at 24 inches. Compact, firm, angular blocky.
25 "	B	Hard bed rock.

Abok Family : Gading series S7458/63

Location:	At mile 1½ Lundu-Sematan road. Ref. S.A. 103.
Site:	On spur (foothill) Gading Mountains.
Topography:	Slope at site approximately 8 degrees.
Vegetation:	Old rubber garden, undergrowth mainly cyperacea and ferns.
Parent Material:	Adamellite (Gading), probably colluvial boulders.
	Very thin layer of dead leaves and decayed twigs on surface.
0 - 2 inches	10YR 4/2, dark greyish brown sandy loam. Well rooted. Fine to medium size roots. Rich on organic matter. Porous. Dry. Loose. Distinct regular change to
2 - 7 "	10YR 5/3, brown sandy clay loam. Friable, massive in profile. Moist. Few fine to medium roots. Some leaching of organic matter. Distinct but wavy change to
7 - 12 "	7.5YR 5/6, strong brown coarse sandy clay loam. Crumbly, moist. Massive in profile. Few fine roots. Gradual wavy boundary to
12 - 24 "	7.5YR 6/6, reddish-yellow coarse sandy clay. Few roots penetrate to 19 inches. Moist. Crumbly, massive in profile. Weak subangular blocky. Gradual wavy change to
24 - 39 "	5YR 6/6, reddish-yellow coarse sandy clay. Moist, crumbly, massive in profile. Weak subangular blocky. Gradual wavy change to
39 - 54 "	5YR 6/6, reddish-yellow coarse sandy clay. Few pieces of weathered rock of mauve colour. Massive in profile.
54 "	Weathered rock.

Abok Family : Jagoi series S.5267/70

Location: Path Kpg. Jantan - Kpg. Pasir Ulu. Ref. S.A. 103.

Topography: On top of ridge, foot slope of Pueh Mountains. Slope at site approximately 5 degrees.

Vegetation: Jeramei, one year old.

Parent Material: Pueh Adamellite.

0 - 6 inches A1 10YR 3/2, very dark greyish brown coarse sandy loam, friable, weak fine angular blocky, (structure elements mainly made of clay with sand particles in between) well rooted, moist. Distinct regular boundary to

6 - 14 " A2 10YR 5/6, yellowish brown coarse sandy loam, friable on slight pressure, compact in profile. Crumbly. Small infillings of clay from 0 - 6 inches (worm activity), moderately well rooted, moist. Gradual regular change to

14 - 27 " B1(t) Between 10YR 5/6 and 7.5YR 5/8, strong brown coarse sandy clay loam, very friable, crumbly. Moderately well rooted, moist. Gradual, regular change to

27 - 50+ " B2 7.5YR 5/8, strong brown sandy clay loam - sandy clay. Very compact in profile. When broken up crumbly and friable. Few roots. Increasingly redder colour with depth. Moist.

Remark: Homogeneous profile, typical for deep weathering on granite.

Analyses

Lab.No.	Fld. No.	Depth (ins.)	P	Ca	Mg	K	Gr.III	%Fe_2O_3 6N HCl
S.5267	J.53	0-6	63	213	512	581	7.08	2.26
S.5268	J.54	6-14	34	105	379	573	9.66	2.88
S.5269	J.55	14-27	28	104	438	774	12.64	4.19
S.5270	J.56	27-50+	31	208	376	1651	18.15	5.07

Abok Family : Jagoi series, colluvial phase? S.5258/61

Location: Path Biawak - Pasir Ulu, halfway between school and Pasir Ulu. Ref. S.A. 103.

Topography: Flat to low undulating terrain resembling cone of alluvial fan. At site flat.

Vegetation: Lallang (Imperata Cylindrica)

Parent Material: Derived from Adamellite, possibly partly colluvial.

0 - 7 inches A1 10YR 3/2, very dark greyish brown sandy loam (coarse sand fraction), crumbly, very friable, well rooted, slightly moist, porous, distinct regular boundary to

7 - 15 " B1 10YR 5/8, yellowish brown sandy clay loam (coarse sand) crumbly, very friable, slightly plastic, poorly rooted. Moist. Gradual indistinct change to

15 - 32 " B2 10YR 6/8, brownish yellow sandy clay loam. In profile very compact. On slight pressure breaking into fine crumbs, very friable. Few small roots. Moist. Gradual change to

32 - 48 " B3 10YR 6/8, brownish yellow sandy clay with 7.5YR 6/8, reddish yellow mottles, compact in profile. Crumbly and friable when broken up. Very coarse sand fraction. No roots, moist.

