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An account of the soils of the
Borneo Abaca Ltd Estates, Tawau

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An account of the soils of the
Borneo Abaca Ltd. Estates
Tawau.

by
T.R. Paton B. Sc.
Soil Scientist,
East Coast.

27 NOV 1957



GEOLOGY

It must be realized that this area is surprisingly young when compared to other areas in the Colony and is made up of a series of ashes and lavas piled one on top of the other. Older and harder rocks occur immediately outside the estate area but the estate boundaries have been drawn so as to avoid these areas.

The key to the geological history of the area is to be found in Imam estate particularly in the new clearing of 1956.

Here is displayed the full sequence of ashes and lavas that make up the estates.

These are from top to bottom.

Basaltic lava		
Washout material	Agglomerate	Brown Ash.
Rhyolitic Lava - rounded white boulders		
Greenish yellow dacitic ash.		

The source of the ashes and lavas is, with the exception of the basalt, from the east and the north.

Mt. Andrassey, which lies about 7 miles north of Tiku Hill on the Apas road, Mt. Lucia and Magdalena much further north are responsible for the yellowish-green type of ash. It is very little seen in the estate areas and it is generally only in the very deepest valleys that it is exposed.

Activity from these areas culminated in the explosive extrusion of rhyolitic lavas probably in the form of molten avalanches of rock (nuée ardente). As far as the estates are concerned this is represented by the rounded white to yellow boulders that are found sporadically throughout the area. It is important however in that these lavas occur as a band which is very resistant to erosion and so it forms, over some areas of the estates,

/ a local base

a local base level of erosion for streams.

Activity then stopped and the centre of vulcanism moved to Mt. Maria about mid-way between Lucia and Magdalena and Andrassey.

Eruption from this centre was prolonged. The products vary from the finest ash to very coarse agglomerate and also lavas. Deposits of these various materials are represented by a thickness of 50 - 70 ft. throughout the estate area. A good idea of the thickness of this deposit, a brown ash at this point, may be gained from observing the valleys in the Imam estate 1956 clearing. The streams run on the rhyolitic lavas and near the Table estate boundary later basalt flows cover the ash. A very coarse facies of this deposit may be seen just within Burut estate (coming from Imam) where a big gully runs parallel and to the east of the road.

There must have been a great deal of wash out and resorting of this deposit by the torrential rains, which generally accompanies these eruptions. This has caused the deposit to be spread a good deal further to the south and west. A good example of such a coarse wash out deposit is to be seen in the cliff overlooking the Tawau river at Jambatan Puteh village in Tawau division.

The eruption of this great thickness of ashes, lavas and agglomerates was followed by a lull during which time the deposits were subject to weathering and erosion. Erosion acting on such a mass of incoherent material, completely out of balance with the base level of erosion, was naturally rapid and severe. Deep gullies were formed with intervening sharp ridges. The products of erosion were deposited on a very low lying coastal plain or in a very shallow sea lying further to the south and west.

This lull in the activity was broken by the

Mt. Maria. This settled indiscriminately on the coastal plain or in the valleys of the already eroded and weathered previously erupted ash. This is the very pale material seen at Koncie 'Lapan and at Quarry Hill.

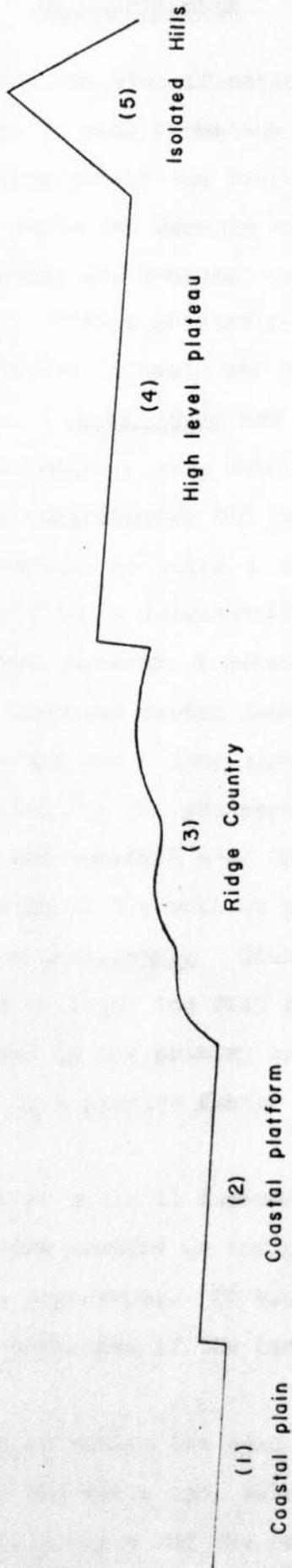
There must have been a very short break between this, the final eruption from Mt. Maria, and the start of the eruptions from Tiger Hill.

Tiger Hill was the first eruption centre for the basaltic lavas during which lava flows were extruded which have now completely weathered away leaving a yellowish brown soil. Following a pause Bombalai joined Tiger as an eruption centre and a younger set of lavas were extruded, (now giving rise to a dark brown soil). Late stage hydro-thermal action caused alteration in the later lavas which were extruded from Tiger, Bombalai and the small hill in between them. These lavas have given rise to the red soils which are such a feature of Tiger Hill and the area between Tiger and Table estates.

Regional uplift to the extent of 50 ft. then took place giving rise to an extensive coastal platform made up of debris eroded from the lavas and ashes of Mt. Maria.

At the present time erosion is proceeding rapidly and alluvium is being laid down by all streams.

Topography Divisions



CLASSIFICATION

In any area the classification of soils must be based on the factors of soil formation which are controlling the dominant processes within the soil mass.

In young soils the passive factors, parent material and topography are dominant and the resulting soils are known as azonal. With a greater period of time during which the active factors, climate and vegetation, can operate on the soil, a zonal group are produced. This two fold division is made by only considering soils derived from normal (approaching the bulk composition of granite) parent materials or soils on which the active factors have operated for a considerable period of time. There is in this area, however, a considerable number of soils derived from aberrant parent materials on which the active factors have not had a long enough time to convert them into zonal soils, yet the processes controlled by the active factors are dominant over those controlled by the passive factors in the soil at present. These soils are classed as intrazonals. Classification within these orders brings to light the fact that this area is extremely youthful as the primary breakdown within each is controlled by a passive factor of soil formation.

Zonal Group.

In the zonal soils it depends whether a soil is developed on the ridge country or the coastal platform i.e. the control is topography. If the first, a soil of the Apas family is developed, if the last, a soil of the Gading family.

Sub-division within the Apas family is by means of parent material, the Maria ash, this has been sporadically hydrothermally altered and the red soil derived from it is known as the Apas series.

The other soils derived from the more normal ash have been subdivided into two series the older series known as the Burut and the younger series the Kuhara. All Kuhara soils, with progress of time, are tending to evolve towards Burut soils. Burut soils ^{are} found in lower topographic positions than Kuhara soils.

Sub-division within the Gading family is also based on parent material. Those soils whose parent materials are derived from the eruptions of Mt. Maria are known as the Gading series. Those soils whose main source of parent material is Mt. Lucia and Mt. Magdalena are known as the Merotai series.

Intrazonal Group.

The primary breakdown is based on parent material. One, minor group, is derived from andesitic ash, Quarry family and the other, major group, is derived from basaltic lava, Quoin family. There is only one series within the Quarry family the Quarry series. Sub-division within the Quoin family is an exact parallel to that found in the Apas family. One series the Quoin is derived from hydrothermally altered basalt and the other two have an age relationship to one another the Jarangan being the older and the Table series the younger.

Azonal Group.

The first division in this group is dependent on whether material is being added to or subtracted from the soil. In the first case this gives rise to the family of alluvial soils and in the last to the family of mountainous skeltals.

Breakdown within the alluvial group is dependent on the origin of the parent material. If it derived from the rich materials Mt. Maria and the basaltic lava flows a Balung family of soils results. However if derived from the much poorer materials making up Mt. Lucia and Mt. Magdalena

Zonal Soils

the Lucia family of soils results.

Further division is by means of the normal differentiation between riverside alluvium which is light textured, well structured and drained and the back areas which are heavy, poorly structured and drained. In the Balung family the first is known as the Balung series the last as Tawau series and in the Lucia family the Lucia series is well drained and the Margdalena series is poorly drained.



