The Soils of Bougainville Island—Their Distribution and main Characteristics in Relation to Agricultural Development

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Introduction.

THE nature of the country, the distribution of the soils in relation to landscape, the characteristics of the main soil types and their agricultural potentialities have been surveyed. Only the areas which topographically appear suitable for future development have been examined, while the extensive area of topographically difficult and dissected mountain country has been omitted.

A provisional map shows the approximate areas and locations of the main soil associations with an indication of areas considered suitable for extension of agricultural activity.

Location.

Bougainville Island, principal island of the northern group of the Solomons, extends in a north-west south-east direction from 5 degrees 26 minutes to 6 degrees 52 minutes south latitude and from 154 degrees 39 minutes to 155 degrees 59 minutes east longitude.

The area is about 3,880 square miles. Administratively the island is part of the Trust Territory of New Guinea and has a population estimated at 46,000.

Natural Conditions.

I. TOPOGRAPHY—

Well over 80 per cent. of the island lies 500 feet or more above sea-level. The northern mountain ranges are part of the Emperor Range, with its highest point the active volcano Mount Balbi (9,000 feet.)

The southern section is dominated by the Crown Prince Range, the Deuro Range and Tonolei Harbour Mountains. The volcanic Mount Takuan-Taroka-Loloru complex constitutes a separate mountain area to the south-west. A number of extinct and dormant volcanoes are present in the Crown Prince Range. The active volcano Mount Bagana (6,560 feet), which is part of the range, is separated from Mount Balbi by a low saddle, which gradually slopes down towards Wakunai on the east coast.

Narrow strips of coastal lowland are present on the west, north and east coast. Owing to the presence of a coastal levee the lowland remains in marshy condition for most of the year. The coastal plain is separated from the rugged mountains by low foothill country, only a few miles wide. An extensive coastal plain has developed along the south-east, south, and south-west coast from Toimanapu Bay to Torokina. It comprises gradually sloping dry lowland country along the Loloru-Taroka-Takuan complex, varying in width from two to six miles, and flat swampy alluvial country several miles wide along the coast.

The eastern portion of the plain, the Loluai river area, is separated from the southern Buin-Siwai plain by the Deuro Range. On the north-west coast, north of the Jaba River towards Torokina, the coastal plain narrows and is in a permanently swampy condition.

The extreme northern part of the island is a raised coral limestone peninsula.

I.2 *Morphology*—

Like New Britain, the island of Bougainville is essentially of continental, rather than of volcanic origin. The mountain core of Emperor and Crown Prince Ranges consists of axial fold ranges, which are composed of metamorphics (altered shales, phyllites, quartzite and silicified

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grit) in association with porphyries (breccias and conglomerates). The basement rock has been covered by Upper Tertiary sediments and volcanic products.

Vulcanizm has been intense and of paramount importance in landscape development. During late Miocene or possibly early Pliocene explosive vulcanizm occurred along the east coast and a cover of fine volcanic sand was deposited over the older landscapes. The origin of the natural harbours (Raua Bay, Teop Harbour, Tinputz Harbour, Kieta Harbour and Tonolei Harbour) has been connected with this vulcanizm.

During the Plio-Pleistocene era volcanic activity along a subsiding coastline gave rise to the deposition of thick strata of grey liparitic coarse sand. This sand underlies the main soils of the southern coastal plain. The grey coarse sandy and gravelly deposits of Mount Balbi, Mount Bagana (and dormant twin volcano Billy Mitchell crater lake) on the east coast between Tenekau and Arakawau are supposedly of the same age.

A layer of fine grey brown sand and gravel, originating from an intermediate magma, is often found superimposed on the grey sands.

The volcanoes of the Takuan-Taroka-Loloru complex consist of yellow-brown andesitic tuff, as do the active volcanoes and foothills.

In the wide environment of active vulcanizm, sandflows carrying rock-fragments, besides pumice, are common.

Recent air borne (aeolian) products are found as layers of fine sand, silt and pumice, covering the soils derived from old rock or tuff. There is a definite variation in these deposits, which is mainly related to the age of the eruptions, composition of the magma, distance and direction from the eruption centre, and power of the eruptions. As a result these recent deposits are heterogenous in composition.

I.3 *Climate and Hydrology*—

The climate at low elevation is warm and humid. Maximum and minimum day temperatures at sea level are in the order of 90 degrees F. and 70 degrees F. respectively. The main rainy period occurs during the north-west monsoon.

The northern coast of the island receives less rainfall than the south-eastern and southern part, where the south-east trade winds bring a higher precipitation.

