PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

Some Soils of the British Solomon Islands Protectorate

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Some soils of the British Solomon Islands Protectorate

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[Plate 46]

CONTENTS

Soils were studied on the islands of Guadalcanal, Kolombangara, Santa Isabel, San Jorge, and San Cristobal, mainly under tropical rain forest in mountainous inland regions.

The climate of the Solomon Islands is characterized by high temperatures and humidity, copious rain and a high proportion of cloudy days, with little seasonal variation except in the rainfall of the central coastal region of northern Gaudalcanal. In the areas studied soils on stable sites are deep, and intensely weathered and leached. On steep slopes soils are shallow and unstable, with much colluvial rock debris. Most soils are strongly acid to acid (pH 3 to 5) clays and have very low plant nutrient contents.

On soils from basic igneous and ultrabasic metamorphic rocks weathering and leaching have resulted in loss of virtually all of the more readily weatherable constituents and extreme relative accumulation of oxides, principally of aluminium, iron and titanium. Rendzinas are found on recently exposed coral limestone, but older limestone areas have strongly leached soils similar to those on basic igneous rocks.

The Solomons soils are related to similar soils in Hawaii, Western Samoa, New Caledonia, New Zealand, Australia, the West Indies and south-east Asia. In general the most strongly leached Solomons soils have reached a stage of degradation beyond that of similar soils described from other regions.

There is apparently an almost closed organic cycle of nutrient turn-over under rain forest, with most of the available plant nutrients concentrated in organic-matter-enriched surface soil horizons and with little contribution to plant growth from underlying mineral horizons. There is little evidence of close relationships between soils and vegetation, except in soils derived from serpentine which have a forest dominated by *Casuarina papuana*. Large-scale destruction by fire of *Casuarina* forest on soils from serpentine has resulted in loss of surface horizons by erosion, failure of the forest to regenerate, and formation of laterite on the bare soil surface. Small-scale destruction of forest for native gardens appears to have little long-term effect on soils or vegetation.

'Soil' animals are usually confined to logs and other above-ground habitats and are rare in the soil, apparently due to the extreme wetness and probably partial anaerobiosis of below-ground habitats.

A. Introduction

As a member of the Royal Society's British Solomon Islands Expedition, 1965, the author studied soils on the islands of Guadalcanal (western districts on and adjacent to Mt Gallego, and terraces south-east of Honiara), Kolombangara in the New Georgia Group, Santa Isabel (eastern districts adjacent to Thousand Ships Bay and Tatamba Harbour), San Jorge, and San Cristobal (eastern districts south and east of Wainoni) (figure 13).

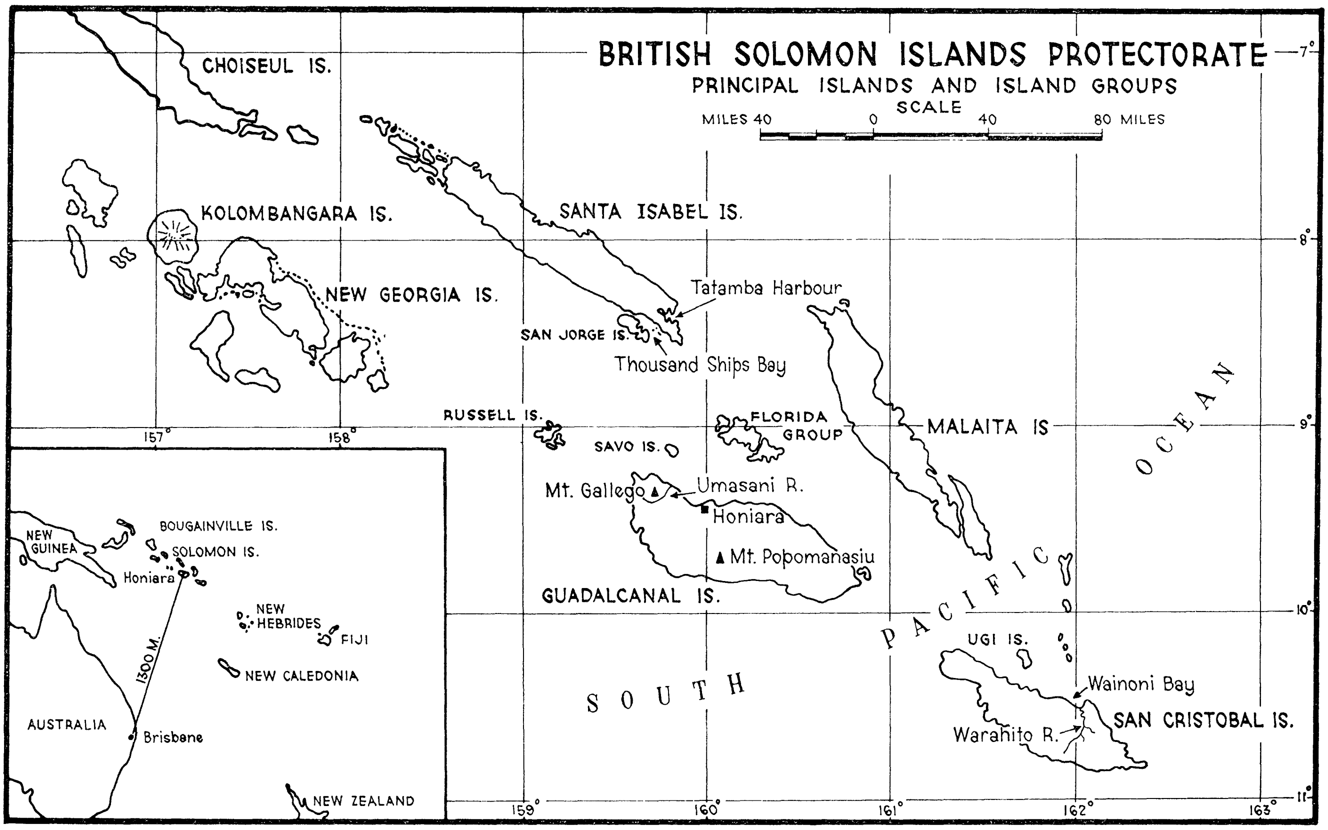

Figure 13. Outline map, principal islands and island groups, British Solomon Islands Protectorate. (The spelling Popomanasiu is retained on this map although the spelling Popomanaseu is used throughout the text of this Discussion.)

The soils of most wet tropical regions are poorly known and understood. The Expedition presented an opportunity to gather basic data on such soils in a little known part of the world. The author was invited to take part in the Expedition as a zoologist and also undertook soil work to help the biologists to interpret their ecological data. It seems likely, however, that the information, together with comments on soil fertility, weathering and soil formation, may be of interest to foresters and agriculturists in the Solomons and other wet tropical areas, and perhaps more generally to scientists concerned with studies of tropical soils.

Because of the lack of adequate base maps, the short time available at each place, and the difficulty of defining landscape units in heavily forested country, no attempt was made to map soils. In each of the areas visited the author attempted to assess what were the most significant soil units in the landscape and to sample soils and describe profiles at selected sites. To help in the ecological work of the expedition, special attention was paid to possible relationships between soils, plants and animals.

Previous soil investigations in the Protectorate have been confined to the Guadalcanal Plains adjacent to Honiara, and a few other areas of possible agricultural interest (Ballantyne 1961; van Baren 1961; Beatty, Colwell & Hutton 1962; Grange 1949; Grover 1958, 1965; Ojala 1947). Van Wijk (1963) described and mapped soils of agricultural importance in Bougainville, and Scott, Heyligers, McAlpine, Saunders & Speight (1967) discussed soils and environmental conditions of Bougainville and Buka Islands. The soils studied by the present author were mainly those of mountainous inland areas and would have little or no agricultural potential. With the proposed future development of large-scale forestry and mineral industries, mountainous inland areas are likely to be involved and there is a need for knowledge of their soils. There is a need for detailed study of lowland soils, which could be important for agricultural development.

The author is grateful for advice and assistance freely given by J. C. Grover, R. B. Thompson, and other officers of the B.S.I.P. Departments of Geological Surveys, Forestry and Agriculture, and to fellow members of the expedition and locally recruited assistants and porters for their help in the field. Analyses reported in this paper were done by J. Buckerfield, R. George, S. McLeod, J. Pickering, G. Moore, and J. T. Hutton, all of C.S.I.R.O., Division of Soils, Adelaide, and their assistance is gratefully acknowledged.

B. The soil environment

1. *Physical factors*

(*a*) *Geography and geology*

The British Solomon Islands Protectorate comprises six large islands or groups of islands and a large number of small scattered islands. The large islands and island groups extend south-eastward in a double chain from the southern tip of Bougainville (part of the Australian Trust Territory of New Guinea) between 7° and 11° S latitude, 156° and 163° E longitude (figure 13), while scattered islands continue south-eastward almost to the New Hebrides. The total land area is approximately 11500 sq. miles, scattered over about 250000 sq. miles of the south-west Pacific Ocean.

The principal islands and island groups are predominantly rugged and mountainous, deeply dissected by closely spaced swift-flowing rivers, with narrow valley floors and ridge crests separated by steep valley sides, except in areas of ultrabasic rocks, where the ridge crests are smoothly rounded. The coastal plain on the north coast of Guadalcanal is the most extensive area of flat land; most islands have narrow coastal platforms, usually of coral rock, and large rivers (e.g. Warahito River, in eastern San Cristobal) have small flat terminal deltas.

The larger islands are 90 to 120 miles in length (NW to SE) and up to 20 to 25 miles wide, rising to about 4000 ft., but much higher on Guadalcanal, where the highest peak (Mt Popomanaseu) in the Kavo Ranges is 8005 ft.

Much geographical information may be found in Grover (1957) and in papers by Grover and others in the four volumes of B.S.I.P. Geological Survey Memoirs and Reports.

A first geological map of the British Solomon Islands has recently been published

(Coleman, Grover, Stanton & Thompson 1965). The map covers most of the islands of the Protectorate at a scale of 32 miles to 1 inch, and is supplemented by many more detailed maps and papers published in the years since the establishment of the Geological Survey in 1950. All the areas in which soil investigations were made during the expedition are included in the 1965 map, and some have been covered by more detailed geological surveys.

Coleman *et al.* (1965) state that the Solomons are of dominantly andesitic affiliation and are composed largely of Tertiary to Recent lavas and volcanically derived sediments, with substantial limestone beds, overlying a basement of older schists and plutonic rocks. Serpentines and other intrusive ultrabasic rocks, with sediments derived from them, are also a prominent feature of the islands. The Kaipito–Korigole thrust zone, with which are associated the ultrabasic intrusive rocks of Santa Isabel, divides the main islands into a north-eastern zone, embracing Malaita and part of Santa Isabel and characterized by folded structures, and a southern zone, in which Guadalcanal and San Cristobal clearly fall, characterized by extensive block faulting. The New Georgia Islands, including Kolombangara, consist of a number of Pleistocene and Recent volcanic cones with marginal reef and lagoonal sediments. Extensive deposits of volcanic ash, like those recognized as soil-forming materials by van Wijk (1963) in Bougainville, were not seen. Recently deposited ash had led to greatly enhanced soil fertility in Bougainville, where it frequently forms a light-textured layer, well supplied with plant nutrients, over old heavy textured soils.

Coleman (1965) discusses the stratigraphy of the islands. Areas in which soils were studied are listed below, with some notes from Coleman and other authors on the parent materials of soils sampled.

(i) *Guadalcanal*

(*a*) Quaternary Gallego lavas and older, probably Oligocene, lavas of the basement complex on the eastern slopes of Mt Gallego in western Guadalcanal. Thompson (1965*a*) identifies these rocks as andesites.

(*b*) Soils on some outcrops of Betilonga limestone (Miocene) on ridges in the Umasani River–Mt Gallego area.

(*c*) Quaternary Honiara beds, a series of terraces resulting from uplift of fringing reefs, south of Honiara. Soils sampled were on coral limestone.

(ii) *Kolombangara Island, New Georgia Islands*

There is a small parasitic cone of Gallego-type andesite, but soil work was confined to the Pleistocene olivine pyroxene basalt lavas (identified by J. C. Grover, pers. comm.) that form the bulk of Kolombangara.

(iii) *Santa Isabel and San Jorge*

(*a*) Ultrabasic intrusive serpentines, probably upper Oligocene on San Jorge, upper Pliocene on eastern Santa Isabel (Stanton 1961; Coleman 1965), adjacent to Thousand Ships Bay and Tatamba Harbour.

(*b*) Pre-Miocene basalt (Sigana volcanics) close to the north-western edge of Tatamba Harbour, and Mesozoic (?) gabbro near the north coast of San Jorge.

(*c*) Several small areas of calcareous and non-calcareous sandstone on the coast of Santa Isabel adjacent to Thousand Ships Bay and on islets in the Bay.

(iv) *San Cristobal*

(*a*) Basaltic pillow lavas (Warahito lavas), pre-Miocene in age, in the catchment area of the Warahito River, which reaches the sea at Wainoni.

(*b*) Soils on lenses of limestone associated with the Warahito lavas and tentatively dated as upper Oligocene, in the Warahito catchment.

(*c*) Serpentines (Wainoni ultrabasics) in the headwaters of the Huni River, about 2 miles east of Wainoni Bay. The age of these rocks is in doubt, but they have been tentatively dated as upper Oligocene. The area sampled is described by Thompson (1965*b*) as a faulted slice of ultrabasic rock, adjacent to a parallel slice of gabbroic rock. It forms the upper slopes and summit of a rounded hilltop, from about 1500 to 1700 ft. above sea level.

(*b*) *Climate*

Information on the climate of the Solomon Islands is scanty. Brookfield (in this Symposium, p. 207) discusses rainfall, temperature and wind directions and relates the seasonal weather patterns to the broader south-west Pacific region. His conclusions are tentative as there is a need for more data.

In relation to soils and soil formation the most important features of the climate may be summarized as follows:

(1) The Solomons are among the wettest regions of the globe; although rain shadow areas are evident on leeward coasts during the south-east season (about April to September) in general there is copious rain. Mean annual rainfall at coastal stations is rarely less than 100 in. There are no records for inland areas, but there is a great increase in orographic cloud and rainfall is much heavier and more frequent than at coastal stations. Wright (1963) quotes estimates by Angenheister that there is an increase of 16 to 22 % in rainfall for each 250 ft. rise in altitude on the foothills of the mountains of Western Samoa, and conditions in the Solomons are probably similar.

(2) The mean monthly temperature at coastal stations is close to 80° F, with little variation through the year. Mean daily minima and maxima are about 74 and 86° F respectively. In Western Samoa it is estimated (Wright 1963) that there is a fall in mean temperature of about 2·7 °F for each 1000 ft. increase in altitude; Speight & Scott (1967) estimate a fall of 3·5 °F for each 1000 ft. in Bougainville; Cline (1955) gives a figure of 2·5 to 3·0 °F for each 1000 ft. in Hawaii but L. D. Swindale (pers. comm.) states that recent work has shown a fall of 5 °F per 1000 ft. up to 3000 ft. and 3 °F per 1000 ft. thereafter. Taking the figures for Western Samoa and Bougainville as a basis, mean annual temperatures at the summit of Mt Gallego (3504 ft.) would be about 68 to 72 °F, of Kolombangara (5540 ft.) about 62 to 68 °F, of Mt Popomanaseu (8005 ft.) about 52 to 62 °F.

(3) Relative humidity at coastal stations rarely falls below 80 % and is usually higher. Measurements made in the rain forest during the expedition were always over 90 % and usually close to 100 %.

(4) There is a high proportion of cloudy days. Mean cloud amount at coastal stations is about 6 on a scale of 0 to 10.

Soils are therefore developed under conditions of heavy rainfall, constant high temperature and low rate of evaporation. Insufficient data are available to calculate potential evapo-transpiration but, with the possible exception of sandy soils near the coast, Solomons soils must be in the class of hydrous soils, as defined by Taylor & Pohlen (1962). This class includes soils that on the average are above field capacity for all months of the year and are continuously above field capacity and over-wet for long periods. Taylor & Pohlen (1962) state that for 18 New Zealand stations with adequate records the mean soil temperature at a depth of 3 ft. is $3{\cdot}2 \pm 0{\cdot}4$ °F higher than mean air temperature. Taking their figures as a basis, mean soil temperatures in the Solomons must be about 80 to 85 °F at coastal stations, and about 55 to 65 °F on the summit of Mt Popomanaseu.