Intrazonal Zonal Soils

Parent Material

Ridge Country

Coastal Platform

Andesitic Ash

Basaltic Lava

Apas Family

Gading Family

Quarry Family

Quoin Family

Hydrothermally altered ash

Normal ash

Derived from Mt. Maria

Derived from Mt. Lucia

Older ash

Younger ash

Hydrothermally altered lava

Normal lava

Older lava

Younger lava

Apas Series

Burut Series

Kuhara Series

Gading Series

Merotai Series

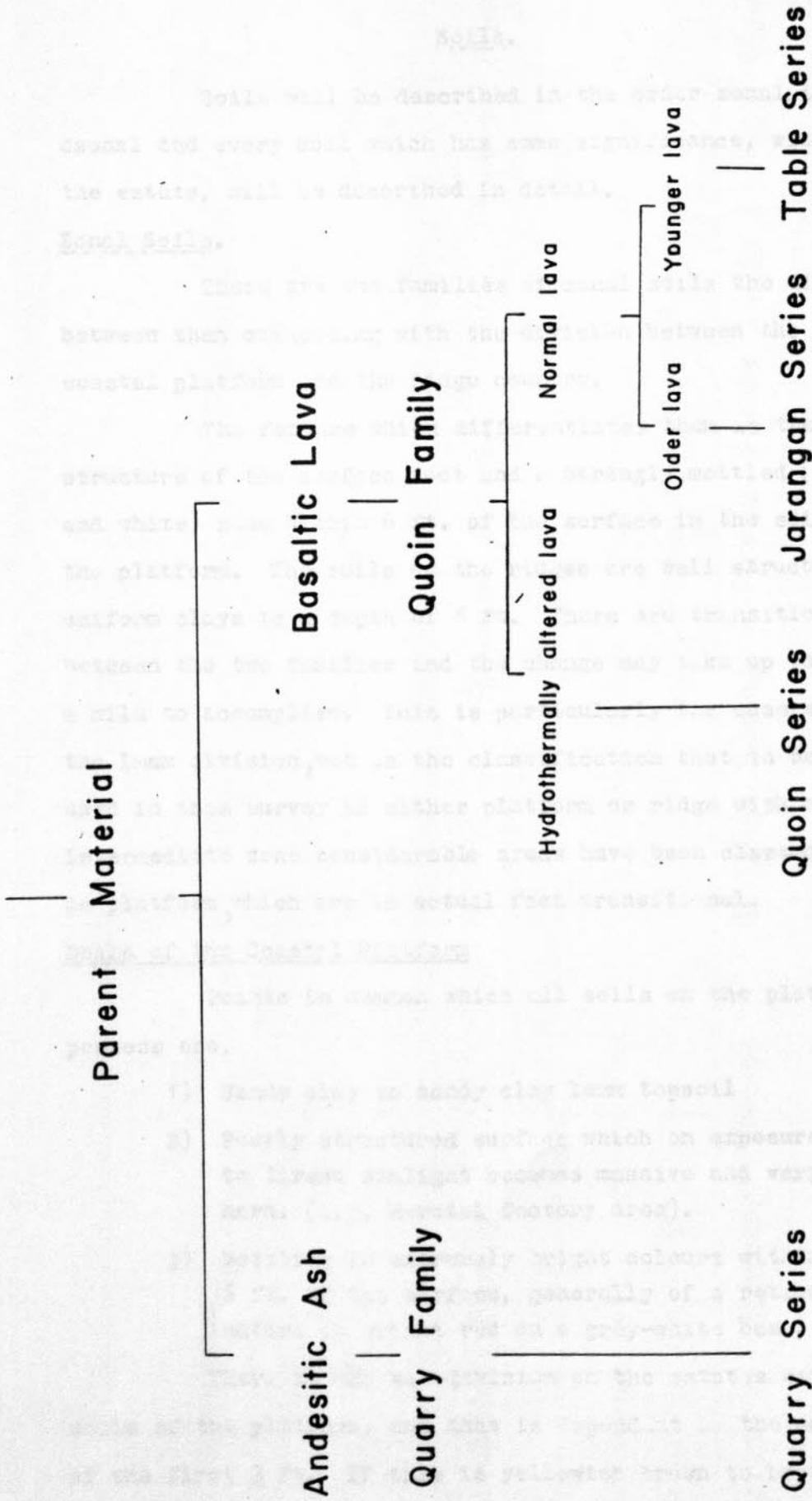
Quarry Series

Quoin Series

Jarangan Series

Table Series

Intrazonal Soils



Soils.

Soils will be described in the order zonal, intrazonal, azonal and every soil which has some significance, within the estate, will be described in detail.

Zonal Soils.

There are two families of zonal soils the division between them coinciding with the division between the coastal platform and the ridge country.

The feature which differentiates them is the poor structure of the surface foot and a strongly mottled (red and white) zone within 6 ft. of the surface in the soils of the platform. The soils on the ridges are well structured uniform clays to a depth of 6 ft. There are transitions between the two families and the change may take up to $\frac{1}{4}$ of a mile to accomplish. This is particularly the case with the Imam division, but as the classification that is being used in this survey is either platform or ridge with no intermediate zone considerable areas have been classed as platform, which are in actual fact transitional.

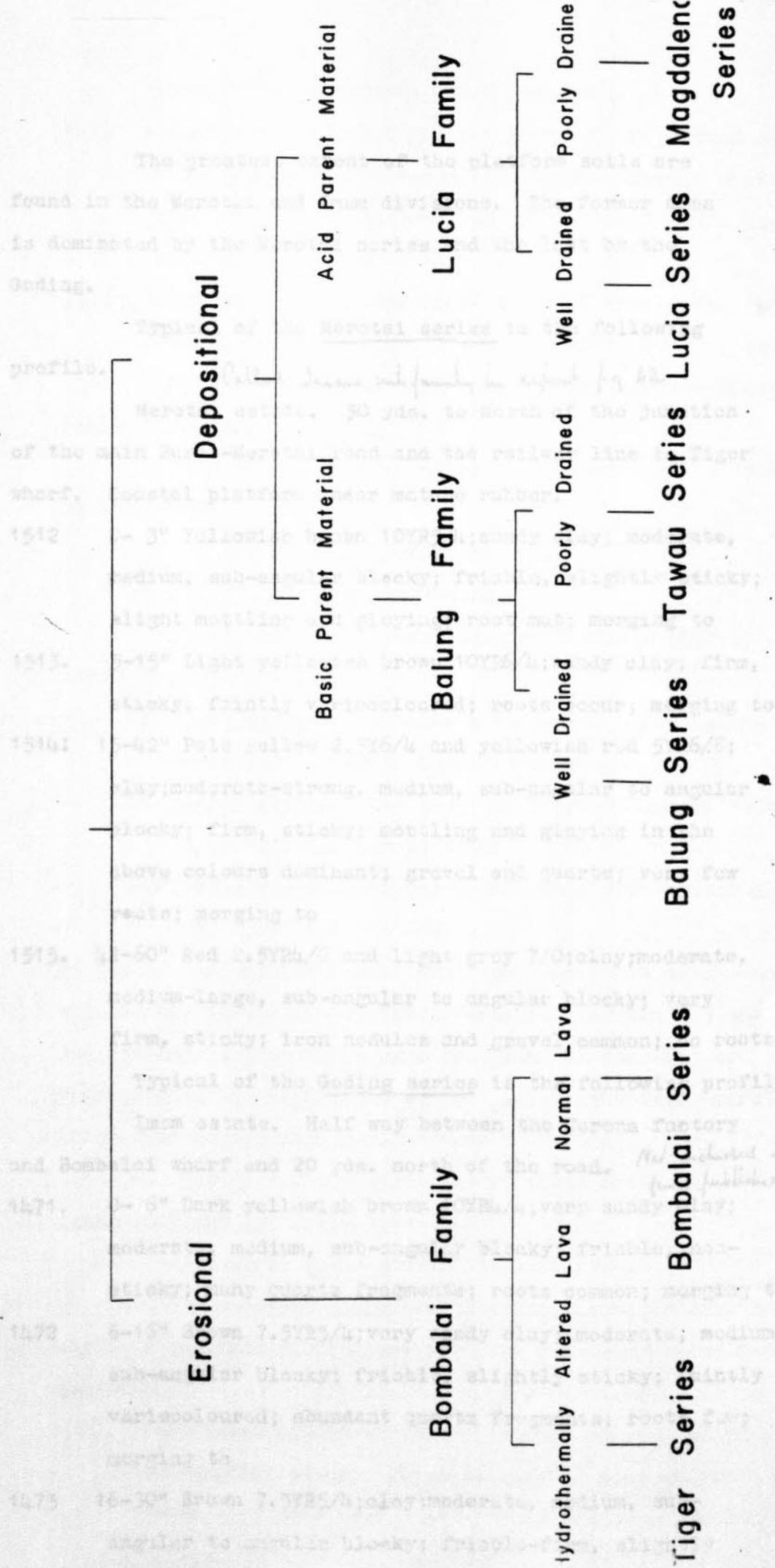
Soils of the Coastal Platform

Points in common which all soils on the platform possess are,

- 1) Sandy clay to sandy clay loam topsoil
- 2) Poorly structured surface which on exposure to direct sunlight becomes massive and very hard. (e.g. Merotai factory area).
- 3) Mottling in extremely bright colours within 6 ft. of the surface, generally of a reticulate nature in bright red on a gray-white base.