Rainfall figures vary from 90 inches at Raua in the north and 90 inches to 120 inches on the central east coast, to 200 inches in the south-east at Toimanapu.

The south coast receives an average annual rainfall of 120 inches, with an increase to the west. An exceptionally high rainfall year has yielded to 250 inches. Soraken on the north-west coast has the lowest average annual rainfall with 75 inches.

Sparse rainfall records indicate the absence of long periods of pronounced drought; a favourable circumstance on the highly permeable soils. However the high rainfall causes heavy leaching and impoverishes plant-nutrients in the sandy soils, as well as impeding drainage in part of the andesitic tuff loams.

Unfortunately the high humidity, particularly in the southern plain, creates optimum conditions for fungal diseases.

Numerous streams with permanent water rise in the forested country. Some of these have sufficient capacity and fall to generate hydro-electric power. A few rivers discharge sulphuric water from areas of active vulcanizm and crater lakes; others transport large amounts of sand and volcanic debris, which have been deposited over large tracts of floodplain.

I.4 *Vegetation*—

The mountain ranges are covered by dense tropical rainforest consisting of several tree storeys and with a reasonable to dense undergrowth of shrubs, weeds and vines. On the lower foothills timber of commercial value is often present in exploitable quantity, but access is a big problem.

In the Buin-Siwai coastal plain good primary forest is scarce, owing to a relatively dense population, and the shifting cultivation system of agriculture. Vast areas are covered with secondary growth, poor in species and of variable age. In the older re-growth, *Pometia* sp. and *Canarium* sp. are common. *Imperata* grasslands are scarce and are mainly confined to the northern coral limestone peninsula and Baniu Hill. Swamp forest is common in extensive areas of the poorly drained coastal plains. Permanent swamps are covered with grass and reed vegetations.

II. SOILS IN RELATION TO LANDSCAPE—

In broad design the soil formation shows a close correlation with the parent material. As a result of strong volcanic activity much of the old landscape has been covered by volcanic ash, and this is reflected in the presence of ash covered soils over large areas. The soil pattern is discussed in following paragraphs in connection with the main physiographic regions, and the main soils are described and discussed in more detail under Soil Profile Descriptions.

II.1 *The northern raised coral limestone peninsula—*

The peninsula is approximately 15 miles long and five miles wide.

It comprises an uplifted coral shelf composed of coral limestone, fringed by a narrow discontinuous strip of flat lower coral shelf of white coral sand. The topography is slightly undulating and dolines (sinkholes) are characteristic.

On the lower coral shelves no soil development is apparent and the soil is merely a dark humic coral sand over fresh white coral sand.

Owing to accretions of volcanic ash, the soils derived from coral-limestone show variations, which are expressed in differences in colour and consistency.

The soils of relatively pure coral-limestone origin are mainly red to red-brown permeable clays (terra rossa), whereas those of mixed ash and limestone derivation are brown-yellow heavy textured clays.

The soils in general are very heterogenous in respect of depth of solum, shallow phases being more common than deep, while rock outcrops appear in many localities.

The natural vegetation is a mediocre forest, interspersed with *Imperata* grasslands.

The coral limestone soils grow healthy and productive coconut palms along the coast.

II.2 *The northern section of the Emperor Range with foothill country, flat to slightly undulating lowland and intermittent narrow coastal plain.*

The red and yellow clay association is only found on the steep mountain ridges, where these soils are severely truncated.

In the northern and eastern foothill country of gentle topography, the original profile has been preserved in ash-covered red and yellow clay soils. The cover-profiles are brown-yellow loamy sands, derived from a grey-brown volcanic fine sand. The sandy ash cover originated from extinct volcanoes in the area and is almost absent on the foothills west of the Emperor Range.

The red and yellow clays on the ranges are of very restricted agricultural importance. Severe limitations on their use are imposed by steep topography, inaccessability, shallowness, and impermeability of the subsoil.

The presence of a light textured covering layer however, particularly when it reaches a reasonable depth, provides for the ash-covered red and yellow clays favourable characteristics for agriculture. Although the apparent porosity of the cover profile suggests droughtiness for shallow rooting crops during a dry spell, this is not likely to occur, as the upper horizon of the cover profile preserves moisture for the crop. On the other hand, conditions of impeded drainage could occur in shallow cover profiles in flat locations under excessively wet conditions, but these could be prevented easily by correct drainage measures.