2. *Biological factors*

(*a*) *Vegetation*

The whole of the Solomon Islands is clothed in tropical rain forest apart from an area adjacent to the north coast of Guadalcanal, including Honiara and the Guadalcanal plain, which lies in the rain shadow of the Mt Popomanaseu mountain massif and has a grassland vegetation (Whitmore 1966), small grassed areas of Nggela Island and open heath on soils from ultrabasic rocks on the islands of Santa Isabel and San Jorge. Whitmore notes that there are local variations in the rain forest, the most striking being the forest type found on many areas of soils derived from ultrabasic rocks. The rainforest variant typical of ultrabasic areas is that commonly dominated by *Casuarina* spp., usually *C. papuana* at inland sites and *C. equisetifolia* along the coasts.

Altitudinal zonation is marked in the typical rain forests. Pendleton (1949) distinguishes lowland (0 to 400 ft. altitude), mid-mountain (600 to 3000 ft.) and upland (above 3000 ft.) forest belts in Guadalcanal. Whitmore (1966) and Whitmore (this Symposium, p. 259) notes that the zones are highly compressed compared with those on the higher mountain ranges of New Guinea. For instance, he states that mossy forest comes down to 2300 ft. on Vangunu Is. (New Georgia Group). During the expedition mossy forest was found at similar altitudes on Kolombangara Is. (*ca.* 2800 ft.) and on Mt Gallego in Guadalcanal (*ca.* 3000 ft.), and even lower (*ca.* 1500 ft.) near Wainoni in San Cristobal. Reijnders (1964) found that on the Star Mountains, in West Irian, mossy forest is present from about 5200 ft., but that forest zonation is compressed on small isolated peaks and ridges and on coastal mountains. Compared with the high inland mountains of New Guinea, all Solomon Islands mountains would be classed as coastal. Local variations in orographic cloud are probably most important in controlling the development of mossy forest in the Solomons. The relationships of altitude, temperature and incidence of fog to zonation in tropical rain forests are discussed in detail by Grubb & Whitmore (1966) and their conclusions are confirmed in Solomons forests.

Casuarina-dominant forests of areas of serpentinous rocks were seen at Santa Isabel, San Jorge, and near Wainoni in San Cristobal. Unlike the typical rain forest, *Casuarina* forest burns readily. Indiscriminate burning at Santa Isabel and San Jorge has resulted in baring of the soil surface over considerable areas, and loss of surface soil horizons by sheet and gully erosion. On severely eroded surfaces forest has not regenerated, and the heath vegetation, which is locally referred to as grassland, now consists of low-growing *Gleichenia* (*s.l.*), *Lycopodium*, some grasses and small shrubs, occasional Pandanaceae, and much bare ground. Soils in the burnt areas have deteriorated to a level where recovery of forest vegetation appears to be unlikely for a long time.

The Guadalcanal Plain and the raised marine terraces parallel to much of the north coast of Guadalcanal are the only extensive grass-covered areas in the Islands. During the season of south-east winds, the grassland areas are in the rain shadow of the highest portion of the Kavo Ranges. Reference to climatic data shows that this portion of Guadalcanal has a definite dry season, which led Ojala (1947) and Pendleton (1949) to conclude that the grasslands are relatively stable plant associations, resulting from inadequate moisture for forest growth in the dry season. Ballantyne (1961), on the other hand, considers that on the Guadalcanal plain there is adequate water for forest growth in the dry season, and proposes that superfluity of water in the wet season prevents forest growth. Whitmore (1966, and in this Symposium p. 259) and authors quoted in Pendleton (1949) consider that the Guadalcanal grasslands may result from long continued burning of formerly forested areas. The last explanation seems most likely, and has been favoured in some other humid tropical areas where extensive grasslands are found. Reiner & Robbins (1961) conclude that the grasslands of the middle Sepik plains, in similar latitudes in New Guinea, are a fire disclimax induced by man-made fires during the last 400 to 800 years on a previously forested landscape. The Sepik grassed plains resemble the Guadalcanal plain in having an annual rainfall of 65 to 80 in. and a dry season, when there is a soil moisture deficit, of 2 to 5 months per year.

In the typical rain forests there is a succession of surface litter types from mull to mor to peat with increasing elevation. The succession is well developed on Kolombangara, where a transect was made by the expedition up one ridge, from 150 ft. above sea level to the summit of the mountain at 5540 ft. In the lowland forest, up to about 1200 ft., the dominant humus form is mull; from 1200 ft. to about 1500 ft. both mull and mor and also intermediate forms between them are found; from about 1500 ft. to about 2800 ft. there is mor, usually fibrous, sometimes greasy; from about 2800 ft., where mossy forest begins, there is spongy moss peat on the ground surface, and this is more or less continuous to the summit of the mountain.

Reijnders (1964) states that in the humid tropics, for rain forest on soils from basic parent material, rapid mineralization of organic matter, i.e. formation of mull type humus, may be expected at altitudes of about 0 to 600 m (0 to 2000 ft.), mineralization and humus accumulation to be more or less equal at 600 to 1000 m (2000 to 3300 ft.), and humus accumulation, i.e. mor or peat formation, to predominate above 1000 m. The corresponding zones are compressed on Kolombangara and on other Solomons mountains, and this is consistent with the compression of altitudinal zonation of forest types, referred to above.

(*b*) *Human influences*

The native population of the Protectorate numbers about 192000 and most of the people live in small villages. Copra production is the main source of export income, and coconut palms are grown in small native-owned coastal plantations, as well as in large Europeanowned plantations, mainly on coastal soils derived from coral limestone, alluvium and colluvial debris. Taro, sweet potato, bananas, pineapples, pawpaws and a few other food crops are grown in small village or family garden plots.

In preparing a garden, a small area of forest is felled, the trees are burned when dry, and the food crops are planted with little cultivation of the soil. A garden may be used for 2 or 3 years and is then abandoned and another area is cleared and planted. Sites selected for gardens are usually on coastal platforms, alluvial terraces in river valleys, or on gently sloping hillsides. Interference with the surface litter and soil is minimal and abandoned garden lands quickly revert to forest, usually with little loss of soil by erosion. A few gardens are located on steep hillsides and severe erosion and slumping were seen on some such sites. Village sites are usually kept bare of all vegetation and, especially where they are built on hilltops, are severely eroded. On San Cristobal many abandoned village sites were seen on ridge crests inland from Wainoni. At an abandoned village site on soil derived from serpentine near Wainoni, a bare ferruginous laterite crust covered much of the ridge crest, but at other abandoned village sites on soils derived from basalt there was no laterite crust and forest regrowth had covered the eroded soil surface. The total area of garden and village sites that had suffered severe erosion was very small on the islands visited.

The only severe and extensive damage unquestionably done by man to soils on the islands visited is on soils derived from serpentine at Santa Isabel and San Jorge. Burning of standing *Casuarina*-dominant forest on these soils has resulted in baring of the ground surface over large areas and loss of the upper soil horizons by sheet erosion (see discussion of soil morphology, p. 222). The reason for burning the forest is not clear. It would not have been burned to clear land for crops as soils derived from serpentine are avoided in selecting garden sites. The fires may be accidental, or they may be deliberately lit by hunting parties or as a form of entertainment. The author considers the last explanation most likely; it was frequently necessary to restrain some locally recruited porters and assistants, who delighted in setting fire to any vegetation that was dry enough to burn.

The great loss of soil, decline in fertility and disastrous effects on regeneration of forest that have resulted from large-scale human interference on soils from serpentine should be carefully considered in the planning of forestry operations on hilly and mountainous lands in the Solomons. Chemical analyses and field examination of soils reported in this paper, e.g. at Kolombangara Island, show that there is usually a concentration and rapid cycling of plant nutrients close to the soil surface under rain forest. The underlying mineral soil is frequently almost devoid of nutrients. If the upper horizons are lost by erosion, and this is likely to happen on cleared land under the very heavy rainfall, there may be little hope of re-establishing plant cover without heavy application of fertilizers. The scale of land clearing is the important factor. Small-scale clearings, such as village and garden sites, are usually quickly recolonized by peripheral invasion from the surrounding forest. Large-scale clearings are very different and may result in far-reaching damage to soils and vegetation.

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C. Soils

The climate of the Solomon Islands is conducive to rapid rock weathering, severe leaching, and flushing of weathering products from the soil. Tropical rain forest, which covers most of the Islands' area, is probably the most spectacular vegetation on the earth and its luxuriance is often taken as an indication of a high level of soil fertility. The results reported in this paper show, however, that nearly all the soils studied are extremely impoverished, and other studies of soils under tropical rain forest elsewhere have led to the same conclusion.

1. *Profile morphology and soil chemistry*

(i) *Guadalcanal*

(*a*) *Soils derived from andesite lavas*

Soils were examined on the andesitic lavas (probably Oligocene in age) of the basement complex on ridges adjacent to the Umasani River valley, and on Pleistocene andesitic (Gallego) lavas adjacent to Hidden Valley on the eastern slopes and summit of Mt Gallego. Ridges in the area are generally narrow and steep, and most of the landscape comprises precipitous scree slopes, frequently over 40°, on ridge sides. Significant soil profile development is confined to relatively stable sites on breaks in the slope of ridge crests.

Morphology. Soils on steep ridge sides are lithosols. Instability apparently prevents the development of mature rain forest and most slopes have dense low forest rooted in rock crevices, and some bare areas where recent landslides have destroyed the vegetation.

Profile 1 (Appendix 1) is on the basement lavas, and is typical of ridge-top sites, though it may be as deep as 4 ft. Some small fragments of andesite are evident throughout the profile, indicating down-slope movement of colluvial debris even on gentle slopes. There is an increase in clay content and associated iron-strained mottles and a decrease in aggregate stability down the profile. These soils are confined to areas of lowland forest and have granular mull-type litter.

The soils on the Pleistocene andesitic lavas of ridge top sites at higher altitudes are more variable. At 2500 ft. on a broad ridge crest there was a deep red-brown soil similar to that on the older andesites (profile 1), but more commonly, on narrower ridge-crest sites, soils are similar to profile 2, at 2380 ft. The litter changes from mull to fibrous mor over a narrow transitional zone at about 2000 ft. Under the fibrous mor at 2380 ft. there are slight signs of development of a bleached A_2 horizon, but there is no iron pan. Stones are present throughout the profile, indicating downslope movement; there is some texture differentiation, with increasing clay content down the profile, but little development of structural aggregates.

Above about 3000 ft. the slopes are very steep and the forest changes to mossy montane rain forest. The soils are regosols except on the small flattish area at the summit (3504 ft.). On the summit (profile 3) there is a soil similar to the thin iron pan soil described below (profile 16) from the summit of Kolombangara Island, but differing in that the iron pan is thicker and less cemented, and is located at the top of the B_2 horizon instead of directly under the gleyed A horizon. In this respect it more closely resembles the normal podzols distinguished by Crompton (1952) on English moorlands, but differs from the latter in having a strongly gleyed A horizon. Saturated strongly acid peaty mor overlies the mineral soil, and as at Kolombangara probably maintains saturated anaerobic conditions in the A horizon, while the underlying material is relatively well drained and aerobic. The soil is a sticky, massive clay, with no stable structural aggregates.

Chemistry. Chemical data are in Appendix 2 (profile nos. 1 to 3). Soils on the older andesite (profile 1) are slightly acid to acid, low in K and P, but comparatively high in Mg, while those on the younger andesite (profiles 2, 3) are strongly acid to slightly acid, with rather low plant nutrient content. Even if these soils were fertile they would be of little economic value, as they are found only in isolated small areas in a predominantly unstable landscape.

(*b*) *Soils derived from coral limestone*

Morphology. Soils developed on hard coral limestone 275 ft. above sea level near Kukum (profile 5) have A–C type profiles very similar to those of rendzinas in temperate regions. The vegetation is predominantly tall grassland, but may formerly have been forest. The A horizon is very dark, with strongly developed blocky structure and lies directly on unweathered rock, or on a transitional AC horizon containing much granular weathered limestone that sometimes extends down into deep solution cracks or fractures in the underlying rock.

On older more deeply weathered limestone surfaces the soils do not resemble rendzinas. Two profiles (nos. 4, 6) are described, one (no. 4) on Miocene limestone on a ridge above the Umasani River valley and one (no. 6) on Quaternary limestone on Mt Austen. Both have developed under lowland rain forest. They are dark red-brown to brown clays, grading to red and yellowish red down the profile with blocky structures near the surface and fine weakly developed crumb structures at depth.

Chemistry. Chemical analyses are in Appendix 2 (profiles 4 to 6). The rendzina (profile 5) is alkaline, with pH 8 to 8·5. There is an abrupt change at the bottom of the A horizon, to material consisting largely of unweathered calcium carbonate. Samples M 123/4, M 123/3 contained respectively 48·0 and 84·0 % $CaCO_3$. The strongly weathered soils (profiles 4, 6) are acid to neutral in reaction. Sample M 124/4, from 28 to 56 in. depth at profile 6, has a pH of 4·5 although it rests on hard, apparently little weathered coral rock. Chemically the soils are similar to strongly leached Solomons soils from a variety of parent materials. It is possible that the soils at profile sites 4 and 6 are not derived entirely from limestone, but may have received additions of volcanic tuff. (See Discussion on p. 234.)

(ii) *Kolombangara*

An altitudinal sequence of soils derived from olivine pyroxene basalt

Kolombangara Island is a Pleistocene volcanic cone, roughly circular, about 20 miles in diameter, and 5540 ft. high on the narrow ridge of the crater rim. The central crater is about 1½ to 2 miles in diameter, 3000 to 4000 ft. deep, with precipitous walls, and is drained by a very deeply entrenched stream which has breached the south-east wall of the crater. There is a narrow coastal shelf consisting largely of raised fringing coral limestone reefs, and a small parasitic cone of andesitic (Gallego) lavas in the southern portion of the island, but the bulk of the island is formed from olivine pyroxene basalt flows (J. C. Grover, pers. comm.). The slopes of the south-eastern lowlands are largely covered by alluvial and colluvial debris derived from the crater and the deep gorge of the stream draining it, and project in a broad tongue from the otherwise nearly circular outline of the island. The remainder of the island is more stable and is drained by radial streams, deeply entrenched, divided by steep-sided narrow ridges in the uplands which grade into broad gently sloping stable slopes in the lowlands.

Apart from small areas on the coastal fringe that are currently used for gardens and plantations by the indigenous population, the whole island is covered with dense rain forest.

The island presents an unusually favourable opportunity to study the altitudinal sequence of soils formed on a near uniform parent material under conditions of high temperature and heavy rainfall, conducive to rapid rock weathering and intense leaching. Soils were examined on a transect about 10 miles long from near sea level adjacent to Dolo Cove, on the south coast of the island, along the ridges adjacent to the Kolombara River to the south summit (5540 ft.) on the crater rim. The transect was selected to avoid the alluvial and colluvial debris of the south-eastern sector of the island and the more recent andesitic lava of the parasitic cone, and the soils are probably typical of the major portion of the island. Sites were selected for special study in lowland forest at 225 ft. and 1000 ft., in montane forest at 2100 ft. and 2600 ft. in a mossy montane forest at 3000 ft., in montane forest at 4000 ft., in mossy upper montane forest on the south summit at 5540 ft., and also on a small alluvial terrace of the Kolombara River at 100 ft. above sea level.

Morphology. Profile descriptions of soils and ecological data for the selected sites are in Appendix 1 (profiles 7 to 17).

On the gentler slopes and up to 3000 ft. or a little more ridge-top sites are relatively stable, and the soils are deep, predominantly clay, with sandy or gritty concretionary inclusions of gibbsite and iron oxides in deeper horizons and with little texture differentiation down the profile. They have unstable coarse granular or blocky structures that break down readily to fine crumb structures in the upper horizons, except in the lowland site at 225 ft., where there is a strongly developed stable granular structure at 0 to 10 in., possibly due to the activities of a large population of earthworms (*Pontoscolex corethrurus*). Greig-Smith, Austin & Whitmore (1967) report fine charcoal particles 'distributed down the profile' in lowland soils of northern and western Kolombangara. Charcoal was not found in the soils sampled by the present author; apparently there has been widespread burning of the forest in the past in northern and western areas of Kolombangara. Greig-Smith *et al.* note that the west-coast soils tended to be more sticky, more compact and yellower than the northern ones, some of which were very friable and dark chocolate brown or occasionally blackish in colour. At higher elevations soils are shallower, with some relatively unweathered parent material evident almost to the surface, indicating some down-slope movement even on gentle slopes.

There is a gradation in surface humus forms from shallow granular mull in the lowland forests, through a transitional zone from mull to mor at about 1200 to 1500 ft., increasing thickness of mor to about 2800 ft., changing to moss peat above this altitude, the peat increasing in depth to 12 to 16 in. on the crater rim.