There is one sub-division on the estates between soils of the platform, and that is dependant on the colour of the first 3 ft. If this is yellowish brown to brown the soils belong to the Gading division or series and if pale yellowish brown or pale yellow to the Merotai series.

Azonal Soils



The greatest extent of the platform soils are found in the Merotai and Imam divisions. The former area is dominated by the Merotai series and the last by the Gading.

Typical of the Merotai series is the following profile.

Called Imam subfamily in report / 19 42

Merotai estate. 50 yds. to north of the junction of the main Burut-Merotai road and the railway line to Tiger wharf. Coastal platform under mature rubber.

- 1512 0- 3" Yellowish brown 10YR5/4; sandy clay; moderate, medium, sub-angular blocky; friable, slightly sticky; slight mottling and gleying; root mat; merging to
1513. 3-15" Light yellowish brown 10YR6/4; sandy clay; firm, sticky; faintly varicoloured; roots occur; merging to
- 1514: 15-42" Pale yellow 2.5Y6/4 and yellowish red 5YR6/6; clay; moderate-strong, medium, sub-angular to angular blocky; firm, sticky; mottling and gleying in the above colours dominant; gravel and quartz; very few roots; merging to
1515. 42-60" Red 2.5YR4/6 and light grey 7/0; clay; moderate, medium-large, sub-angular to angular blocky; very firm, sticky; iron nodules and gravel common; no roots.

Typical of the Gading series is the following profile.

Imam estate. Half way between the Corona factory and Bombalai wharf and 20 yds. north of the road. *Not included in final published report.*

1471. 0- 6" Dark yellowish brown 10YR4/4; very sandy clay; moderate, medium, sub-angular blocky; friable, non-sticky; many quartz fragments; roots common; merging to
- 1472 6-16" Brown 7.5YR5/4; very sandy clay; moderate, medium, sub-angular blocky; friable, slightly sticky; faintly varicoloured; abundant quartz fragments; roots few; merging to
- 1473 16-30" Brown 7.5YR5/4; clay; moderate, medium, sub-angular to angular blocky; friable-firm, slightly

- sticky; quartz common; few roots; merging to
- 1474 30-42" Light grey 7/0 and red 10R4/6 (first dominant); clay; moderate-strong, medium, angular blocky; friable, sticky; abundant boulders of acid volcanics; no roots; merging to
- 1475 42-60" Red 10R4/6 and light grey 7/0 (former dominant); clay; strong, medium, angular blocky; friable, sticky; mottling dominant, strong and large; quartz fragments.

Soils of the Ridge Country.

Factors which are common to all soils of the ridge country are.

- 1) Uniform profile to 6 ft.
- 2) Strongly structured

There are 3 subdivisions within this family of soils based on general colour.

- 1) Burut series, which has a yellowish brown colour going into a strong brown at depth.
- 2) Kuhara series, this has strong brown topsoil going to a yellowish red at depth.
- 3) Apas series, which has a yellowish red topsoil going into a red soil at depth.

So far no fundamental factor has been discovered which can explain the seemingly haphazard variation between one series and another in this ridge country. Some of the extreme reddening may be explicable by late stage localized hydrothermal alteration of the parent materials.

The greatest development of these soils is to be found in Burut and Tawau divisions

A typical Burut profile is as follows.

Not included in final report.

Imam estate, 1956 new clearing, on south east ridge adjacent to Table estate just north of the branch road from Goodwood.

1480. 0-8" Yellowish brown 10YR5/4; clay; moderate, medium, sub-angular blocky; friable, sticky; many quartz

fragments; many roots; merging to

1481. 8-16" Yellowish brown 10YR5/6 to strong brown 7.5YR5/6; clay; moderate-strong, medium, sub-angular to angular blocky; friable, sticky; many quartz fragments; roots fewer; merging to
1482. 16-45" Strong brown 7.5YR5/6; otherwise the same; merging to
1483. 45-60" Strong brown 7.5YR5/8; clay; strong, fine-medium, sub-angular to angular blocky; friable, sticky; boulders of acid volcanics, dolerite, fine gravel, ironstone nodules and abundant quartz; faintly varicoloured in yellowish brown; no roots.

A typical Kuhara Profile is,

Not included in final published report

Imam estate. Junction of Imam-Burut-Silverstone

road. Elevated position on 50 ft. ridge with a 2-3° rise to the north. Under mature rubber.

- 1493 0-6" Brown-dark brown 10YR4/3; clay; moderate, medium, sub-angular to angular blocky; friable, sticky; quartz fragments; many roots; merging to
1494. 6-20" Strong brown 7.5YR5/6; otherwise the same; merging to
1495. 20-42" Strong brown 7.5YR5/6; clay; strong; medium, sub-angular to angular blocky; friable, sticky; quartz fragments; few roots; merging to
1496. 42-60" Yellowish red 5YR5/6; clay; strong, medium, sub-angular to angular blocky; friable, sticky; quartz fragments, a few nodules; no roots.

A typical Apas profile is

Imam estate new clearing (1956) where rentis number 2 crosses onto the north bank of the small stream. At this point the stream has a meandering course and is entrenched about 30-40 ft. The profile was taken on the top of a spur.

1486. 0-15" Reddish brown 5YR4/4; clay; moderate, medium, sub-angular blocky; friable, slightly sticky; many quartz fragments; many roots; vague and merging to

1187. 15-42" Yellowish red 5YR4/6; clay; moderate, medium, sub-angular to angular blocky; friable, slightly sticky; many quartz fragments; roots common; vague and merging to
1188. 42-66" Red 2.5YR4/6; clay; moderate to strong, medium, angular blocky; friable to firm (compact, brittle) slightly sticky; many quartz fragments; roots occur; vague and merging to
1189. 66-90" Same.
1190. 90-114" Same. Roots stop at 114"
1191. 114-138" Same.
1192. 138-146" Same, but is a silty clay because of the presence of some fragments of parent material.
1193. 146-162" Finely bedded coarse ash.

Intrazonal Soils.

All these soils are derived from materials laid down long subsequent to the materials from which the zonal soils have been derived.

There are two divisions in this group.

- 1) Those soils derived from andesitic ash.
 - 2) Those soils derived from basaltic lava.
- 1) This is of relatively minor importance and will be dealt with first.

It is a shallow soil a typical profile of which is Imam estate, 200 acres 1956 replant. On a ridge top at the south side of the main road. *See page 40 + XVIII*

1458. 0-4" Very dark greyish brown 10YR4/2; slightly sandy clay; moderate-strong, sub-angular to angular blocky; friable, slightly sticky; some quartz fragments; roots common, vague and merging to
1459. 4-12" Brown 10YR5/5; sandy clay; moderate, medium, sub-angular blocky; friable, slightly sticky; weathering parent materials; many worm channels; some roots; abrupt and undulating to

2). Table *Published report page 37 and XV*

- Table-Bombalai ridge near Table hill end and on a 5° slope to the east. Primary jungle.
- 0959 0-4" Dark brown 7.5YR5/2; clay; moderate, medium, sub-angular to angular blocky, crumb and cast granular; friable, non-sticky; quartz fragments; roots common; vague and merging to
- 0960 4-15" Dark brown to brown 7.5YR4/3; clay; moderate to strong, medium, angular blocky and local crumb; friable, slightly sticky; quartz fragments; roots occur; vague and merging to
- 0961 15-33" Dark brown to brown 7.5YR4/3; clay; weak to moderate, medium, angular blocky; friable (brittle), slightly sticky; quartz fragments; few roots; vague and merging to
- 0962 33-72" Dark brown to brown 7.5YR4/4; clay; moderate, medium, angular blocky; friable, slightly sticky; quartz fragments; few root

3) Quoin. *Not included - published report*

Table estate, 10 yards west of the Table-Tiger road near brow of the first hill. On a 5° slope to the south soon developing to 10°. The stream at the base is flowing to the S.W. in a 20 ft. gully. Under very deep rooting sheet lallang.

- 0935 0-8" Reddish brown 5YR4/3; clay; moderate, medium, sub-angular blocky, some crumb; friable to firm, sticky; quartz fragments common; many roots, much carbonized; vague and merging to
- 0936 6-24" Yellowish red 5YR4/6; clay; moderate, medium, sub-angular to angular blocky and sporadic crumb; friable to firm, sticky; quartz fragments common; many black ants; roots less common; vague and merging to
- 0937 24-48" Yellowish red 5YR4/6; clay; moderate, medium, angular blocky and sporadic crumb; friable to firm,

1460 12-60# Level bedded light yellowish brown ash.

Its greatest development is on Imam division at the junction of the ridge country and coastal platform, from Quarry hill to the west as far as the Bombalai-Imam-Table road. There are however occurrences to the north west of this road. There is ~~a very little~~ ^{more} of it in Tawau division near the stone crusher and on Tunnel hill.

