COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

REPORT No. 82

The Geology of Fergusson and Goodenough Islands, Papua

BY

H. L. DAVIES and D. J. IVES

Issued under the Authority of the Hon. David Fairbairn
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CORRECTIONS

Contents : Numbers after 'APPENDIX 2' refer to Tables in text.
Plate 11 is reproduced at 1:250,000 and Plates 12 and 13 at 1:100,000.

p. 3 para 2 line 5: for 'Towara', read 'Tewara'.

p. 4 para 2 line 3: for 'Gosiages', read 'Gosiagos'.

p. 16 para 3 line 1: insert 'gneiss' at end of line.

p. 19 para 5 line 2: for 'Bebulibuli', read 'Mebulibuli'.

p. 21 para 1: reference is to p.25.

p. 34 para 5: for 'p36ft', read 'p36ff'.

p. 40 para 5 line 1: for 'Salame', read 'Salamo'.

p. 41 para 3 line 3: for 'selfatara', read 'solfatara'.

p. 45 para 2 line 1: for 'Fegg', read 'Fogg'.

p. 47 para 2: reference is to p.38.

p. 51 para 1 line 4: for 'Gwabe', read 'Gwabe Gwabe'.

para 3 line 5: for 'p.12,ft', read 'p12ff'.

p. 55 para 1 line 6: for 'examplified', read 'exemplified'.

para 3 item 2: for 'emphibolite', read 'amphibolite'.

Plate 2: The captions to Figs. 1 and 2 are reversed.

Plate 7, Fig. 2 caption: for 'entruded', read 'extruded'.

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SUMMARY

The D'Entrecastreaux Islands lie between 15 and 65 miles north of the eastern end of the Papuan mainland. There are three major islands, Normanby, Fergusson, and Goodenough, and a number of smaller islands.

Goodenough Island, 22 miles long and 16 miles wide, consists of an 8000-foot mountain range, the 'Goodenough Block', flanked by foothills and gently sloping plains. Fergusson Island, 32 miles long and 20 miles wide, consists of two 6000-foot mountain ranges, the 'Mailolo Block' and the 'Oiatabu-Morima Arc', separated by a lower range in the centre of the island, and flanked by low foothills and plains.

The Goodenough Block is a dome consisting of metamorphic rocks with a granodiorite core; the Mailolo Block is the northern half of a dome of metamorphics, and the Oiatabu-Morima arc is a remnant of the south-eastern half of a dome of metamorphics with a granodiorite core. The margins of the domes are faulted. Ultramafic rocks occur within the metamorphic rocks and on some of the marginal faults. Volcanic rocks also occur on some of the marginal faults; elsewhere they have built up peninsulas (on Fergusson and Goodenough Islands) and small islands (Amphlett Group, etc.).

The metamorphic rocks are at least 7000 feet thick, and consist of quartzo-feldspathic gneiss and minor schist, amphibolite, and calcareous gneiss. They are commonly of almandine-amphibolite facies (kyanite-almandine-muscovite subfacies), but include some granulite and eclogite. The more deeply buried metamorphic rocks have been mobilized in places.

The ultramafic rocks are highly magnesian dunite, harzburgite, and pyroxenite; they are partly or completely serpentinized and, in places, opalized and carbonated. The granodioritic rocks show local variations in composition to trondhjemite and adamellite, and even to granite. Metasomatized gabbro occurs as inliers within the granodiorite.

The volcanics are found in three provinces:

1. Fergusson Island (south-east and south-west) - acid and intermediate, predominantly fragmental;
2. Goodenough Island - basic and intermediate lavas;
3. Amphlett Group and Uama and Towara Islands - intermediate (and rare basic) lava and agglomerate.

There are volcanic cones on south-eastern Fergusson Island (Lamonai and Oiau) and on Dobu Island nearby, and small cones on Goodenough Island. Thermal activity occurs on Fergusson, Goodenough, and Dobu Islands.

The postulated geological history of the islands is

1. Deposition of at least 7000 feet of sediments;
2. Regional metamorphism by deep burial;
3. Emplacement of ultramafic and gabbroic rocks, perhaps contemporaneously;

4. Emplacement of medium-to high-level plutons of granodiorite resulting in (a) local doming of the metamorphics, and (b) faulting on the dome margins;
5. Elevation of the domes of metamorphics, probably in Quaternary time, by movement on the marginal faults;
6. Vulcanism;
7. Partial dissection of the domes by transcurrent faulting and erosion; continuing vulcanism.

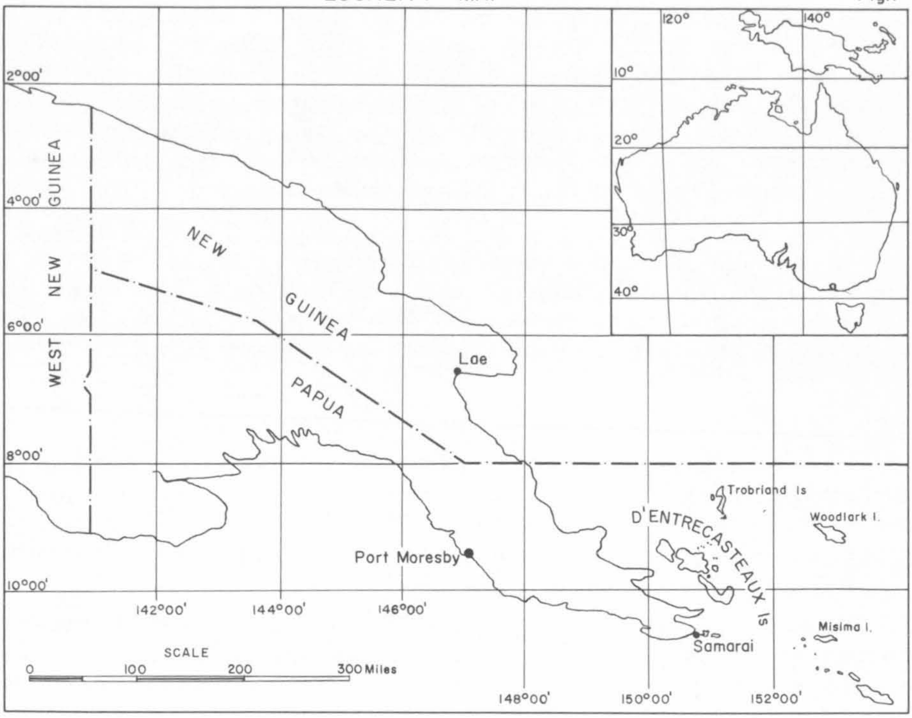
Pumice in Oiau and Dobu cones may be of economic interest; there is an estimated 10 million tons of pumice on Oiau alone. Bauxite may occur on Sanaroa and south-eastern Fergusson Island, but this possibility has not been checked in the field.

INTRODUCTION

This Report presents the results of a geological survey of Fergusson and Goodenough Islands and some of the adjacent islands, excluding Normanby. The islands lie north of the eastern end of the Papuan mainland and belong to the D'Entrecasteaux Group.

The D'Entrecasteaux Islands lie between 15 and 65 miles north of the eastern end of the Papuan mainland, between latitudes 9°12'S and 10°12'S and longitudes 150°5'E and 151°17'E (Fig. 1). There are three major islands, Goodenough, Fergusson, and Normanby, which are roughly aligned in a north-westerly direction. Smaller islands include the Amphlett Group, Uama, Towara, Sanaroa, and Dobu.

LOCALITY MAP Fig.1



Administration and Population

The islands constitute the Esa'ala Sub-district of the Milne Bay District of Papua, and are administered by the Administration of the Territory of Papua and New Guinea through the District Commissioner, Samarai, and the Assistant District Officer, Esa'ala (Esa'ala is situated on the northern tip of Normanby Island). A patrol post and hospital are located at Mapamoiwa on south-western Fergusson Island, and there are European planters and traders at Seblugomwa and Kedidia on south-eastern Fergusson Island, and at Nuamata, Nuatutu, and Nou Nou on the coast of Goodenough Island.

European staff of the Methodist Mission are stationed on Dobu Island, at Salamo in the south-east of Fergusson Island, at Kalo Kalo on north-western Fergusson Island, and at Wailagi on south-eastern Goodenough Island. The Mission headquarters is on Dobu Island, hospitals are at Salamo and Wailagi, and a slipway and workshops are at Salamo.

European staff of Roman Catholic missions are stationed at Budoia on south-eastern Fergusson Island, and at Wataluma on northern Goodenough Island.

The native population of the sub-district is about 29,000; of these 8100 are on Goodenough, 10,900 on Fergusson, Sanaroa, and Dobu, 9600 on Normanby, and 460 in the Amphlett Group. The native peoples are collectively known as Gosiages, and are highly regarded as mine and plantation labourers, as they have a name for good character, industry, and intelligence. Recruiting from Goodenough is at present restricted. The natives are mostly primitive and live by subsistence agriculture (yams, taro, etc.) supplemented by a little 'cash-cropping' in copra, coffee, and chilis. A small degree of self-government has been introduced in south-eastern Fergusson and part of Normanby Island, with the formation of Local Government Councils.

Few of the natives speak English, but most speak Police Motu, except in parts of Goodenough Island where the recruiting restrictions have limited their contact with other language groups. Their own languages vary from one part of the islands to another; thus, a native from one part of Fergusson Island may not understand the speech of a native from another part. The language spoken on Dobu Island has been adopted by the Methodist Mission as a lingua franca, and is taught in its missions throughout the islands. Thus an educated native may understand four languages, his own native tongue, English, Police Motu, and Dobuan.

The head-hunting days are only 70 years past, and stories and relics, such as special war spears, are still preserved. With the advent of the missions and government control the different tribes have forgotten their old animosities, and there has been a general migration of villages from good defensive positions in the hills down to flatter, more open ground.

Access

A fortnightly seaplane service links Esa'ala with Samarai and Port Moresby. A sealed wartime airstrip at Vivigani on north-eastern Goodenough Island is in quite good order, despite lack of maintenance over the last ten or fifteen years. The amount of traffic to and from the area does not, at present, warrant a regular service, so the airstrip is only occasionally used.

Most traffic in the area is by sea, in craft ranging from 60-foot workboats to launches, speedboats, and native canoes. The large vessels ply fairly regularly between the islands and Samarai; some call at the Trobriands and Woodlark Island en route, and others continue up the north coast of the mainland as far as Lae. They are available for charter at a general rate of £30 to £35 per day.

All-weather anchorages are located at Esa'ala, in Gomwa Bay on the south-eastern Fergusson Island, and in Mud Bay on south-eastern Goodenough, and there are jetties at Esa'ala, at Salamo and Seblugomwa in Gomwa Bay, at Mapamoiwa, and at Wailagi and Nou Nou in Mud Bay. The southern coasts of the islands are exposed to the south-easterly monsoon and are accessible only when the winds are favourable. The northern coasts are sheltered for most of the year, but are unsafe during the north-west monsoon.

Movement on the islands is generally by foot. There are 20 or 30 miles of formed road on northern Goodenough Island and a mile of vehicle track at Salamo; The formed road has not been maintained since the war years, and many of the creek crossings are now impassable. Foot-tracks linking the main villages and Government rest houses are generally on flat ground; grass along them is kept trimmed, and they are bordered by shrubs or coconut palms. Most of the mountain ranges are traversed by smaller tracks linking villages on different sides of the ranges, and by hunting tracks; some of these tracks are marked only by the occasional shrub or knife scar, and are not apparent to the untrained eye. The forest has relatively little undergrowth, and it is usually possible to traverse it at little less than normal walking speed.

Climate

Climate is controlled by the monsoonal seasons and topography. The seasons are (National Development, 1951);

North-west Monsoon:	mid-December to mid-March.
South-east Monsoon:	May to October.
Doldrums:	November to mid-December and mid-March to April.

Rainfall is spread throughout the year, but on the southern flanks of the mountains it is heaviest during the south-east season, whereas on the northern slopes it is heaviest during the north-west season (R. Leach, pers.comm.). The only monthly rainfall figures available are those recorded at Salamo; the average figures over a period of 8 years are

Month:	J	F	M	A	M	J	J	A	S	O	N	D	Total
Rainfall:	8	6	8	7	9	14	8	6	10	10	8	6	101 inches

For the duration of the survey the weather was mostly fine, but there were occasional spells of very heavy rain lasting from two days to a fortnight.

No records of temperatures have been kept but it may be assumed that temperatures in the coastal regions are comparable with those for Samarai, where the average maximum reading ranges from over 90° in the north-west season to 83° in July and August (National Development, 1951).

In general the climate is not trying during the south-east season, as there is almost always a refreshing breeze, but during the north-west season and doldrums the days are hotter and the wind less consistent. The uplands are relatively cool throughout the year, and the higher mountain peaks are hidden by cloud after 8 or 9 a.m. almost every day.