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The soils are generally well drained, red, reddish brown or yellowish red in colour, but at gently sloping ridge-top sites where surface accumulation of peat is very deep, e.g. at profile sites 12 (3000 ft.) and 16 (5540 ft.), the soils are intensely gleyed in surface horizons immediately under the saturated peat. On the crater rim (profile site 16) under deep moss peat there is a profile morphologically very similar to the shallow thin iron-pan soils described by Crompton (1952) from northern England. Morphologically, this soil with strongly gleyed bleached A_2 horizon overlying a thin iron pan might be taken as a shallow gley podzol. However, its chemistry and mineralogy, which are discussed below, are entirely different from those normally associated with gley podzols in temperate regions of the earth.

On steep ridge-side slopes adjacent to the ridge-top sites soils are generally shallow, with much colluvial debris mixed throughout the profiles (see profile descriptions 11, 13 and 15).

The alluvial soil sampled at 100 ft. above sea level (profile 17) shows some indication of clay movement and iron accumulation and formation of a B horizon below 24 in. Alluvial soils are confined to small areas beside the Kolombara River. Most of these areas are in use or have been used as garden land by the local people.

Chemistry. Results of chemical analyses of soil samples are listed in Appendix 2 (profiles 7 to 17).

All the soils are strongly acid to acid, with pH values generally between 3·0 and 5·0, increasing down the profile, sometimes to 6·0 or 6·5. On the summit of the island (profile 16) bleached material from the gleyed $\frac{3}{4}$ to $1\frac{1}{2}$ in. (A_2) horizon had a pH of 2·5, probably due to the presence of sulphuric acid produced by bacterial activity in the saturated anaerobic soil. Total K and Mg figures are very low in lowland soils, reflecting the strongly leached nature of the soils, but are higher in the soils of the montane zone (profiles 14, 16) and that from alluvium (profile 17), reflecting the presence of relatively unweathered parent material in the soil. Total P figures are comparable with those recorded by Stace (1961) in some strongly leached Australian krasnozems and lateritic krasnozems derived from basalt.

There is some concentration of nutrients in the humified surface horizons. The profile descriptions show that plant roots are concentrated close to the surface and are rare below 12 to 18 in. Nye & Greenland (1960) have pointed out that in tropical soils under mature forest it is well known that the nutrients are maintained in a nearly closed organic cycle from which few nutrients are lost in the drainage water, and this would seem to be the case in the Kolombangara soils. The mineral soils are so low in nutrients that they probably contribute little to plant growth.

Mineral weathering in the Kolombangara soils is discussed later in this paper (p. 226). The soils of stable areas may prove to be a worth-while source of bauxite for aluminium production, but their potential for sustained agricultural or forestry use is probably very low.

(iii) *Santa Isabel and San Jorge*

(*a*) *Soils derived from serpentine*

Eastern Santa Isabel and the adjacent island of San Jorge have extensive areas of soils derived from serpentinized peridotites. The serpentine areas are readily distinguished from

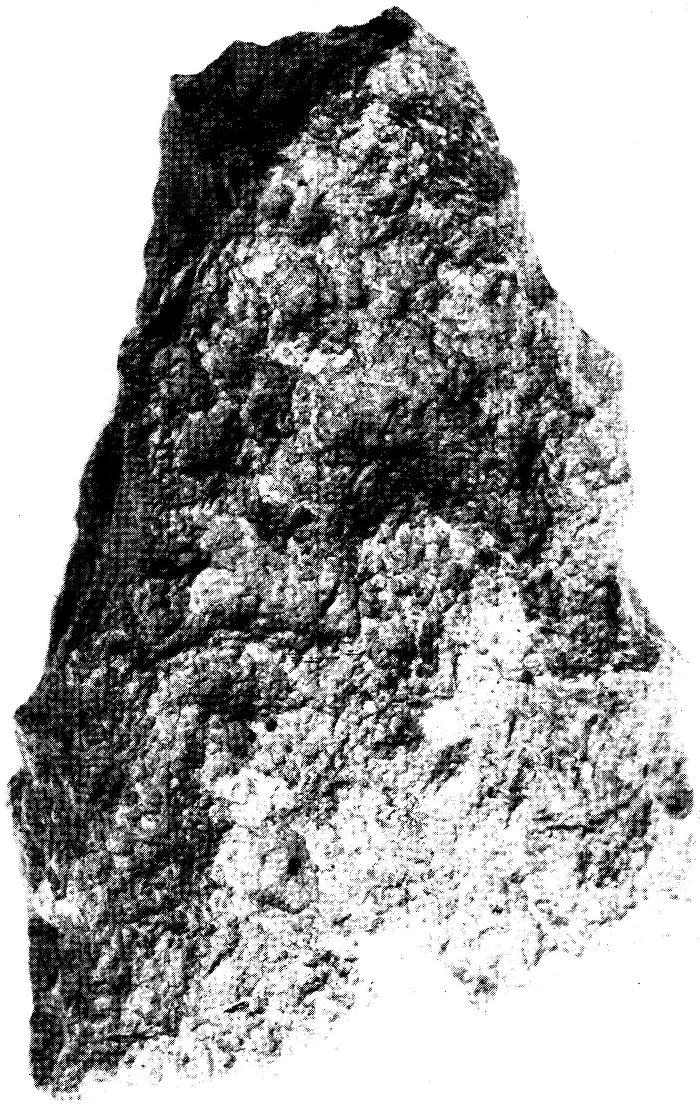

FIGURE 14. Upper surface of irregular flattened laterite concretion from bare ground surface of soil derived from serpentine, Tanameko Cove, Santa Isabel Island. (Maximum dimensions 12 cm × 8 cm × 4·5 cm thick.)

(*Facing p.* 223)

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adjacent sedimentary and igneous rocks by their gently rounded contours, which contrast with the rugged topography of the landscape in other rock types, and by their vegetation, which is an unusual forest climax dominated by a few species, in many places by the very distinctive *Casuarina papuana*, or where the forest has been burned by low fern, scrub and grasses with much bare ground. Thompson (1965*b*) has mapped the distribution of serpentinized ultrabasic rocks and their associated soils in the Solomons and has distinguished forest-covered from fern-covered areas. All the fern-covered areas were probably formerly in forest.

Soils were examined on the ridge above Tanameko Cove at Santa Isabel and in the eastern portion of San Jorge, inland from Astrolabe Bay and Albatross Bay. Two soil profiles, one under *Casuarina* forest (no. 18) and one on a ridge bared by fire (no. 19) are included in Appendix 1. The soils are predominantly red and contain small nodular lateritic concretions. Clay textures are characteristic apart from slight sandiness in upper horizons, and the proportion of clay increases with depth. Under forest there is a superficial layer of fibrous litter, up to 12 in. deep, but usually 3 to 6 in. deep, overlying the mineral soil. In de-forested areas there is no litter, and the soil surface is usually covered with a thin layer of laterite concretions, mainly rounded, 1 to 2 mm in diameter, but occasionally irregular flattened fragments, up to 15 cm across and 5 cm thick, consisting of cemented masses of small concretions and laminae of indurated material (figure 14, plate 46). This material is associated with very stable fine granular non-lateritic aggregates in the surface soil, more stable than the aggregates in soil under forest. Small particles of charcoal are mixed with the surface material. There is abundant field evidence of sheet erosion and down-slope movement of soil on de-forested areas, with deep accumulations of colluvium in gullies and in the sea at the mouths of streams. The granules and lateritic nodules are apparently all that remain of former soil horizons after the removal of finer materials by erosion. Very small lateritic nodules are present in the profile described under forest and are most numerous at 6 to 33 in. Comparing the morphology of the forested profile with that described from de-forested country it seems likely that the residue of what was formerly equivalent to the 6 to 33 in. horizon under forest is now concentrated in the 0 to 6 in. horizon of the profile from de-forested country. The de-forested profile may have lost about 2 ft. of surface material by erosion since the forest was destroyed. At some other de-forested sites erosion has resulted in loss of greater depths of soil; occasionally the soil mantle has been entirely removed and weathered serpentine is exposed at the ground surface.

Chemistry. These soils are strongly acid (pH 3·25 to 4·5), extremely leached, and very low in plant nutrients, especially P and K (Appendix 2, profiles 18, 19). They appear to have reached a stage of mineral degradation where all but the upper organic-matter-rich layers under forest have virtually ceased to be soils, in the usual sense of the word, and have become accumulations of residual oxides (see tables 4 to 6) that cannot be further weathered by soil-forming processes. Their apparent infertility and unusual forest cover could be taken as due to selection of plant species able to tolerate specific chemical toxicities, especially Ni and Cr. However, Spence & Millar (1963) have shown that in a Shetland serpentine soil infertility was due to P deficiency associated with low N and K, and not to mineral toxicity. All major nutrients are so low in the Santa Isabel soils that the same limitations on plant growth must apply. Dominance of *Casuarina* may be primarily due to its ability to fix atmospheric N.

(*b*) *Soils derived from basalt and gabbro*

Near Regi village, on the western side of Tatamba Harbour, coconuts are grown on cleared areas of hilly land on basaltic (Sigana) lavas, formerly in lowland forest. The coconuts grow very poorly and produce little fruit. The soil (profile no. 21) is a well-drained deep brown clay loam, grading into sandy clay with some iron-stained nodules and becoming redder with increasing depth. There are some earthworms near the surface, and fairly stable structural aggregates may be due to their burrowing and casting; in deeper horizons the structural aggregates are unstable. The soil is slightly acid to neutral; total K and Mg are not low, but total P is very low and may be limiting for plant growth (Appendix 2, profile 21).

Similar soils have developed on gabbro, of the basement complex, on the hills near Talise village, San Jorge (profile 20). These soils are used for gardens; like the soil from basalt described above, levels of K and Mg are not low, but levels of P are probably limiting (Appendix 2, profile 20).

(*c*) *Soils from calcareous and non-calcareous sandstones*

Small areas of sandstone, calcareous sandstone and limestone outcrop around the margins of Thousand Ships Bay and make up many of the small islands in the Bay.

Profile 22 (Appendix 1) was recorded at Kirigi Is., on soft calcareous sandstone. The soil is reddish brown to red in colour, with sandy loam to sandy clay texture. This is the only soil seen by the author in the Solomons that is greatly influenced by earthworm activity; the upper horizons have strongly developed nutty to blocky structures, consisting largely of the casts of a large earthworm species, whose burrows extend down to 10 to 12 in. pH is near neutral (Appendix 2, profile 22) and plant nutrients appear to be adequate for garden crops. Lilihinia Is., adjacent to Cockatoo Anchorage, has similar soils.

On non-calcareous sandstone, near Sesendo village, Santa Isabel, soils are similar, but more strongly leached (profile 23), with lower Mg but similar K and P content.

(iv) *San Cristobal*

(*a*) *Soils derived from basalt pillow lavas*

Most of the area visited by the expedition in eastern San Cristobal consists of basalt pillow lavas (Warahito lavas). On ridge crests soils derived from the basalt are red clays (profile 24), with weakly developed structure, acid to slightly acid, varying in depth up to 6 ft. or a little more. They are similar to soils from basic andesite in the Umasani River area of Guadalcanal (profile 1). Ridge sides are steep and usually have very shallow soils, but are not as unstable as in the Umasani area.

(*b*) *Soils on limestone*

Limestone outcrops are scattered through the basalts. Soils on the limestone (profile 25) are deep, reddish brown to red, plastic clays, with weakly developed structure and little differentiation into horizons. They are very strongly leached and like the soils on old limestones in Guadalcanal (profiles 4, 6) may not be derived entirely from the underlying calcareous rocks. The forest that grows on them has no consistent special features that distinguish it from the forest on adjacent basalts.

(c) *Soils derived from serpentine*

Serpentine outcrops on a hilltop in the headwaters of the Huni River, about 2 miles east of Wainoni R.C. Mission Station. It coincides almost exactly with a small area of mossy *Casuarina–Podocarpus* forest, and soils have developed under shallow strongly acid moss peat (profile 26). There is a slight concentration of plant nutrients in the surface peat, but the underlying mineral soil has very low plant nutrient content. Like the 'soils' derived from serpentine on Santa Isabel and San Jorge, there would seem to be no economic potential in the soils of this small area of serpentine. The area is of great botanical interest, and might best be reserved for scientific purposes.

2. *Weathering and soil formation*

In the hot, wet climate, of the Solomon Islands, weathering and leaching of soil minerals on stable sites have led to the formation of soils low in silica and high in residual oxides of iron, aluminium, titanium and sometimes chromium. Soils with low silica/sesquioxide ratios which are typical of humid tropical regions, especially on basic rocks, contrast with many soils of humid temperate regions, especially those on quartz-rich rocks, which are characterized by high silica and low sesquioxide content in upper horizons and accumulation of sesquioxides in lower horizons. The contrast has led many authors to the conclusion that different soil-forming processes must operate. The tropical process is referred to as laterization, and the temperate process as podzolization. That there is no validity in this distinction has been pointed out by Carter & Pendleton (1956) and by other authors.

The soil-forming processes that operate in the humid tropics are essentially the same as those that operate in humid temperate regions. Because of the high temperatures and heavy rainfall of the humid tropics leaching is more intense than in temperate climates, the chemical effects of soil-forming processes are more strongly expressed, and differences in the mineral composition of parent rocks are sometimes reflected in great differences in the mineral composition of the resultant soils.

D'Hoore (1954) considers the mineral and solid part of the soil as a mixture of three groups of constituents:

(A) *The constituents which accumulate or will accumulate.* These include free oxides of Fe, Al, Ti, Mn, etc., together with the same elements still bound in the form of weatherable minerals.

(B) *The exportable constituents.* These include materials more soluble in water, such as salts and silica, together with the same elements still bound in the form of weatherable minerals.

(C) *The stable constituents.* These are the minerals that are only slightly weatherable, such as quartz, heavy residual minerals, etc.

He distinguishes between absolute accumulation of sesquioxides, which results from the import into the system of group A constituents, and relative accumulation of sesquioxides which results from the export of group B constituents. The end products of weathering are greatly influenced by the constitution of the original unweathered rock. Basic rocks weather rapidly under humid tropical conditions and leaching of mobile elements from well-drained soils is also rapid, leaving a residuum rich in gibbsite, and some iron oxides. If this material becomes indurated it may occur as 'gibbsitic laterite' or 'bauxite laterite'. Ferruginous rocks, such as peridotites, yield a residuum rich in iron oxides and with some gibbsite, which if indurated may occur as 'ferruginous laterite'. More acid rocks weather more slowly and clay minerals, especially kaolin, are formed (near the surface the content of aluminium oxide and iron oxides increases and laterite may be formed).

Examples of the processes described by d'Hoore are evident in the soils of the Solomon Islands, especially those of Kolombangara Island and those derived from serpentine at Santa Isabel, San Jorge and San Cristobal.

Chemical analyses of the unweathered olivine pyroxene basalt of Kolombangara and of some samples of soils derived from it on the island are in table 1. Comparing the composition of soil with rock it is apparent that in lowland soils and up to 3000 ft. rock weathering has been severe, with removal of exportable constituents of d'Hoore's group B, including much silica and nearly all of the more soluble soil constituents, such as Mg, Ca, Na and K. Relative accumulation has resulted in high concentrations of aluminium and iron oxides. The removal of silica is particularly marked in a sample from 36 in. in the profile at 3000 ft., where the ratio silica:sesquioxides has fallen to 0·02, compared with 1·67 in the unweathered rock. This is a reflexion of the particularly strong weathering and leaching associated with very heavy rainfall (see discussion below) and development of deep acid peat (pH 3·5) on a stable site. The lowland sites show similar tendencies, but not such extreme degradation. Some absolute accumulation of sesquioxides in the soil horizons sampled has probably added to the effects of relative accumulation. At the 4000 ft. and 5540 ft. sites some sesquioxide accumulation has also taken place, but its effect is masked by the presence throughout the profiles of minerals contained in colluvial unweathered rock, as the general slope of the landscape is steeper than at the lower sites. In table 2 the ratios of the various elements in the samples of table 1 are related to those in unweathered rock. All sites show relative enrichment in sesquioxides and loss of silica. At the montane sites loss of the more soluble constituents is less pronounced.

Minerals identified in whole soil samples from the profiles are listed in table 3. The dominant minerals at all sites up to 3000 ft. are gibbsite, iron oxides and kaolin. At the montane sites there are significant amounts of feldspars and pyroxenes, which are components of the parent material. Some feldspar is also present in the soil from alluvium at 100 ft., probably in particles of unweathered rock brought down the mountain and deposited by the Kolombara River.