2) This division covers the rich and fertile soils of Table and Tiger divisions. It is a deep, uniform, strongly structured soil which despite its extremely high clay content (80 - 90%) handles as if it were a loam. There are three subdivisions which are again, as in the case of the ridge soils, determined by the colour of the profile.

(1) Jarangan series is yellowish brown.

(2) Table series is brown.

(3) Quoin series is red.

Typical profiles are as follows.

1) Jarangan. *Not included in published report*

Tiger estate, on rentis 1(b), within the estate, 1 chain from the top of a 6 chains 20° slope, marking the eastern boundary of the basalt. Under dense eucalyptium.

0974 0-4" Dark brown 10YR5/3; clay; moderate to strong, medium, sub-angular to angular blocky; friable to firm, slightly sticky; no quartz fragments; some roots; some worms; vague and merging to

0975 4-15" Dark brown to brown 10YR-7.5YR4/3; clay; moderate, medium, sub-angular to angular blocky and localized fine, strong, crumb; friable, slightly sticky; some quartz fragments; roots; vague and merging to

0976 15-72" Dark brown to dark yellowish brown 10YR-7.5 YR4/4; clay; moderate to strong, medium, sub-angular to angular blocky; friable to firm, slightly sticky; quartz fragments; roots few.

soils developed on isolated hills.

(brittle), slightly sticky; quartz fragments common; some roots; vague and merging to
0938. 48-72" Red to yellowish red 2.5YR4/6; clay; moderate to strong, medium, angular blocky and crumb; friable to firm, slightly sticky; quartz fragments common; roots down to 6 ft.

Azonal Soils

For the sake of completeness azonal soils must be discussed but as far as the estates are concerned they are of very minor importance.

Azonal soils are those which are still being actively formed or destroyed and are not in a state of balance with the present environment. There are two main divisions in this soil group.

(1) These soils developing on such steep land that they cannot approach maturity due to the constant loss of weathered material by slip and slide. These soils are found in topographic division (5).

(2) These soils developing on flat land in river valleys which cannot reach maturity due to the constant addition of material carried in flood waters. These soils are found in topographic division (1).

There is a further division in the alluvium in that areas which are constantly under water have been delimited.

There are two types

- 1) Fresh water swamp.
- 2) Marine or mangrove swamp.

Profiles however have not been included due to their very small acreages within the estate area.

The following are two typical profiles of azonal soils developed on isolated hills.

1) Bombalai series.

Final report page 35 n 811

RRIR analysis not available

Bombalai hill on rim of crater just above a 30° slope to the south at about 1,700 ft. Primary jungle with a good leaf litter.

0944 0-4" Dark brown 7.5YR3/2; sandy clay loam; moderate, medium, sub-angular to angular blocky and crumb; friable, non-sticky; many quartz fragments and pebbles of vesicular basalt; roots common; worms; vague and merging to

0945 4-9" Dark brown to brown 7.5YR4/4; sandy clay; moderate, medium, sub-angular to angular blocky and crumb; friable, slightly sticky many quartz fragments and pebbles; roots less common; ants occur; vague and merging to

0946 9-15" Dark brown to brown 7.5YR4/4; very sandy clay; moderate, medium, sub-angular to angular blocky; friable, slightly sticky; basalt dominates the horizon; roots die out; vague and merging.

0947 15" Weathering parent material.

2) Tiger series.

8 chains from the top of Tiger hill on a 25° slope to the south east, under primary jungle.

0-4" Red; clay; moderate, medium, sub-angular to angular blocky and crumb; friable to firm, slightly sticky; many quartz fragments; roots common; vague and merging to

4-12" Red; clay; moderate to strong, medium, sub-angular to angular blocky, firm, slightly sticky; roots common; vague and merging to

12-60" Red; clay; moderate to strong, fine to medium angular blocky; firm, slightly sticky; many quartz fragments; rocks dominant; few roots.

They are both included in the Bombalai family having been derived from basaltic lavas.

The riverine alluvium of the Balung family can be divided into two series, the Balung, which is well drained and the Tawau which is poorly drained.

Type profiles are as follows.

1) Balung. *Not included in final published report*

Rentis 6, 20 chains, under primary jungle.

01610. 0-6" Dark brown 7.5Yr4/3; sandy clay; moderate-strong, medium, sub-angular blocky; friable, sticky; abundant mica; roots common; merging to
01611. 6-18" Brown-dark brown 7.5YR4/4; sandy clay; moderate, medium-large, sub-angular blocky; friable, sticky; much quartz and mica; roots; merging to
01612. 18-36" Same as above; merging to
01613. 36-72" Brown 7.5YR5/4; sandy clay; moderate-strong, medium-large, sub-angular blocky; sticky; quartz and mica fragments; some roots.

2) Tawau. *Not included in published report.*

Sinon road mile 1, level site under mature coconuts.

1538. 0-4" Very dark greyish brown 10YR3/2; clay; moderate-strong, medium, sub-angular blocky; friable, non-sticky; many roots; abrupt to
1539. 4-36" Light grey N7/0 and reddish yellow 7.5YR6/8; clay; sticky; common, medium, distinct, mottles; merging to
1540. 36-52" Yellowish red 5YR5/8 and light grey 7/0; silty clay; sticky; equal mixture of distinct, medium, mottles and gleys; abruptly into
1541. 52-72" Light brownish grey 2.5Y6/2; silty clay; sticky; many old root channels.

These two profiles come from outside the estate area but are quite typical of certain areas within it. The Balung series is overwhelmingly dominant the Tawau only appearing in the very southerly part of Tawau division.

The soils of the Lucia family, Lucia and Magdalena series, cover such a small area on Merutai Kechil estate that they can be disregarded. They are however important in the Merotai Besar valley, outside the estate area.

Mapping.

A map has been prepared of each estate and there is a separate legend sheet, covering all the symbols and colours used. The primary mapping unit was topographic, which could be defined from aerial photographs. As the topography of this area is intimately related to the geology and each topographic unit can, in addition, have a unique time factor allocated to it, i.e. the high level plateau is much younger than the ridge country, it is not surprising that each unit carries a closely associated family of soils. Series have been tentatively designated within each of these families and where they dominate a particular area the appropriate symbol has been used.

A complicating factor has been the occurrence of the Quarry series which, does not remain within any one topographic division and whose thickness is extremely variable. On the estates affected, Tawau and Imam, the limit of the spread of this material has been defined by a ~~green~~^{purple} line.

The level of mapping is variable. In the zonal soils only families have been differentiated on a colour basis the series being indicated, where possible, by symbols. This is due to the intricate and haphazard variation within the families. In the intrazonal group, however, due to the uniform and more widespread soil, the series have been defined. The azonal soils are of such little significance that no attempt has been made to differentiate soils below the family level.

LEGEND

Zonal Soils

Yellow - Brown latisols

- Merotai Series - M.
- Gading Series - G.

Intrazonal Soils

Pale Soils

- Quarry Series - Y.

Azonal Soils

Erosional

- Bombalai Series - Bi.
- Tiger Series - Ti.

Red - Brown latisols

- Apas Series - A.
- Kuhara Series - K.
- Burut Series - B.

Reddish - Brown earths

- Jarangan Series - J.
- Tahle Series - T.
- Quoin Series - Q.

Depositional

- Swamp Family - S.
- Balung Family - Ba.
- Lucia Family - L.

MERUTAI KECIL ESTATE.

This estate has a total acreage of 5,405 acres.

Zonal soils are the dominant element, intrazonal and azonal soils being largely confined to the north east.

Zonal soils

The platform soils occupy 63% of the estate, mainly to the west. They belong to the Merotai series of the Gading family.

The soils of the ridge country (10% of the estate) are confined to the south eastern margin, which is adjacent to Burut estate. The Kuhara series (60%) is dominant over Apas series (40%).

Intrazonal soils

These are derived from the basalt flows from Mt. Tiger. In the north occurs the Quoin series covering 5% of the estate and further to the south and west occurs the soils of the Table - Jarangan catenary association, more fully discussed in the description of the Tiger division, which make up 9% of the estate.