Flora

Vegetation on the islands may be classified into five types, which are, in order of prevalence: (i) rain forest, (ii) grassland, (iii) secondary growth, (iv) alpine grassland, and (v) open forest with grassland.

Rain forest covers about 80 percent of the islands; it generally has little undergrowth, and is fairly easy to penetrate. However, on the higher parts of the Goodenough Island, above about 5000 feet, there is considerable undergrowth, including some fine bamboo creeper. This is due to a relative thinning of the forest at these altitudes; the tree-top canopy is not as complete, and thus permits sunlight to reach the undergrowth. Pines were noted in parts of the Morima Range.

Grassland occurs on some of the plains and foothills flanking the mountain ranges. In addition, the northern slopes of the Mialolo Block and parts of the north-eastern slopes of the Goodenough Block are grassed. The grass is between 2 and 6 feet high. Common belief is that the grasslands have developed where rain forest has been destroyed initially by clearing for gardens and later by repeated burning off.

Secondary growth, consisting of a tangle of saplings, small trees, and vines, is difficult to penetrate and commonly infested with small scrub ticks (mokkas). It develops on the sites of abandoned gardens and, over the years, is probably replaced by normal rain forest.

Alpine grassland is restricted to some of the peaks of Goodenough Island at elevations greater than 5000 feet.

Open forest with grassland occurs on the low raised coral hills near Mapamoiwa and on low volcanic hills in the Iamelele area. Many of the trees look rather like the Australian 'paper-bark'.

Nipa and sago palms grow locally in swamps; nipa is used in the building of huts.

Fauna

Pigs, dogs, and poultry are found in almost every village; they were introduced to the islands long before European settlement (National Development, 1951). Native animals include the wallaby, tree kangaroo, cuscus, and flying fox. Native birds include the common grey pigeon, Torres Strait pigeon, hornbill, scrub-hen, sulphur-crested white cockatoo, and a variety of colourful smaller birds; the cassowary, a fairly common bird on the Papuan mainland, is not present in the islands. The most common snake is the python, but there are, reputedly, no venomous snakes on the islands. The coral reefs abound with fish.

The only insect pests of note are the flying beetles which flock to a lamp at night. Mosquitos were encountered only at Deba on north-western Fergusson Island, and on Lawa Island near Mapamoiwa. Their general absence is probably the result of spraying by anti-malaria teams from the Department of Public Health.

Topographic names

Wherever possible names of topographic features used in this report are those accepted in common usage. For many of the features no such names are available, and in these instances names used by local natives, preferably those with rights to the land on which the feature occurs, are used.

In the naming of streams confusion arises from the fact that one stream may have a number of different names for different parts of its course. The names given to mountain peaks may vary from village to village. Thus on the military map the four eastern peaks of Goodenough Island, from west to east, are named (i) Vineuo, (ii) Oiatukekea, (iii) Nimadao, and (iv) Oiamadawa'a. According to Brass (1956) the same peaks are called (i) Mouna, (ii) Natuioli, (iii) Vineuo, and (iv) Oiamadawa'a. According to Galuwata villagers questioned by one of the authors the names are (i) unknown (not visible from Galuwata Creek), (ii) Iauiau, (iii) Oiatukekela, and (iv) Oiamadawa'a, and a subsidiary peak on Oiatukekela is called Natuioli. Mount Oiamadawa'a is known to the Wataluma villagers as Gubuwama.

Method of working

The party, consisting of two geologists, a field assistant, and about 30 native labourers, began the survey in early July and completed it in late November 1961. Eleven weeks were spent on Fergusson Island, and four weeks on Goodenough.

Initially the party circled Fergusson Island in the m.v. Govilon, landing stores at various points around the coast. Field work commenced from Salamo on 12th July, with a traverse northwards through Gamabila to Boselewa and Wadelei on the north coast. Thence the party moved westward to the Bwinai River and south through the Salakadi area to the Morima coast, then eastwards along the coast to Salamo (15th August). After a week of re-organization the party moved north-eastward through the Galea area to the Basima coast, thence around the north-eastern coast to Wadelei. A chartered vessel took the party to Gwabe Gwabe on the coast north-east of the Mailolo Block on 4th September. In the following three weeks the Mailolo Block was mapped by traverses through and around the range and the party moved on to Mapamoiwa, arriving on 23rd September.

A fresh supply of stores was received at Mapamoiwa, and these were disposed at various points around the coast of Goodenough Island. Field work on Goodenough began on the 9th October and was completed on 8th November. The party then traversed through the Amphlett Islands and Uama, Tewara, and Sanaroa Islands on the m.v. Koonwarra, finally reaching Esa'ala on 20th November.

While in the field the party moved camp every second day, and sometimes on successive days. Long traverses were made on alternate days. In the mapping of Goodenough Island the geologists operated from separate camps, and thus covered the ground more quickly.

Most of the native labourers were recruited from the Daga area of the Baniara sub-district on the Papuan mainland. Local natives were employed as guides, and whenever extra carriers were needed.

Information was plotted direct on vertical and oblique air-photographs, which give an almost complete coverage of the islands. The photographs were taken by the United States Air Force at different times during and after the 1939-45 war. Many are of inferior quality, and may also have cloud cover and obscured edges; scales range from 1:52,000 to 1:40,000 and 1:28,000 over the higher mountains.

Information was later plotted on base maps compiled from the military one-mile maps of Fergusson and Goodenough Islands and Dawson Strait; in some areas the base maps were corrected using later air-photographs and field observations.

Acknowledgements

The members of the party wish to express their sincere thanks to all the people of the islands who, without exception, provided friendly co-operation and generous hospitality. In particular we would like to thank the Acting District Commissioner at Samarai, Mr R.T. Galloway, the Regional Stores Officer at Samarai, Mr H. Morton, the Assistant District Officer at Esa'ala, Mr C.T. Healy, the Patrol Officer at Mapamoiwa, Mr J.C. Battersby, and the Methodist Mission.

During the survey, equipment and rations were stored at the Methodist Mission at Salamo, the Patrol Post at Mapamoiwa, and in Mrs Gribben's trade store at Nou Nou. Mr A.J. Scott-Branagan at Salamo, Mr and Mrs Battersby at Mapamoiwa, Mrs A. Hall of Nou Nou, and Mr C. Rich of Naututu acted, in effect, as our agents, handling mail services, telegrams, and other arrangements such as boat charter. Others who provided similar services from time to time were Rev. and Mrs C. Garlick of Kalo Kalo, Mr M. Preece of Kedidia, Mr N. Everett of Seblugomwa, Fr. Abbott of Wataluma, Mr R. Leach of Naumata, Ansi of Gabila, Tom of the Wadelei trade store, and Thomas of Ailuluai.

Mr and Mrs J.H. Gosbell of Esa'ala, and Mr and Mrs Battersby and Mr M. O'Callaghan of Mapamoiwa, opened their homes to us during field-breaks, and their hospitality is gratefully acknowledged.

W.B. Dallwitz and C.D. Branch of the Bureau of Mineral Resources and Drs. A. White and J.H. Lovering of the Australian National University assisted greatly in the petrological study of rocks.

TOPOGRAPHY

Goodenough Island, 22 miles long (north-west/south-east) and 16 miles wide (south-west/north-east), is roughly circular in outline, with a peninsula in the south-east. The island is dominated by a mountain range which rises higher than 8000 feet at Mount Vineuo; this range will be referred to as the Goodenough Block (Pl. 1, fig. 1). On the western, south-eastern, and eastern flanks of the range are low foothills, and on the northern flank a broad plain slopes up to the front of the range. The plain is broken by Mount Oiava'ai and a group of low hills around Wataluma Hill; there are smaller plains on other flanks of the range. The main streams are Wauna and Galuwata Creeks in the north and north-east and Fakwakwa and Goiala Creeks in the south. A small crater lake (Diodio Lake) lies near Fakwakwa Creek.

Fergusson Island, about 32 miles long (east-west) and 20 miles wide (north-south), is roughly rectangular, with a large promontory in the north-west and peninsulas in the south-west (Kukuia) and south-east (Bwaioa). The coastline features large bays in the west (Seymour) and north (Hughes) and smaller bays in the south-east (Sebutuia and Gomwa). The two main mountain ranges, one in the north-west and one in the east and south, will be referred to as the Mailolo Block and Oiatabu-Morima Arc, respectively. The latter range is arcuate in outline and is made up of the Oiatabu and Morima Ranges. The highest peaks are 5615 feet in the Mailolo Block, 5977 feet in the Morima Range and 6800 feet (Mount Oiatabu) in the Oiatabu Range.

In the centre of the island are lower hills rising to about 2000 feet. On Kukuia Peninsula the general elevation is about 1000 feet. In the south-eastern part of the island a large area of plain and low hills (up to 200 or 300 feet elevation) is flanked to the east by two volcanic cones, Lamonai and Oiau (Pl. 1, fig. 2).

The main rivers are the Ata'ata and Bwinai, which drain from the Morima Range north to Hughes Bay, and the Salamo, which drains much of the south-eastern and central part of the island. Some of the rivers, particularly those running into Hughes Bay, flow strongly through the mountains but are marked by dry bouldery beds on the plains, where the water apparently seeps into the ground. This phenomenon is also seen on northern Goodenough Island.

In the western central part of Fergusson Island there is a lake, Lake Lavu, 1 3/4 miles long and almost a mile wide. Natives report that the lake is drained by Lavu Creek, a tributary of Ata'ata River; the course of the creek could not be ascertained in air photographs owing to the dense forest cover. There are several small lakes in the Iamelele thermal area.

The Amphlett Group lies between 6 and 16 miles north and north-east of Fergusson Island. It consists of about 10 small hilly islands arranged in a roughly rectangular pattern. The individual islands are irregular in outline and none has an area greater than about 5 square miles. The highest peak is 1921 feet on Yabweia Island.

Uama and Tewara are two elongate islands of moderate relief about 8 miles off the north-eastern coast of Fergusson Island. They have a combined area of about 6 square miles.

Sanaroa is a low island of moderate relief, about 17 square miles in area, which lies about 2 miles east of the south-eastern coast of Fergusson Island.

Dobu Island is a volcanic cone about 4 square miles in area and a thousand feet high, which lies 2 miles south of a tip of Bwaioa Peninsula. Neumara and Oaiobe are two small islands immediately north-east of Dobu.

The major topographic features are shown on Plate 11.

HISTORICAL NOTES AND PREVIOUS INVESTIGATIONS

The first recorded sighting of the islands was by Rear-Admiral Bruny D'Entrecasteaux in 1793. Captain John Moresby visited the islands in 1874, charted parts of the coast, and reported thermal activity on the north-western coast of Fergusson Island near Cape La Billardiere (Moresby, 1876). Sir William MacGregor visited the islands in 1888 (Annual Report for British New Guinea for 1888-1889); he could find no thermal activity near Cape La Billardiere, but discovered thermal and solfataric activity in the Iamelele area. He collected rock specimens from Goodenough and Fergusson Islands, which were examined by A.W. Clarke of the Queensland Geological Survey (Jack & Clarke, 1889). B.H. Thompson visited the Iamelele solfatara field in 1888 (Thompson, 1889).

The first geologist to visit the islands was A. Gibb Maitland, of the Geological Survey of Queensland, in 1891. He spent several days in the Dawson Straits area and made a detailed examination of Dobu and Oiau cones (Maitland, 1892). He was followed in 1915 or 1916 by Evan R. Stanley, the Government Geologist for Papua, who made a reconnaissance survey of Normanby and Dobu Islands (Stanley, 1916). Stanley returned in 1919 to make a reconnaissance survey of Fergusson Island (Stanley, 1920). He made only one traverse, moving anti-clockwise around the island from Kedidia to Basima, to Boselewa, across the south-eastern flank of the Mailolo Block to Iamelele, thence to the south coast of Kukuia Peninsula and eastwards to Salamo; the whole survey took less than two months. From it he produced a report and map which subsequent surveys have borne out as substantially correct. Stanley divides the metamorphics into a Huronian or Algonkian series (schist and gneiss with a few limestones and phyllites) and a pre-Algonkian or Archaean complex (gneisses and schists of igneous origin). His 'Huronian' rocks may be the layered metamorphics of groups II and III, and his 'Archaean' may be the partly mobilized and contorted gneisses of group I (see under 'Metamorphics', p. 11). The two varieties of metamorphics are now regarded as parts of the one metamorphic sequence and their age is thought to be Palaeozoic or possibly Mesozoic.

A. Coulson collected rock specimens from northern Goodenough Island, north-western Fergusson Island, and Urasi Island in the Amphlett Group, during the 1939-45 war. These specimens were subsequently examined by G. Baker of the University of Melbourne, and the results, together with Coulson's field notes, were published in 1948 (Baker & Coulson, 1948). Baker concluded that most of the metamorphic rocks which he examined were derived from acid and basic igneous rocks. We do not feel competent to question Baker's petrological work, but have concluded, from field observations and petrological study, that much or most of the metamorphics are of sedimentary origin.