Remark: Colluvial phase? Very homogeneous profile. Significant is the increase in size of sand particles with depth possibly indicating a fan deposit.

Analyses

Lab.No.	Fld.No.	Depth (ins.)	Reserves				Gr.III	% Fe_2O_3 6N HCl
			P	Ca	Mg	K		
S.5258	J.44	0-7	118	209	314	415	7.58	1.65
S.5259	J.45	7-15	50	106	190	471	11.19	2.31
S.5260	J.46	15-32	34	210	126	886	15.86	3.49
S.5261	J.47	32-48	36	220	132	1307	20.52	4.54

Bekenu Family : Biawak series S.5262/66

Location: Near Rh. Bakar (pasir Tengah) along path to Pasir Ulu. Ref. S.A. 103.

Topography: Low undulating terrain, on ridge between two streams, almost on top ridge. Slope approximately 3 degrees.

Parent Material: Serabang formation. Possibly greywacke sandstone.

Vegetation: Rubber garden.

0 - 6 inches A1 10YR 3/2, very dark greyish brown sandy clay loam, weak fine angular blocky, friable, well rooted. Dry. Distinct regular boundary to

6 - 14 " A2 2.5Y 5/4, light olive brown sandy clay loam, weak blocky structure, friable. Compact in profile. Dry, moderately well rooted. Many infillings from 0-6" (worm activity). Gradual change to

14 - 24 " B1(t) 2.5Y 5/4, light olive brown clay loam with clear sand grains, clayskins present, porous, compact in profile, crumbly and friable upon pressure, few roots. Slightly moist. Gradual change to

24 - 43 " B2 2.5Y 6/4, light yellowish brown sandy clay, large individual clear quartz grains mixed with clay. Very compact in profile. Fine angular blocky and friable when broken up, slightly moist, few roots. Gradual change to

43 - 60 " B/C 10YR 5/6, yellow brown sandy clay, very compact, on pressure, friable, weak blocky. Faint reddish yellow mottles (possibly from weathered rock). Large individual sand grains (quartz). Few roots. Slightly moist. Reddish yellow mottles increase with depth.

Remark: at 70 inches augering green coloured weathered rock is coming in the sandy clay matrix.

Analyses

Lab.No.	Fld.No.	Depth (ins.)	Reserves				Gr.III	% Fe_2O_3 6N HCl
			P	Ca	Mg	K		
S.5262	J.48	0-6	103	217	390	697	7.92	1.67
S.5263	J.49	6-14	42	106	381	811	10.43	1.82
S.5264	J.50	14-24	38	tr	507	1045	12.41	2.58
S.5265	J.51	24-43	35	tr	385	1693	19.44	2.65
S.5266	J.52	43-60	48	tr	259	1769	17.45	2.56

Nyalau Family - S.5244/47

Location: Path from Selampit to Munti (Lundu Area) pole 17/1, Ref. S.A. 103.

Topography: On scarp slope of relatively high (about 100 feet above local flood level) hill.

Slope: Approximately 20 degrees.

Vegetation: Old secondary jungle.

Parent Material: Tertiary sandstone (Plateau sandstone).

Thin litter layer of leaves and twigs, rotten wood (irregular, in places more than 2 inches).

0 - 6 inches A1 10YR 4/4, dark yellowish brown sandy loam - loamy sand, weak subangular blocky, very friable to loose, well rooted, much soil fauna activity (ants, worms), dry. Clear, distinct boundary to

6 - 20 " A2 10YR 6/6, brownish yellow sandy loam, weak crumbly, in-cracks soil from A1 leached down (possibly also worm activity) porous, moderately well rooted, dry. Gradual change to

20 - 43 " B 7.5YR 6/8, reddish yellow sandy clay loam, crumbly, friable, porous, moist. Few roots, gradual change to

43 - 60 " B/C As 20 - 43 inches but slightly more reddish, no roots, increasingly more compact and moist.