Sherman (1952) discusses the sequence of clays formed with increasing intensity of weathering of basalt in Hawaii. The general sequence is: primary minerals of the parent material → montmorillonite → kaolinite → free oxides. Where the climate is seasonally wet and dry the free oxides are predominantly hydrated iron and titanium oxides. Under continuously wet conditions, as at Kolombangara, the end product is predominantly

TABLE 1. COMPOSITION OF SOME IGNITED ROCK AND SOIL SAMPLES FROM OLIVINE PYROXENE BASALT, KOLOMBANGARA ISLAND

altitude (ft.)	sample no.	sample depth (in.)	loss on ignition (%)	SiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	TiO_2 (%)	MnO (%)	Mg0 (%)	CaO (%)	Na_2O (%)	K_2O (%)	P_2O_5 (%)	total (%)	ratio: $\frac{SiO_2}{Al_2O_3}$	ratio: $\frac{SiO_2}{Fe_2O_3}$	ratio: $\frac{SiO_2}{R_2O_3}$
unweathered olivine pyroxene basalt …				50·52	18·72	11·54	0·93	0·19	5·97	8·33	3·01	1·64	0·38	101·23	2·70	4·38	1·67
soil samples																	
225	M 91/5	54	22·0	16·34	50·48	27·00	2·59	0·10	0·34	0·09	0·01	0·06	0·34	97·36	0·32	0·61	0·21
2100	M 88/6	36–54	22·2	22·02	50·51	23·01	1·80	0·15	0·23	0·07	0·01	0·07	0·22	98·09	0·44	0·96	0·30
2600	M 89/7	60	21·6	21·28	44·27	29·01	2·54	0·54	0·41	0·06	0·01	0·08	0·28	98·48	0·48	0·73	0·29
3000	M 84/6	36	27·8	2·18	67·52	25·05	2·47	0·10	0·38	0·05	0·00	0·03	0·23	97·99	0·03	0·09	0·02
4000	M 87/5	24	11·8	45·53	23·97	14·45	1·25	0·23	6·02	6·21	0·00	0·62	0·29	98·57	1·90	3·15	1·19
5540	M 86/6	32	16·3	43·14	23·70	14·79	1·45	0·24	8·23	6·46	0·41	0·75	0·34	99·49	1·82	2·92	1·12

TABLE 2. RATIO OF CHEMICAL CONSTITUENTS IN KOLOMBANGARA ISLAND SOIL SAMPLES TO THOSE OF PARENT MATERIAL

altitude (ft.)	sample depth (in.)	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5
parent material (olivine pyroxene basalt)		1·00	1·00	1·00	1·00	1·00	1·00	1·00	1·00	1·00	1·00
soil samples											
225	54	0·32	2·70	2·34	2·78	0·53	0·06	0·011	0·003	0·04	0·89
2100	36–54	0·44	2·70	1·99	1·94	0·79	0·04	0·008	0·003	0·04	0·58
2600	60	0·42	2·37	2·51	2·73	2·84	0·07	0·007	0·003	0·05	0·74
3000	36	0·04	3·61	2·19	2·66	0·53	0·06	0·006	0·000	0·02	0·61
4000	24	0·90	1·28	1·25	1·34	1·21	1·01	0·75	0·000	0·38	0·76
5540	32	0·85	1·27	1·28	1·56	1·26	1·38	0·78	0·136	0·46	0·89

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TABLE 3. X-RAY DIFFRACTION ANALYSIS OF ENTIRE SOIL SAMPLES FROM KOLOMBANGARA ISLAND

soil profile no.*	sample no.	depth (in.)	altitude (ft.)	gibbsite	goethite and/or haematite	magnetite	kaolin	hydrated halloysite	quartz	cristobalite	feldspar	pyroxene	amorphous material
7	M91/2	10–27	225	little	little (G) and (H)	little	much	—	—		—	—	—
	M91/4	40–54	225	little	little (G) and (H)	little	much	—	—	—	—		
	M91/5	54	225	much	little (G)	moderate	little	—	—	—	—		—
8	M90/2	4–11	1000	moderate	moderate (G) and (H)	moderate	moderate	—	—	—	—		—
	M90/4	32–50	1000	moderate	moderate (G) and (H)	little	moderate	—	—	—	—	—	—
9	M88/2	0–3	2100	little	little (G)	moderate	much	—	—	—	—		
	M88/4	12–36	2100	little	little (G)	moderate	much	—	—	—	—	—	—
	M88/6	36–54	2100	much	little (G)	moderate	moderate	—	—	—	—	—	—
10	M89/2	0–4	2600	much	moderate (G)	little	trace	—	—	—	—	—	—
	M89/4	21–33	2600	much	moderate (G) and (H)	moderate	trace	—	—	—	—		—
	M89/6	48–60	2600	much	moderate (G) and little (H)	moderate	little	—	—	—	—	—	—
	M89/7	60	2600	much	moderate (G), trace (H)	little	moderate	—	—	—		—	—
12	M84/2	0–2	3000	little	moderate (G)	—	—	—		—	—	—	moderate
	M84/4	6–25	3000	much	moderate (G) little (H)	little	little	trace	—	—	—	—	—
	M84/6	36	3000	much	little (G)	little	—	—	—	—	—	—	—

TABLE 3 (*cont.*)

soil profile no.*	sample no.	depth (in.)	altitude (ft.)	gibbsite	goethite and/or haematite	magnetite	kaolin	hydrated halloysite	quartz	cristobalite	feldspar	pyroxene	amorphous material
13	M85/2	6–24	3000	much	little (G) and (H)	moderate	little	trace	—	—	—	—	—
	M85/4	30	3000	much	little (G), moderate (H)	little	—	—	—	—	—	—	—
14	M87/2	0–1½	4000	trace	little (G)	moderate	little	—	—	—	—	—	moderate
	M87/3	1½–7	4000	trace	little (G)	moderate	little	little	—	—	—	—	—
	M87/5	24	4000	trace	—	moderate	trace	little	—	—	moderate	moderate	—
16	M86/2	0–1½	5540	—	—	—	—	—	—	—	—	—	much
	M86/3	1½–3	5540	little	moderate (H)	moderate	—	—	trace	little	—	—	—
	M86/5	10–30	5540	little	moderate (H)	little	trace	moderate	—	—	—	—	—
	M86/6	32	5540	—	moderate (H)	little	—	moderate	—	—	little	much	—
17	M92/1	0–18	100	trace	little (G) and (H)	moderate	moderate	little	—	—	little	—	—
	M92/3	34–40	100	trace	little (G) and (H)	moderate	moderate	trace	—	—	little	—	—

Notes. The amorphous material reported in samples M84/2, M87/2 and M86/2 is largely organic. In the presence of gibbsite and magnetite the distinction between goethite and haematite is difficult and where necessary the dominant of these two minerals has been indicated by the appropriate capital letter. The quantities expressed have the following significance: much, > 40 %; moderate, 20–40 %; little, 5–20 %; trace, < 5 %.

* Refers to soil profile number in Appendix 1.

gibbsite or kaolin. Two Hawaiian hydrol humic latosols quoted by Sherman have silica/alumina ratios of 0·37 and 0·31, similar to those of lowland Kolombangara soils (table 1). Montmorillonite was not found in any of the Kolombangara soil samples. Lang (1967) discusses weathering of a sequence ranging from basaltic to dacitic volcanic rocks in Dominica, where climate, vegetation and topography are similar to those of the Solomons. In the most strongly leached soils of very high rainfall areas the clay fraction was largely callophane or gibbsite (up to 50 to 60% of whole soil), with free iron oxide, probably limonite. Allophane was not found in Kolombangara soil samples, but gibbsite contents of more than 40% (up to more than 70%) were common in soils up to about 3000 ft. The most common parent rock of Dominican soils is hypersthene andesite, though some basalt is found.

In the soil at 5540 ft. absolute accumulation of sesquioxides has resulted in the formation of a thin iron pan (see profile description no. 16). A thick layer of strongly acid peat (pH 3·0), saturated with water, overlies the mineral soil. Above the iron pan there is a strongly gleyed, saturated horizon, apparently kept wet and anaerobic by the spongy mass of peat overlying it. Beneath the iron pan the soil is better drained and is not gleyed. The situation closely resembles that described by Crompton (1952) for thin iron pan soils in northern England.

D'Hoore (1954) has pointed out that to be maintained in the mobile condition trivalent iron requires larger quantities of complexing compounds than does bivalent iron. Iron compounds would become mobilized as ferrous ions in the anaerobic gleyed horizon and would be deposited to form a pan when oxidized to the ferric state in the relatively aerobic conditions at the bottom of the gleyed layer. Once a thin iron pan is formed, drainage of the overlying gleyed material would be further impeded. It would be expected that, given sufficient time, the thin iron pan would move down the profile, slowly disintegrating in the anaerobic environment of the gleyed horizon and reforming in the aerobic environment beneath the pan, and the gleyed horizon would increase in depth. The gleyed soil described from 3000 ft. (profile 12) closely resembles that at 5540 ft., except that it has no iron pan beneath the gleyed horizon. The absence of a pan probably results from the removal of weathering products by lateral subsurface drainage which would be more effective on the steeper slopes at the 3000 ft. site than on the gentle slope of the 5540 ft. site. The processes that operate at these sites are essentially the same as those that operate in a 'podzolic' process, and the profiles, especially that at 5540 ft. are morphologically similar to the gley podzols of humid temperate climates. The difference would seem to be that there is little quartz or other highly resistant material of d'Hoore's group C in the parent rock, so that there is no relative accumulation of siliceous material in the upper horizons, as is frequently found in podzolic soils on quartz-rich rocks.

The serpentinized peridotites of Santa Isabel and San Jorge have similar SiO_2 and Fe_2O_3 contents to the Kolombangara rocks, but are much lower in Al_2O_3. Comparison of the composition of rock and soil samples from a typical profile (table 4) shows that weathering and leaching have degraded the soil more than in the lowlands of Kolombangara. Most of the SiO_2, MgO, CaO and K_2O have been removed, resulting in extreme relative accumulation of Al_2O_3, Fe_2O_3, TiO_2, MnO and Cr_2O_3. Table 5 shows the ratios of concentrations of various elements in soil samples to those in unweathered rock. The

TABLE 4. COMPOSITION OF SOME IGNITED ROCK AND SOIL SAMPLES FROM SERPENTINE, SANTA ISABEL AND SAN CRISTOBAL ISLANDS

soil profile no.	sample no.	material	sample depth (in.)	loss on ignition (%)	SiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	TiO_2 (%)	MnO (%)	MgO (%)	CaO (%)	K_2O (%)	NiO (%)	Cr_2O_3 (%)	P_2O_5 (%)	SO_3 (%)	total (%)	ratio: SiO_2/Al_2O_3	ratio: SiO_2/Fe_2O_3	ratio: SiO_2/R_2O_3
Santa Isabel Island																				
18	M116/2	soil	0–3	23·8	n.d.	n.d.	68·64	0·50	n.d.	n.d.	n.d.	n.d.	0·38	7·50	n.d.	n.d.	—	—	—	—
	M116/4	soil	6–33	15·7	1·62	13·17	72·75	0·19	1·09	1·50	0·01	0·00	1·09	6·00	0·03	0·31	97·76	0·12	0·02	0·02
	M116/5	soil	33–54	14·6	3·72	9·88	77·10	0·14	0·89	1·31	0·01	0·00	1·02	4·50	0·01	0·23	98·81	0·48	0·05	0·40
	M116/6	soil	54–84	15·2	6·09	10·01	74·10	0·09	1·59	2·17	0·06	0·01	0·89	4·50	0·03	0·30	99·84	0·61	0·08	0·07
	M116/8	serpentine rock		9·4	48·15	1·43	9·28	0·02	0·15	37·57	0·81	0·01	0·78	0·70	0·01	0·24	99·15	33·67	5·19	4·50
San Cristobal Island																				
26	M114/2	soil	0–6	20·5	n.d.	n.d.	82·25	0·67	n.d.	n.d.	n.d.	n.d.	0·89	6·00	n.d.	n.d.	—	—	—	—
	M114/3	soil	6–26	20·7	3·02	20·76	68·94	1·94	0·25	1·02	0·00	0·01	0·25	3·00	0·03	0·45	99·67	0·14	0·04	0·03
	M114/5	soil	29–39	17·9	n.d.	n.d.	75·72	1·33	n.d.	n.d.	n.d.	n.d.	0·25	4·50	n.d.	n.d.	—	—	—	—

n.d. = not determined.

TABLE 5. RATIO OF CHEMICAL CONSTITUENTS IN SANTA ISABEL SOIL SAMPLES TO THOSE OF PARENT MATERIAL (SERPENTINE)

sample no.	sample depth (in.)	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	MgO	CaO	K_2O	NiO	Cr_2O_3	P_2O_5	SO_3
parent material (serpentine)		1·00	1·00	1·00	1·00	1·00	1·00	1·00	1·00	1·00	1·00	1·00	1·00
soil samples													
M116/2	0–3	—	—	7·40	25·00	—	—	—	—	0·55	10·72	—	—
M116/4	6–33	0·03	9·21	7·28	9·50	7·27	0·04	0·01	0·00	1·40	8·59	3·00	1·27
M116/5	33–54	0·08	6·13	8·31	7·00	5·94	0·03	0·01	0·03	1·31	6·42	1·00	0·96
M116/6	54–84	0·13	7·90	7·99	4·50	10·60	0·06	0·07	1·00	1·14	6·42	3·00	1·25

TABLE 6. MINERALOGY OF $< 2\ \mu m$ FRACTION OF SOIL SAMPLES FROM SERPENTINE, SANTA ISABEL AND SAN CRISTOBAL ISLANDS

soil profile	sample no.	sample depth (in.)	goethite	haematite	talc
18	M116/2	0–3	much	little	trace
	M116/4	6–33	much	—	trace
	M116/5	33–54	much	—	—
	M116/6	54–84	much	—	trace
19	M115/1	0–6	much	moderate	trace
	M115/3	9–18	much	moderate	—
	M115/4	18–36	much	moderate	—
26	M114/2	0–6	much	—	trace
	M114/3	6–26	much	—	trace
	M114/5	29–39	much	—	trace

The quantities expressed have the following significance: much, > 40 %; moderate, 20–40 %; little, 5–20 %; trace, < 5 %.

very high concentration of Fe_2O_3 relative to Al_2O_3 in soil samples reflects similar proportions in the unweathered rock, and contrasts with the opposite situation in the Kolombangara samples, where in rock and soil samples Al_2O_3 predominates over Fe_2O_3. It is apparent that the same processes have operated as at Kolombangara, i.e. the exportable constituents of d'Hoore's group B have been removed, leaving high concentrations of the oxides of d'Hoore's group A.

The clay fraction of the soil samples (table 6) consists almost entirely of iron oxides with small quantities of talc (hydrated magnesium silicate) surviving from the parent rock. In profile 19, from a de-forested area at Santa Isabel, there are moderate concentrations of haematite in all samples, contrasting with profile 18, under *Casuarina* forest, where haematite is found only in small quantities near the surface.

Few analyses are available for a soil (profile 26) derived from serpentine under mossy forest (*Casuarina* dominant) near Wainoni in San Cristobal. Chemical analyses (table 4) and clay mineralogy (table 6) indicate that it is similar to profile 18, under forest at Santa Isabel.

3. *Correlation with soils in other areas*

Insufficient information has been accumulated to attempt a classification of all Solomon Islands soils, but it is possible from the data in this paper to relate the soils described to those of other Pacific areas where more detailed soil studies have been made.

(*a*) *Soils derived from basalt and other basic igneous rocks*

Relationships can be seen between soils derived from these rocks in the Solomon Islands and soils derived from similar rocks in Australia and New Zealand. It could be said that if the concept of an Australian krasnozem or a New Zealand red loam were extended to include soils that are very much more leached and in which mineral weathering has proceeded far beyond that found in typical krasnozems and red loams, the Solomons soils could be included in these groups. The author considers that there is little to be gained by doing this, and it is preferable to compare the soils more directly with soils described from Pacific islands with more similarities in environment.

The sequence of soils from olivine pyroxene basalt at Kolombangara has close parallels in soils from olivine basalt, under heavy rainfall and non-seasonal climate, described by Wright (1963) from Western Samoa.