A.K.M. Edwards, then Bureau of Mineral Resources Senior Resident Geologist at Port Moresby, visited the Iamelele solfatara field in 1950 to investigate the sulphur deposits of the area. From his estimates and observations it appears that the sulphur could not be exploited economically (Edwards, 1950).

G.A. Taylor, of the Vulcanological Observatory in Rabaul, briefly inspected the Deidei thermal area in 1951, and in June 1955, he examined parts of Lamonai and Oiau cones and the Deidei thermal area (Taylor, 1955a). In August 1955, fellow vulcanologist M.A. Reynolds examined Oiau, Dobu, and Wagipa cones, and the thermal areas at Deidei and Iamelele (Reynolds, 1958a & b). In May 1957, Taylor briefly examined Lamonai crater (Taylor, 1957), and in September 1958, re-visited the Deidei thermal area (Taylor, 1958). Volcano-seismic phenomena in the islands to 1957 are summarized in a report by Reynolds (1957).

Specimens of sulphide-bearing opalized serpentinite breccia were collected from Mebulibuli Creek by L.H. Wilkinson in 1958. These were examined by W.B. Dallwitz and W.M.B. Roberts, of the Bureau of Mineral Resources' Canberra laboratory (see Appendix 1). In 1959 J.E. Thompson, then Bureau of Mineral Resources Senior Resident Geologist in Port Moresby, visited Mebulibuli Creek and collected further specimens of the breccia, which were partly analyzed by S. Baker of the Canberra laboratory (Baker, 1959).

P.W. Pritchard, then of the Bureau of Mineral Resources resident staff in Port Moresby, made a five-week reconnaissance of Fergusson and Goodenough Islands in June-August 1960. His report was of considerable use in the current survey. In February 1962, Taylor (1962) re-visited Oiau and Dobu cones to locate possible pumice quarry sites.

Papers which refer briefly or indirectly to the geotectonic position of the D'Entrecasteaux Islands have been published by Carey (1938) and Glaessner (1950). Carey groups the D'Entrecasteaux Islands with the Bonvouloir islets and reefs and Misima Island, as the northern margin of the still active Upper Tertiary Vogel Geosyncline.

GEOLOGY

In the following pages the rocks which form the islands are discussed in order of decreasing age, as listed below:

> Metamorphics; Ultramafics; Metasomatized gabbro; Granodioritic intrusives; Pegmatites; Dyke rocks; Volcanics; Raised coral; Talus; Alluvium.

Each rock group is described in detail, and its relationship with the other rock groups discussed.

METAMORPHICS

The metamorphic rocks of Fergusson and Goodenough Islands are predominantly quartzo-feldspathic gneiss; schist, calcareous gneiss, and amphibolite are found in parts of the section. Metamorphic grade is generally almandine-amphibolite facies (kyanite-almandine-muscovite subfacies) and rarely granulite and eclogite facies.

The age of the metamorphics is not known. Stanley (1920) suggested that they were Huronian and Archaeon, probably on the basis of the high metamorphic grade. The consensus of current opinion is that the metamorphics of Papua and New Guinea are Palaeozoic or Mesozoic or both. The metamorphics of Fergusson and Goodenough Islands may be related to the Owen Stanley Metamorphics of the eastern Papuan mainland, though the latter are generally of lower grade (greenschist facies).

Metamorphics of almandine-amphibolite grade, on Fergusson and Goodenough Islands, may be divided into the following types on the basis of composition and fabric:

1. Quartzo-feldspathic
   (a) layered gneiss
   (b) quartzose gneiss
   (c) micaceous gneiss
   (d) leucocratic gneiss
   (e) hornfelsed gneiss

2. Highly aluminous

3. Calcareous

4. Basic
   (a) layered amphibolite or gneiss
   (b) homogenous amphibolite.

These rock types were probably formed by high-grade regional metamorphism of an original sedimentary pile containing acid and basic igneous rocks. They now form a sequence of metamorphics, with a minimum thickness of 7000 feet, which grades from very acid near the bottom to about 50 percent basic and calcareous at the top.

This simple variation in composition is complicated by partial mobilization of the lower part of the sequence; parts of the sequence which have not been mobilized retain a simple layered fabric which generally represents original bedding. Three broad groups of metamorphics are recognized on the grounds of (i) composition and (ii) presence or absence of layering; they are summarized in the following table. Code figures refer to the list of rock types.

	GROUP	THICKNESS	DESCRIPTION	CODE
Top	III	Up to 2000 feet.	Mixed layered calcareous, basic, and quartzo-feldspathic gneiss; about 50 percent quarzo-feldspathic	1a,3,4a
	II	Up to 3000 feet.	Layered quartzo-feldspathic gneiss with some more micaceous or more quartzose layers.	1a,1b,1c
Bottom	I	Probably greater than 2000 feet.	Quartzo-feldspathic gneiss, mostly leucocratic, rarely layered, some apparently mobilized.	1d(1a)

Groups II and III have a regular layering, produced by alternation of light and dark folia; group III is distinguished from group II by the higher proportion of basic and calcareous gneiss (between 10 and 50 percent). Group I gneiss is characterized by the rarity or absence of regular layering; this may be due to either partial mobilization, or increasing homogeneity associated with decreasing femic content.

Thus the boundary between groups I and II may correspond to either the upper limit of mobilization, or the upper limit of leucocratic homogeneous gneiss. In a more detailed survey it might be possible to define group I on grounds of mineral composition alone, and to map the limit of mobilization separately.

For clarity some of the less common or more erratically disturbed rock types are not included in the tabulated section above. Highly aluminous gneiss and schist (2) were found at only one locality; together they are between 100 and 200 feet thick, and occur at the base of group III. Homogeneous amphibolite (4b), basic granulite, and eclogite occur as sub-concordant sills, pods, and lenses up to 6 feet thick within the quartzo-feldspathic metamorphics and as xenoliths within granodiorite. Homogeneous amphibolite also forms two large bodies up to a mile across within or adjacent to the quartzo-feldspathic metamorphics. Hornfelsed quartzo-feldspathic gneiss (1e) occurs at the margin of the Omara Granodiorite.

Foliation within the metamorphics (e.g., in the layered quartzo-feldspathic gneiss) is thought to represent or coincide with original bedding, though some minor modification by lit-par-lit injection of acid material, and, perhaps, by metamorphic differentiation, appears to have taken place. It is consistent through up to 4000 feet of section, and is broadly folded into anticlines and domes. It is conformable with the contacts between the different groups and with local variations in rock type within the groups (e.g., layers of quartzite, mica schist, marble, and amphibolite within the layered quartzo-feldspathic gneiss).

Origin

The layered quartzo-feldspathic gneiss (1a,1b,1c) is probably derived from bedded arenite or acid volcanics. The more homogeneous quartzo-feldspathic gneiss (1d) may be derived from similar rocks or possibly from homogeneous acid igneous intrusives. The rare aluminous gneiss and schist (2) is derived from pelitic sediments. Calcareous (3) and layered basic metamorphics (4a) are derived from pure and impure limestone and possibly basic tuff and lava. Homogeneous amphibolite (4b) is probably derived from gabbroic intrusives, but some may have formed by retrograde metamorphism of eclogite.

Before metamorphism the sedimentary pile probably contained 10,000 feet or more of sediments and some basic and acid igneous rocks. Most of the 'sediments', particularly in the lower half of the section, were arenites or acid volcanics. Towards the top of the section calcareous sediments, basic tuff and lava, and rare pelitic sediments occur.

Distribution and structure

The present distribution of the metamorphics is controlled by folding, faulting, and erosion. Thus in the following account of their distribution it is necessary to make brief mention of structure.

The metamorphic rocks are broadly folded into domes and anticlines which form the main mountain ranges: the Goodenough Block, Mailolo Block, and Oiatabu-Morima Arc. The Goodenough Block is an almost complete dome, the Mailolo Block is a dome the southern half of which has been deeply dissected, and the Oiatabu-Morima Arc is thought to be the south-eastern flank of a dome which once covered the Omara Granodiorite and which will be referred to as the Omara Dome. The Mailolo Block and Oiatabu-Morima Arc may both be parts of the Omara Dome which has been ruptured by transcurrent movement on the Lavu Fault (see under 'Structure', p. 54) and dissected by erosion. The picture is complicated by a broad anticlinal fold in the Oiatabu Range at the northern end of the Oiatabu-Morima Arc.

Group I rocks occur within the domes and anticlines, and are only exposed where the fold structures are dissected by faulting or erosion. Layered rocks of groups II and III form the outer shell of the domes and anticlines, but in many places group III rocks have been removed by erosion.

Goodenough Block: The Goodenough Block is a dome of metamorphics with a core of massive granodiorite.

Group I gneiss is exposed only in the few streams which cut deep into the dome, namely Fakwaoia Creek in the south-west, and Galuwata, Aligabou, and Tuabeda Creeks in the north-east. It is generally richer in biotite than the typical group I gneiss of Fergusson Island, and is distinguished from group II gneiss by its contorted and discontinuous layering rather than by more acid composition.

Group II gneiss forms a complete shell over the dome except near Fakwaoia Creek in the south-west and between Goiala and Gunawala Creeks in the south-east. In the former area it may have been removed by the Ta'uleleia Fault, and in the latter area the dome appears to have been ruptured, perhaps by a fault along the line of Gunawala Creek. In the north-western half of the dome the group is probably more than 2000 feet thick, but in the south-eastern half it is thinner, e.g., 1800 feet on Galuwata Creek, and only about 500 feet on Tuabeda Creek. This thinning effect may be simply due to mobilizing solutions advancing higher in the section than elsewhere, as the group I gneiss in this area has about the same mineral composition as the group II. No contacts between the two groups were seen; in the Galuwata Creek section they are separated by a large body of homogeneous amphibolite which may represent an original gabbroic pluton.

Group III metamorphic rocks consist of a few hundred feet of finely layered amphibolite which is exposed on Wauna and Alua Creeks in the north and north-west.

In the extreme south-eastern part of the Block exposure is generally poor. In Gunawala Creek a little impure marble crops out, and is apparently underlain by massive amphibolite and layered quartzo-feldspathic gneiss. Niubula Creek is remarkable for the occurrence of both basic and acidic granulites.

Low hills flanking the Block on the western and south-western side are mostly of group II gneiss. Low hills south of the block between Niubula Creek and Lauela are of group I gneiss and some homogeneous amphibolite.

Mailolo Block: The Mailolo Block is a dome of metamorphics, the southern half of which has been partly removed by erosion and possibly faulting. Although no granodiorite core is exposed the prevalence of granodioritic pegmatite and, less commonly, coarse-grained granodiorite dykes suggest that such a core might exist.

Group I gneiss, which forms most of the southern half of the Block, has apparently been mobilized, as the gneissosity dips in various directions and, even in small exposures, shows contortions; it is leucocratic and homogeneous. It is typically exposed on the track between Mailolo and Saibutu, in Gudanai Creek, and in the low hills on the south-eastern flank of the block near Lake Lavu. On Awavula, Dilia, and Gaveta Creeks it is mixed with layered gneiss, which also has random orientation.

Group I gneiss in the northern half of the Block is exposed only on Wavuna Creek. It is richer in biotite than the typical group I gneiss, and also contains some marble and amphibolite. Like the group I rocks of Goodenough Island it is distinguished from group II by its contorted and discontinuous layering rather than by more acid composition.

Layered gneiss of groups II and III forms a half dome over the northern half of the Block. Group II gneiss is exposed in most creeks, except in the north-western part of the Block, and has a thickness of about 500 feet in Wavuna Creek. In the centre of the Block it extends about as far south as Mailolo, and on the western and eastern flanks of the block it extends as far south as Kegwagiluma and Wagounai Creeks, respectively. It is mainly quartzo-feldspathic gneiss with up to 10 percent marble and calcareous and basic amphibolite; marble is particularly common on Wauda Creek.

Group III gneiss is best exposed on Wabawe Creek in the north-west, where it has a thickness of about 2000 feet. On the northern flank of the Block, between Mwadeia and Wavuna Creeks, it is about 500 feet thick, except near Wauda Creek where it lenses out, or is, perhaps, removed by the Mwadeia Fault. It is not present on the north-eastern, eastern, and western flanks. It consists of layered basic amphibolite, some marble, quartzo-feldspathic gneiss, and mica schist. Highly aluminous (kyanite-quartz-muscovite) schist occurs near the base of the group III section on Waibewe Creek.

A large body of massive amphibolite containing minor ultramafic inclusions is exposed in Potai and Kwakwau Creeks in the north-western part of the Block. It appears to break the dome, and may represent an original pluton of gabbro with cognate inclusions representing ultramafic segregations.