Analyses

Lab.No.	Fld.No.	Depth (ins.)	Reserves				Gr.III	%Fe_2O_3 6N HCl
			P	Ca	Mg	K		
S.5244	J.30	0-6	104	212	444	629	2.68	1.28
S.5245	J.31	6-20	72	209	502	674	4.75	1.96
S.5246	J.32	20-45	78	316	505	834	7.36	2.42
S.5247	J.33	45-60	95	107	964	954	9.21	2.72

Selarat profile : (Bekenu Family?)

Location: R.38 at pole 34 (850 m). Near Chinese School. Sematan area. Ref. S.A. 103.

Topography: On low hill. Broken hilly terrain (old dissected peneplain).

Vegetation: Mainly resam.

Parent Material: Uncertain. Possibly greywacke or metamorphosed sandstone.

Surface litter layer of mainly resam roots 1½ inches thick.

0 - 3 inches	10YR 4/2, dark grey brown sandy loam. Loose. Many fine roots. Moist. Distinct wavy change to
3 - 10 "	10YR 5/4, yellowish brown sandy loam. Clear quartz grains. Weak subangular blocky. Some material from top horizon leached into this horizon. Moist. Few fine roots. Indistinct wavy change to
10 - 23 "	10YR 7/6, yellow, sandy clay loam. Subangular blocky, slightly firm. Few fine roots. Moist. Distinct wavy change to
23 - 38 "	7.5YR 6/6, reddish yellow sandy clay loam. Clear quartz particles. Blocky. Firm. Diffuse change to
38 - 51 "	7.5YR 7/6, reddish yellow sandy clay loam to clay. Clear quartz particles. Distinct pale yellow mottles, very common. Fine blocky structure. Moist. Diffuse change to
51 - 60 "	7.5YR 7/6, reddish yellow clay. Very common pale yellow mottles. Very firm. Slightly sticky. Blocky structure. Moist.

Saratok Family - S.5248/52

Location: Path Selampit - Munti (Lundu area), pole 10. Ref. S.A. 103.

Topography: On flat topped hill, slope approximately 5 degrees.

Vegetation: Old rubber garden with much fern undergrowth.

Parent Material: Tertiary sandstone (Plateau sandstone)

3 inches thick litter layer of resam roots with some leaves on surface. Not present in all places.

0 - 6 inches A1 10YR 4/2, dark greyish brown fine sandy loam, friable, crumbly, much humus stains, well rooted, porous, slightly moist, clear, regular boundary to

6 - 18 " A2 5Y 7/3, pale yellow fine sandy to silty loam, crumbly, friable, weak humus stains along fracture planes, few roots, moist. Distinct regular boundary to

18 - 28 " B1 As 6 - 8 inches with yellow brown fine mottles, silty clay loam, gradual change to

28 - 42 " B2(t) Pale yellow silty clay loam with yellow and light grey mottles, compact, firm. Plastic, slightly sticky. No roots, moist. Gradual change to

42 - 60 " B3 Silty clay loam, grey, strongly yellow mottled. Plastic, slightly sticky, no roots, moist.

Remark: Possibly bisequent at 28 inches (texture change due to layering in parent rocks)

Analyses

Lab.No.	Fld.No.	Depth (ins.)	Reserves				Gr.III	%Fe_2O_3 6N HCl
			P	Ca	Mg	K		
S.5248	J.34	0-6	57	tr.	511	316	3.65	0.46
S.5249	J.35	6-18	31	105	106	311	4.20	0.46
S.5250	J.36	18-28	28	104	436	411	6.66	0.89
S.5251	J.37	28-42	38	106	638	789	10.89	0.92
S.5252	J.38	42-60	51	107	512	1477	5.49	1.49

Kerait Family : 'Serayan series' S7464/69

Location: R.39. pole 275 m. Ref. S.A. 103.

Topography: Terrace edge. Slope approximately 10 degrees.

Vegetation: Jeramei, mainly ferns and cyperacea.

Parent Material: Probably chert (Serabang Formation)

Very thin layer of dead leaves and decayed branches on surface.