Fusion analyses of the Samoan olivine basalt (Wright 1963) show less SiO_2 and Al_2O_3, more TiO_2 and iron oxides, but there is a general similarity in composition to the Kolombangara rock. Soils from the Samoan rocks have similar content of SiO_2, less Al_2O_3, and about the same or lower content of other mineral constituents.

The Kolombangara lowland soils and those up to 3000 ft. are similar, on the basis of fusion analyses, to Wright's strongly weathered very strongly leached soils, e.g. Tiavi silty clay, Vivao peaty clay. The Kolombangara soils have higher gibbsite, similar iron oxides and lower kaolin contents, but are fairly similar to the Samoan Tiavi hill soils (Wright's samples from 2200 ft. 200 in. annual rainfall). Much allophane is reported in Vivao peaty clay and in this respect it differs from the Kolombangara soils. There is reasonable similarity in profile morphology between the Kolombangara soils and Tiavi hill soils, but the latter have more stable structure and deeper incorporation of organic matter.

The Kolombangara upland soils (4000 ft., 5540 ft.) are similar, on the basis of fusion analyses, to Wright's moderately weathered moderately leached Saleimoa very stony loam, but this is a stony lowland soil and the resemblance probably only reflects the presence of much unweathered rock in the profiles. In profile morphology the Kolombangara soils more closely resemble the peaty soils of Wright's Puapua and Mulifanua minor soil suites, but no chemical or mineralogical data are available for these Samoan soils.

All the Samoan soils mentioned above are classified by Wright as hydrol humic latosols a great soil group recognized by Cline (1955) from Hawaii. The Kolombangara soils closely resemble soils included by Cline in the Koolau family of Hawaiian hydrol humic latosols. In their report on Samoan and Hawaiian soils, Wright and Cline regard the hydrol humic latosols that are analogous to those of Kolombangara as very infertile, with little or no potential for development. Lang (1967) recognizes a group of Dominican soils which he names allophanoid clay soils, developed on andesitic, dacitic, or occasionally basaltic parent materials. There appears to be no subgroup in Lang's classification that is exactly comparable with the Kolombangara soils, but his subgroup BL (allophanoid latosolics) includes among its most weathered members (Families BL 1, BL 2, BL 3 and BL 4) soils that have much in common with Kolombangara soils. Lang states that mature soils in Dominica with annual rainfall of 170 in. or more are almost entirely devoid of nutrients except in the surface organic horizon, which persists under rain forest but is soon lost under clean cultivation. In addition, he states that rain-forest environments are ideal for undesirable organisms and plant diseases are common; problems of husbandry are therefore considerable.

Soils derived from basalts and from gabbro at Santa Isabel (profiles 20, 21) are apparently fairly similar to the Fagaga silty clays, formed from basalt under 135 to 175 in. rainfall at 450 to 800 ft. altitude in Samoa. They resemble the Fagaga soils in profile morphology, pH, and in having generally moderate plant nutrient content except that the Santa Isabel soils have very low levels of P. Wright classifies the Fagaga soils as humic latosols, using Cline's terminology, with low to moderate natural fertility and limited potential for development without the use of fertilizers.

Soils derived from the basalt pillow lavas of eastern San Cristobal (profile 24) seem to stand between the Kolombangara and Santa Isabel soils described above, in levels of weathering and leaching and in plant nutrient content. None of the Samoan soils from basalt described by Wright (1963) is strictly comparable; Tuave clay and hill soils are probably the closest.

(*b*) *Soils derived from andesite*

Soils derived from the basic andesites of the 'basement complex' of western Guadalcanal are rather similar to the soils from San Cristobal basalts described above, but differ from them principally in having higher Mg content. There seem to be no soils previously described from other Pacific island environments with which they can be closely compared.

On the more acid, younger Gallego andesites there is a mosaic of deep red soils on stable sites, similar to those on the older basic andesites, and shallow brown soils, some of which are slightly podrolized (profile 2), on slightly less stable sites. Dudal & Moormann (1964) distinguish a group of youthful soils on steep lands in south-east Asia, (acid) brown forest soils, to which the shallower brown soils might be compared. (Acid) brown forest soils have not previously been recorded on andesite, but Dudal & Moormann consider that andesitic ash may give rise to such soils. Van Shuylenborgh & van Rummelen (1955) have described a series of soils developed at altitudes between 700 and 2000 m on andesitic tuffs in Indonesia. There is a reasonable similarity between the soil described in profile 2 and a profile described by these authors from Tapanunli in Sumatra at an altitude of 1300 m. The Sumatra soil was classified as a (tropical) grey-brown podzolic soil.

(*c*) *Soils derived from serpentine*

The Santa Isabel and San Jorge soils on serpentine are similar to soils described by Tercinier (1962) on serpentines covering about 20% of the total area of New Caledonia. The New Caledonian soils are derived from peridotites and serpentines and are classified by Tercinier as strongly ferrallitic soils in a subgroup of ferruginous ferrallites. There are no comparable Western Samoan or Hawaiian soils.

(*d*) *Soils derived from limestone*

On recently exposed coral limestone beds (e.g. profile 5) the soils are rendzinas, closely resembling those of temperate regions. Narrow coastal strips of coral limestone are common features of islands in the Solomons, and the rendzinas formed on them are widely used for crops and plantations. Often there is non-calcareous colluvial or alluvial debris from adjacent hilly land incorporated in these soils. Grover (1965) has reported the presence of volcanic pumice in limestone deposits on Bellona and Russell Islands, and many of these soils probably contain tuffaceous materials.

Soils on older coral limestones (e.g. profiles 4, 6, 25) are deep, acid, reddish brown to yellowish red clays, with little apparent affinity with the underlying calcareous rocks. Wright (1965) studied soils on the isolated coral island of Niue, about 200 miles east of Tonga, and concluded that the soils there are derived mainly from unconsolidated finely divided basic volcanic sediments, possibly deposited as ash showers, and mixed with calcareous material from the limestone. It is possible that some of the deep red soils on limestone in the Solomons have a similar origin. They are leached and weathered far beyond the levels of the Niue soils described by Wright.

(*e*) *Soils derived from other sedimentary rocks*

Soils on relatively unconsolidated sandstone and calcareous sandstone (profiles 22, 23) resemble the immature soils from similar materials that are found in the North Auckland Peninsula in New Zealand (N.Z. Soil Bureau 1954). Only small areas were seen, adjacent to Thousand Ships Bay at Santa Isabel, but somewhat similar and older sediments are found in many parts of the Solomons. Extensive areas of sedimentary rocks on moderate slopes may prove to be good prospects for agricultural development.

4. *Relationships between soils and vegetation*

In humid temperate regions the organic cycle of nutrient turnover is to some extent open ended, i.e. organic materials produced by the vegetation are intimately involved with inorganic materials physically and in the chemical reactions that determine the course of soil formation. The effects of these reactions in turn influence the availability of mineral nutrients to plants, so that close relationships are apparent between soils and the vegetation they support. Since the soil-forming processes that operate in the humid tropics are essentially the same as in humid temperate regions it would be reasonable to assume that similar relationships must exist between soils and vegetation in tropical rain forests. Many examples of such relationships have been discussed by previous workers, but other workers have found no such relationships. This anomaly appears to arise from failure to recognize that there are three major aspects of the soil/plant relationship: (*a*) the influence of plants on soils; (*b*) the influence of soils on plants; (*c*) the influence of the site, of which the soil is only a part, on plants. It is in the last aspect of the relationship that most confusion has arisen.

Richards (1961) states that in humid tropical regions with non-seasonal climates there are clear relationships between soils and forest types, and quotes studies in British Guiana, Brazil and Borneo as evidence. Most of Richards's examples illustrate relationships between vegetation and site factors, and although they indicate clear correlations between vegetation types and soils they do not prove that there is any close cause and effect relationship. Site factors such as altitude, slope, stability, aspect and drainage influence soil-forming processes and also influence vegetation, and there is good evidence, particularly in the example quoted by Richards from British Guiana, that these factors are operating to produce the observed correlations.

There are many similar examples in the Solomons of differences in site factors influencing soils and vegetation to produce clear non-causal relationships. For example, at Kolombangara the vegetation on ridge crests at about 3000 ft. (site 12, Appendix 1) is a mossy montane rain forest, while on the adjacent steep ridge sides (site 13) it is not mossy and includes some species of lower elevations. The mineral soil on the ridge crests is intensely gleyed in the upper horizons while that on the ridge side is not gleyed. The differences in forest and soil result directly from differences in slope, drainage, aspect, and possibly exposure to rain, and though vegetation, and soil may influence each other directly to some extent they cannot be regarded as showing a direct cause and effect relationship.

On the other hand, in the catchment area of the Warahito River in San Cristobal, there are continuous ridges composed mainly of basalt but with isolated outcrops of limestone. There is no consistent difference in vegetation on adjacent areas of soils formed on these very different rocks. Similar lack of vegetation differences is apparent over abrupt changes in soil parent materials where diorite intrusions and small areas of limestone outcrop in the andesitic lavas on the eastern slopes of Mt Gallego in Guadalcanal.

Weathering and leaching of soil minerals have proceeded, in most of the soils studied in the Solomons, to a point where there are low or very low levels of plant nutrients in the mineral soils. The organic cycle of nutrient turnover, in contrast to its influence in the soils of humid temperate regions, has become almost completely dissociated from the underlying mineral soil. Plant roots are largely confined to the top few inches of organic-matter-enriched mineral soil or to surface layers of mor and peat. The organic cycle is apparently efficient, involving little loss, and almost self-sustaining. Kira & Shidei (1967) compare the rates of litter fall, decomposition and turnover of organic matter in various forest ecosystems in the Western Pacific. For a tropical rain forest in Thailand, annual litter fall is about 23 tons/ha, compared with 3·5 tons/ha in a subalpine spruce forest in Japan. The time necessary for decomposition of 95 % of freshly fallen litter is estimated to be 0·26 years in tropical rain forest, whereas it is 23·3 years in subalpine spruce forest. The initial supply of mineral nutrients necessary for the establishment of forest must come from the soil, and the system must continue to receive a small increment from the mineral soil to compensate for losses in drainage water, but in a mature tropical rain forest on most stable sites the influence of the mineral soil must be very slight.

Soils derived from serpentine are a notable exception to these generalizations. On all soils from serpentine seen in the Solomons during the expedition, regardless of the size of the serpentine area, altitude, aspect, slope, rainfall, or soil profile depth, the rain forest was dominated over much of its area by *Casuarina papuana*, or the forest had been burned and sparse fern, grass and shrubs had replaced the forest. The edges of serpentine areas were clearly marked by an abrupt vegetation change. There is little doubt that this is a direct effect of soils on vegetation, resulting from selection of plant species that can tolerate the unusual mineral composition of serpentine and soils derived from it.

Direct effects of vegetation on soils are not obvious. Rainwater percolating through the strongly acid mor or peat commonly found on the forest floor must influence the weathering of soil minerals. However, the acidity of the saturated organic debris is induced principally by the activity of anaerobic micro-organisms, although the debris is derived from the vegetation, which might therefore be regarded as directly influencing the soil.

5. *Soil animals*

A notable feature of all but a few of the soils examined is a complete lack of macrofauna. Earthworms, millipedes, centipedes and other larger invertebrates commonly found in forest soils elsewhere are usually confined to rotting logs, moss, under the bark of trees, in accumulations of organic debris at the base of epiphytic plants, and most commonly between the leaf bases of Pandanaceae and some palms. A tendency for the larger 'soil fauna' to move out of the soil into above-ground habitats has been noted previously (Lee 1959) in the wet forests of western South Island, in New Zealand. This tendency is related to the development of anaerobic conditions in saturated litter and soil horizons and associated low pH, and appears to reach its ultimate expression in the very wet climate of the Solomon Islands.

Absence of macrofauna, especially earthworms, may be a major factor in the isolation of the organic cycle from the mineral soil (see Discussion in previous section), as in soils where earthworms are numerous they are important in mixing organic matter into mineral soil horizons.

Occasionally in the soils examined (see profiles 1, 4, 7, 21, 22) there were earthworms in the mineral soil. Where they were numerous (profiles 4, 7, 22) there were noticeable effects on soil structure, and the sites were better drained than usual. Taxonomic and ecological features of the earthworm fauna of the Solomon Islands will be discussed by the author in a separate paper.

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Appendix 1

Soil profile descriptions and site data

Terms used in the profile descriptions are as defined by Taylor & Pohlen (1962). Botanical names are as listed by Whitmore (1966). The author is indebted to botanists in the expedition and local Forestry Department assistants for field identification of dominant plant species. pH values were determined in the field on a soil paste prepared from fresh samples, using a portable colorimetric test kit developed by C.S.I.R.O., Division of Soils, and described by Raupach & Tucker (1959). Soil colour symbols are as in Munsell Soil Colour Charts. Sample numbers listed in profile descriptions refer to those in the table of chemical analyses in Appendix 2 and in tables of mineralogical data in the text.

A. *Guadalcanal Island*

(*a*) *Mt Gallego area*

Soils on andesitic lavas

1. *Location.* Crest of steep-sided ridge above East bank of Umasani River; *ca.* 300 ft. above s.l.; 5 miles inland from Tamboko Village.

Slope. Almost flat.

Vegetation. Lowland tropical rain forest. Dominant species: *Vitex cofassus*, *Neoscortechinia forbesii*, *Rhopoblaste elegans*.

Parent material. Basic andesite of old Gallego lavas (probably Oligocene).

Profile

A_0 1 in. loose leaf litter and granular mull. Indistinct boundary

A_{11} 0–3½ in. dark greyish brown (2·5Y 4/2) sandy loam, friable, moderately developed fine to medium blocky structure, few small stones, many fine roots, some large roots. Few small earthworms (*Pheretima hawayana*), but not noticeable effect on soil. pH 7·0. Sample M 107/1. Distinct boundary

A_{12} 3½–6 in. brown (10YR 4/3) sandy loam, slightly more clay than at 0–3½ in., friable, slightly sticky, moderately developed medium blocky structure, few small strongly weathered stones, some large, few fine roots. pH 7·0. Sample M 107/2. Indistinct boundary

AB 6–10 in. reddish brown (5YR 5/4) sandy clay loam, slightly plastic when wet, weakly developed fine nut structure, few small stones, very few roots. pH 6·5. Indistinct boundary

B_1 10–16 in. light reddish brown (5YR 6/4) sandy clay loam, plastic when wet, medium granular structure, some mottling of paler pinkish stained weathered fine gravel, very few fine roots. pH 5·5. Indistinct boundary

B_2 16–24 in. red (10R 5/8) clay, plastic when wet, weakly developed fine granular structure, some mottling and gravels as at 10 to 16 in., very few roots. pH 5·5. Sample M107/3. Indistinct boundary

BC 24 in.+ red (2·5YR 5/8) wet plastic clay, massive, increasing proportion of stones and boulders of basic andesite with increasing depth. pH 5·5–6·0. Sample M107/4.

2. *Location*. Crest of steep-sided ridge north of Hidden Valley, eastern slopes of Mt Gallego; 2380 ft. above S.L.; *ca.* 8 miles inland from north coast of Guadalcanal.

Slope. *ca.* 10°, NE aspect.

Vegetation. Transitional lowland/montane tropical rain forest. Dominant species: *Calophyllum kajewskii*, *Areca macrocalyx*, *Eugenia* sp., *Calophyllum paludosum*.

Parent material. Gallego andesite lavas (Quaternary).

PROFILE

A_{00} 3–2 in. fibrous root mat (some large roots) with much greasy humic material. Indistinct boundary

A_0 2–0 in. very dark greyish brown (10YR 3/2) greasy mor, with many fine fibrous roots. pH 3·5. Sample M109/1. Sharp boundary

A 0–5 in. reddish brown (5YR 4/4) clay loam, very sticky when wet, weakly developed fine granular structure, some stones, few roots, some up to 10 mm diameter. Slight bleaching and gleying at *ca.* 3 to 5 in. pH 4·75. Sample M109/2. Indistinct boundary

AC 5–10 in. reddish brown (5YR 5/3) very sticky clay loam, weakly to moderately developed fine granular structure, stony, few roots. pH 4·5. Sample M109/3. Diffuse boundary

C 10 in. + yellowish red (5YR 5/8) very sticky clay, very weakly developed fine granular structure, some sand, *ca.* 50% stones at 10 in., increasing to *ca.* 75% large andesite boulders at 18 in., very few fine roots. pH 4·5. Sample M109/4

3. *Location*. Small flattish summit area of Mt Gallego, West Guadalcanal; 3504 ft. above S.L.

Slope. Flat.

Vegetation. Mossy forest. Dominant species: *Metrosideros* sp., *Calophyllum cerasiferum*, *Dipteris conjugata* (Fern).