Oiatabu-Morima Arc: The Oiatabu-Morima Arc is an arcuate mountain range consisting of metamorphics, which generally dip outwards from the Omara Granodiorite. The Arc is thought to be a remnant of a dome of metamorphics (the Omara Dome) which once covered the Omara Granodiorite. This simple picture is complicated by a broad anticlinal fold at the northern end of the Arc. The northern part of the Arc will be referred to as the Oiatabu Range and the southern part as the Morima Range. The Oiatabu Range is only moderately dissected, and consists predominately of layered gneiss of groups II and III; group I gneiss is exposed only in a few of the larger streams. The Morima Range is apparently deeply dissected by erosion and possibly partly displaced by a fault immediately off-shore from the Morima coast, and consists predominantly of group I gneiss with some group II and rare group III gneiss in the eastern part.

Group I gneiss in all parts of the Arc is leucocratic and fairly homogeneous. Gneissosity, imposed by preferred orientation of mica, dips consistently and conforms to the simple fold structure expressed in the overlying layered gneiss. The consistent attitude of the gneissosity suggests that the group I gneiss has not been mobilized, and thus it appears that in the Arc mobilizing solutions have generally not penetrated as high in the section as they have in the northern Mailolo and Goodenough Blocks. Some of the gneiss shows a faint, broad-scale layering in large exposures (e.g., on Wealana Creek) owing to minor variations in the relative proportions of quartz, feldspar, and mica. Towards the top of the group the proportion of femic minerals increases, and layering may be discerned in places. As layering becomes more distinct the group I gneiss grades into group II. Group I gneiss makes up the greater part of the Morima Range, but in the Oiatabu Range it is largely concealed by group II gneiss, and is only exposed in streams which cut deep into the range, namely Ama'wa, upper Magoa, Marasi, and Bwaiwi Creeks.

Group II gneiss forms a northerly-plunging anticline at the northern end of the Oiatabu Range, and extends southwards from the range as far as the eastern end of the Morima Range. It consists of layered quartzo-feldspathic gneiss with up to 10 percent amphibolite and marble, and has a thickness of about 3000 feet on Ama'wa Creek. The amphibolite and marble layers are restricted to the upper part of the group.

Shallow-dipping group III gneiss forms Mebulibuli Peninsula and is excellently exposed in Mebulibuli Creek. It has an estimated thickness of 1000 feet, and consists of interlayered quartzo-feldspathic gneiss, basic amphibolite, and minor calcareous amphibolite and marble.

A thickness of about 150 feet of group III gneiss is exposed in lower Seliselina Creek; it consists of layered calcareous amphibolite, basic amphibolite, and mica schist.

Other exposures: The metamorphic rocks of Kukuia Peninsula are largely concealed by volcanics. On the northern slopes leucocratic gneiss of group I type is exposed, and the gneissosity dips in various directions. On the steeper southern flank leucocratic gneiss, layered quartzo-feldspathic and basic gneiss and some marble are exposed; again dips are in various directions.

A small isolated outcrop of weathered quartzo-feldspathic gneiss is exposed in Lasieiotu Creek, 3 miles west of Salamo, where the stream has cut Quaternary tuff cover. This may indicate that the Lower Seliselina ultramafic body (see under 'Ultramafic') does not extend much farther east than its present outcrop limit.

Description of rock types

The different metamorphic rock types are described under the headings listed on page 14; granulites and eclogites are discussed separately on p. 22. A few brief notes on field occurrence are also given, especially for the less common rock types such as calcareous rocks and granulites and eclogites. Petrographic notes are appended to each sub-section. Figures in brackets after a mineral name indicate the approximate percentage by volume of that mineral in the rock, e.g. hornblende (60) indicates that the rock contains about 60 percent hornblende by volume.

Quartzo-feldspathic

Layered gneiss: Layered quartz-feldspathic gneiss forms the greater part of Group II, which is up to 3000 feet thick. It also occurs in Group I (e.g., on southern Fergusson Island) and in Group III, where it is interlayered with calcareous and basic gneiss. Typically the layering has consistent dip, and conforms to broad domes and anticlines; small-scale folding is rare. Layered gneiss within Group I may have irregular orientation.

The rock is distinguished by a clearly defined layering which consists of alternating folia of quartz-feldspar and femic minerals; the layers range in thickness from tenths of an inch to about a foot (Pl. 2, fig. 1). Much of the layering resembles sedimentary bedding (e.g., R10432 and R10437), but in some areas the quartz-feldspar component appears to have been partly mobilized or, possibly, to have been injected lit-par-lit. This effect is seen in layered gneiss (R10460) which crops out near the Fakwakwa and Wakonai Faults on Goodenough Island. In this the sharply-defined layers of mica do not conform to a regular foliation; instead they converge and diverge, joining and parting in haphazard manner.

Finely layered gneiss (R10949) in the western Salakadi area (Lilahi and Manpau'una Creeks) shows little variation in texture over an area of several square miles. It has been derived from either a mass of homogenous sediments or a granodiorite body.

Some of the layered gneiss contains augen of large plagioclase grains. Augen in Bwagura Creek (Wadelei area) also contains larger scale 'augen' (2 to 3 feet long) of amphibolite.

The typical layered gneiss is of granodioritic or granitic composition, and consists of approximately equal amounts of quartz and plagioclase, totalling about 70 percent of the rock, minor potash feldspar (about 15 percent) and biotite (10-15 percent); muscovite, chlorite, garnet, epidote, or hornblende may form up to 5 percent of the rock; sphene, apatite, and iron oxides are typical accessories. The quartz and feldspar are typically granoblastic anhedra, and the femic minerals are arranged in layers, and are usually oriented parallel to the layering.

Quartzose gneiss: Quartzose gneiss is not common, and was found only as boulders (R11034 and R11035) at one locality, Wavuna Creek in the northern Mailolo Block. The main minerals are quartz and garnet; rutile is accessory, and feldspar is absent. Minor minerals which may be present are pyrite, chlorite (after garnet), secondary tremolite, and muscovite. The texture suggests granulite-facies metamorphism.

A scapolite-quartz-garnet gneiss (R10447) from Niubula Creek on Goodenough Island is similar to the Wavuna Creek rocks, but is definitely of granulite grade, and is discussed under the heading 'Granulite and eclogite facies', p. 22.

Micaceous gneiss: The micaceous gneiss or schist is darker than the typical layered gneiss, as it contains between 25 and 35 percent femic minerals. In most specimens the predominant femic mineral is biotite, but in a few it is epidote. The rock occurs as layers within the layered quartzo-feldspathic gneiss or associated with amphibolite (e.g., on lower Seliselina Creek, west of Salamo). It may have been derived from the metamorphism of pelitic sediments or from the metasomatic alteration of amphibolite.

In some places it contains thin laminae of quartz-feldspar which give the impression of original bedding (e.g., R10432). In other places the quartz and feldspar appear to have been injected along planes of schistosity (e.g. R10964). Two specimens have augen texture: in R11033 the augen consist of aggregates of anhedra of oligoclase-andesine and epidote; in R10965 the augen are large cracked anhedra of albite-oligoclase. In both specimens the plagioclase contains poikiloblastic inclusions of quartz, zircon, apatite, and other minerals.

Leucocratic gneiss: The leucocratic gneiss contains less than 10 percent femic minerals, of which not more than half is biotite. The femic minerals are generally dispersed through the rock, and not concentrated in layers as in the case of the layered gneiss.

Leucocratic gneiss is the typical group I rock type in the Oiatabu-Morima Arc and the southern half of the Mailolo Block. It also forms layers 3 or 4 feet thick within group II gneiss; these layers are generally conformable, but may locally transgress the adjacent gneiss, indicating some mobilization (e.g., on upper Omara Creek). Group I rocks may occur as xenoliths in granodiorite, but they are difficult to distinguish in places where the enclosing rock is also gneissic.

Typical specimens of the leucocratic gneiss contain 70-90 percent plagioclase and quartz, 0-25 percent potash feldspar, about 5 percent mica, and some chlorite or epidote.

Hornfelsed gneiss: Near the margins of the Omara Granodiorite the gneiss appears to have undergone metasomatism and some thermal metamorphism. The contact metamorphism is superimposed on regional metamorphism, and has not resulted in the development of new minerals. Quartz, plagioclase, biotite, and possibly potash feldspar have been introduced into the gneiss. Twinning in the relict plagioclase is partly or completely obliterated, and some of the plagioclase is altered to a more sodic variety. In one specimen (R10097) porphyroblasts of quartz rimmed with fine biotite have developed.

The only evidence of contact metamorphism from dykes associated with Quaternary vulcanism is a granoblastic biotite-quartz-plagioclase rock (R10957, Pl. 2, fig. 2), which crops out at several points on Kukuia Peninsula. The rock has little or no directed texture and consists of large poikiloblastic porphyroblasts, up to half an inch across, of albite-oligoclase in a groundmass of quartz, biotite, and other minerals.

Petrography of the quartzo-feldspathic gneisses: Twenty-four specimens of quartzo-feldspathic gneiss were examined in thin section; their approximate mineral compositions are summarized in Table 1. As noted in the preceding pages, the predominant minerals are quartz and plagioclase; minor constituents are potash feldspar and various amounts of femic minerals, of which biotite is the most common. Muscovite, chlorite, epidote, hornblende, garnet, and calcite are present in some specimens. Sphene, apatite, and iron oxides are typical accessories; zircon and pyrite are less common.

Plagioclase composition is generally An_{10} to An_{20}, and less commonly An_{30} to An_{35}. It is thus slightly more sodic than the typical plagioclase in amphibolite facies metamorphics which, according to Turner & Verhoogen (1960, p. 546), is between An_{25} and An_{45}. Potash feldspar is not twinned. It is interstitial and has also replaced plagioclase; replacement has produced anti-perthite in places. The potash feldspar has negative 2V ranging between 20^{o} and 50^{o} and in one specimen the optic axial angle was accurately determined by C.D. Branch as 43^{o}. On optic axial angle and sign the feldspar can only be anorthoclase, not adularia or orthoclase.

Biotite is normally reddish-brown and rarely khaki-brown; it is commonly part-altered to chlorite. Hornblende, where present, is pleochroic from pale brown (X) to brownish green (Y) and deep green (Z). In a few specimens the colours are pale, indicating low iron content. Epidote is the most common representative of the epidote group, but clinozoisite is present in several specimens.

Highly aluminous

The only known outcrop of highly aluminous metamorphics is in Waibewe Creek on the northern flank of the Mailolo Block. The rock is a staurolite-kyanite-garnet-quartz-muscovite schist, and is probably derived from pelitic sediment. The presence of hypidiomorphic kyanite indicates metamorphism to the kyanite-almandine-muscovite sub-facies of the almandine-amphibolite facies. Baker (Baker & Coulson, 1948) found kyanite in a biotite schist from northern Goodenough Island, and Edwards (1950) found grains of kyanite in streams draining the southern flank of the Mailolo Block.

Petrography: The one specimen examined in thin section, R11013, consists of muscovite (55), quartz (20), garnet (10), kyanite (10), minor staurolite, and accessory apatite, sphene, and rutile. Garnet occurs as cracked augen up to 10 mm long, and as smaller rounded grains which appear to have been rotated; it contains poikiloblastic quartz, muscovite, rutile, and fine iron oxidies. In some garnet grains the rutile and iron oxides are aligned in streaks. Kyanite occurs as prisms up to 6 mm long; some of them are bent through about 15^{o}.

Calcareous

Calcareous metamorphics are of two types - calcareous amphibolite and 'marble' - which may occur interlayered or, in the case of the 'marble', form massive beds with weak gneissosity. On lower Seliselina Creek there is a sequence of about 150 feet of interlayered calcareous amphibolite and 'marble', and similar rock forms about 10 percent of the group III gneiss exposed on Mebulibuli Peninsula; some of the layers show ptygmatic folding. 'Marble' crops out separately in south-eastern Goodenough Island (Gunawala Creek), the northern Mailolo Block (Wauda Creek), the south coast of Kukuia Peninsula (near Igwageta), and the eastern Morima Range (Bwabwau Creek). The Wauda and Igwageta bodies are 300 and 200-500 feet thick, respectively. The rock weathers to form caves, some with stalactites, and Wauda Creek flows underground through 'marble' for part of its course.

Petrography: The layered calcareous amphibolite (R10960, R11048) consists of calcite (25-30), hornblende (20-25), diopside (0-25), epidote (5-10), plagioclase (albite or oligoclase), quartz, potash feldspar (rare), and garnet, with accessory sphene and veins of epidote, calcite, and, in one specimen, potash feldspar. Layering is produced by local concentration of coloured minerals and, in the Seliselina specimens, local chloritization and injection of calcite.