0 - 4½ inches	A1	10YR 5/2, greyish brown sandy loam, well rooted. Many earth worms. Friable when broken up. Porous. Moist. Distinct regular change to
4½ - 13 "	A2?	10YR 7/3, very pale brown coarse clay loam. Very few fine roots. Massive, compact. Moist. Clear but wavy change to
13 - 22 "	B	7.5YR 7/4, pink coarse sandy clay. Few fine roots. Distinct few very pale brown mottles. Moist. Massive and compact. Diffuse wavy change to
22 - 35 "	B2	5YR 8/4, pink coarse sandy clay. Few clayskins (coatings along old root channels and cracks.) Firm. Compact and massive. Moist. Diffuse, wavy change to
35 - 51 "	B/C	5YR 8/4, pink coarse sandy clay. Common, distinct very pale brown (10YR 7/3) mottles. Strong clayskins developed along cracks. Firm. Compact and massive. Moist. Gradual wavy change to
51 - 63 "	C	Pink coarse sandy clay with a large pocket of very pale brown colour. Increasingly more quartz rich with depth. Few clayskins along cracks. Moist. Very firm. Compact.

Note: White puppet form concretions embedded in this soil at road cutting 20 feet from this profile at approximately 10 feet depth.

Miri Family - S7445/53

Location: R.45. Pole 66 (1650 m from sea). Sematan area. Ref. S.A. 103.

Topography: High terrace. Almost on highest point. Sloping gently towards lagoon (5-10 degrees). Broken slope.

Vegetation: Kerangas Forest. Rich in Kapur (Paya), Rengas.

Parent Material: Bisequent. Top A1/A2 terrace alluvium. Probably marine. Subsoil probably residual. P.M. uncertain.

0 - 3 inches	O	Dark brown rotten leaves and roots, moist, peat like. Mixed with some sand grains. Clear, abrupt over
3 - 6 "	A1	10YR 4/1, dark grey coarse to medium sand. Many large lateral roots. Below 6 inches no roots. Moist. Gradual change to
6 - 11 "	A1/2	As 3 - 6 inches but no roots and wet loose sand.
11 - 13 "	A2	10YR 6/2, light brownish grey medium sand, loose. Perched watertable. Water pouring out. No roots. Abrupt change to
13 - 16 "	Bh	10YR 2/2, very dark brown medium sand, humus. Wet. Weakly cemented. Wet. Clear regular boundary to
16 - 19 "	Bh(c)II	7.5YR 5/8, strong brown coarse sand particles mixed with clay, cemented. Very dry. No roots, gradual change to
19 - 30 "	IIB2	10YR 6/3, pale brown sandy clay loam (coarse sand fraction) with much humus staining (very dark brown) mainly along old root channels. Very dry. Water filters into pit through old root channels. One large pocket of humus stained sand with many roots (illuviated material, weakly cemented, possibly old large root channel). Gradual change to
30 - 46 "	B2.2	As 19 - 30 but lighter in colour. Gradual change to B/C.
46 - approx. 60" (augering)		Moist, white coarse sandy clay, very sticky and plastic with some organic coatings. C.
60 - 80 " (augering)		Coarse sandy clay, white, sticky, plastic, moist. Micaceous.

Jerijeh Family : Pueh series S7392/99

Location: R.45, pole 7/0 (700 m from coast) - Kuala Siru-Kuala Pueh stretch. Sematan area. (Ref. S.A. 103).

Topography: Flat, very gentle slope towards landside. Slope of old storm beach.

Parent Material: Subrecent beach sands of probably Pueh Adamellite and Serabang Formation rock origin.

Vegetation: Very poor resam.

0 - ½ inch		Loose, 10YR 7/1, light grey medium sand. Very dry. No organic matter. Abruptly overlying
½ - 7 inches	A1	10YR 6/2, light brownish grey medium sand, loose, single grain structure, many roots. Many dark grey infilled wormholes. Slightly moist. Gradual regular change to
7 - 14 "	A2	10YR 8/2, white medium sand, loose, structureless, slightly moist, very small roots stopping at 12 inches.
14 - 15 "	A3	Transition A to B, brown mottled white sand, boundary irregular sloping down with slightly steeper inclination as surface slope.
15 - 19 "	Bh(ir)	Medium to fine sand, 7.5YR 4/4, dark brown with common hard (2.5YR 3/6, dark red) concretions and soft mottles like concretions of same colour. Structureless. In places this horizon is brittle and weakly cemented. Slightly moist. Clear regular change to
19 - 24 "	Bir(2)	5YR 4/4, reddish brown medium sand, slightly moist, structureless, firm, with common dark red concretions and mottles (as 15-19, but colour less brown). Clear, very wavy change to
24 - 44 "	B2.1	7.5YR 5/8, strong brown fine sand, firm, structureless, no roots, slightly moist, gradual wavy change to
44 - 54 "	B2.2	7.5YR 5/6, strong brown fine sand with abundant strong 7.5YR 4/4, dark brown mottles and some red, structureless, irregular wavy change to
54 - 60 "	C?	Wet. 2.5YR 5/6, light olive brown medium sand, in places with much black to strong brown material (confirmed to be manganese)
Water Table		60 inches.