Parent material. Gallego andesite lavas (Quaternary).

PROFILE

A_{00} 4–2 in. fibrous matted peaty mor, wet and greasy, many fine roots. Sharp boundary

A_0 2–0 in. black (5YR 2/1) greasy mor. pH 3·5. Sample M110/1. Sharp boundary

A 0–3 in. dark reddish brown (5YR 2/2) sticky clay, very wet and strongly gleyed in patches, very few fine roots. Separate A_1 and A_2 horizons could not be distinguished, but a boundary may be masked by the strong humus staining and gleying. pH 3·0. Sample M110/2. Distinct very irregular boundary

B_1 3–6 in. reddish brown (5YR 4/3) and dark reddish brown (5 YR 3/3) very wet sticky clay with some gritty inclusions, almost structureless, some roots. pH 5·0. Sample M110/3. Sharp, irregular boundary

B_2 6–12 in. humus and iron pan at 6 to 7 in., weak red (2·5YR 4/2) firm massive clay, with about $\frac{1}{10}$ in. thick black humus layer on top, no roots (pH 4·0, sample M110/4), overlying reddish brown (5YR 5/4) clay, massive, very few fine roots (pH 6·0, sample M110/5). Indistinct boundary

C 12 in. + yellowish red (5YR 4/8) clay, with sand, massive, no roots.

Soil from Miocene Limestone

4. *Location.* Broad crest of steep-sided limestone ridge, east side of Umasani River; 300 ft. above S.L.; *ca.* 4½ miles inland from North coast of Guadalcanal.

Slope. ca. 10°, west aspect.

Vegetation. Lowland tropical rain forest. Dominant species: *Calophyllum kajewskii*, *Pometia pinnata*.

Parent material. Betilonga limestone (Miocene).

PROFILE

½ in. loose leaf litter

0–8 in. dark reddish brown (5YR 2/2) sticky clay, moderately developed unstable fine nut structure, few large many small roots. Numerous small earthworms (*Pheretima hawayana* and *P. solomonis*) at 0–3 in., few to 8 in. pH 7·0. Sample M111/1. Indistinct boundary

8–14 in. dark reddish grey (5YR 4/2) clay, plastic, weakly developed unstable very fine crumb structure, few fine roots. pH 6·75. Sample M111/2. Indistinct boundary

14–26 in. yellowish red (5YR 5/6) clay, plastic, very weakly developed unstable fine crumb structure, very few fine roots. pH 6·5. Diffuse boundary

26–48 in. + yellowish red (5YR 5/8) clay, plastic, moderately developed unstable fine crumb structure, few fine roots. This horizon continued to a greater depth, but it was not practicable to dig deeper. pH 6·0. Sample M111/4.

(*b*) *Terraces south-east of Honiara*

Soils on coral limestone

5. *Location.* Near crest of rounded hilltop (dissected terrace surface), 2 miles from Kukum on Kukum–Mt Austen road; 275 ft. above S.L.

Slope, *ca.* 10°, NW aspect.

Vegetation. Grassland. *Imperata cylindrica* dominant, with some ferns and shrubs.

Parent material. Coral reef limestone (Quaternary); the underlying rock is very irregular, with hummocks of hard coral rock separated by deep fissures.

PROFILE

A	0–10 in.	very dark greyish brown (10YR 3/2) sandy clay, very firm medium nut structure breaking to very firm fine-medium granular, many fine grass roots throughout, some fragments of coral (up to *ca.* 2 in. across) mainly below 6 in. pH 8·5. Sample M123/1. Indistinct boundary
AC	10–13 in.	(varying in pockets to 10–24 in.) brown to dark brown (10YR 4/3) sandy clay, strongly developed medium granular structure incorporating much recognizable weathered limestone (*ca.* 15–20 % in aggregates), many fragments of limestone (up to *ca.* 2–3 in. across), few fine roots. pH 8. Sharp boundary
C	13 (up to 24)–60 in +	massive white coral limestone, with much recognizable coral, some crystalline limestone (sample M123/3), some deep fissures containing weathered limestone (pH 8·5, sample M123/4).

6. *Location.* Crest of rounded hilltop beside Kukum–Mt Austen road, near summit of Mt Austen, *ca.* 6 miles from Kukum; 1000 ft. above S.L.

Slope. ca. 5°, west aspect.

Vegetation. Lowland tropical rain forest, regrowth probably not more than 100 years old. Dominant species *Pometia pinnata*, canopy height *ca.* 100 ft.

Parent material. Coral limestone (Quaternary), deeply weathered.

PROFILE

½ in.	loose leaf litter
2–0 in.	fibrous litter, many fine roots, some large roots up to 2–3 in. diameter. Indistinct boundary
0–9 in.	very dark brown (10YR 2/2) sand clay, strongly developed fine granular structure, many roots up to *ca.* 1 in. diameter. pH 6·0. Sample M124/1. Indistinct colour boundary, but distinct change in structure
9–16 in.	dark brown (7·5YR 3/2) sandy clay, massive *in situ* but breaking to strongly developed coarse blocky to granular structure, many roots up to *ca.* 1 in. diameter. pH 6·0. Indistinct boundary
16–28 in.	dark reddish grey (5YR 4/2) clay, massive *in situ*, breaking to weak fine to medium granular structure, many roots up to *ca.* 1 in. diameter. pH 5·5. Sample M124/3. Indistinct boundary
28–56 in.	yellowish red (5YR 5/6) clay, more massive than 16–28 in. horizon, breaking to weak fine granular structure, few large roots. pH 4·5. Sample M124/4. Sharp boundary
56 in +	white coral rock

B. *Kolombangara Island*, *New Georgia Islands*

Soils from olivine pyroxene basalt lavas

Profiles 7–16 were recorded from ridges running north from 225 ft. above sea level near the mouth of the Kolombara River, on the south coast of Kolombangara, to the south summit of the island (5540 ft.). Profile 7 was from the ridge above the east bank of the Kolombara River, profiles 8 to 15 from the ridge above the west bank and profile 16 from the summit. Profile 17 was recorded from an alluvial terrace on the east bank of the Kolombara River.

7. *Location*. 225 ft. above s.l., ridge east of Kolombara River.

Slope. *ca*. 2° on very broad ridge crest; south aspect.

Vegetation. Lowland tropical rain forest; has possibly been garden land, but long ago. Dominant species: *Calophyllum* sp., *Teysmanniodendron ahernianum*, *Erythroxylum ecarinatum*, *Xanthophyllum papuanum*, *Amoora* sp., *Neoscortechinia forbesii*, *Celtis latifolia*. Canopy height *ca*. 125 ft.

Parent material. Deeply weathered olivine pyroxene basalt.

Profile

A_0		Very thin layer (*ca*. $\frac{1}{2}$–1 in.) of leaves, twigs, etc.
A	0–10 in.	humus stained reddish brown (2·5YR 4/4) clay, slightly sticky, very friable in top 2–3 in., strongly developed medium-coarse granular structure, earthworms (*Pontoscolex corethrurus*) numerous at 0–3 in., possibly responsible for granular structure, many roots of forest trees. pH 3·5. Sample M91/1. Distinct boundary
B_1	10–27 in.	red (10R 5/6) friable loamy clay, plastic, unstable coarse nut structure breaking to stable fine crumb, very few roots. pH 4·0. Sample M91/2. Indistinct boundary.
B_2	27–40 in.	weak red (10R 4/4) clay, compact, massive *in situ* breaking to stable fine crumb, very few roots. pH 4·0. Sample M91/3. Indistinct boundary
B/C	40–54 in. +	weak red (10R 4/4) silty clay, very compact, massive *in situ*, breaking with difficulty to fine crumb, few roots, some small iron-stained nodules. This horizon has about the consistency of weak concrete. Occasional recognizable fragments of strongly weathered parent material. It was not practicable to dig deeper. pH 4·0. Sample M91/4

8. *Location*. 1000 ft. above s.l., ridge west of Kolombara River.

Slope. *ca*. 4°, on broad ridge crest; south aspect.

Vegetation. Lowland tropical rain forest. Grove of *Dillenia salomonensis*; probably has been garden land, but long ago. Canopy height 90–100 ft.

Parent material. Deeply weathered olivine pyroxene basalt.

PROFILE

A_0	1–0 in.	loose leaf litter and granular mull with many fibrous roots. Indistinct boundary
A_{11}	0–4 in.	weak red (2·5YR 4/2) humus stained clay, sticky, weakly developed medium nut structure breaking to fine crumb, many roots up to 1–2 in. diameter. pH 3·5. Sample M 90/1. Indistinct boundary
A_{12}	4–11 in.	reddish brown (5YR 4/4) sandy clay, non-sticky, fairly stable fine granular structure, few roots up to *ca.* ½ in. diameter. Distinct boundary
B	11–32 in.	yellowish red (5YR 5/6) sandy clay, non-sticky, stable fine granular structure, very few fine roots. pH 4·5. Sample M 90/3. Diffuse boundary
	32–50 in. +	reddish brown (2·5YR 4/4) sandy clay with many small iron stained concretions, slightly plastic, fine granular structure, no roots. pH 4·5. Sample M 90/4.

9. *Location*. 2100 ft. above s.l., ridge west of Kolombara River.

Slope. *ca.* 5°, on rounded ridge crest *ca.* 20 ft. wide; south aspect.

Vegetation. Montane tropical rain forest. Dominant species: *Eugenia isorufa*, *E. aimela*, *Teysmanniodendron* sp., *Prunus schlechteri*, *Ascarina maheshwarii*.

Parent material. Olivine pyroxene basalt.

PROFILE

A_0	3½–0 in.	greasy mor with many fine roots and larger roots up to *ca.* ½ in. diameter. pH. 3·25. Sample M 88/1. Distinct boundary
A_1	0–3 in.	humus stained weak red (2·5YR 4/2) clay, sticky, weak fine granular structure, many large roots. pH 3·5. Sample M 88/2. Distinct boundary
B_1	3–12 in.	reddish brown (5YR 5/3) clay, sticky, coarse nut structure breaking to fine granular, few small roots. pH 3·5. Sample M 88/3. Diffuse boundary
B_2	12–36 in.	weak red (10R 4/3) slightly gritty clay (small concretions, mainly gibbsite, some iron oxide), medium nut structure breaking to fine granular, very few small roots. pH 4·5. Sample M88/4. Diffuse boundary
BC	36–50 in.	weak red (10R 4/4) clay with many fine and some large red (10R 5/6) nodules, fine granular structure, more stable than in upper horizons, very few roots, some weathered parent material. pH 4·5. Sample M 88/5. Diffuse boundary
C	50 in +	strongly weathered parent material, mixed with nodules and clay. Sample M 88/6.

10. *Location*. 2600 ft. above sea level, ridge west of Kolombara River.

Slope. *ca*. 3° on broad flattish ridge crest; south aspect.

Vegetation. Montane tropical rain forest. Dominant species: *Garcinia* sp., *Aporosa papuana*, *Astronia* sp., *Calophyllum cerasiferum*, *Ascarina maheshwarii*. Canopy height *ca*. 60 ft.

Parent material. Olivine pyroxene basalt.

PROFILE

A_0	$2\frac{1}{2}$–0 in.	very dusky red (2·5YR 2/2) fibrous mor, many fine roots, few very large, some medium sized roots up to $\frac{3}{4}$ in. diameter. pH 3·0. Sample M 89/1. Distinct boundary
A	0–4 in.	reddish brown (5YR 5/4) slightly gritty clay loam, very sticky, very weak fine-medium granular structure, very few fine roots. pH 5·0. Sample M 89/2. Diffuse boundary
B	4–21 in.	yellowish red (5YR 5/6) gritty clay loam, weakly developed medium granular structure breaking to weak fine granular, very few fine roots. pH 5·5. Sample M 89/3. Diffuse boundary
BC	21–33 in.	reddish brown (5YR 5/3) gritty clay, with increasing weathered parent material at depth, weakly developed nut structure, no roots. pH 5·0. Sample M 89/4. Indistinct boundary
C_1	33–48 in.	reddish brown (5YR 4/3) coarse sandy material with many small fragments of weathered rock, coarse nut structure, no roots. pH 4·5. Sample M 89/5. Indistinct boundary
C_2	48–60 in. +	dark reddish grey (5YR 4/2) coarse sandy strongly weathered rock, with some clay and iron staining, some relatively unweathered rock, no roots. pH 4·5. Sample M 89/6.

11. *Location*. On a steep ridge-side site (35° slope) 30 yards from profile site 10, under similar vegetation; east aspect.

PROFILE

A_0	2–0 in.	fibrous mor with many fine roots
A	0–8 in.	fine sandy clay, very sticky, fine granular structure
AC	8–36 in.	similar to A horizon, but with increasing proportion of weathered and unweathered parent material with increasing depth.
C	36 in. +	shattered rock and rubble, relatively unweathered, some clay

12. *Location*. 3000 ft. above S.L., ridge west of Kolombara River.

Slope. *ca*. 13° on rounded ridge crest *ca*. 50 ft. wide; south aspect.

Vegetation. Mossy montane tropical rain forest. Dominant species *Metrosideros* sp., *Eugenia* 2 spp., *Aporosa papuana*. Thick moss on ground surface, roots, logs, buttresses and boles of trees. Canopy height 30–40 ft.

Parent material. Olivine pyroxene basalt.

PROFILE

A_0	9–0 in.	dark reddish brown (5YR 3/3) moss peat, saturated and greasy, many roots. pH 3·5. Sample M84/1. Distinct boundary
A_1	0–2 in.	dark reddish brown (5YR 2/2) peaty clay, very weak fine granular structure, many fine roots. pH 3·0. Sample M84/2. Sharp boundary
A_1G	2–6 in.	light grey (10YR 7/2) bleached strongly gleyed clay with coarse gritty inclusions, very weak fine crumb structure, very few roots. pH 4·75. Sample M84/3. Sharp boundary
B	6–25 in.	red (2·5YR 5/6) clay, very sticky, slightly plastic, weakly developed fine granular structure, very few roots. pH 5·0. Sample M84/4. Distinct boundary
C	25–36 in. +	reddish brown (5YR 4/4) coarse sandy material with some clay and much weathered rock (fragments up to *ca.* 2 in. diameter at 36 in. sample M84/6), fine crumb structure, no roots. pH 6·25. Sample M84/5

The water table at the time of sampling was at about 18 in., but there was no evidence of gleying in the deeper material, which probably has good lateral drainage.

13. *Location*. On a steep ridge side site about 50 yards east of profile site 12.

Slope. *ca*. 25°, east aspect.

Vegetation. Small fern-covered area in forest similar to that at site 12, but canopy *ca* 60 ft.

Parent material. Colluvial debris from olivine pyroxene basalt.

PROFILE

A_0	4–0 in.	moss peat, wet and greasy, many roots. Sharp boundary
A_1	0–6 in.	strong brown (7·5YR 5/6) clay with gritty inclusions, some fine roots pH 5·0. Sample M85/1. Indistinct boundary
A_1G	6–24 in.	reddish brown (5YR 4/4) gritty clay, with some gleyed patches, very few roots. pH 6·0. Sample M85/2. Indistinct boundary
AC	24 in. +	reddish brown (5YR 4/3) bouldery sand (sample M85/3), grading to greyer colour at 30 in. +, with increasing proportions of large fragments of strongly weathered rock (sample M85/4), no roots. pH 6·0

Some stones and boulders were found throughout the profile.

14. *Location*. 4000 ft. above S.L., on ridge west of Kolombara River; south aspect.

Slope. *ca*. 5°, on narrow rounded ridge crest, *ca*. 20 ft. wide.

Vegetation. Montane tropical rain forest. Dominant species *Eugenia* sp., *Aporosa papuana*, *Calophyllum cerasiferum*, *Polyosma* sp. Ground surface and boles of trees with thin layer of mosses and filmy ferns. Canopy height 40–50 ft.

Parent material. Colluvium from olivine pyroxene basalt.

PROFILE

A_0	8–0 in.	dusky red (10R 3/3) moss peat, very wet, greasy, many roots. pH 3·25. Sample M87/1. Indistinct boundary
A	0–1½ in.	dusky red (10R 3/2) clay, humus stained, very greasy, very weak fine granular structure, many fine roots. pH 3·5. Sample M87/2. Distinct boundary
AC	1½–7 in.	weak red (10R 4/3) sandy clay, with some fragments of weathered rock, weakly developed fine granular structure, few roots. pH 3·5. Sample M87/3. Indistinct boundary
C_1	7–24 in. +	weak red (10R 4/4) coarse sandy material with some clay, increasing proportion of weathered rock (sample M87/5), very weak fine granular structure, few roots. pH 4·0. Sample M87/4.