The ash-covered red and yellow clays have the potential for growing a variety of foodcrops, besides plantation crops, such as coconuts, cacao, coffee, and rubber.

II.3 *The slope and foothill country of Mount Balbi—*

The steep volcano Mount Balbi consists of andesitic material. The lower flanks are covered with soft andesitic tuff. This material is presumed to be of late Pleistocene and of Recent age and has weathered into juvenile yellow-brown friable sandy loam and silt loam.

Soils derived from older tuffs of Pliocene age show a more advanced stage to maturity. The latter soils have a higher clay content to depth, while the colour varies from red-brown to red. These red-brown clayloams are present under covering ash layers on the lower slope and in the foothills.

The covering layer, which is seldom less than two feet deep, is composed of material of variable particle size and contains much

pumiceous sand. Its solum development is only at an early stage and is restricted to the formation of a thin layer of yellow-brown sandy loam of favourable physical properties. These soils are highly fertile and have a high agricultural potential. Special management however will be required to preserve the fertility.

Annual crops produced in the area include maize, rice, peanuts, indigenous food crops, and tobacco of a good quality.

Plantation crops are mainly coconut and cacao, which are highly productive. Extension of existing agriculture is unfortunately limited by steep topography and dissection, and would not be possible much further than a few miles away from the coast, in the area between Uruai River and Wakunai.

The area on the western slope of Mount Balbi, south of Kiakara is of the same agricultural potential, with possibilities of development. Access to this area is difficult, however, because of an exposed coastline.

II.4 *The saddle between Mount Balbi and Mount Bagana, fanning out into coastal lowland and adjacent lower hill country of Mount Bagana and Mount Billy Mitchell—*

As a result of recurrent eruptions of Mount Bagana, its dormant twin volcano Billy Mitchell (with crater lake) and Mount Balbi, the country is covered with thick deposits of gravelly, sandy, and silty ashes. The coarser material has been transported in sandflows, while the fine sandy and silty ash strata are predominantly aeolian.

The recognition of separate soils is complicated, as the deposits originate from various eruptions and show an irregular stratification of material of variable granular size.

Thin organic layers of destroyed vegetations which have been found in the soils, would enable the ages of successive eruptions to be determined by radio active carbon 14 tests.

A general characteristic of the soils is that profile development is extremely limited; it does not go beyond the formation of a thin layer of sandy loam over the loose volcanic material.

The ash soils are freely permeable and have an apparently low waterholding capacity by virtue of lack of a clay fraction. This applies in particular to the compact grey coarse sandy and gravelly ash soils, which occupy a large area of the east coast between Tenekau Plantation and Terara. The latter sands are, in addition, somewhat cemented, and consequently water absorption and root penetration are impeded.

Coconut palms on these dry sands show unsatisfactory development and are unproductive. The natural vegetation consists of low primary forest.

Ash soils with strata of coarse sand, alternating with layers of fine sand and silt ash, have improved soil moisture conditions. These soils are of higher agricultural value, in particular for plantation crops, under the conditions of well distributed rainfall. Even in depressed areas, where the groundwater level is normally high, palms grow well, provided that the land is sufficiently drained.