Seduau Family : Sebat series S.5253/57

Location: 500 metre from Rh. Bakar (S. Pasir Tenggah along path to Pasir Ilir (Lundu). Ref. S.A. 103.

Topography: Flat floodplain of Sungei Pasir, on levee.

Parent Material: Recent alluvium derived from Adamellite and rocks of the Serabang formation (Greywacke, phyllite).

Vegetation: Rubber garden, also many Engkabang.

0 - 7 inches A1 10YR 4/2, dark greyish brown sandy clay loam, strong angular blocky, weak friable, well rooted, soft, few mica's. Porous, moist. Distinct, wavy boundary to

7 - 26 " B1 10YR 5/6, yellowish brown silty to fine sandy clay loam, fine angular blocky, friable, moist. Moderately well rooted, porous, few mica's, very small specks of dark brown material (Mn?). Very gradual change to

26 - 37 " B2 10YR 5/6, yellowish brown fine sandy clay loam, compact, friable in hand, weak blocky structure. Few roots, slightly moist. Brown specks present (Mn?), abrupt change to

37 - 48 " C/II 2.5Y 6/4, light yellowish brown sandy loam, very compact, many mica's, almost dry, few brown mottles, structureless, very wavy but clear boundary to

48 - 60 " C/III 2.5Y 6/4, light yellowish brown clay loam with common brown 10YR 5/8, mottles, very friable, weak crumbly structure, compact in profile, many large dark brown specks becoming smeary in profile when touched (soft Mn concretions?), increasing in intensity with depth, no roots, mica's present, moist.

Remark: Layered alluvium. Possibly rich in Mn in sublayers.

Analyses

Lab.No.	Fld.No.	Depth (ins.)	Reserves				Gr.III	$\%Fe_2O_3$ 6N HCl
			P	Ca	Mg	K		
S.5253	J.39	0-7	332	455	2403	3156	18.38	4.74
S.5254	J.40	7-26	126	436	688	3692	21.01	5.68
S.5255	J.41	26-37	118	454	2725	3316	19.56	5.54
S.5256	J.42	37-48	103	217	2079	3270	19.47	4.16
S.5257	J.43	48-60	151	225	2713	3571	28.13	7.60

Kabong Family : Siru series S7375/80

Location: R.45. Pole 0. At shore Kuala Siru-Kuala Pueh stretch, Sematan area. Ref. S.A. 103.

Topography: Flat, long gentle slope towards sea.

Vegetation: Pioneer beach association. Creepers, Casuarina trees.

Parent Material: Young marine sand (beach sand) derived mainly from Pueh Adamellite and Serabang Formation rock types.

0 - 9 inches — 10YR 6/3, pale brown fine sand with fine shell fragments, loose, single grain structure, bits of organic matter (depositional), fine roots present, slightly moist, clear, abrupt change to

9 - 15 " — 10YR 6/3, pale brown slightly coarser sand than 0-9, dry, no roots, shell fragments present and bits of organic matter (depositional), clear over

15 - 28 " — 10YR 5/4, yellowish brown fine sand, moist, Micaceous. Some large roots. Structureless, gradual change to

28 - 43 " — 10YR 5/4, yellowish brown fine sand with large common 7.5YR 4/4, strong brown mottles, few roots. Some very thin (almost lines) of black coloured sand. Gradual change to

43 - 52 " — As 28 - 43 but no root sand no brown mottles.

52 - 60 " — 10YR 5/4, yellowish brown fine sand with brownish red mottling in places from 52 - 57. At 52 one large flat thin rock piece coated with iron. Very moist.

Note: All sand below 15 inches smears brown if cut by spade.

Sematan Family : Rambungan series S7381/86

Location: R.45, pole 1/1 (125 m from coastline) - Kuala Siru - Kuala Pueh stretch - Sematan area (Ref. S.A. 103).

Topography: Third stranded beach. Gentle slope towards landside. Near swale separating third ridge from fourth ridge.

Vegetation: Mixed secondary jungle. Some coconut (good growth).