15. *Location.* On a steep ridge side slope, *ca.* 15 yards east of profile site 14.

Slope. ca. 45°; east aspect.

Vegetation. Similar to site 14, but canopy *ca.* 80 ft.

Parent material. Colluvial debris from olivine pyroxene basalt.

PROFILE

A_0	2–0 in.	peaty mor, greasy, many roots. Distinct boundary
AC	0–6 in.	reddish brown (5YR 4/3) sandy clay, weak fine granular, fragments of parent material, few roots. pH 4·0. Sample M/87A. Diffuse boundary
C_1	6–24 in.	mixed sand and rock, with some clay. Diffuse boundary
C_2	24–30 in. +	shattered weathered rock

16. *Location.* 5540 ft. above S.L., south summit of Kolombangara, on the gently sloping narrow ridge of the crater rim.

Slope. Almost flat; hummocky surface.

Vegetation. Upper montane mossy tropical rain forest. Dominant species: *Garcinia* sp., *Eugenia* sp., *Astronia* sp. Thick covering of moss peat on the ground surface, hummocks of moss between tree boles; tree boles and branches moss covered, to more than twice thickness of timber.

Parent materials. Olivine pyroxene basalt.

PROFILE

A_0	16–0 in.	very dusky red (5R 2/2) moss peat, very greasy, many living and dead roots, many logs; peat saturated—water poured out of peat into profile pit during sampling. pH 3·0. Sample M86/1. Distinct boundary
A_1	0–¾ in.	dark reddish brown (5YR 2/2) gritty clay, humus stained, very greasy, weakly developed blocky structure, few fine roots. pH 3·5. Distinct boundary

A_2G $\frac{3}{4}$–1$\frac{1}{2}$ in. dark grey (5Y 4/1) gritty clay, very greasy, strongly gleyed (some blue-green patches), almost structureless, few fine roots. pH 2·5. (Sample M86/2 from 0–1$\frac{1}{2}$ in.). Sharp boundary

B 1$\frac{1}{2}$–3 in. dark reddish brown (2·5YR 3/4) gritty clay, firm, indistinctly laminated for *ca.* $\frac{1}{2}$ mm at top, with very thin humus stained layer on top of laminations, massive, very few fine roots. pH 3·5. Sample M86/3. Distinct boundary

BC 3-*ca.* 10 in. weak red (2·5YR 5/2) sandy clay, non-plastic, fine granular structure, fragments of weathered rock, very few fine roots. pH 3·5. Sample M86/4. Indistinct boundary

C 10–30 in. reddish brown (2·5YR 4/4) sandy loam with fragments and some large boulders of weathered (sample M86/6) and unweathered rock, fine granular structure, very few fine roots. pH 5·0. Sample M86/5.

17. *Location.* Alluvial terrace *ca.* 25 ft. above river level, east bank of Kolombara River, *ca.* 1$\frac{1}{2}$ miles inland, *ca.* 100 ft. above sea level.

Slope. Flat.

Vegetation. Cocoa plantation, with large forest trees; original vegetation lowland tropical rain forest, probably similar to site 7 at 225 ft.

Parent material. Alluvium from olivine pyroxene basalt.

PROFILE

1–0 in. loose leaf litter

0–18 in. weak red (2·5YR 4/2) sandy silt, weak crumb structure, many fine roots. pH 3·5. Sample M92/1. Diffuse boundary

18–24 in. weak red (2·5YR 4/2) silty clay, sticky, massive *in situ*, breaking to very weak granular structure, very few roots. pH 4·0. Sample M92/2. Distinct boundary.

24–40 in. + dark reddish brown (2·5YR 3/4) silty clay, with some scattered slightly firmer orange mottles, massive *in situ*, breaking to weak medium granular structure, very few fine roots. pH 4·0. Sample M92/3.

C. SANTA ISABEL, SAN JORGE AND OFF-SHORE ISLANDS

(*a*) *Soils on serpentine*

18. *Location.* Thousand Ships Bay area, Santa Isabel, *ca.* 2 miles inland, 800 ft. above sea level, on ridge top above Tanameko Mining Camp.

Slope. *ca.* 10°, on rolling ridge crest; east aspect.

Vegetation. *Casuarina*—forest. Dominant species *Casuarina papuana*, *Dacrydium* sp., bamboo.

Parent material. Serpentine.

Profile

A_0	3–0 in.	dusky red (2·5YR 3/2) fibrous litter of *C. papuana* and bamboo, many roots. pH 3·5. Sample M 116/1. Sharp boundary
	0–3 in.	red (10R 4/6) fine sandy clay, medium blocky structure breaking to stable fine granular, many roots up to 1–2 in. diameter. pH 3·25. Sample M 116/2. Indistinct boundary
	3–6 in.	red (10R 4/6) fine sandy clay, fine-medium granular structure, many roots up to 2 in. diameter. pH 4·0. Indistinct boundary
	6–33 in.	red (2·5YR 5/6) sticky clay with many small nodular concretions, friable, very few fine roots. pH 4·0. Sample M 116/4. Distinct boundary
	33–54 in.	light reddish brown (2·5YR 6/4) fine sandy clay, sticky, massive *in situ* breaking to weak fine granular structure, very few fine roots. pH 4·0. Sample M 116/5. Indistinct boundary
	54–84 in.	reddish brown (5YR 5/4) sandy clay with fine mottles, greasy, massive *in situ* breaking to fairly large blocks and further to fine granular structure, very few fine roots. pH 4·5. Sample M 116/6. Distinct boundary
	84 in. +	reddish brown (5YR 5/4) sandy clay with fine reddish yellow (5YR 6/8) mottles, greasy, some strongly weathered parent material. pH 4·0. Sample M 116/7.

19. *Location*. Thousand Ships Bay area, Santa Isabel, *ca.* $\frac{1}{4}$ mile inland, 200 ft. above s.l., beside ridge-top track leading to Tanameko Mining Camp.

Slope ca. 10° on rolling ridge crest; S.E. aspect.

Vegetation. Fern (*Gleichenia* sp.), *Lycopodium* sp., occasional grasses and small shrubs (Myrtaceae). This vegetation appears to follow long-continued burning of *Casuarina* forest.

Parent material. Serpentine.

Profile

0–6 in.	dusky red (10R 3/3) gritty sandy loam, very stable fine granular structure, very friable, many small very dusky red (7·5R 2/2) hard concretions, some large concretions at and near soil surface composed of cemented masses of small concretions, few fine roots. pH 4·0. Sample M 115/1. Distinct boundary
6–9 in.	weak red (10R 4/4) fine sandy clay, mottled with dusky red (10R3/4) patches, very stable fine granular structure, no roots. pH 3·5. Sample M 115/2. Distinct boundary
9–18 in.	red (2·5YR 4/8) fine sandy clay, strongly developed fine granular structure, no roots. pH 3·5. Sample M 115/3. Distinct boundary

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18–36 in. + red (2·5 YR 4/6) clay, massive, becoming increasingly compact with increasing depth, no roots. pH 4·0. Sample M 115/4. The last horizon continues down to weathered parent material, at depths up to *ca.* 120 in.

(b) Soils on basalt and rocks of the basement complex

20. *Location.* 1 mile inland (south) from Talise village, NE coast of San Jorge Island, 200 ft. above S.L. on crest of ridge.

Slope. ca. 5°, north aspect.

Vegetation. Lowland tropical rain forest. Dominant species: *Dillenia crenata*, *Vitex cofassus*, *Canarium* sp., *Celosia* sp.

Parent material. Gabbro (?) of 'basement complex'.

PROFILE

A_0	½–0 in.	loose leaf litter and granular mull. Diffuse boundary
A_1	0–5 in.	reddish brown (5 YR 4/4) sandy clay, weak very coarse granular structure, many roots up to *ca.* 2 in. diameter. pH 4·5. Sample M 119/1. Distinct boundary
B	5–12 in.	brown (7·5 YR 5/4) sandy clay, coarse nut breaking to weak finegranular, very few fine roots. pH 4·5. Sample M 119/2. Distinct boundary
C	12–30 in. +	coarse sandy material with some clay and some masses of strongly weathered clay, some relatively unweathered rock. (Sandy material pH 6·5. Sample M 119/4; strongly weathered clay pH 5·0, Sample M 119/3)

21. *Location.* Coconut plantation on ridges south of Regi village, *ca.* ½ mile from coast Tatamba Harbour, eastern Santa Ysabel. 100 ft. above S.L.

Slope. ca. 5°, south aspect.

Vegetation. Coconut plantation belonging to Funabai of Regi village; ground cover of low fern (*Thelypteris* sp.).

Parent material. Basalt.

PROFILE

ca. ½ in.	litter, mainly fern, and surface layer of coconut roots. Diffuse boundary
0–6 in.	dark greyish brown (10 YR 4/2) clay loam, coarse nut structure breaking to fairly stable fine granular, many roots, earthworms present but not numerous. pH 6·25. Sample M 121/1. Diffuse boundary
6–10 in.	dark brown (10 YR 3/3) sandy clay, massive *in situ* breaking to weak fine granular structure, many roots up to *ca.* ½ in. diameter. pH 6·25. Sample M 121/2. Distinct boundary
10–30 in.	brown (7·5 YR 4/4) coarse sand clay with small iron stained nodules up to *ca.* $\frac{1}{10}$ in. diameter, very weak fine granular structure, few fine roots. pH 5·0. Sample M 121/3. Indistinct boundary

30–48 in. yellowish red (5 YR 5/6) coarse sandy clay with fragments of weathered parent material, weak fine granular structure, very few roots. pH 5·5. Sample M 121/4. Indistinct boundary.

48 in. + reddish brown (5 YR 5/4) gravelly clay with much weathered parent material, coarse granular structure, no roots. pH 5·5. Sample M 121/5

(*c*) *Soils on sedimentary rocks*

22. *Location*. Top of ridge above Kirigi village, Kirigi Is., about 1 mile off coast of San Jorge, near Turungurungu Is., Thousand Ships Bay. *ca.* 100 ft. above sea level.

Slope. ca. 10°, SE aspect.

Vegetation. Secondary forest, former garden land.

Parent material. Calcareous sandstone, young and relatively unconsolidated.

PROFILE

A_0 *ca.* ½ in. loose leaf litter and surface roots. Diffuse boundary

A_{11} 0–3 in. dark reddish brown (5 YR 3/4) sandy loam, very strongly developed medium and coarse nut structure breaking with difficulty to strongly developed fine to medium granular, many roots, up to *ca.* 1 in. diameter. pH 6·5. Sample M 120/1. Distinct boundary

A_{12} 3–5 in. reddish brown (2·5 YR 4/4) fine sandy clay, very strongly developed medium nut structure breaking to well developed fine granular, many roots up to *ca.* 1 in. diameter. pH 6·5. Distinct boundary

B_1 5–22 in. red (2·5 YR 4/6) fine sandy clay, massive, some fine roots. pH 7·0. Sample M 120/3. Indistinct boundary

B_2 22–42 in. + yellowish red (5 YR 5/8) sandy clay, weakly developed fine crumb structure, few roots. pH 7·0. Sample M 120/4.

Many large earthworms at 0–5 in. The well-developed structure in the top 5 in. is almost certainly due to their activity, as many aggregates have the appearance of worm casts. Some worm channels go down to *ca.* 12 in. and occasional large cast aggregates of A horizon material are found in the B horizon.

23. *Location. ca.* ¾ in. mile from Sesendo village on slope at head of Mindoro Cove, Thousand Ships Bay, south coast of Santa Isabel; *ca.* 300 ft. above S.L.

Slope. ca. 10°, SW aspect.

Vegetation. Lowland tropical rain forest.

Parent material. Sandstone.

PROFILE

A_0 very thin layer of loose leaf litter and granular mull. Indistinct boundary

A 0–4 in. dusky red (2·5 YR 3/2) silty clay, weak nut structure, many roots up to *ca.* 1 in. diameter. pH 5·0. Sample M 117/1. Distinct boundary

B 4–15 in. weak red (10R 4/4) clay loam, weak nut structure breaking to weak fine crumb, roots fairly numerous, up to *ca.* ½ in. diameter. pH 4·0. Sample M 117/2. Distinct boundary

BC 15–30 in. + reddish brown (2·5YR 4/4) stony clay loam, fine granular structure, few roots. pH 4·5. Sample M 117/3

D. San Cristobal Island

(*a*) *Soils from basalt pillow lavas*

24. *Location.* Crest of ridge dividing Pegato and Warahito valleys, *ca.* 6 miles south of Wainoni Bay. 330 ft. above S.L.

Slope. Flat.

Vegetation. Lowland tropical rain forest. Dominant species *Canarium* sp., *Teysmanniodendron ahernianum*, *Neoscortechinia forebesii.*

Parent material. Basalt pillow lava (Warahito lavas).

Profile

A_0 ½–0 in. granular mull and roots up to *ca.* ½ in. thick. Distinct boundary

A_{11} 0–1 in. yellowish red (5YR 4/6) clay loam, slightly plastic, moderately developed fine crumb structure, many fine roots, some up to ½ in. diameter. pH 5·0. Sample M 112/1. Indistinct boundary

A_{12} 1–3½ in. yellowish red (5YR 4/8) clay loam, slightly plastic, very weakly developed medium granular structure, some fine roots. pH 4·75. Indistinct boundary

AB 3½–15 in. red (2·5YR 4/6) sandy clay, slightly plastic, weakly developed fine nut structure, few fine roots. pH 4·25. Sample M 112/3. Indistinct boundary

B_1 15–28 in. red (2·5YR 5/6) sandy clay, slightly sticky, non plastic, weakly developed fine crumb structure, few fine roots. pH 4·0. Indistinct boundary

B_2 28–34 in. red (2·5YR 5/6) sandy clay, few concretions (red-brown coating, grey interior), weakly developed nut structure breaking to weakly developed fine crumb, few fine roots. pH 4·5. Sample M 112/5. Indistinct boundary

BC 34–44 in. red (2·5YR 5/6) sandy clay, some nodular concretions and some fragments of strongly weathered basalt, weakly developed nut structure breaking to weakly developed fine crumb, very few roots. pH 5·5. Distinct boundary

C 44–66 in. + coarse gravelly sand, blocky structure, blocks heavily iron stained, inside of block reddish brown (2·5YR 4/4); some grey weathered basalt, very few roots. pH 6·5. Sample M 112/7

(*b*) *Soils on limestone*

25. *Location*. Crest of ridge east of Pegato River, close to confluence of Pegato and Warahito Rivers, 750 ft. above S.L.

Slope. Flat.

Vegetation. Lowland tropical rain forest. Dominant species: *Pometia pinnata*, *Elaeocarpus sphaericus*, *Dillenia crenata*, *Ficus majestica*, *Areca macrocalyx*.

Parent material. Upper Oligocene (?) limestone.

PROFILE

1–0 in.	leaf litter and granular mull, many fine roots. Distinct boundary
0–3 in.	reddish brown (5YR 5/4) sandy clay loam, slightly plastic, weakly developed fine granular structure, many fine roots. pH 5·0. Sample M113/1. Indistinct boundary
3–14 in.	red (2·5YR 5/6) clay loam, plastic, weakly developed fine granular structure, few roots. pH 5·0. Indistinct boundary
14–27 in.	reddish brown (2·5YR 5/4) clay loam, fairly plastic, medium blocky structure breaking to weakly developed fine crumb, few roots. pH 5·0. Sample M 113/3. Indistinct boundary
27–33 in.	yellowish red (5YR 5/6) clay, fairly plastic, weakly developed blocky structure breaking to weakly developed fine crumb, few roots. pH 5·0. Indistinct boundary
33–53 in.	yellowish red (5YR 5/8) sandy clay with fine mottling of light reddish brown (5YR 6/3), coarse irregular blocky structure breaking to weakly developed fine granular, some roots. pH 5·0. Sample M 113/5. Distinct boundary
53–72 in. +	red (2·5YR 5/8) sandy clay with fine mottling of reddish yellow (5YR 6/6) sandy clay, coarse block structure, surfaces of blocks often with well developed clay skins and red and brown coatings, few roots, some flecks of fine white material. pH 5·5. Sample M 113/6

(*c*) *Soils from Serpentine*

26. *Location*. Near summit of rounded hilltop *ca*. 2 miles SE of Wainoni R.C. Mission, 1650 ft. above S.L.

Slope. Flattish slightly hummocky surface.