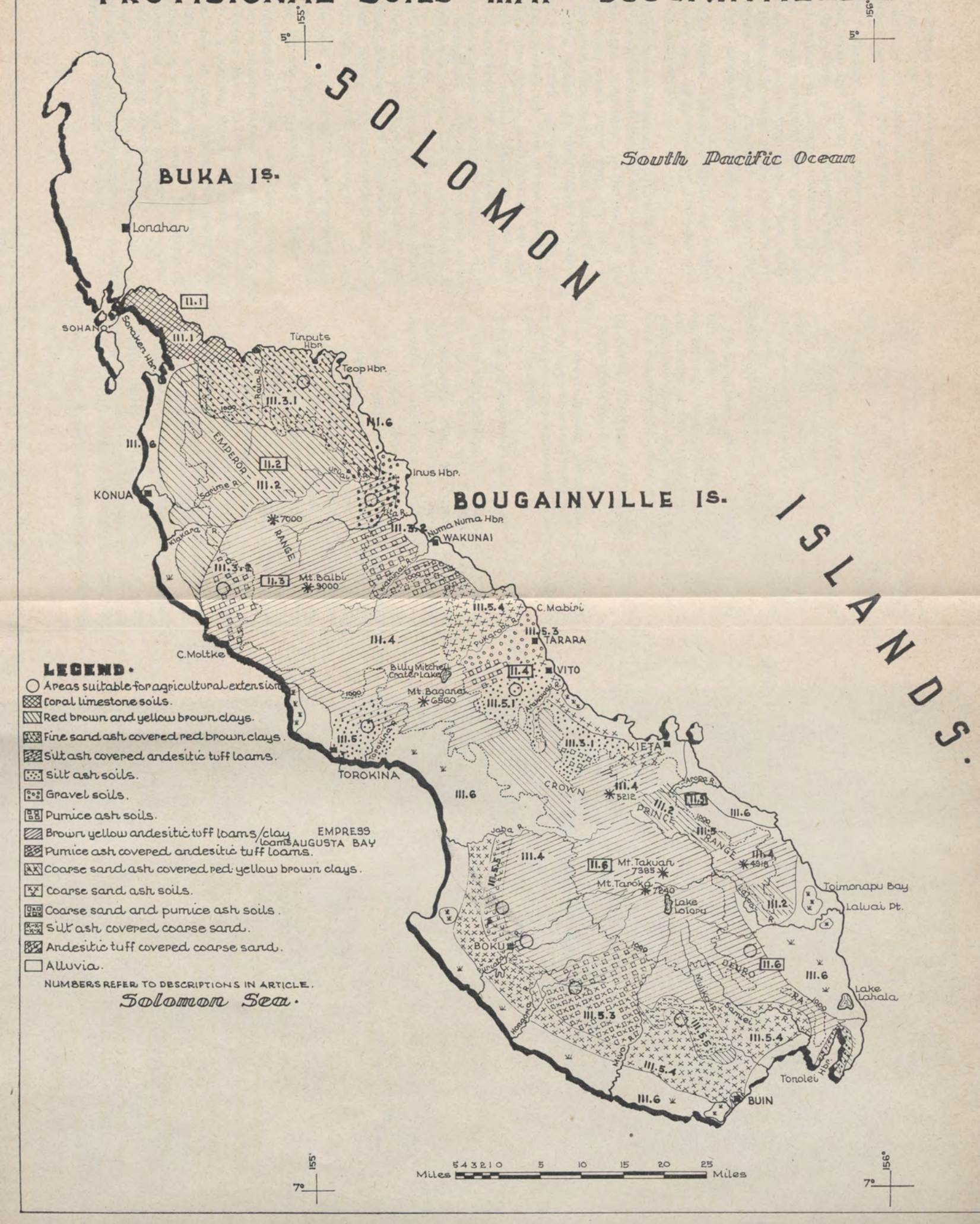
Ash soils composed of fine grey sandy ash or silty ash overlying grey coarse sand and gravel occupy the area from Mount Bagana and Mount Billy Mitchell towards the coast, approximately between Tarara and Arakawau River (Vito Area). Their agricultural value depends mainly upon thickness of the aeolian deposits. The difference in fertility between deep and shallow phases is reflected in the natural vegetation, which ranges from good quality rain forest on the deep, to scanty low forest on the shallower ones. Ash covered andesitic clayloams are found in higher locations around the periphery.

II.5 *The Crown Prince Range and alluvial lowland—*

This landscape consists of rugged mountain country with steep foothills and narrow isolated coastal plains. Soils consist of red and yellow heavy clays of mixed metamorphic-porphyric origin and of redbrown andesitic clayloams in areas of extinct vulcanizm. The soils have been exposed to severe truncation, and barren rock is present in many locations.

Agricultural development is restricted to a strip of foothill country and to the alluvial soils of the narrow coastal plain and valleys. The latter soils are heterogenous and are composed of alternating strata of brown medium clay and heavy clay overlying gravelly clays.

PROVISIONAL SOILS MAP - BOUGAINVILLE



LEGEND.

- Areas suitable for agricultural extension.
- Coral limestone soils.
- Red brown and yellow brown clays.
- Fine sand ash covered red brown clays.
- Silt ash covered andesitic tuff loams.
- Silt ash soils.
- Gravel soils.
- Pumice ash soils.
- Brown yellow andesitic tuff loams/clay loams.
- Pumice ash covered andesitic tuff loams.
- Coarse sand ash covered red yellow brown clays.
- Coarse sand ash soils.
- Coarse sand and pumice ash soils.
- Silt ash covered coarse sand.
- Andesitic tuff covered coarse sand.
- Alluvia.

NUMBERS REFER TO DESCRIPTIONS IN ARTICLE.

Solomon Sea.

The alluvial clays are exclusively occupied for copra and cocoa production. Deep drainage and discharge of superficial run off are pre-requisite measures for development.