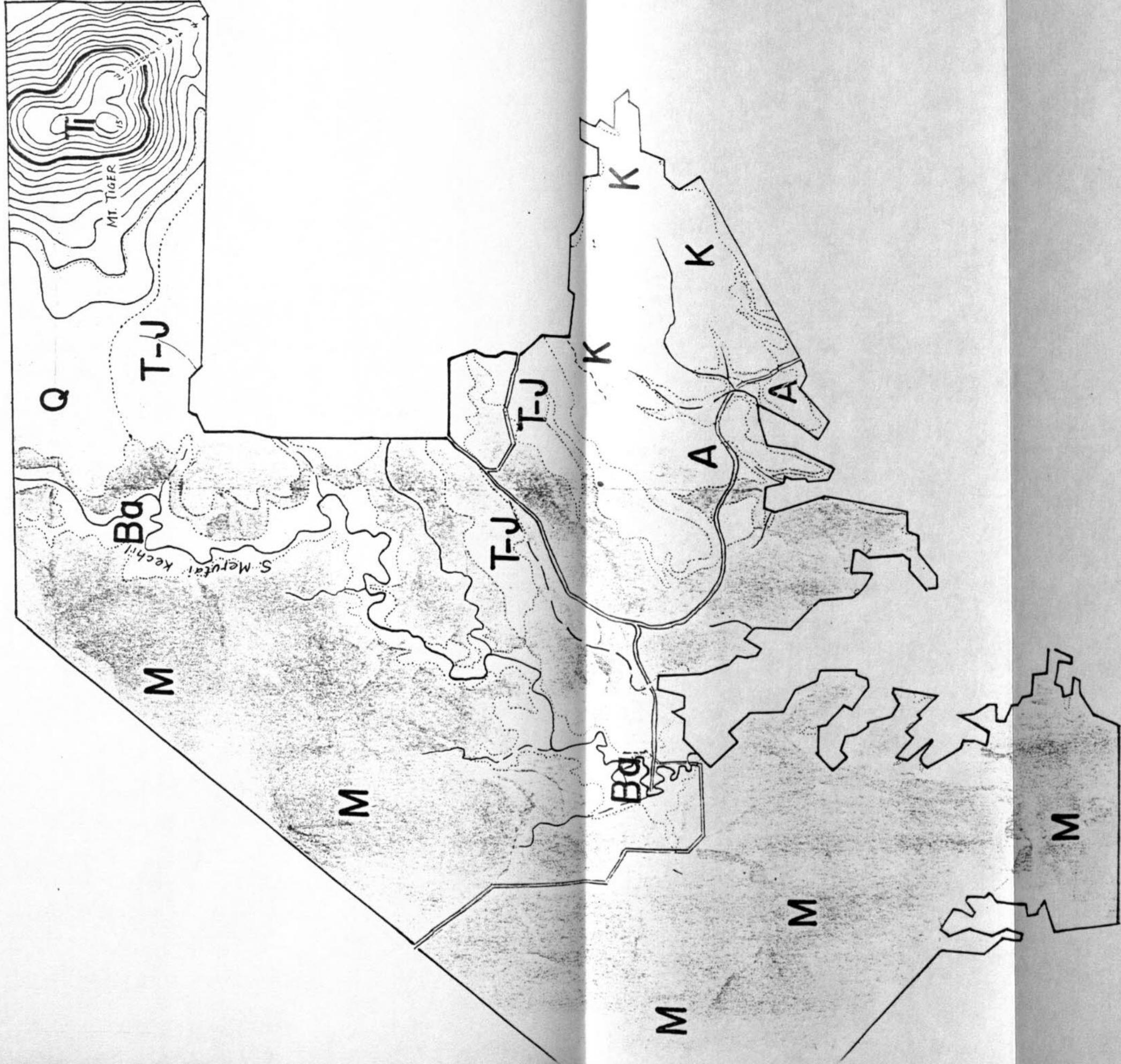
Azonal soils.

Both erosional and depositional forms occur. The first consist of the skeletal soils of the Tiger series, Bombalai family, on Tiger Hill itself, this covers some 7% of the estate.

The depositional azonal soils covering 6% of the estates occur along the valley of the Merutai Kechil valley, they can, mostly, be assigned to the well drained series of the Balung family.

There is a very slight amount of mangrove round the southern margins of the estate.

MEROTAI KECHIL ESTATE



Scale 1:25,000 Approx.



BURUT ESTATE

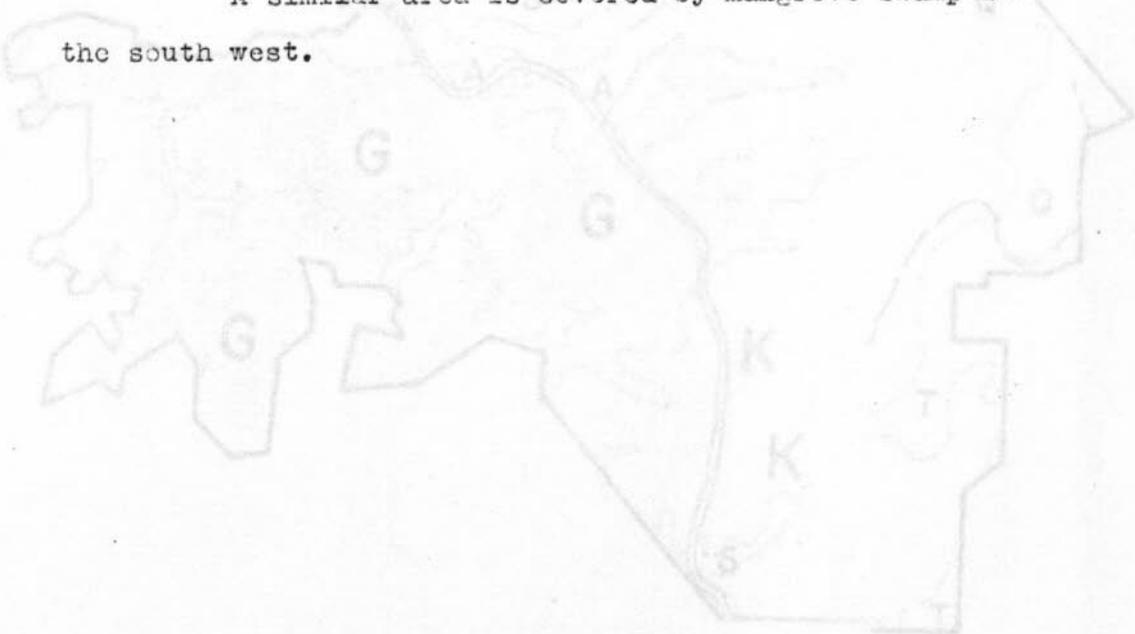
The total acreage of this estate is 3,309

Zonal soils cover 86% of the estate. The ridge soils of the Apas family are dominant, 64% of the area, 80% of these are of the Kuhara with 20% belonging to the Apas series. It is in this estate that the ridge soils reach their greatest development.

The platform soils of the Gading family which cover 22% of the area are for the most part typical soils of the Gading series.

Intrazonal soils are confined to the northern and eastern boundaries where soils of the Quoin family, both Quoin and Table series, cover some 7% of the area.

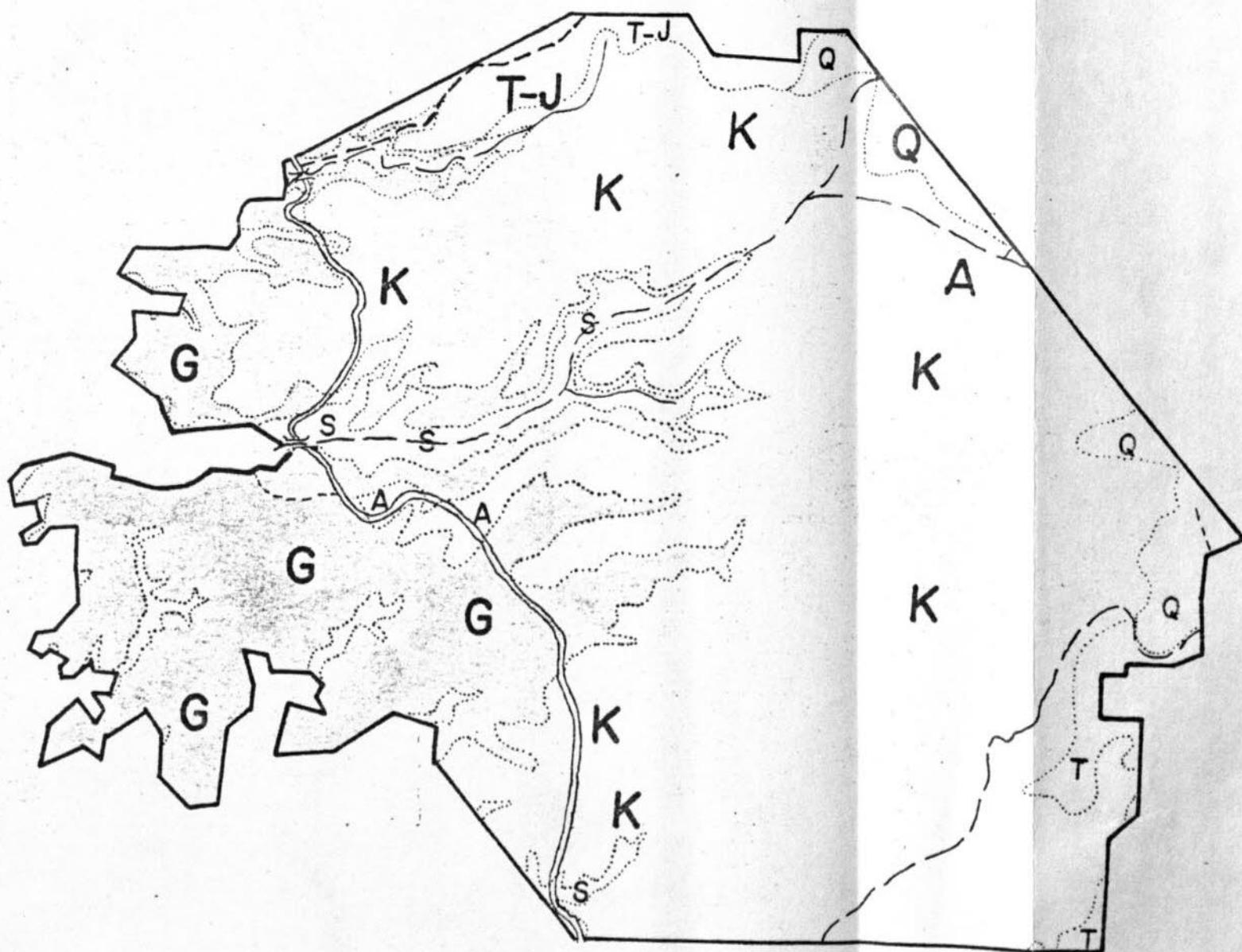
A similar area is covered by mangrove swamp in the south west.