Typical 'marble' (R10997, R10998) from near Igwageta consists of calcite (25-45), quartz (20-40) and oligoclase-andesine (25-30) with minor muscovite, tremolite, and zoisite, and accessory sphene, apatite, and pyrrhotite. Fabric is granoblastic or weakly gneissose owing to elongation of quartz grains and parallel alignment of the scattered muscovite flakes. Hydrothermally altered 'marble' (R1105) from near Igwageta consists of calcite, albite, epidote, garnet, chlorite, quartz, muscovite, and accessory rutile and pyrite; about a third of the rock is altered to clay minerals. 'Marble' in Gunawala Creek and the upper part of the Igwageta 'marble' contain bands of dark minerals. In the Gunawala rock (R1044) these are diopside, hornblende, garnet, chlorite, and rutile rimmed with sphene.

Leucocratic feldspathic gneiss in Banadia Creek (R11008) may be derived from limy arkose. The mineral assemblage is potash feldspar (60), oligoclase (20), quartz (10), epidote (5), diopside (5), and rare calcite. The potash feldspar may have been introduced, as it is interstitial, and has partly replaced large porphyroblasts of plagioclase.

TABLE 1

APPROXIMATE MINERAL COMPOSITIONS OF SPECIMENS OF QUARTZO-FELSDPATHIC METAMORPHICS

Specimen No.	Locality	Plagioclase %	Plagioclase An	K-feldspar %	Quartz %	Biotite %	Muscovite %	Chlorite %	Epidote %	Hornblende %	Remarks
(a)	Layered gneiss										
R10940	Bwagura Creek	30	35	15	40	10	-	-	-	3	Augen of feldspar
R11039	Wabawe Creek	45	10	15	25	12	1	1			Also garnet
R10949	Lilahi Creek	25	20	15	40	8	-	7	-	-	No textural variation over several sq. miles
R10437	Wanda Creek	40	20	10	35	7	7				Also garnet and calcite
R10460	Aligabou Creek	45	20	10	30	7	7				
R11007	Banadia Creek	50	20	1	45	3	-	-	-	-	Augen gneiss
R11001	Bwabwau Creek	60	10 & 20	-	20	7	5	5	3	-	
(b)	Quartzose gneiss										
R11034	Wavuna Creek	-	-	-	65	-	-				Also pyrite (20) garnet (10, tremolite (3) and rutile.
R11035	" "	-	-	-	35	-	3				Also rutile.
(c)	Micaceous gneiss										
R10953	Wealana Creek	15	10	10	40	5	5	5	15		
R11033	U. Wavuna Creek	25	30	-	40	10	-	-	15	10	Augen of epidote-plagioclase aggregates
R10432	Wetubwoiabwoiala Creek	35	35	10	20	15	-	10	-	-	
R11024	Mebulibuli Creek	50	35	3	20	25	-			1	
R10961	L. Seliselina Creek	25	10	15	20	30	-	-	5	1	Contorted micaceous layers
R10964	"	25	10	-	45	25	-	-	3	-	Schist with quartz-feldspar stringers
R10965	"	30	10	5	30	30	1	1	1		Augen gneiss. Epidote mineral is clinozoisite.
R10988	Wadelei area	10	10	10	55	20	-	5	-	-	Also pyrite
R10989	" "	40	20	1	25	20	1	5	-	5	Also calcite
(d)	Leucocratic gneiss										
R10937	U. Omara Creek	15	32	15	60	5	-	5	-	-	Xenolith in granodiorite
R10955	Wealana Creek	45	10	-	45	1	7	1	-	-	Has faint large-scale banding
R10993	Auwafwo Creek	40	10 & 20	25	30	-	1	-	5		
R11000	Ipwapaia Creek	45	20	1	45	2	2	-	6		Epidote mineral is clinozoisite.
(e)	Hornfelsed gneiss										
R10927	Wapera Creek	30	10	15	40	5	-	-	-	8	Near or within Omara Granodiorite
R10935	U. Omara Creek	20	32	10	45	5	-	-	-	20	"
R10977	U. Salamo River	-	-	-	80	15	-	-	-	-	" Also 5% garnet.
R10957	Matau Creek	55	10	5	25	10	1	-	3	-	K-feldspar is orthoclase, epidote mineral is clinozosite; near contact with volcanic dyke.

Note: (i) Sphene, apatite and iron oxides (some titaniferous) are present in almost all specimens and thus are not indicated in the table.
(ii) Potash feldspar is anorthoclase unless otherwise indicated.

Plagioclase in the calcareous suites ranges in composition from albite to andesine. Hornblende is pleochroic according to either X neutral, Y pale brown, Z green (e.g., R10960) or X light brown, Y brown-green, Z dark bluish green (e.g. R10444). Diopside is colourless. Epidote is colourless or pleochroic in pale yellow. Garnet is pale pinkish brown, and does not show crystal outlines.

Alteration is common, particularly in the Seliselina amphibolite (R11048), in which plagioclase is saussuritized and garnet and hornblende are locally completely altered to chlorite. Some of the Igwageta marble has been hydrothermally altered, presumably by solutions from the nearby Quaternary volcanics.

Basic

The basic metamorphics are of two types, layered amphibolite and amphibolite without layered fabric; the latter is loosely referred to as 'massive' amphibolite, though in point of fact it has directed texture owing to parallel alignment of crystals.

The layered amphibolite consists of alternating layers of amphibolite and quartzo-feldspathic material. There are two varieties, one with coarse layering (3 to 6 inches) and one with fine layering (tenths of an inch). The coarse layering is thought to represent original bedding, as the layers are sharply defined and may show minor folds, some of which look like slump structures. The fine layering may represent original bedding or alternatively may have been produced in originally homogeneous amphibolite by the injection of quartz and feldspar along planes of schistosity.

Coarsely-layered amphibolite is restricted to Group III and is found only on Fergusson Island, e.g., on Bebulibuli Peninsula and the northern Mailolo Block. Finely-layered amphibolite is found on both islands in Group III, and as xenoliths within Luboda Granodiorite. Altered amphibolite near the Elologea and Mwadeia Faults on northern Fergusson Island is probably layered amphibolite which has been affected by shearing near these faults.

The massive amphibolite occurs in two large bodies up to a mile across, one exposed in Potai Creek on the north-western flank of the Mailolo Block, and one in Galuwata Creek in the north-eastern part of the Goodenough Block. Both probably represent original gabbroic plutons with, in the Potai body, some ultramafic segregations. Massive amphibolite also occurs as subconcordant 'sills' and lenses up to 10 feet thick within the layered quartzo-feldspathic gneiss (Group II) and as tabular bodies, pods, lenses, and schlieren within leucocratic gneiss (Group I) and in pegmatite and granodiorite. Some of these tabular bodies may represent original basic sills or lavas; others may have formed through metasomatism or retrograde metamorphism of tabular bodies of eclogite.

In both layered and massive amphibolite the main minerals are hornblende and sodic plagioclase, An_{10} to An_{30}; quartz is a major constituent of a few specimens, and garnet, epidote, potash feldspar, biotite, and chlorite are minor minerals; calcite, clinopyroxene, zoisite, and muscovite are rare. Typical accessories are sphene, apatite, and iron oxides; rutile and pyrite are less common. Locally sulphide minerals (pyrite and, less commonly, chalcopyrite) form up to 30 percent of the rock; a selected specimen (A207) contains no gold and negligible amounts of base metal. A gossan which appears to have formed from sulphide-bearing amphibolite assayed 1.3 percent copper (see under "Economic Geology").

Petrography: Two specimens of coarsely-layered amphibolite were examined petrographically, one (R11037) from Mwadeia Creek and one (R11015) from Wauda Creek, Fergusson Island. The rock consists of alternating layers, 3 to 6 inches thick, of amphibolite and quartzo-feldspathic gneiss. In places the quartzo-feldspathic gneiss transgresses the layering; this may indicate either that original sedimentary layers have been mobilized or that the layers consist of material injected into the amphibolite. The amphibolite layers consist of hornblende (50-60), oligoclase-andesine (10-35), quartz (10-20), epidote (0-7), garnet (0-3), biotite (0-5), and rare calcite (Pl. 3 fig. 1).

Basic gneiss (R10990) exposed in Obuana Creek east of Wadelei, Fergusson Island, appears to be a similar coarsely-layered amphibolite, but differs greatly in composition. It is about 10 feet thick and occurs within typical group II layered gneiss. The amphibolite layers are predominantly hornblende (95 percent); minor constituents are oligoclase, garnet, biotite, muscovite, chlorite, and relict pyroxene. The hornblende has low iron content, as it is mostly colourless, though crystal margins are slightly pleochroic. Hornblende in the other specimens has a 'normal' pleochroism, namely, X pale brown, Y brownish green, Z dark bluish green.

Four specimens of finely-layered amphibolite were examined, two from north-eastern Fergusson Island (R11009, Banadia Creek; R11031, Magoa Creek), and two from the northern part of the Goodenough Block (R10436, Wauna Creek; R10457, Alua Creek).

Their mineral compositions are :

	Hbde.	Plag.	K-felds.	Qtz.	Garn.	Epid.
R11009	25	40	2	30	-	-
R11031	35	35	5	1	1	33
R10436	40	40	20	-	-	-
R10457	60	5	-	30	-	2

R11031 contains a little relict pyroxene, R11009 a little chlorite, and R10457 a little calcite.

The presence of equal amounts of hornblende and plagioclase and the virtual absence of quartz in R11031 and R10436 suggest that they are derived from basic igneous rocks (Williams, Turner, & Gilbert, 1958, pp. 241-243).

Altered ampholite from near the Elologea Fault on north-eastern Fergusson Island consists predominantly of colourless amphibole, and may be locally completely carbonated. The amphibole is tremolite or hornblende poor in iron; in places it is pale blue (in thin section), suggesting local increase in soda content. Near the Mwadeia Fault there are boulders of mica schist which contain clusters of hornblende crystals up to the size of a fist. In R10920 the mica is brown biotite which occurs interstitially and in the cleavage traces of the hornblende; quartz is interstitial and poikiloblastic within the hornblende. In R10921 the mica is phlogopite. In both, the hornblende is pleochroic in pale colours: X very pale brown, Y pale greenish brown, Z pale green.

Large bodies in Potai and Galuwata Creeks probably represent original gabbroic plutons, with, in the Potai body, some ultramafic segregations. Both bodies are foliated owing to preferred orientation of the amphibole and (in the Galuwata body) to the local development of garnet-rich streaks. Both contain thin discontinuous quartz-feldspar stringers. Mineral compositions vary greatly :

	Hbde.	Plag.	K-felds.	Qtz.	Garn.	Epid.	Biot.
R11040 (Potai)	98	-	-	-	-	-	2
R11041 (Potai)	65	23	-	2	2	8	-
R10440 (Galuwata)	10	35	10	10	1	5	20

R10440 also contains a little chlorite and calcite. Two varieties of plagioclase, albite and oligoclase, are present in R11041; one variety may have been introduced by later solutions. R11040 may be derived from magnesian ultramafic rock as the specimen consists almost entirely of hornblende, and the hornblende has low iron content (it is very weakly coloured). The occurrence nearby of tremolite-bearing harzburgite (see p.) adds some weight to the hypothesis.

Subconcordant 'sills' and lenses of homogeneous amphibolite are farly common in the upper part of Group II. One of these (R10959) is exposed on the south coast of Fergusson Island, half a mile east of Daboia Point. It is a tabular body about three feet thick; it generally conforms to layering in the quartzo-feldspathic gneiss, but is transgressive in places. It consists of normal hornblende (70), albite (5), quartz (5), garnet (5), chlorite (5), greenish-brown biotite in veinlets (5), zoisite (3), epidote, and accessory apatite, rutile, and pyrite. Hornblende porphyroblasts are up to 18 mm. long. Potassic solutions have entered along a network of joint planes, and have locally altered the amphibolite to mica schist; quartz has crystallized in some of the joints.

Two other specimens of amphibolite 'sills' of somewhat different composition were examined. Both crop out in the Morima Range - one (R10999) in Ipwapaia Creek, and the other (R10954) in Wealana Creek. They are fine-grained and melanocratic, and contain irregular acid blebs and streaks. Compositions are :

	Hbde.	Plag.	K-felds.	Qtz.	Garn.	Epid.	Biot.
R10999	25	25	3	30	10	4	1
R10954	50	45	-	-	-	-	3

R10999 contains some zoisite. Accessories in both include pyrite.

Massive amphibolite in the eastern central Mailolo Block near Atugamona is veined by, and in places completely enclosed in, granodioritic pegmatite. A typical specimen (R11032) consists of hornblende (35), oligoclase-andesine (30), garnet (20), quartz (5), ilmenite (5), epidote (5), and accessory rutile and apatite.

The Luboda Granodiorite, exposed in the core of the Goodenough Block, contains massive amphibolite and rare finely-layered amphibolite as tabular inliers, partly absorbed schlieren, and angular xenoliths. A typical specimen of the massive amphibolite (R10456) consists of hornblende (15), oligoclase (5), quartz (50), garnet (20), epidote (5), and sericite (5). Much of the quartz was probably introduced by the granodiorite magma.