The sedentary red and yellow clays on adjacent steep hill country are less productive than the alluvial soils. Although there are several centres of extinct vulcanizm in the Range, steep topography has prevented the formation of ash covered soils. Where these soils are found however, as fine ash sands over red-brown andesitic clayloams (Arawa), they are very productive plantation soils.

II.6 *The Mount Takuan-Taroka-Loloru foothill country and coastal plain of south-east and south Bougainville*—

Yellow brown loams and clayloams, derived from fine textured soft andesite tuff deposits and of the same composition as the soils of the Mount Balbi lower slope, cover the slope of this mountain complex and of the Deuro Range. The tuff is present as a thick deposit of yellow-brown soft rock, gradually decreasing in thickness towards the plain, where it covers the stratified fine brown sands, gravel, and grey coarse volcanic sands, originating from older liparitic sand flows. The tuff consists essentially of consolidated aeolian material of volcanic origin and disintegrates easily into fine sand under atmospheric influences. In the wet condition it has a distinctly greasy consistency. Denser layers of cemented sandy ash are often present and these soft "pan" formations commonly cause impeded drainage. Soil formation has only reached a juvenile stage and depth of the solum usually does not exceed two feet.

The soils are mainly friable grey-brown to yellow-brown sandy or silty loams, with red-brown variants of a more clayey texture.

Unfortunately these soils are frequently present as shallow phases, in particular west of the Puriata River in Nagovissi District, and there is a potential danger of waterlogging in these soils in cases where they occupy flat locations. Lateral water movement averts this possibility to a certain extent, but under all circumstances drainage measures are recommended. Growing conditions for tree-crops in particular will be improved considerably by deep drainage and the preparation of planting holes prior to planting.

Volcanic gravel and coarse pumice soils occur in central and east Siwai, between Hongorai and Mivo Rivers. Their agricultural value depends on the depth of the gravel layers below the surface and on the density of this material. The major part is either shallow or even skeletal.

The southern coastal plain has an elevation which ranges from sea level to about 300 feet. The higher elevations have well developed drainage ways, whereas the lower part is liable to periodic flooding and remains in a poorly drained condition throughout the year.

Owing to these adverse hydrological conditions this part of the plain has practically no agricultural value. This applies not only to the alluvia of the southern and south-western plain, but also to the low lying alluvia of the south-eastern Laluai plain.

III. SOIL PROFILE DESCRIPTIONS AND DISCUSSION—

In the following paragraphs more detailed descriptions of representative soils are given and where possible comparison is made with similar soils elsewhere.

III.1 *Coral limestone soils*—

With the exception of a narrow fringe along the coast of friable well drained red-brown to red calcareous clays of variable, but mainly shallow depth (Terra rossa), the soil profiles are typically of the following composition:—

0-12 inches.—Brown granular clay loam, in wet condition sticky and moderately plastic, cracking when dry; some accumulation of organic matter in the surface two inches, gradually grading into

12-24 inches.—Red-brown clay, in dry condition angular blocky and heavily cracking; in wet condition very sticky and very plastic, in this condition impermeable; good waterholding capacity.

24-40 inches.—Brown-red heavy clay, characteristics as for previous layer; internal drainage and water penetration very slow; irregularly grading into

40 inches +.—White compact coral limestone.

These heavy textured soils show a great similarity to the coral limestone soils of New Ireland. An elaborate investigation into the

chemical properties of the latter soils has revealed a close correlation between potassium content and productivity of coconut palms.

No indications of serious decline in productivity of coconuts are known from coral limestone soils of Bougainville or adjacent Buka Island, which is doubtless attributable to a certain potash-enrichment by volcanic ash.

For general agriculture the coral limestone soils are not attractive, being limited by heavy texture and the danger of droughtiness during periods of low rainfall.

III.2 *Red-brown and yellow-brown clay soils*—

A representative profile of these soils shows the following average composition:—

0-12 inches.—Grey-brown loam to clayloam, crumbly permeable, friable, good water-holding capacity, containing organic matter in the four inch top-layer, where under forest.

12-18 inches.—Reddish-brown clay, weakly cloddy, permeable, good waterholding capacity.

18-36 inches.—Yellow-brown clay, weakly compacted and cloddy, increasingly sticky and plastic in moist condition, containing concretions, reasonably permeable.

36-48 inches.—Greyish-brown and yellow mottled medium clay, compact, sticky and plastic when moist, containing angular blocky aggregates of heavy clay and an increasing amount of soft blue concretions; impeded internal drainage; good water-holding capacity.