Scale 1:25,000 A.



BURUT ESTATE



Scale 1:25,000 Approx.

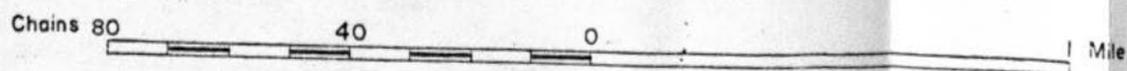
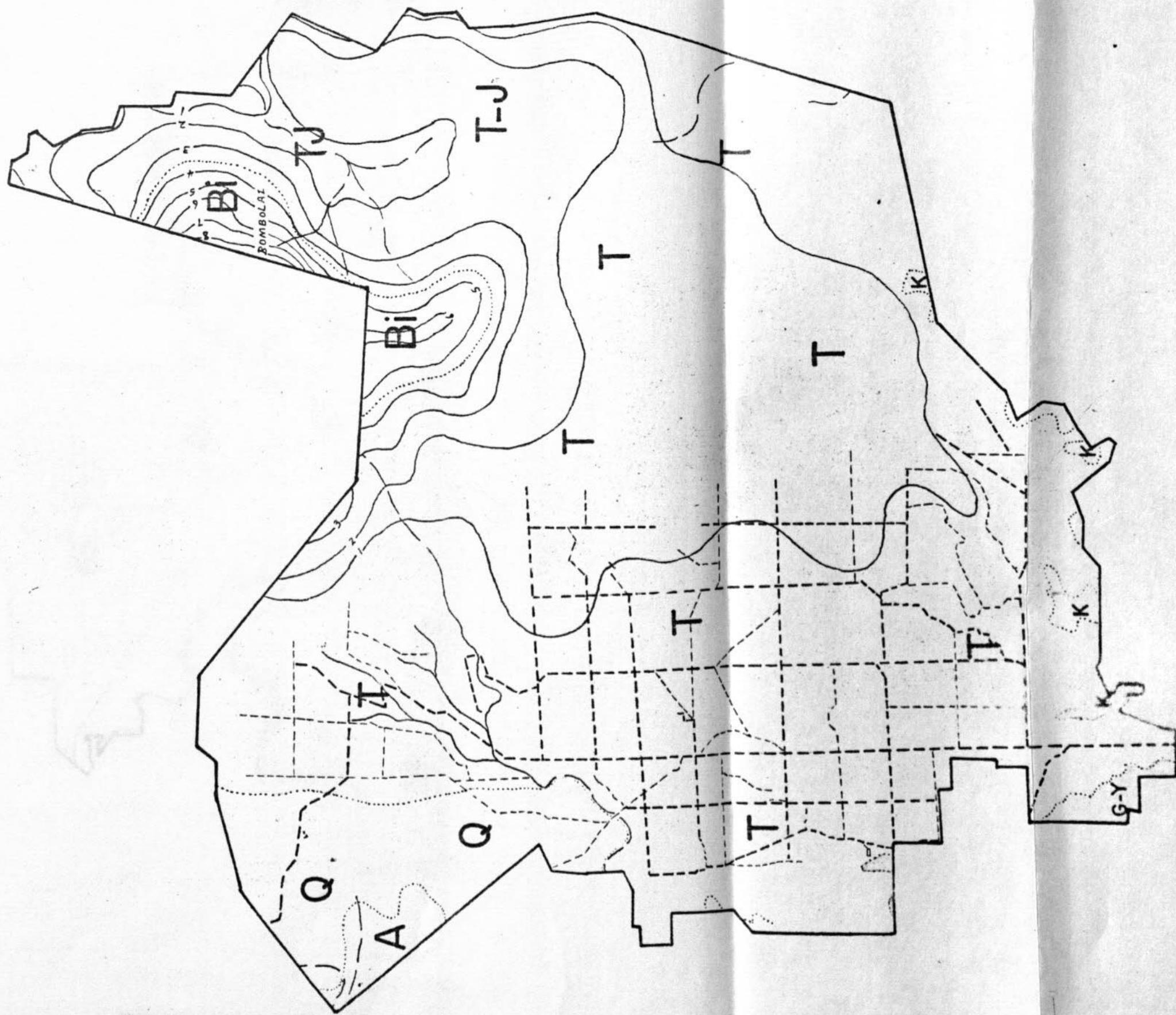


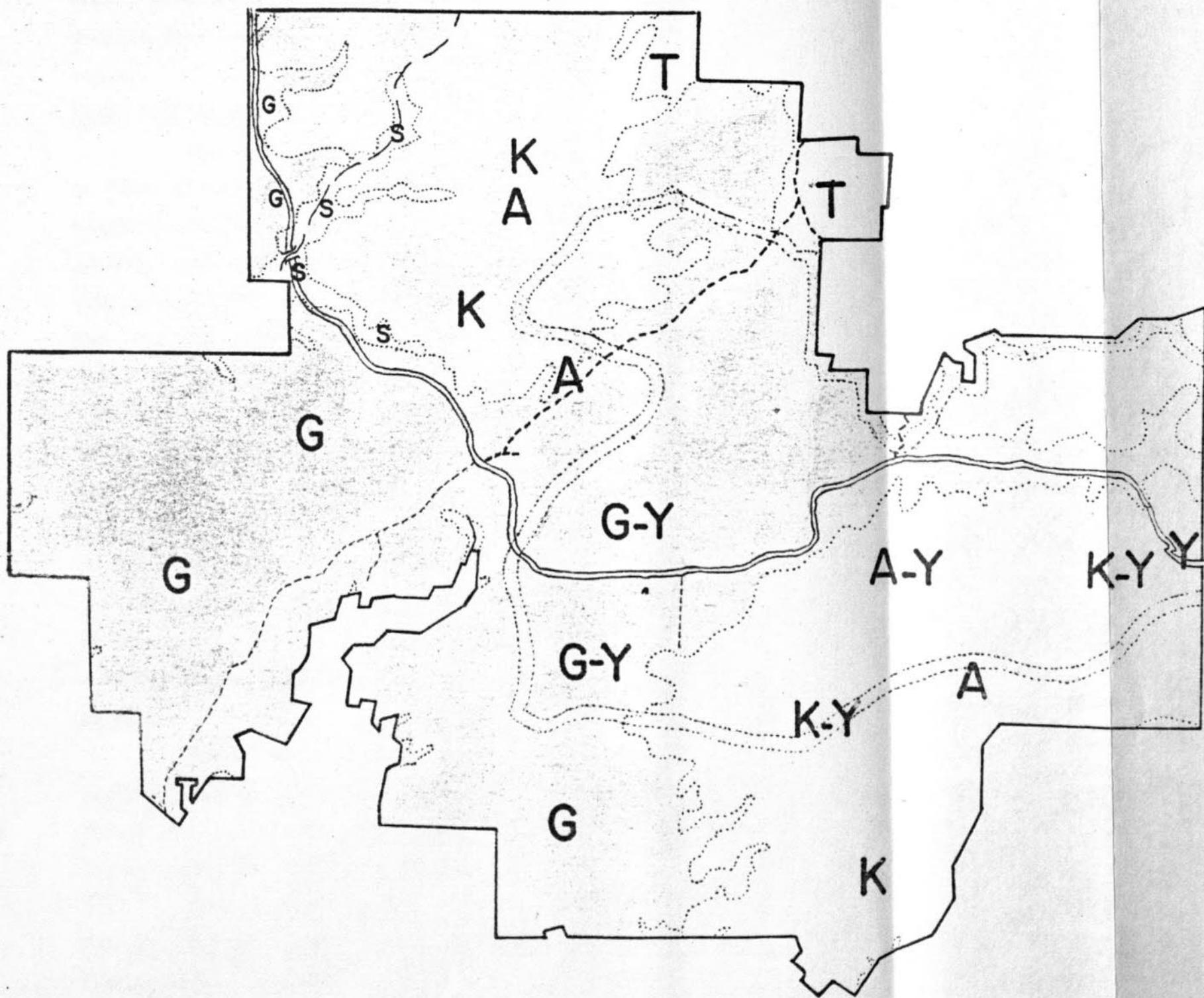
TABLE ESTATE



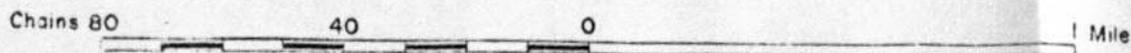
Scale 1:25,000 Approx.