GRANULITE AND ECLOGITE FACIES

Rocks with mineral assemblages characteristic of granulite and eclogite facies crop out at widely separated points on both islands. Most are basic, and occur as subconcordant sills and lenses in quartzo-feldspathic gneiss or, in one instance, as an inclusion in granodiorite. One is quartzose and may be part of the layered quartzo-feldspathic gneiss sequence.

The main minerals are clinopyroxene, garnet, hornblende, plagioclase, quartz, rare micas, and accessory rutile and sphene. In eclogite the clinopyroxene is omphacite, a sodic variety of diopside. Hornblende, plagioclase, and sphene are products of retrograde metamorphism or metasomatism, or both; mica and some quartz have probably been formed by later solutions.

Because of the invariable presence of hornblende in the granulites and eclogites they should strictly be termed hornblende granulites and hornblende eclogites. The former fall within the hornblende-granulite subfacies of the granulite facies as defined by Turner & Verhoogen (1960, p. 555).

Fine-grained basic granulite and eclogite consist of fine-grained (about 0.1 mm) pyroxene and garnet, together with poikiloblastic porphyroblasts of hornblende, which form between 10 and 70 percent of the rock (Pl. 3, fig. 2). Texture is granoblastic (and porphyroblastic) and rarely gneissose. Pyroxene in the granulites is augite, and in the eclogites is omphacite; omphacite is distinguished by large optic axial angle (70^{o} to 80^{o} according to Williams, Turner, & Gilbert, 1958, p. 245). A puzzling feature is the paucity of plagioclase, which might be expected to develop when the pyroxene breaks down to form hornblende. The presence of garnet, pyroxene, and hornblende gives the rocks a distinctive red, green, and black colouring in hand specimen.

Fine-grained basic granulites were found at widely separated places on both islands, and typically occur as subconcordant tabular bodies, about a foot thick, within layered quartzo-feldspathic gneiss. Eclogite occurs as a tabular xenolith within granodiorite on Tomagabuna Island, as an isolated outcrop on a hillside in the Morima Range, and as boulders in Dudunaia Creek on Kukuia Peninsula.

The coarse-grained basic granulites are mineralogically similar to their fine-grained counterparts, but both garnet and pyroxene are coarsely crystalline, and have an average grainsize of about 4 mm; maximum grainsize is about 12 mm (Pl. 4, fig. 1). Pyroxene is partly altered to fibrous amphibole or a dendritic symplectite of hornblende and plagioclase, or, where alteration is more complete, to porphyroblastic hornblende and plagioclase. In one specimen (R11038) the alteration appears to have taken place along cracks and joints, and is probably a metasomatic effect. The same specimen is veined by quartz and biotite.

The coarse-grained granulites were found at only two localities; upper Awavula Creek in the southern Mailolo Block, and upper Niubula Creek in the south-eastern Fergusson Block. The coarse grainsize of pyroxene and garnet in these rocks might indicate that the metamorphic conditions responsible for the formation of granulite were sustained for a longer period than in the case of the fine-grained granulites.

Quartzose granulite crops out on upper Niubula Creek (south-eastern Goodenough Block) within 30 yards of the coarse-grained basic granulite. It is layered by variation in the proportions of quartz, garnet, and femic minerals. Composition of that part of it which was examined in thin section is quartz (50), garnet (30), scapolite (10), and minor diopside, hornblende, and other minerals. It may be a part of the layered quartzo-feldspathic gneiss, but this could not be ascertained, as the only outcrop nearby is massive granodiorite with amphibolite xenoliths.

In almost all of the granulitic rocks there are signs of retrograde metamorphism or metasomatic alteration towards amphibolite facies. It is, thus, surprising to find one specimen in which a granulitic assemblage is developing from amphibolite. The rock (R11010) is mainly hornblende (about 60) and andesine (about 40) in small (1 mm) grains with gneissose arrangement. It includes a flattened lens of unaltered augite made up of poikiloblastic grains of augite about 5 mm long. The augite appears to have formed from the hornblende and andesine. The accessory mineral is sphene, not rutile. This very localized development of granulite facies may be due to locally anhydrous conditions.

Petrography: The approximate mineral compositions of the granulitic and eclogitic rocks are shown in Table 2. Plagioclase is sodic, An_{10} to An_{20}, except in R11010, where it is An_{35}. Clinopyroxene is augite in the granulites and omphacite in the eclogites. Hornblende has normal pleochroism. Zoisite in R10447 is faintly pleochroic in brown. Sphene may occur as rims on rutile grains.

The formation of quartz and mica through the action of later solutions is illustrated in R10995 and R11038, in which there are veinlets of quartz and muscovite, and quartz and biotite, respectively.

ULTRAMAFIC ROCKS

Ultramafic rocks are present on both Fergusson and Goodenough Island, where they crop out over a total area of about 13 square miles. Bodies of ultramafic rocks are typically marginal to the metamorphic blocks and separated from them by major faults. A few small bodies occur within the metamorphics; their contacts are invariably sheared. The large ultramafic masses are expressed topographically by areas of low rounded relief with simple drainage.

The rocks are, or are derived from, highly magnesian dunite, harzburgite, and pyroxenite; dunite is almost wholly olivine, harzburgite is composed of olivine and orthopyroxene (25 to 50 percent), and pyroxenite is almost wholly orthopyroxene. The olivine is chrysolite or forsterite, Fo 85-90, and the orthopyroxene is enstatite or magnesian hypersthene; accessory chromite is almost invariably present.

All the ultramafic rocks are altered, some severely. The first stage of alteration of olivine is the development of chrysotile veinlets. The second stage is the alteration of the remaining olivine to antigorite. Pyroxene may alter to fibrous tremolite or bastite. Talc may develop with the chrysotile. Many of the completely serpentinized olivine-rich rocks show mesh texture; that is, they consist of antigorite aggregates reticulated by chrysotile veinlets; these rocks are referred to as mesh-texture serpentinites. The alteration of the ultramafics is generally metasomatic, possibly deuteric, rather than an effect of regional metamorphism. Serpentinization may be followed by carbonation and silicification, which produce such rock types as the carbonated and opalized serpentinite breccia discussed below. The carbonate is usually magnesite, and rarely calcite.

The ultramafics occur as xenoliths and inliers within the Omara Granodiorite and thus were obviously emplaced before the granodiorite. They do not appear to have been subjected to regional metamorphism, except perhaps in the north-western Mailolo Block, and thus probably post-date the period of regional metamorphism. However, it is possible that they are pre-metamorphic, as ultramafics do not always respond to metamorphism (Dr A.J.R. White, pers. comm.).

As all contacts are sheared or concealed by tuff or alluvium, their relationship with other rock types is left in doubt. Most of the larger bodies of ultramafics abut against faults, and this suggests that they may have been emplaced in the solid state along faults. On the other hand, ultramafics in the north-western Mailolo Block are apparently inclusions within massive amphibolite, and may represent ultramafic segregations in a gabbroic pluton which has been metamorphosed to amphibolite.

Oredi Fault area: The Oredi Fault is a north-easterly fault on the south-eastern margin of the Oiatabu - Morima Arc. Apparently three major bodies of ultramafics abut against or, in one case, straddle the fault; they are referred to as the Bwabwau, Lower Seliselina, and Oredi - Boskwahoia bodies, after the creeks in which they are exposed. They may all be parts of one large mass of ultramafics which is concealed, in places, by volcanics and alluvium. A separate smaller body of ultramafics crops out within the metamorphics on upper Seliselina Creek, three-quarters of a mile north-west of the fault.

The rock types are dunite, harzburgite, pyroxenite, and sulphide-bearing, carbonated, and opalized serpentinite breccia. The breccia crops out in Oredi and lower Seliselina Creeks and appears to form a zone about half a mile wide adjacent to the Oredi Fault. It consists of angular fragments of black glassy opaline silica and serpentine in a matrix of opaline silica and magnesite; serpentine mesh texture is preserved in some of the glassy fragments. The weathered rock is limonitic and not unlike gossan. Veins of tremolitic asbestos up to an inch thick are exposed in parts of the small body of ultramafics on upper Seliselina Creek.

Elologea Fault area: The Elologea Fault is on the north-eastern margin of the Oiatabu-Morima Arc, and extends north-north-west from Mebulibuli Peninsula to near Gameta. Two bodies of ultramafics abut against the fault, one on Mebulibuli Peninsula and the other inland from Ulua. They may be parts of the one large mass which is partly concealed by alluvium and ocean.

The main rock types are dunite, harzburgite, and pyroxenite. Asbestos veins up to an inch thick are exposed in weathered pyroxenite near Ulua. Sulphide-bearing, opalized, and carbonated serpentinite breccia crops out near the fault in Mebulibuli and Elologea Creeks, and on the coast east of Gobaiawe, all within the Mebulibuli body. The breccia near Gobaiawe forms a low ridge striking at 350°. Greenish grey and black serpentinite pug is exposed near the fault on Elologea Creek.

Some of the breccia contains up to 20 percent sulphides, which are predominantly marcasite and pyrite; a selected sulphide-rich specimen (A176) assayed 3 dwt gold per ton, 0.01 percent copper, and lesser amounts of lead and zinc. Other specimens collected by L.H. Wilkinson in 1958 and J.E. Thompson in 1959 contain up to 1.5% chromium and 0.25% nickel; the nickel is held in fine magnetite which formed during serpentinization (see Appendix 1).

TABLE 2

APPROXIMATE MINERAL COMPOSITIONS OF SPECIMENS OF GRANULITE AND ECLOGITE

Specimen No.	Locality	Hornblende %	Clinopyroxene %	Garnet %	Plagioclase %	Quartz %	Muscovite %	Biotite %	Rutile %	Sphene %	Remarks
(a) Fine-grained basic - Granulites											
R10976	U. Salamo River	65	20	10	-	-	-	-	x	x	
R10995	Auwafwe Creek	10	15	20	-	15	15	-	x	-	
R11004	Bwabwau Creek	70	1	1	10	10		1	x	x	Also clay minerals (15)
R11019	Kegwagiluma Creek	45	20	15	5	5	-	-	x	x	Also epidote (5), calcite, and chlorite.
	Eclogites										
R10916	Dudunaia Creek	15	40	28	15	-	-	-	2	-	
R10919	Tomogabuna Island	10	50	35	2	-	1	-	2	-	
R10996	Awafwe Creek	20	28	23	-	20	3	-	x	-	Also clinozoisite (5)
(b) Coarse-grained basic											
R11038	Awavula Creek	15	15	10	15	15	3	10	x	x	Also clay minerals (15), tremolite, K-feldspar.
R10446	Niubula Creek	45	20	-	15	10		1	2	3	Also chlorite and K-feldspar.
(c) Quartzose											
R10447	Niubula Creek	3	2	30	-	50	-	1	x	-	Also scapolite (10), zoisite, chlorite.
(d) Granulitic amphibolite											
R11010	Magoa Creek	55	3		40				-	x	

Note: (i) x indicates present in small amount

(ii) other accessory minerals present in some specimens are iron oxides and apatite.

Wadelei Fault area: The Wadelei Fault is on the western margin of the Oiatabu Range, and extends south-south-west from Matalala Point to near the upper reaches of Omara Creek, where its trace is lost in the Omara Granodiorite. Inland from Wadelei, ultramafic rocks form low hills at the foot of the Oiatabu Range, and are partly concealed by talus from the range. Farther south the ultramafics are intruded by the Omara Granodiorite; this area is hatched on the accompanying map (Pl. 12), as it was not mapped in sufficient detail to delineate the ultramafics and granodiorite accurately. Rock types are dunite and harzburgite; one specimen is 95 percent serpentinized.

Within and adjacent to the Omara Granodiorite: Ultramafics crop out over an area of about 3 square miles in the Koradidia area on the south-eastern margin of the Omara Granodiorite. No contacts were seen. Rock types are dunite, harzburgite, and pyroxenite; they are between 10 and 60 percent serpentinized. Xenoliths and inliers of ultramafics in the granodiorite are exposed in the south-eastern Salakadi area, near Iagila Creek. Near the contacts the granodiorite is dark, gneissic, and veined with pegmatite, and the ultramafics contain veins of asbestos. There are small isolated exposures of ultramafics in the western Boselewa area, near the north-western margin of the granodiorite.

North-western Mailolo Block: In the north-western part of the Mailolo Block small bodies of ultramafics crop out within or near massive amphibolite in Potai and Kwakwau Creeks. Another small body is exposed in a shear zone in acid gneiss in Melewaie Creek, and there are ultramafic boulders in the Mwadeia Fault shear zone exposed in Mwadeia Creek.

Massive amphibolite exposed in Potai and Kwakwau Creeks is thought to be derived from the metamorphism of a gabbroic pluton. Small bodies of ultramafics cropping out within or near the amphibolite may be the remnants of segregations within the pluton. Some of the massive amphibolite is 98 percent iron-poor hornblende, and may be derived from metamorphism of a somewhat feldspathic ultramafic rock.