48 inches +.—Decomposed, weathered out parent rock.

These soils occupy extensive areas of steep and dissected mountain country in the interior, where the topographic aspect minimizes agriculture to extensive shifting cultivation. Their fertility is mediocre to poor by local standards. On the lower foothills of Regions two and five (ref. II.2 and II.5) these clays are important as part of ash covered profiles.

III.3 *Ash-covered profiles*—

In general the sequence of horizons in ash covered soils, varies according to the origin of the volcanic deposits, distance from the eruption-centre, and force of the eruptions.

Along the north and adjacent section of the east coast (ref. II.2) the average foothill profile shows the following composition (On map indicated III.3.1):—

0-6 inches.—Brown-yellow loamy fine sand, friable, permeable; organic matter accumulation in the top two inches.

6-16 inches.—Grey-brown loamy fine sand, fine crumbly to loose, very permeable.

16-22 inches.—Reddish-brown clayloam, angular blocky in dry condition, granular to crumbly when moist; permeable, good water holding capacity.

22-36 inches.—Red or yellow-brown clay, compact, cloddy, good waterholding capacity; decreased permeability.

36-56 inches +.—Red or yellow brown mottled heavy clay, compact, sticky and plastic; good waterholding capacity; impeded internal drainage; containing blue stained weathered rock.

The cover layer in this area originates from old extinct volcanoes and has a uniform size sand particle. However, within the sphere of recent vulcanizm of Mount Balbi and Mount Bagana, the covering layer shows variability in grain size as indicated in the profile description of a representative soil from the area south of the Aita River. (Ref. II.3 on map indicated III.3.2.):—

0-10 inches.—Grey-brown yellow slightly loamy sand, crumbly to loose, very permeable; accumulation of organic matter in four inches topsoil.

10-18 inches.—Grey coarse pumiceous sand, loose, porous.

18-24 inches.—Light grey-brown fine volcanic sand, loose, porous.

24-36 inches.—Grey-yellow coarse volcanic sand and pumice, loose, porous.

36-48 inches.—Red-brown clayloam, friable, crumb structure with small angular blocky aggregates; permeable; good waterholding

capacity; slightly sticky and weakly plastic in wet condition (representing the top layer of the covered profile).

48-55 inches +.—Red-brown medium clay, cloddy, angular blocky, increasingly sticky and plastic; decreased permeability, good waterholding capacity.

The ash covered profiles, in particular the pumiceous ones, resemble soils of the Warangoi Series of New Britain, described by G. K. Graham.

Judging from the healthy appearance and high production of economic and subsistence crops, the ash covered soils of Bougainville have a satisfactory plant nutrient status.

Previous work on the Warangoi soils by Baseden confirmed a high nutrient status there.

However, it has been anticipated that mechanical stability and sustained fertility most likely will depend upon the maintenance of organic matter in these soils.

III.4 *Brown-yellow juvenile andesite tuff loams or clayloams*—

A representative profile is as follows:—

0-8 inches.—Brown-yellow loam, crumbly, permeable and friable, rich in organic matter in the top 4 inches under forest conditions.

8-16 inches.—Reddish-brown loam to clayloam, crumbly with fine angular blocky aggregates, permeable, slightly sticky and plastic.

16-22 inches.—Brown-yellow clayloam, granular to cloddy; clods easily crumbling under pressure when dry; slightly sticky and moderately plastic when wet ; good waterholding capacity.

22-36 inches.—Brown-yellow light clay, granular to cloddy; sticky and slightly plastic in wet condition; permeable; good waterholding capacity; containing some decomposing tuff of sandy clay texture and greasy consistence.

36-44 inches +.—Grey-brown decomposing andesite tuff, in which internal drainage is somewhat impeded.

The above profile is considered to be of favourable depth for general agriculture. In the shallower soils the effect of impeded drainage restricts the agricultural use considerably. "Soft pan," consisting of a compact layer of brown-yellow, partly decomposed tuff within the profile causes less severe impedance, which is easily ameliorated by drainage.

In general the plant nutrient status, except for nitrogen is considered satisfactory for the usual method of indigenous agriculture and for plantation crops. Deficiencies in nitrogen, phosphate and potash are likely to occur, however, under intensified agriculture.

These soils have their counterpart in the soils of the Sangara Crown land near Popondetta and the agricultural experience gained in this area is applicable to large areas of South Bougainville as well.

III.5 *Volcanic ash soils*—

Profile description of a silty ash profile (Vito area ref. II.4).