Parent Material: Subrecent beach sand; likely derived mainly from Pueh Adamellite and Serabang Formation rocks.

Very thin litter layer on surface.

0 - 6 inches 10YR 4/4, yellowish brown fine sand, well rooted, weak crumbly, many wormcasts. Gradual, regular change to

6 - 12 " 10YR 5/8, yellowish brown fine sand, structureless, faint light brown mottles, well rooted. Distinct, regular boundary to

12 - 18 " 7.5YR 5/8, strong brown fine sand with strong brown 6/8 mottles, well rooted. Structureless to weak crumbly. Distinct sloping boundary following surface slope but steeper inclination to

18 - 30 " 5YR 3/4, dark reddish brown fine sand with 7.5YR 6/8, reddish yellow (75-25%) mottles. Dark reddish brown material is probably caused by Mn. In places soft dark reddish brown concretions, often with a layer of more reddish material (iron oxide?), surrounding it. Material most concentrated in 18-24 inches. From 24-30 inches material is less dark and more like mottles. Most roots stop at 18 inches. Gradual, indistinct change to

30 - 48 " 7.5YR 4/4, dark brown fine sand with light coloured mottles. Few roots. Very weak crumbly. Moist. Indistinct regular change to

48 - 60 " 10YR 6/4, light yellowish brown, very weak crumbly fine sand. Slightly moist.

at 60 " Coarser sand, distinctly micaceous.

Sematan Family : Sematan series S7387/91

Location: R.45. Pole 2/3 (275 m from beach) - Kuala Siru - Kuala Pueh stretch. Sematan area. Ref. S.A. 103.

Topography: Flat, slight slope not more than 2 degrees towards landside. Almost on top of fourth beach ridge.

Vegetation: Much resam undergrowth. Sipul trees.

Parent Material: Subrecent beach sand probably dominantly derived from Pueh Adamellite and Serabang Formation rocks.

On surface white coloured sand veneer (organic matter oxidised due to sun exposure).

0 - 6 inches — 10YR 4/4, dark yellowish brown fine sand. Crumbly, well rooted. Many wormcasts, slightly moist. Gradual, regular change to

6 - 12 " — 7.5YR 5/8, strong brown fine sand, crumbly with many wormcasts. Well rooted, slightly moist, distinct regular boundary to

12 - 22 " — 7.5YR 5/8, strong brown fine sand, very weak crumbly, very few roots, slightly moist. Gradual wavy boundary to

22 - 38 " — 10YR 5/8, yellowish brown fine sand, weak crumbly. Common large brown mottles. One rounded green coloured rock-fragment with dark brown coating. Some large light yellow coloured mottles. Many mica's. No roots. Slightly moist. Very gradual indistinct change to

38 - 68 " — Multicoloured, brown, yellow and yellowish brown fine sand. Mottles very round, particularly light coloured ones. Slightly moist. Loose. Light colours become dominant with depth. Slightly wet at 68 inches.

MAP 2.

LAND POTENTIAL MAP
LUNDU DISTRICT (WEST)
Ist. Division.

LAND RATING

Categories	Sub-categories (limiting factors)
CATEGORY I.	a DRAINAGE
CATEGORY II.	b SOIL
CATEGORY III.	c TOPOGRAPHY
CATEGORY IV.	D DRAINAGE & SOIL
	E SOIL & TOPOGRAPHY

THE RATING OF LAND INTO CATEGORIES IS BASED ON THE INCREASING AMOUNT OF EFFORT, TIME AND EXPENSE NEEDED TO REMOVE MAIN LIMITATIONS FOR AGRICULTURAL USE AS INDICATED BY THE SUBCATEGORIES. CATEGORY IV REPRESENTS LAND OF THE LOWEST VALUE IN SARAWAK.

Soil Survey Drawing No. 200 Soil Survey Area No. 103 December, 1968

Base map derived from Land & Survey Department, Sarawak

Compiled by : J. P. Andriesse

Drawn by : Sabli Mohd. Ap & M. Lim

MAP 3

RECONNAISSANCE SOIL SURVEY
LUNDU DISTRICT (WEST)

POSITION SOIL OBSERVATION SECTIONS AND SAMPLE PITS

Soil Survey Drawing No. 200 Soil Survey Area No. 103 December, 1968 Base map derived from Land & Survey Department, Sarawak Compiled by J. P. Andriesse Drawn by : Sabli Mohd Ap