The ultramafic rock in Kwakwau Creek is a completely altered harzburgite, which now consists of chlorite and magnesite replacing antigorite serpentine. Its outcrop is separated from the massive amphibolite by a shear zone containing biotite, chlorite, sericite, talc, and possibly antigorite schist. The ultramafic rock in Potai Creek is also harzburgite which is 65 percent altered to tremolite, magnesite, talc, and chlorite (Pl. 4, fig. 2). A peculiar feature of the rock is the absence of both accessory chromite and serpentinous alteration-products. It crops out near massive amphibolite, but no contact was seen.

In Melewaie Creek a small body of ultramafic rock about 25 feet wide is exposed in a shear zone within a sequence of acid gneiss; the shear zone appears to conform to layering in the gneiss. The body consists of harzburgite which is about 80 percent altered to serpentine and magnesite.

The Mwadeia Fault shear zone, exposed in lower Mwadeia Creek, consists of boulders of metamorphics and minor harzburgite in a schist matrix. The presence of ultramafics in the shear zone indicates that ultramafics may underlie the alluvium north of the fault.

On the Wakonai Fault: Scattered outcrops and boulders of ultramafics were found on the line of the Wakonai Fault on northern and north-eastern Goodenough Island. This may indicate that ultramafics underlie some of the volcanics, talus, and alluvium north of the Goodenough

Block. At the south-eastern end of the fault trace, ultramafics form a triangular plateau about half a mile across on the Fabuva - Afauna divide. The rock types are opalized and carbonated serpentinite breccia, partly serpentinized dunite, and a limonitic rock which is probably weathered pyroxenite. Boulders of the breccia occur in Tuabeda and Ualafa Creeks, a mile and a mile and a half to the north-north-west, respectively, and in Duau Creek there are large boulders of partly serpentinized and calcite-veined dunite. At the north-western end of the fault trace, near Iuda Creek, small outcrops of weathered dunite and harzburgite project from talus slopes.

Within the Goodenough Block: On upper Goiala Creek, in the southern central part, ultramafic rocks form a flat area about 400 yards wide. The contact with the enclosing acid gneiss appears to be sheared, but is not well exposed. Two miles north-west of Mount Vineuo, in the central western part of the Block, at 7000 feet elevation, there are boulders of garnet amphibolite and rare harzburgite. The harzburgite is partly altered to tremolite and chlorite, and is very similar to altered harzburgite which crops out in Potai Creek on Fergusson Island, in that both accessory chromite and serpentinous alteration are lacking; furthermore, the chlorite is a similar, colourless variety, with brown interference-colours.

Petrography

Dunite: In hand-specimen, dunite is yellow-green or black, weathering to brown, and is characterized by the presence of mesh-texture. Olivine is colourless or pale yellow-green; chrysotile veinlets are yellow-green or black; antigorite is greenish black, weathering to greenish brown and brown (iron hydroxides). A fairly typical specimen (R10983) consists of small colourless olivine grains enclosed in green-black antigorite containing a meshwork of black chrysotile veinlets. In some specimens (e.g., R10926), grains of chromite up to 6mm across can be seen.

In thin section the dunite is seen to consist of large (4 to 25 mm) anhedra of olivine, which are invariably reticulated by chrysotile veinlets; the resulting meshwork accounts for the fine to medium-grained appearance of the hand-specimen. In the more altered dunites the small olivine fragments within the mesh are partly or completely replaced by antigorite. Dusty magnetite which is usually present in the chrysotile veinlets was formed during serpentinization. In one specimen (R10972) from the Koradidia body, the chrysotile meshwork is flattened, resulting in a rough foliation within the rock. This, together with mild granulation on the margins of the olivine grains, indicates that the rock was stressed during or after serpentinization.

Some specimens have a soapy feel owing to the development of talc along with the chrysotile. A specimen (R10924) from the Oredi body is veined by magnesite.

Harzburgite: Primary minerals in the harzburgite are olivine, enstatite or magnesian hypersthene, and accessory chromite; olivine forms 50 to 75 percent of the rock. In hand-specimen the rock resembles dunite, but the presence of pyroxene may usually be discerned by its cleavage or, on the weathered surface, because it is more resistant than olivine and tends to stand out. Pyroxene may alter to tremolite or bastite. In some specimens, e.g. R10434, olivine is only slightly (about 5 percent) serpentinized, but pyroxene is completely uralitized to fibrous and prismatic tremolite. In other specimens, e.g., R10938, olivine is more than 50 percent serpentinized, but pyroxene is almost unaltered. In R11042, from lower

Omara Creek, mesh texture is not preserved; instead there are in places sub-parallel veinlets of chrysotile and associated dusty magnetite. This may indicate deformation after serpentinization.

Specimens from Potai Creek (R11042) on north-western Fergusson Island and from near Mount Vineuo (R10435) on Goodenough Island differ from the normal harzburgite in that there is no chromite, and although the rocks are partly uralitized, the olivine is not serpentinized: it is fresh, and occurs in clusters which consist of kidney-shaped grains arranged in two rows. Enstatite, which may have formed 50 percent of the original rock, is partly altered to tremolite, which is in long prisms or, less commonly, fibrous. Both specimens contain colourless chlorite, which has an anomalous brown interference colour. R11042 also contains carbonate and talc.

Pyroxenite: Pyroxenite is not common. Two specimens (R10968 and R10970) from the Koradidia body consist of grey enstatite moderately dissected by yellow veinlets of alteration-products. Enstatite in R10968 is optically continuous throughout the thin section (30 mm x 20 mm) and is veined by fibrous tremolite, chlorite, and talc. In R10970 it is partly altered to tremolite and serpentine minerals (Pl. 5, figs. 1 and 2).

Serpentinite: Some of the rocks which are completely altered to serpentine or have been partly or completely replaced by carbonate and opaline silica are brecciated, others are massive.

Serpentinite breccia occurs near faults, and is generally completely replaced by opaline quartz and magnesite. A few specimens contain relict antigorite (e.g., R10926). Typical specimens consist of black, angular, opaline silica fragments in a matrix of magnesite and opaline silica. The mesh texture of the original serpentinite may be preserved in the opal fragments. In one specimen (R11026) the roles of carbonate and silica appears to be reversed: there are angular carbonate fragments in a matrix of opaline silica. Parts of the opaline silica may be recrystallized as quartz.

Specimens of sulphide-bearing breccia (P190 and P191), collected from Mebulibuli Creek by L.H. Wilkinson in 1958, have been described in detail by W.B. Dallwitz and W.M.B. Roberts (see Appendix 1). They found that the sulphides are marcasite and pyrite, and that nickel, which was probably held in the olivine lattice in the fresh rock, is now held in fine-grained magnetite which probably formed during serpentinization. Similar specimens from the same locality, collected by J.E. Thompson of the Bureau of Mineral Resources, in 1959, have been chemically analysed for four metals by S. Baker (B.M.R.).

Specimen No.	Fe%	Cr%	Ni%	Cu%
P396	14.74	0.48	0.20	trace
P398	22.8	1.51	0.25	trace

A sulphide-rich breccia specimen from Elologea Creek (A176) assayed 3 dwt gold per ton, 0.01 percent copper, 0.003 percent lead, and 0.007 percent zinc.

The massive serpentinite is more variable in appearance and composition, and is generally only partly replaced by carbonate and silica. A fairly common type in the Ulua area and on Boskwahoia Creek is serpentinized and weathered pyroxenite (e.g., R10966). This consists of irregular black grains of bastite in a brown matrix of hydrated iron oxides. Serpentinized harzburgites consist of mesh-texture serpentine and bastite, and less commonly talc, which are partly replaced by magnesite and silica. The colour of the hand-specimen ranges from dark greenish black (R11020) to yellowish white (R11261), according to the amount of carbonate present. In R11261, opal forms pseudomorphs after pyroxene, and thin magnesite veinlets mark the pyroxene cleavage.

METASOMATIZED GABBRO

Massive metasomatized gabbro and diorite crop out within the Omara Granodiorite on Fergusson Island. They are thought to be remnants of a basic intrusion which preceded the granodiorite, perhaps rising along the same magma channels. The gabbro and diorite crop out over an area of about six square miles in the southern part of the granodiorite pluton (Salakadi area), and there are scattered remnants in the northern part of the pluton (southern Boselewa area). Similar rock is exposed in the core of the Oiatabu Range within granodiorite. Two small exposures of gabbroic rock on Goodenough Island are thought to have formed by metasomatic alteration of more basic rock.

The typical rock consists of hornblende porphyroblasts and sodic labradorite. The hornblende crystals are commonly half an inch long, and rarely 1 1/2 inches long; in some specimens they contain relict pyroxene. Labradorite is partly altered to more sodic plagioclase; hornblende is partly altered to biotite and chlorite. The absence of directed texture in the gabbro indicates that its intrusion post-dates the period of regional metamorphism.

The Salakadi gabbro is restricted to the headwaters of Bwinai River and Adeta Creek in the extreme southern part of the Omara Granodiorite. It occurs in a belt about five miles long and one to one and a half miles wide. It is reticulated by quartz-feldspar veins and intruded by granodiorite, some of which is basified by assimilation of the gabbro (see R10946, Table 3). Gabbro is also exposed in the northern part of the Omara Granodiorite in Waliboalina Creek. Gabbro in the core of the Oiatabu Range is exposed in Ama'wa Creek; here it is a coarse-grained phase in tabular amphibolite zenoliths within massive granodiorite. The granodiorite may be an apophysis of the Omara Pluton.

On Goodenough Island there are small exposures of gabbroic rock in Aligabou Creek in the north-east and in Goiala Creek in the south. The Aligabou gabbro is a pegmatitic hornblende-feldspar rock which occurs as small irregularly-shaped bodies within mobilized granitic gneiss; it was probably formed by metasomatic alteration of basic pods or lenses within the gneiss. The Goiala 'gabbro' is a quartz-feldspar-hornblende rock which cements a moderately brecciated garnet pyroxenite; it has probably formed by metasomatic alteration of the garnet pyroxenite by acid solutions introduced along the fractures.

Petrography

The estimated mineral compositions of specimens from each gabbro area on Fergusson Island are tabulated below. Neither of the Goodenough Island 'gabbros' was examined in thin section.

Specimen No.	Plag.	Hbde.	Aug.	Biot.	Chl.	Qtz.	K-felds.
Salakadi area;							
R10945	45	30	5	20	-	1	-
R10951	45	40	-	1	10	-	-
R10992	55	35	-	5	-	5	-
Waliboalina Creek (Boselewa area)							
R10982	55	30	-	5	-	5	-
Ama'wa Creek (Oiatabu Range)							
R11029	20	35	-	5	5	10	10

Common accessories are sphene, apatite, and iron ores; epidote, zircon, and pyrite are less common.

Plagioclase is generally sodic labradorite, An_{50-55}. It shows Carlsbad and albite twinning, is generally saussuritized, and is commonly partly altered to a more sodic variety. In R11029 it is partly replaced by potash feldspar. Hornblende is porphyroblastic; normal pleochroism is X pale brown, Y brownish green, Z dark green; The pleochroic scheme in R10982 and R10992 is X pale brown, Y dark brown, Z green. The hornblende normally contains much dusty iron ore - a typical feature of hornblende derived from pyroxene. Augite is rimmed with hornblende or occurs as inclusions in hornblende. Biotite has developed within and marginal to the hornblende; it is deep brown, and commonly contains sub-rectangular grains of iron ore. Some of the biotite is altered to chlorite.

A specimen (R10973) from Mwadia Hill in the eastern Salakadi area differs considerably from the typical metasomatized gabbro. It consists of plagioclase and phenoblasts of olivine which are surrounded by prismatic and fibrous tremolite-actinolite; this is bordered, in turn, by fine-grained green pleonaste. A little diallage is also present. Approximate mineral percentages are tremolite-actinolite, 50; andesine or labradorite, 30; olivine, 10; pleonaste, 5; and diallage, 2. The plagioclase is strained and granulated. The rock may be derived by metasomatic alteration and crushing of olivine gabbro.

GRANODIORITIC INTRUSIVES

Granodiorite is the most common igneous rock type; it occurs (a) as a large pluton in central Fergusson Island (the Omara Granodiorite); (b) in the core of the Oiatabu Range; (c) in the core of the Goodenough Block (the Luboda Granodiorite); (d) in parts of the Morima Range; and (e) on Mebulibuli Peninsula; and (f) as dykes (of microgranodiorite) on both islands; these dykes are probably apophyses from the granodiorite plutons.

The Omara, Oiatabu, and Luboda granodiorites are generally similar in appearance, being massive and medium to coarse-grained, and containing 10 to 20 percent of biotite and, less commonly, hornblende. The Morima granodiorite is strictly an adamellite, and is very leucocratic (only 1 percent biotite). Potash feldspar in the Mebulibuli and Morima rocks is orthoclase, whereas in the others it is probably anorthoclase.