Vegetation. Mossy *Casuarina* forest. Dominant species: *Casuarina papuana*, *Podocarpus neriifolius*, much moss and fern on ground surface, fallen logs and tree boles.

Parent material. Serpentine.

PROFILE

5–3 in.	living moss and decaying fragments
3–0 in.	greasy, dark brown peat, with many roots. pH 3·5. Sample M 114/1 (5–0 in.). Sharp boundary

0–6 in.	strong brown (7·5YR 5/6) clay with some gritty inclusions, fairly stable medium crumb structure, very few roots. pH 4·0. Sample M 114/2. Indistinct boundary
6–26 in.	yellowish red (5YR 5/8) sandy clay, compact, fairly stable medium crumb structure, very few roots. pH 4·75. Sample M 114/3. Distinct boundary
26–29 in.	mottled red (10R 4/6) and reddish yellow (7·5YR 6/6) coarse sandy clay, many small gritty nodules, very compact, no roots. pH 4·5. Sample M 114/4. Distinct boundary
29–39 in. +	strong brown (7·5YR 5/6) sandy clay, prismatic structure (prisms *ca.* $\frac{3}{4}$ to 1 in. high, tightly fitting) breaking to fine granular, no roots; water table at *ca.* 30 in. at time of sampling, but no obvious gleying. pH 4·25. Sample M 114/5

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

Appendix 2. Chemical analyses of some Solomon Islands soils

	site data					chemical analysis								
profile no.	location	altitude (ft.)	parent material	sample no.	depth (in.)	pH*	loss on ignition (%)	organic carbon (%)†	N (%)†	C/N	K (%)‡	Mg (%)‡	P (%)‡
1	Umasani Valley, W. Guadalcanal	300	basic andesite lava	M 107/1	0–3½	7·0	12	3·20	0·32	10	0·024	0·50	0·034
				M 107/2	3½–6	7·0	8	n.d.	n.d.	n.d.	0·018	0·41	0·073
				M 107/3	16–24	5·5	6	0·32	0·03	10	0·033	0·50	0·015
				M 107/4	24–30	6·0	5	0·24	0·02	12	0·014	0·41	0·012
2	Mt. Gallego, W. Guadalcanal	2380	andesite lava	M 109/1	2–0	3·5	54	23·00	1·40	16	0·062	0·19	0·066
				M 109/2	0–5	4·75	22	5·00	0·33	15	0·031	0·22	0·034
				M 109/3	5–10	4·5	15	n.d.	n.d.	n.d.	0·036	0·16	0·021
				M 109/4	10–18	4·5	14	1·50	0·10	15	0·130	0·10	0·031
3	Summit, Mt. Gallego, W. Guadalcanal	3504	andesite lava	M 110/1	2–0	3·5	77	41·00	2·00	21	0·044	0·08	0·067
				M 110/2	0–3	3·0	36	24·00	0·93	26	0·032	0·15	0·041
				M 110/3	3–6	5·0	31	n.d.	n.d.	n.d.	0·035	0·35	0·019
				M 110/4	6–7	5·0	33	9·10	n.d.	n.d.	n.d.	n.d.	n.d.
				M 110/5	7–12	6·0	25	n.d.	n.d.	n.d.	0·025	0·32	0·030
4	Umasani Valley, W. Guadalcanal	300	limestone	M 111/1	0–8	7·0	18	4·30	0·45	10	0·037	0·21	0·100
				M 111/2	8–14	6·75	14	1·40	0·18	8	0·031	0·19	0·070
				M 111/4	26–48	6·0	14	n.d.	n.d.	n.d.	0·022	0·08	0·071
5	near Kukum, Guadalcanal	275	limestone	M 123/1	0–10	8·5	17	5·10	0·42	12	0·077	0·56	0·066
				M 123/4	24–28	8·5	24	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
				M 123/3	13–60	8·0	38	n.d.	n.d.	n.d.	0·027	n.d.	0·031
6	Mt. Austen, Guadalcanal	1000	limestone	M 124/1	0–9	6·0	23	5·50	0·50	11	0·034	0·27	0·270
				M 124/3	16–28	5·5	17	1·50	0·14	11	0·021	0·18	0·260
				M 124/4	28–56	4·5	15	n.d.	n.d.	n.d.	0·015	0·25	0·170
7	Kolombangara	225	olivine pyroxene basalt	M 91/1	0–10	3·5	20	4·20	0·066	64	0·024	0·065	0·059
				M 91/3	27–40	4·0	15	0·50	0·035	15	0·020	0·068	0·042
				M 91/5	54	n.d.	21	0·20	n.d.	n.d.	0·012	0·076	0·120
8	Kolombangara	1000	olivine pyroxene basalt	M 90/1	0–4	3·5	36	7·60	n.d.	n.d.	0·020	0·05	0·050
				M 90/3	11–32	4·5	22	1·00	n.d.	n.d.	0·010	0·06	0·036
9	Kolombangara	2100	olivine pyroxene basalt	M 88/1	3½–0	3·25	95	55·00	2·2	25	0·049	n.d.	0·083
				M 88/2	0–3	3·5	36	15·00	0·83	18	0·023	0·069	0·052
				M 88/4	12–36	4·5	16	0·60	n.d.	n.d.	0·011	0·090	0·035
				M 88/6	50–54	n.d.	21	0·07	0·003	23	0·008	0·066	0·073

APPENDIX 2 (*cont.*)

profile no.	location	altitude (ft.)	parent material	sample no.	depth (in.)	pH*	loss on ignition (%)	organic carbon (%)†	N (%)†	C/N	K (%)‡	Mg (%)‡	P (%)‡
	site data					chemical analysis							
10	Kolombangara	2600	olivine pyroxene basalt	M89/1	2½–0	3·0	82	47·80	2.4	20	0·055	n.d.	0·130
				M89/2	0–4	5·0	29	3·60	0·2	18	0·011	0·050	0·058
				M89/4	21–33	5·0	24	2·40	n.d.	n.d.	0·003	0·096	0·045
				M89/6	48–60	4·5	19	0·12	0·002	60	0·013	0·180	0·075
12	Kolombangara	3000	olivine pyroxene basalt	M84/1	9–0	3·5	96	56·00	2·2	25	0·057	n.d.	0·093
				M84/2	0–2	3·0	63	38·00	1·7	22	0·041	n.d.	0·110
				M84/4	6–25	5·0	24	1·10	0·037	30	0·010	0·053	0·040
				M84/6	36	6·0	28	0·22	0·005	44	0·005	0·096	0·065
13	Kolombangara	3000	olivine pyroxene basalt	M85/1	0–6	5·0	28	0·49	0·12	4	0·009	0·074	0·044
				M85/3	24–30	6·5	24	0·53	0·019	28	0·009	0·140	0·074
				M85/4	30–33	n.d.	26	0·12	0·006	20	0·007	0·150	0·059
14	Kolombangara	4000	olivine pyroxene basalt	M87/1	8–0	3·25	77	45·00	2·10	22	0·019	n.d.	0·083
				M87/2	0–1½	3·5	46	26·00	1·40	19	0·019	n.d.	0·240
				M87/4	7–24	4·0	14	0·93	0·043	22	0·011	0·290	0·041
				M87/5	24–26	n.d.	11	0·47	0·026	18	0·016	0·590	0·042
16	Kolombangara	5540	olivine pyroxene basalt	M86/1	16–0	3·0	95	55·00	1·60	34	0·047	n.d.	0·064
				M86/2	0–1½	3·0	73	41·00	1·40	29	0·013	0·027	0·038
				M86/4	3–10	3·5	20	8·50	0·13	65	0·025	0·190	0·031
				M86/6	30–33	n.d.	10	1·10	0·033	33	0·050	0·280	0·110
17	Kolombangara	100	alluvium from olivine pyroxene basalt	M92/1	0–18	3·5	13	8·10	0·12	68	0·056	0·390	0·079
				M92/3	24–40	4·0	14	9·00	0·11	82	0·041	0·230	0·090
18	Santa Isabel	800	serpentine	M116/1	3–0	3·5	58	30·00	1·70	18	0·043	0·130	0·017
				M116/2	0–3	3·25	17	4·90	0·30	16	0·022	0·061	0·008
				M116/4	6–33	4·0	17	n.d.	n.d.	n.d.	0·018	0·063	0·006
				M116/5	33–54	4·0	13	0·20	n.d.	n.d.	0·020	0·120	0·002
				M116/6	54–84	4·5	12	n.d.	n.d.	n.d.	0·019	0·170	0·003
				M116/7	84–88	4·0	10	n.d.	n.d.	n.d.	n.d.	0·550	n.d.
19	Santa Isabel	200	serpentine	M115/1	0–6	4·0	18	5·00	0·19	26	0·042	0·071	0·013
				M115/2	6–9	3·5	15	n.d.	n.d.	n.d.	0·024	0·064	0·009
				M115/3	9–18	3·5	14	1·20	0·13	9	0·020	0·054	0·007
				M115/4	18–36	4·0	13	n.d.	n.d.	n.d.	0·020	0·058	0·005

Appendix 2 (*cont.*)

	site data					chemical analysis							
profile no.	location	altitude (ft.)	parent material	sample no.	depth (in.)	pH*	loss on ignition (%)	organic carbon (%)†	N (%)†	C/N	K (%)‡	Mg (%)‡	P (%)‡
20	San Jorge	200	gabbro (?)	M119/1	0–5	4·5	15	2·70	0·25	11	0·490	1·30	0·019
				M119/2	5–12	4·5	10	0·70	0·067	10	0·580	1·20	0·009
				M119/3	18–24	5·0	10	n.d.	n.d.	n.d.	0·580	0·640	0·003
				M119/4	12–30	6·5	9	n.d.	n.d.	n.d.	0·620	0·620	0·003
21	Santa Isabel	100	basalt	M121/1	0–6	6·25	14	2·40	0·28	9	0·380	0·740	0·019
				M121/2	6–10	6·25	11	n.d.	n.d.	n.d.	0·450	0·690	0·010
				M121/3	10–30	5·0	11	0·50	0·064	8	0·500	0·550	0·005
				M121/4	30–48	5·5	11	n.d.	n.d.	n.d.	0·540	0·560	0·004
				M121/5	48–52	5·5	11	n.d.	n.d.	n.d.	0·410	0·580	0·003
22	Kirigi Is., Thousand Ships Bay	100	calcareous sandstone	M120/1	0–3	6·5	21	6·80	0·64	11	0·029	1·50	0·043
				M120/3	5–22	7·0	10	n.d.	n.d.	n.d.	0·022	0·650	0·018
				M120/4	22–42	7·0	10	n.d.	n.d.	n.d.	0·012	0·640	0·012
23	Santa Isabel	300	sandstone	M117/1	0–4	5·0	19	5·70	0·55	10	0·440	0·890	0·045
				M117/2	4–15	4·0	11	0·70	0·062	11	0·360	0·650	0·024
				M117/3	15–30	4·5	10	n.d.	n.d.	n.d.	0·330	0·560	0·019
24	San Cristobal	330	basalt pillow lavas	M112/1	0–1	5·0	21	5·60	0·52	11	0·043	0·460	0·080
				M112/3	3½–15	4·25	13	0·80	0·077	10	0·019	0·440	0·044
				M112/5	28–34	4·5	12	n.d.	n.d.	n.d.	0·018	0·540	0·043
				M112/7	44–66	6·5	11	n.d.	n.d.	n.d.	0·067	0·690	0·024
25	San Cristobal	750	limestone	M113/1	0–3	5·5	24	5·30	0·54	10	0·180	0·330	0·100
				M113/3	14–27	5·0	14	0·70	0·074	9	0·310	0·600	0·063
				M113/5	33–53	5·0	13	n.d.	n.d.	n.d.	0·210	0·390	0·042
				M113/6	53–72	5·0	12	n.d.	n.d.	n.d.	0·190	0·410	0·040
26	San Cristobal	1650	serpentine	M114/1	5–0	3·5	72	36·00	2·20	16	0·046	0·086	0·040
				M114/2	0–6	4·0	19	2·60	0·13	20	0·021	0·180	0·008
				M114/3	6–26	4·75	17	n.d.	n.d.	n.d.	0·014	0·086	0·006
				M114/4	26–29	4·5	18	n.d.	n.d.	n.d.	0·019	0·058	0·005
				M114/5	29–39	4·25	14	n.d.	n.d.	n.d.	0·021	0·061	0·013

* Field pH on saturated soil paste method of Raupach & Tucker (1959). † On oven dry basis.
‡ Total extracted by boiling for 4 h in 20·24 % HCl. n.d. = not determined.

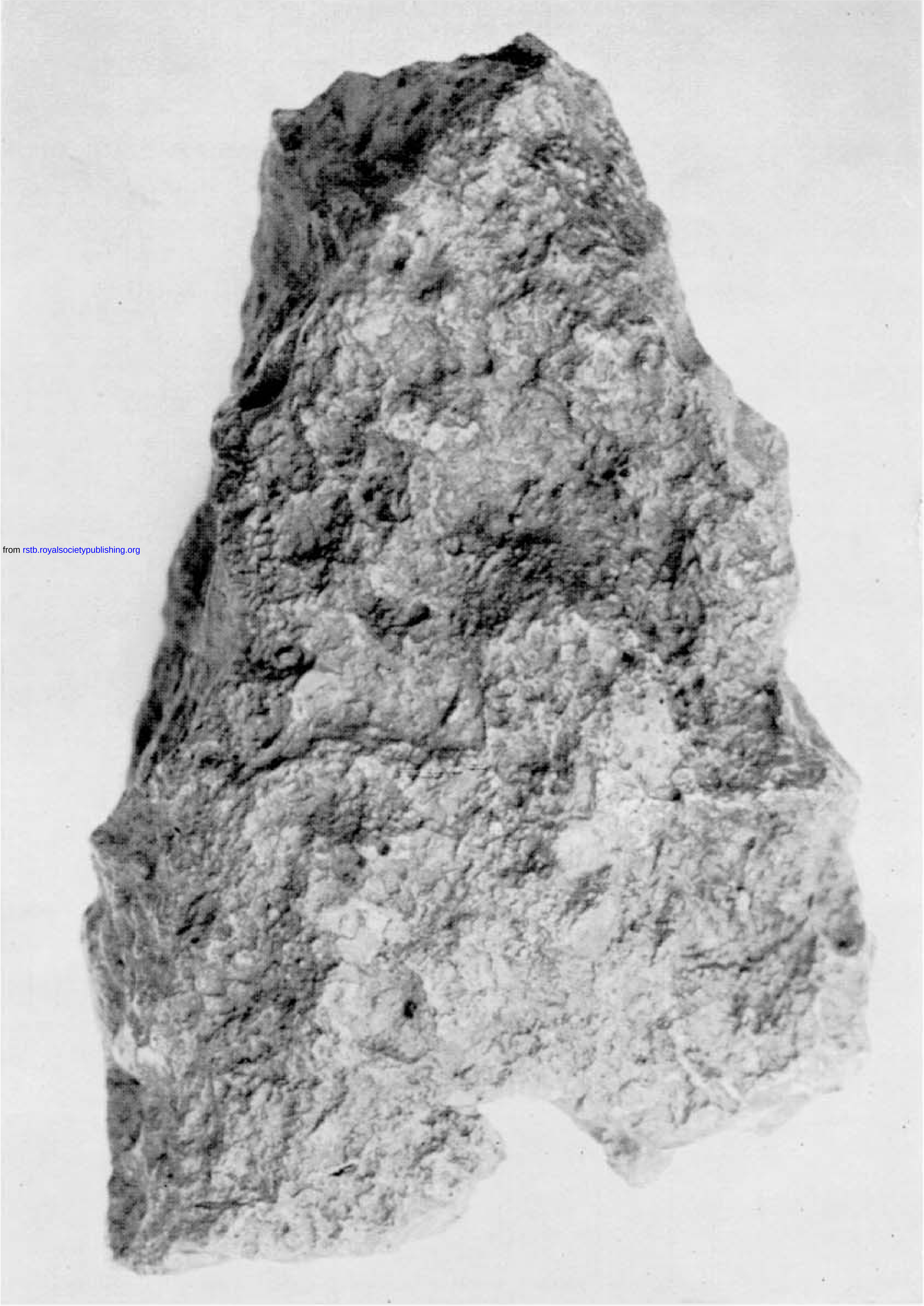

FIGURE 14. Upper surface of irregular flattened laterite concretion from bare ground surface of soil derived from serpentine, Tanameko Cove, Santa Isabel Island. (Maximum dimensions 12 cm × 8 cm × 4·5 cm thick.)