IMAM ESTATE



Scale 1:25,000 Approx.



TIGER ESTATE

The total area of the estate is 4,290 acres which, even though it is dominated by the intrazonal soils derived from basalt, contains a very varied selection of soils.

Intrazonal soils.

The main area of the estate has been classified as Table soils (i.e. intrazonal brown soils derived from basaltic lava flows). There is however a continuous gradation from these brown (Table) to the yellow brown (Jarangan) soils. The younger a flow of basalt is the more the soil derived from it tends towards the Table series. The older the flow of basalt the more the soil derived from it tends towards the Jarangan series. Naturally the Table series has a topographically superior position and the Jarangan series inferior. Thus in the main body of Tiger estate which is rather strongly dissected the soils on the ridges tend towards the Table series while in the valleys Jarangan soils are dominant. Thus the area marked as T-J on the map is a catenary association of Table and Jarangan soils. 54% of the estate area has been mapped as such.

True Jarangan series soils occur only on the eastern boundary where they occupy 2% of the estate. They extend from the north east towards the Table-Bukit Glass ridge beyond the estate boundaries.

The soils of the Quoin series extend north west from Tiger Hill and are derived from hydrothermally altered basalt flows. They cover 18% of the estate area but agricultural value is detracted from by the strong topography. It is the basalt flows from which these soils have been derived that dammed up the Merutai Kechil so causing the formation of the alluvium which occupies the north eastern part of the estate.

Zonal Soils.

These soils, which dominate the make up of the soils of the rubber divisions, are found in very small quantities round the southern and western margins. Merutai soils of the Gading family occupy 2% and Kuhara soils of the Apas family 1% of the estate area.

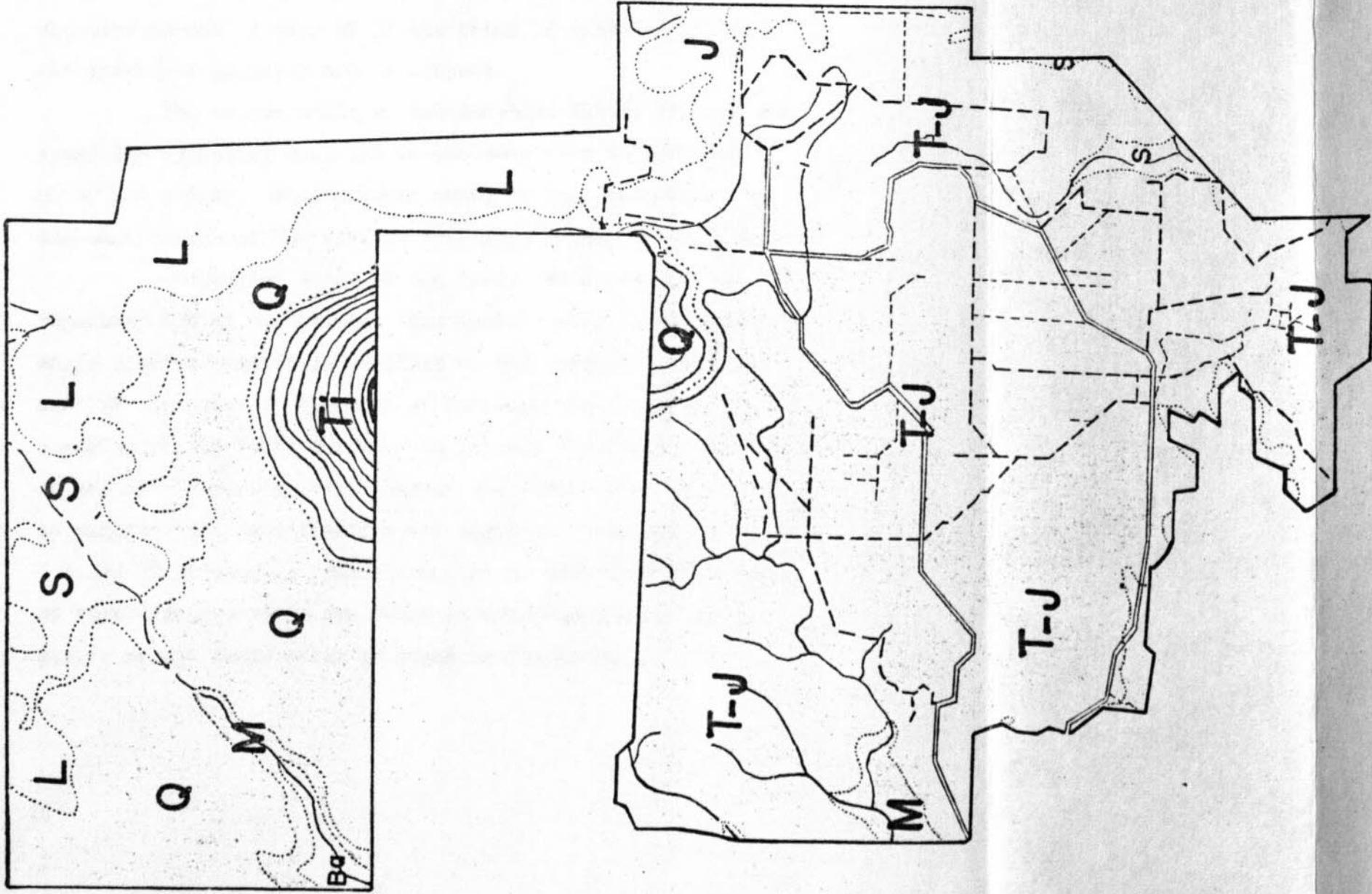
Azonal Soils.

Soils of this order are more important than on other estates and both erosional and depositional types are represented.

Erosional soils are represented by the shallow soils of the Tiger series covering Tiger hill which is 4% of the estate. These soils cannot be utilized for agricultural purpose without a great deal of erosion resulting. Depositional soils are found mainly in the north east where they have been deposited due to the damming up of the Merutai Kecil drainage by a basalt flow from Tiger Hill. This alluvium however is of a different type from that of the Tawau division (i.e. Balung) for it is derived from a totally different province of igneous rock which is inherently poorer than the Balung type of alluvium. (This same type occurs at Merutai Besar and is called the Lucia series). In addition, due to its manner of formation, it is very swampy and out of the 16% of the estate that it occupies 3% has been separated off as swamp.

About 1% of similar swamp occurs in the south east of the estate.

TIGER ESTATE



Scale 1:25,000 Approx.



TABLE ESTATE

This estate together with Tiger is almost wholly confined to those intrazonal soils derived from basaltic lava flows.

Small patches of zonal Kuhara, Apas and Gading soils occur along the western and southern boundaries but in all they amount to only 3% of the total of 5,290 acres and for practical purposes can be ignored.

The azonal soils of the Bombalai series which occur round the fringes of the hill of the same name accounts for 4% of the estate. This however owing to its steepness and the shallowness of the soil is totally unsuited to agriculture.

Intrazonal soils of the Quoin family occupy the remaining 93% of the estate. The Quoin series (from hydrothermally altered basalt) is confined to 360 acres in the north west of the estate. The rest of the high level plateau is composed of the Table series. It is only towards the margins of the estate particularly towards the Tawau river that erosion is digging into this fairly level surface. With this erosion a state of affairs is arising similar to that on Tiger estate in that Jarangan soils are found in topographically inferior positions and Table soils in superior positions.

IMAM ESTATE

This estate with an acreage of 4,055 (before additions) is dominated by the zonal soils of the coastal platform and ridge country. There is a small (3%) area of Table soils (Quoin family) on the north east and of marine swamp soils to the south east (2%).

The soils of the coastal platform occupy 54% of the estate area. In the south and east, roughly beyond the main road, type Gading soils are dominant but towards the north and west transitional Gading-Kuhara, Gading-Aspas soils become dominant.