III.5.1—

0-12 inches.—Brown fine sandy loam; fine crumb structure, friable, permeable, reasonable waterholding capacity.

12-18 inches.—Grey-yellow loamy fine sand, fine crumb structure, permeable.

18-24 inches.—Grey pumice sand, with volcanic silt strata, porous as a layer, but water retaining in the separate pumice particles.

24-40 inches +.—Dark grey coarse volcanic sand, with strata of finer sand, ash and pumice.

The obviously aeolian deposits of sandy ash and pumice in the 24 inch upper layers are far superior in quality to the underlying coarse sand, originating from sand (lahar) flows.

Towards the coast the depth of the aeolian deposits decreases and the coarse sand is present within 14 inches from the surface.

III.5.2 *Gravelly ash profile from east coast near Terara (Bagana, Balbi area)*—

0-4 inches.—Brown fine sandy loam, fine crumbly, permeable, friable.

4-12 inches.—Yellow-grey silty ash, good waterholding capacity, permeable, friable.

12-30 inches +.—Gravelly ash, consisting of a grey coarse volcanic sand, rich in pumiceous gravel, porous.

III.5.3 *Gravelly ash profile from South Bougainville (Takuan, Taroka, Loloru complex)*—

0-4 inches.—Brown humic fine sandy loam, permeable, friable, good waterholding capacity.

4-18 inches.—Grey-brown fine sandy to silty loam, permeable, friable, good waterholding capacity; rich in pumice gravel.

18-22 inches.—Grey-brown clayey sand and dense pumice gravel, good waterholding capacity, permeable, friable.

22-30 inches.—Grey-yellow pumice sand and gravel.

30 inches +.—Gritty coarse volcanic sand.

III.5.4 *Sandy ash profile, from south Bougainville*—

0-8 inches.—Brown to yellow-brown sandy loam, permeable, friable, good waterholding capacity. Some organic matter in the top two inches.

8-12 inches.—Grey-brown slightly loamy sand, fine crumbly to loose, permeable.

12-40 inches +.—Coarse grey volcanic sand and rotten volcanic rock; rusty mottled due to a fluctuating high groundwater table.

III.5.5 *Fine sandy ash profile from South Bougainville*—

0-4 inches.—Brown sandy loam, crumbly, friable, permeable; organic matter restricted to three inches surface.

4-16 inches.—Brown-yellow sandy loam, crumbly, friable, good waterholding capacity.

16-28 inches.—Yellow-brown slightly loamy sand, weakly crumbly to loose, permeable, poor waterholding capacity.

28-36 inches +.—Grey coarse sand, loose, porous, showing rusty mottling, where under influence of a fluctuating groundwater table.

The above brief profile descriptions give an impression of the composition of the various ash soils. It should be borne in mind however, that profile depths are variable and that variations occur over rather short distances.

Adverse physical conditions exclude shallow gravelly ash soils, porous coarse sandy ash soils and compact, cemented sandy ash soils from successful agricultural development.

Generally, ash soils are provided with satisfactory total amounts of plant nutrients, but a high proportion is not readily available.

The weathering of soils from volcanic ash usually leads initially to the formation of very fine "allophane" clay.

This clay has no mechanism for potash retention and supplying power.

Having the availability to absorb organic matter strongly, allophane keeps phosphate out of circulation by slowing down the decomposition of the organic fraction. Phosphate becomes available to plants as the organic matter slowly decomposes.

The benefit of a legume ground cover on soils derived from volcanic ash, the andesite tuff clayloams included, it herewith explained.

Sudden deficiencies in potash and phosphorous are likely to occur with intensified cropping.

It is generally known that ash falls have a rejuvenating effect on the landscape.

III.6 *Alluvial soils*—

Alluvia are of comparatively minor importance. Coastal flats are narrow, discontinuous and only in the Laluai River area and along the south and south-west coast are there extensive alluvia. Textures are variable and usually show similarities with textures of surrounding soils. On the narrow coastal flats along the Emperor and Crown Prince Ranges and in the river valleys in these ranges, alluvia are of clayey texture, and gravel is often present as a component of the subsoil. As a result of adverse hydrological conditions most alluvia have a pale grey colour and show rusty mottling features

The alluvia of the Laluai area and of the south coast are composed of a wide variety of soils due to deposition of material of different

grain size in thin layers during recurrent floods. The major part of the alluvia are silts or silty loams at the surface, grading into a variety of light textured material to depth. The topography is flat, but in micro relief the country shows a complex pattern of slightly higher ground, separated by faint depressions. The ground-water level is high for long periods, and mottling in the upper horizon is common. Extensive areas remain in a permanent swampy condition.