The soils of the ridge country occupy the remaining 41%. They are predominantly of the Kuhara series, 60%, with the remaining 40% of the Aspas series.

This relatively simple arrangement of soils is complicated by the pale andesitic ashes, from which is derived the intrazonal soil of the Quarry series, which overlies haphazardly the area of the ridge and platform soils shown on the map by the green line. This material, which is relatively rich in plant nutrients, has modified the characters of both soil families on which it lies.

Most of the soils will fall within the well drained Table series. Some Table soils do occur on the southern margin of the estate.

Less than 1% of the area is found to have soils of the Table series (Quoin family) which occur where there are slight projections southward of basalt flows from the estate.

Such more important are the soils of the Quarry series which occur, or have occurred, about 1% of the eastern part of the estate. They have in this region modified, or completely washed, the normal characters of the ridge soils.

TAWAU ESTATE

This estate has a total acreage of 5,926 acres.

Zonal soils are dominant, though azonal alluvium occurs to a greater extent than on any B. A. Ltd. estate:

Zonal Soils.

The estate occurs at the junction of the ridge country with the coastal plain, at a point where the coastal platform has almost been cut out, so that soils of the Apas family, 54% of the area, are much more important than those of the Gading family, 21%.

Of the three series covered by the Apas family it has been estimated that the soils consist of 70% Kuhara, 20% Apas and 10% Burut series.

The Gading family of soils is found in the southern half of the estate, south of White Bridge. There is a very small percentage of these soils that can be assigned to typical Gading soils. Most of them would fall into types transitional between Kuhara and Gading.

Azonal Soils.

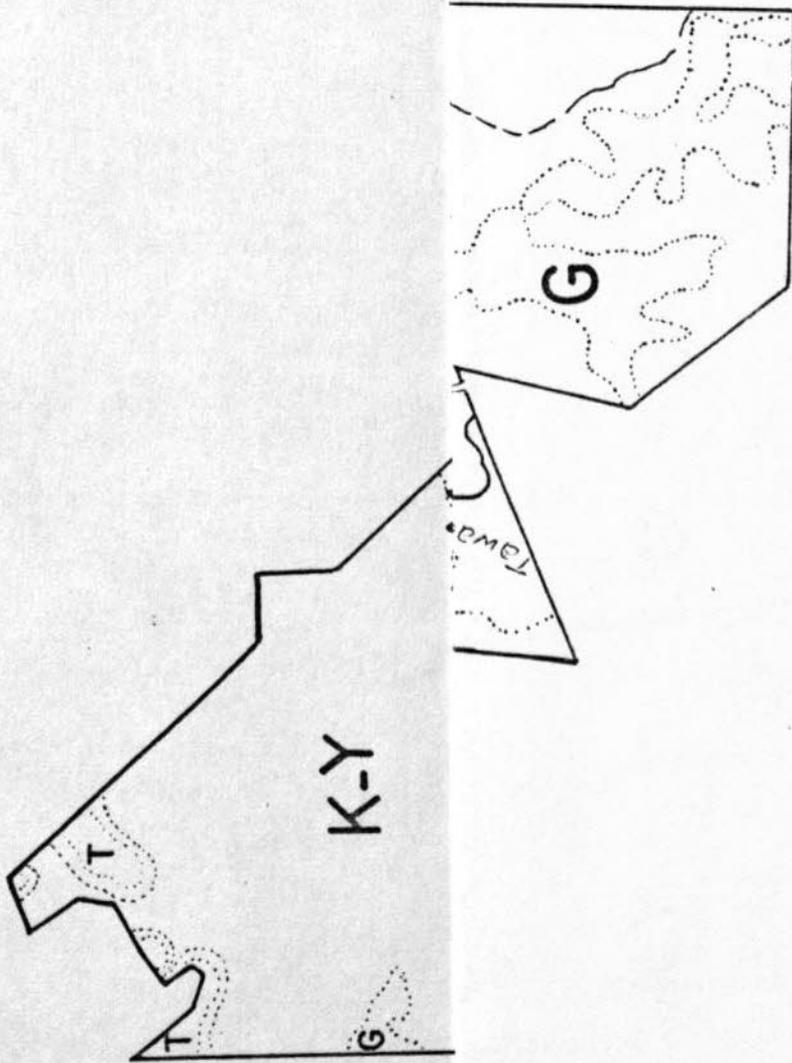
This is confined to the riverine alluvium of the Tawau valley, 26% of the estate, this belongs to the Balung family and over 90% of the soils will fall within the well drained Balung series. Some Tawau soils do occur on the southern margin of the estate.

Intrazonal Soils.

Less than 1% of the area is found to have soils of the Table series (Quoin family) which occur where there are slight projections southward of basalt flows from Table estate.

Much more important are the soils of the Quarry series which cover, or have covered, about a $\frac{1}{4}$ of the northern part of the estate. They have in this region modified, or completely masked, the normal characters of the ridge soils.

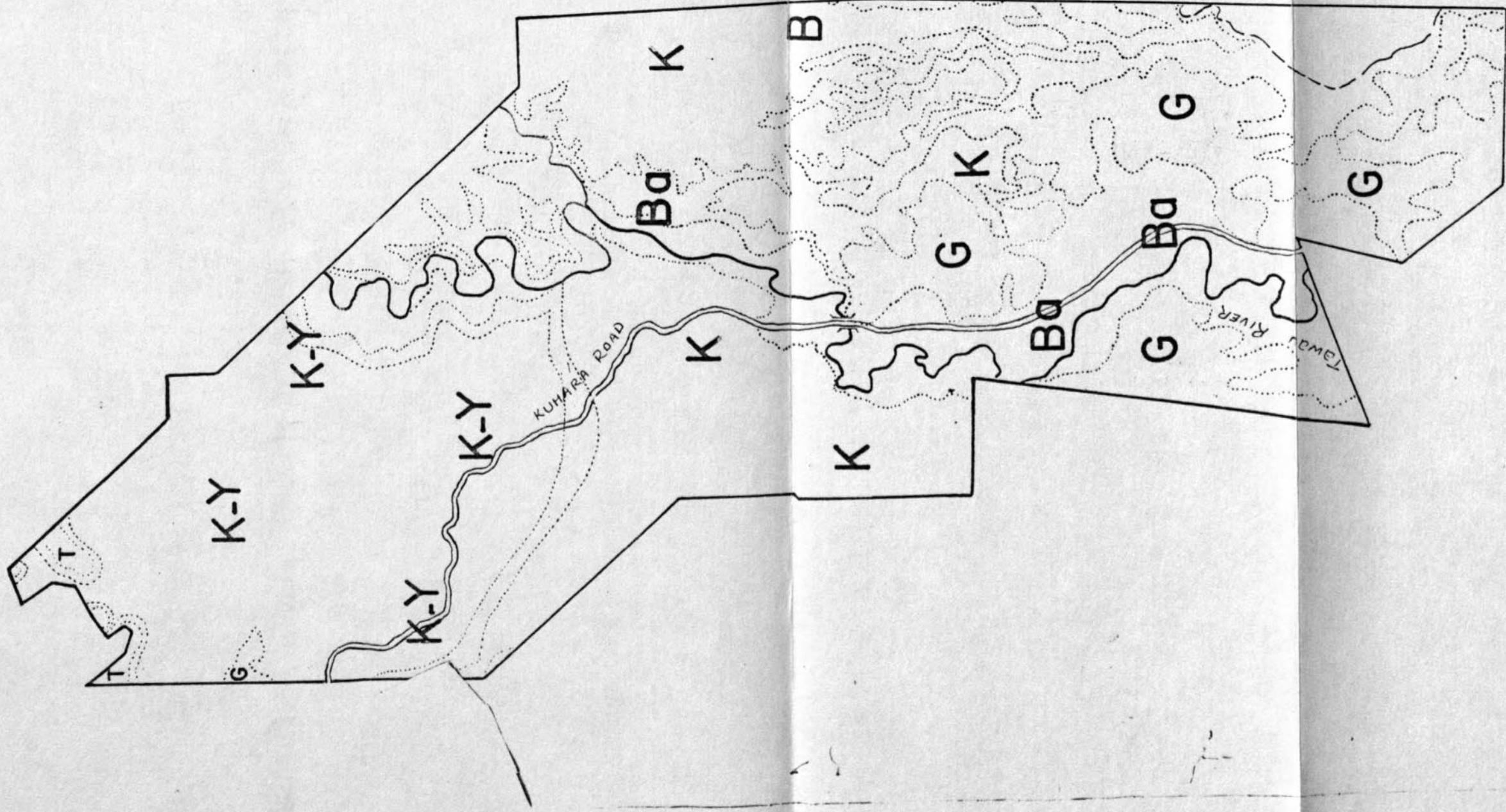
TAWAU ESTATE



Scale 1:25,000 Approx.



TAWAU ESTATE



Scale 1:25,000 Approx.