The heterogenous composition of the soils, the high groundwater table and the possibility of frequent flooding, exclude most of these soils from agricultural development. The same restrictions apply to the alluvia on the south and south-west coast of Bougainville, which consist predominantly of pale grey coarse sands, often gravelly and inter-stratified with layers of clayey sand. The groundwater level is high throughout the year, and rusty mottling close to the surface is usual. Apart from the fact that drainage creates a major problem for these low marshy areas, the soils apparently have a low fertility status, even for paddy rice.

IV. CURRENT LAND USAGE AND AGRICULTURAL POTENTIAL—

The economy of the island is similar to that of the other parts of the Territory and depends mainly on income from the plantation products, copra and cocoa. Indigenous agricultural production of subsistence crops is determined by local demand, but could eventually contribute to the food supply of urban centres in other parts of the Territory.

In postwar years there has been a strong tendency among the populaton to grow commercial crops, but as a result of the economic position and distance to prospective markets, the specific ability of soil and climate for the production of particular crops has not been fully utilized.

Crops of significance for the indigenous economy are coconuts, cacao, and coffee, besides dryland rice, peanuts, maize, soya beans, and tobacco.

In general coconut palms are healthy and productive along the north-west, north and east coast. Poor soil conditions caused by compacted and cemented volcanic sands and hence droughtiness, and shallowness of soils and poor drainage in depressed areas are the main contributing factors to unsatisfactory development and production. It appears that the coconut plantations north of Kieta show a higher average production than those south of this town.

There are no coconut plantations along the south and south-west coasts, and attempts to establish plantations on the coarse grey sands with a shallow loamy topsoil have not been encouraging, even where drainage has been introduced.

Village groves are usually closely spaced, which has favoured the spread of *Corticium* disease, and this has caused some unproductivity of the palms.

The production of cocoa ranks second in importance after copra. Cacao growing on plantations, on Mission stations, and by the population, has made steady progress in recent years. The crop shows a vigorous development and satisfactory production on the foothills of the north and east coasts, as well as on well drained alluvia. Occasional borer attacks are a cause of concern.

In south Bougainville this crop thrives well on sandy ash soils, provided that at least two feet of sandy loam, loamy sand and fine sand overlies the coarse sand. The importance of a green manure groundcover for the purpose of increasing the organic matter content of the soils and the need for good shade are often under-estimated. Where these essential measures are omitted, cacao growing is threatened with failure. Serious menaces for the crop are *Corticium* (pink) disease and black pod.

Cacao growing on the coarse grey sands with a very shallow topsoil should be discouraged since these soils have no clay fraction and have a very low exchange capacity. This, combined with the characteristic of high permeability, makes cacao growing hazardous.

Successful growing of cacao on the andesite tuff loams and clayloams depends on effective drainage, preparation of planting holes and establishment of groundcover and shade prior to planting.

The creation of rural societies fosters land use in compact areas contrary to the usual system of gardening in small and often isolated plots. Concentration enables correct management and

protection of crops such as rice, peanuts, maize, and soybeans against pests and diseases. At the same time it opens the possibility for mechanized agriculture in the southern plain and on flat and gently sloping country on the east coast for progressive groups.

Coffee as a cash crop could be a valuable asset for the lower mountainous regions, where the temperature is a limiting factor for cacao growing.

However, most of the mountain country is too steep and dissected to advise its occupation by primitive communities. Coffee has been introduced successfully in the hilly country and valleys of the north-west and east coast.

A good quality cigar tobacco is grown on ash-covered soils and ash soils on the east coast. The product is for local use only, but with proper guidance this crop could become of importance to the local economy. Soils and climate favour a good quality product.

The villagers engage in shifting cultivation and rely on a period of forest fallow to build up organic matter in the soils and so maintain fertility.

The institution of rural societies tends inevitably to stimulate land reform in areas with suitable soils and topography. Unfortunately a big part of the population dwells on steep, dissected country, where development of prosperous rural societies is problematic.

The southern plain has by far the best prospects for agricultural expansion. The agricultural potential is high, the topography favourable, and the area is accessible along a system of roads. A big drawback is the absence of a safe anchorage, a condition that could be corrected at Buin by constructing a breakwater. Development of the at present inaccessible fertile Laluai River area depends entirely on the construction of a road to Tonolei Harbour.

Favourable areas for prospective development have been indicated on the accompanying map.

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