The granodiorite intrudes metamorphics, ultramafics, and gabbro. The emplacement of the large plutons may have caused the broad domes and anticlines which are the major structures in the metamorphics.

Omara Granodiorite

The Omara Granodiorite is larger and better exposed than the other granodiorites, and will be discussed in most detail. The name is taken from Omara Creek, in the Boselewa area, in which the granodiorite is very well exposed. The pluton crops out in central Fergusson Island over an area of about 70 square miles. Its western boundary coincides with the Bwinai River, except for a marked westward bulge in the Salakadi area. The southern boundary generally coincides with the Morima-Salakadi watershed. The eastern boundary is generally along the line of the upper Salamo River and Omara Creek, and there is an eastward bulge near the Salamo-Omara divide. The northern boundary is concealed by the Boselewa alluvial plain.

The granodiorite has a distinctive topographic expression similar to that noted in areas of trondhjemite on the New Guinea mainland (Dow & Davies, 1964). Relief is moderate, the maximum elevation being about 2000 feet in the centre of the outcrop area. The drainage pattern is characterized by many closely-spaced small streams. It is thus possible to interpret the boundaries of the granodiorite from air-photographs.

The central part of the pluton is mostly homogeneous, but towards the periphery the rock is partly hybridized, and there are xenoliths and inliers of metamorphics, altered gabbro, and ultramafic rocks. Gabbro and metamorphic xenoliths are partly or wholly altered to minerals typical of the granodiorite. Metamorphics at the margins of the pluton and in the larger inliers are hornfelsed (see p. 17). The contact of the granodiorite with metamorphics on upper Omara Creek, and with ultramafics on lower Omara Creek, is difficult to define without detailed mapping, as host rock and granodiorite are intermingled in a complex of inliers and apophyses; these two areas have been hatched on the accompanying map (Pl. 12).

Immediately north-west of Lake Lavu, in the vicinity of the Lavu Fault, there are low ridges composed predominantly of weathered leucocratic (?)granodiorite; some pegmatite and leucocratic gneiss are also present. These exposures may represent an apophysis of the Omara Granodiorite.

The granodiorite is medium- to coarse-grained (average grainsize about 1 mm) and typically massive, though it is gneissic in places near the periphery. The main constituent minerals and their approximate volume percentages are: oligoclase-andesine (60), quartz (20), potash feldspar (10), biotite and hornblende (20), and accessory apatite, sphene, and iron ore. Thus, apart from the unusual potash feldspar, it is a fairly typical granodiorite. Composition ranges locally to adamellite and trondhjemite, and even granite, owing to variation in the potash feldspar content. The mineral composition of six typical specimens from different parts of the pluton are summarized in Table 3. Compositions of two specimens of hybridized granodiorite and two specimens with femic clots (relict xenolithic material) are also presented.

Petrography: The Omara Granodiorite is typically hypidiomorphic-granular, and contains subhedral to euhedral plagioclase, biotite, hornblende, and sphene. Quartz and potash feldspar are anhedral. Some specimens have directed texture due to preferred orientation and alignment within the rock of femic minerals. Grainsize is generally about 1mm, with some plagioclase phenocrysts up to 2 and, rarely, 4 mm long.

Most of the plagioclase is of sodic andesine composition (around An_{33}), and is markedly zoned; limits of core and rim compositions are about An_{60} and An_{10}, respectively (Pl. 6, fig. 1). Most grains are twinned according to Carlsbad and albite laws, but in some the twinning has been largely obliterated by later alteration. Quartz and potash feldspar are typically interstitial. However, potash feldspar has also replaced plagioclase; in some large plagioclase crystals the replacement is restricted to the calcic core, but in others only the calcic core remains intact. The potash feldspar is probably anorthoclase ((-) $2V = 20$ to 50^{o}). One specimen, R10936, a trondhjemite, is cut by a veinlet of quartz and potash feldspar, which has a negative 2V of 43^{o} (C.D. Branch, pers.comm.).

Hornblende has normal pleochroism but the colours are weaker than in the amphibolites. Biotite is strongly pleochroic from pale brown to very dark brown, and is generally partly altered to pale green chlorite. Sphene is commonly euhedral. Ilmenite in one specimen (R10948) forms skeletal grains up to 1mm long.

Oiatabu Range granodiorite

Probable granodiorite exposed in the headwaters of Ama'wa Creek, a tributary of Magoa Creek, may be the roof of a separate pluton forming the core of the Oiatabu Range. Alternatively, it may be a part of the Omara Granodiorite, which it resembles in hand-specimen; the Omara pluton crops out only three miles away to the south-west. The rock intrudes leucocratic quartz-feldspathic gneiss, and contains tabular xenoliths of amphibolite which are partly gabbroic (these are discussed on p. 28). It is, in turn, intruded by simple biotite-quartz-feldspar pegmatite. Texture is massive or slightly gneissic.

Weathered leucocratic (?) granodiorite crops out immediately south of the Oiatabu Range in the Galea district, where it forms country of low relief near the Oredi Fault. Exposure is poor, and the limits of the body are not known.

Luboda Granodiorite

The Goodenough Block appears to have a core of massive granodiorite, the roof of which is exposed in the few streams which have cut deeply into the block - Galuwata and Fakwaoia Creeks and their tributaries. This granodiorite is referred to as the Luboda Granodiorite, after Luboda Creek, a tributary of Fakwaoia Creek, in which it is typically exposed. Massive granite and (?)granodiorite exposed in the south-eastern part of the Goodenough Block, in Gunawala and Niubula Creeks, may be a part of the same pluton.

In the Galuwata and upper Fakwaoia valleys the granodiorite is at present overlain by 3000 to 4000 feet of metamorphics, and it is estimated that the cover of metamorphics at the time of intrusion was probably not greater than 6000 feet (see Section AB on Plate 13). The granodiorite contains many xenoliths and inliers of gneiss and amphibolite, and some basic schlieren.

In the Fakwaoia Creek tributaries, Luboda, Iagile, and Kaboima Creeks, all the xenoliths are amphibolite, some homogeneous, some layered, probably by the injection of granodiorite along planes of schistosity. These amphibolite xenoliths form between 10 and 50 percent of the rock. Many of them are tabular, strike at about 080°, and dip vertically or steeply to the south, but probably an equal number are oriented in other directions or are intricately contorted. Some of the granodiorite is hybridized by absorption of amphibolite, and this hybrid rock may show gneissosity parallel to any nearby schlieren or zenoliths.

In the upper reaches of Galuwata Creek there are approximately equal quantities of granodiorite and metamorphics. The latter are predominantly layered gneiss containing some amphibolite bands. Typical exposures show massive granodiorite or layered gneiss and amphibolite dislocated by intersecting granodiorite veins.

In the headwaters of Gunawala and Niubula Creeks in the south-eastern part of the Goodenough Block massive or slightly gneissic granite and (?)granodiorite contain xenoliths of biotite amphibolite.

The Luboda Granodiorite is generally similar in appearance to the Omara Granodiorite, in that it is massive and medium to coarse-grained, and contains from 10 to 20 percent biotite and hornblende. Of four specimens examined in thin section two are granodiorite (R10434, Luboda Creek, R10439, Galuwata Creek), one is adamellite (R10438, Galuwata Creek), and one granite (R10443, Gunawala Creek).

Petrography: The specimens of Luboda Granodiorite are generally similar to the Omara Granodiorite, but in the Luboda specimen (R10434) muscovite is present, and plagioclase is not zoned. In the two Galuwata specimens (R10438 and R10439) plagioclase (An_{10}) is more sodic than that in the Omara Granodiorite. R10439 is probably a hybrid as it is more basic than the typical granodiorite, the femic minerals are bunched together, and there are large (1mm) euhedra of sphene. The minerals are as described for the Omara Granodiorite.

Morima Range granodiorite

Granodiorite exposed in the Morima Range differs considerably from the Omara and Luboda Granodiorites. It is gneissic and leucocratic, contains muscovite and clinozoisite, and lacks biotite and hornblende. It crops out near the margin of the Omara Granodiorite in two localities, one in the headwaters of Faiaiana Creek, and one on the divide between Lilahi and Matau Creeks. It also crops out in the middle reaches of Matau Creek and on Morima Coast at the mouth of Wealana Creek.

A specimen (R11046) from Wealana Creek consists of quartz (50), albite (25), orthoclase (15), muscovite (5), clinozoisite (5), and accessory apatite. The granodiorite on Wealana Creek intrudes leucocratic gneiss (R10953). There are no apparent thermal effects at the contact, but muscovite and, possibly, orthoclase have been introduced into the gneiss, which has the composition: quartz (40), albite (20), epidote (15), orthoclase (10), biotite (5), chlorite (5), and muscovite (5). The muscovite is restricted to veinlets.

Mebulibuli Peninsula adamellite.

A small body of adamellite intrudes ultramafics in the eastern part of Mebulibuli Peninsula. It was seen only on the coast, and the outline of the body as shown in Plate 12 has been interpreted from air-photographs. The rock (R10450) is very leucocratic and consists of equal parts of quartz, albite-oligoclase, and orthoclase; biotite is present.

Microgranodiorite dykes

Dykes of microgranodiorite between 1 and 6 feet thick are exposed at a number of scattered localities on and near the peripheries of the Mailolo and Goodenough Blocks. Their composition is similar to that of the plutonic granodiorites, and they are probably related to them. Three such dykes were found in the Mailolo Block, one on the northern margin (Mwadeia Creek), and two in the south-eastern part (Wagounai and Gaveta Creeks). Another four were found in the Goodenough Block, one in the north-east (Aligabou Creek), two in the south-east (upper Goiala Creek), and one in the south-west near Cape Varieta. Weathered, massive, granitic rock which crops out in low hills a mile north-east of Iauiaula in the south-west may be part of another dyke. The rocks are medium-grained allotriomorphic-granular or porphyritic and, rarely, gneissic. They consist of plagioclase (40-60 percent), quartz (up to 30 percent), potash feldspar (up to 25 percent), and biotite (around 10 percent). Plagioclase composition ranges from An_8 to An_{46}.

Other dyke rocks, mostly microdiorites, are discussed on p. 34, though many of them may be related to the granodiorite plutons.

PEGMATITE

Simple pegmatite intrudes the metamorphics of both islands; it is particularly common in the Mailolo Block and in the Oiatabu Range, and relatively rare elsewhere. It is

TABLE 3

APPROXIMATE MINERAL COMPOSITIONS OF SPECIMENS OF GRANODIORITIC ROCKS

Specimen No.	Locality	Plagioclase			K-feldspar %	Quartz %	Biotite %	Chlorite %	Hornblende %	Remarks
		%	Ave. An.	Zoning An.						
(a)	Omara Granodiorite - typical									
R10931	U. Seliselina Creek	60	28	35-34	10	20	8	1	-	Gneissic, from near periphery
R10936	Omara River	65	33	41-23	1	15	3	-	15	Trondhjemite
R10937	Omara River	30	32		20	30	12	7	-	Adamellite
R10948	Lilahi River	40	32	60-27	30	15	10	2	-	Adamellite
R10969	Koradidia	50	40		10	30	5	2	3	
R10974	Wogavoga	45	44	?-25	10	35	5	5	-	
	Omara Granodiorite - hybridized									
R10975	Mwadia	55	32, 38		10	15	7	3	10	Quartz diorite
R10946	Idava Creek	60	34	?-10	1	7	10	20	1	
	Omara Granodiorite - xenolithic with ferric clots									
R10981	Waliboalina Creek	70	30-40	55-20	10	15	5	-	-	
R10986	"	65	c. 30	?-10	5	5	-	5	20	Quartz diorite
(c)	Luboda Granodiorite									
R10434	Luboda Creek	40	25-30	None	7	35	3	5	-	Also 10% muscovite
R10438	Galuwata Creek	30	10	-	30	25	10	5	-	Adamellite
R10439	"	40	10	-	5	25	10	-	10	Hybridized
R10442	Gunawala Creek	15	c. 30	-	30	45	5	5	-	Granite
(d)	Granodiorite in Morima Range									
R11046	Wealana Creek	25	08	-	15	50	-	-	-	Also muscovite (5), clinozoisite (5) K-feldspar is orthoclase.
(e)	Adamellite on Mebulibuli Peninsula									
R10450	Mebulibuli Peninsula	33	10	-	33	33	1			K-feldspar is orthoclase
(f)	Microgranodiorite dykes									
R11036	Mwadeia Creek	50	08	-	10	30	2	2	-	Also muscovite and epidote
R10430	C. Varieta	40	24	-	25	25	10	-	-	Slightly gneissic
R10433	Goiala Creek	60	43-46	-	?	?	2	10	-	Almost 30% clay minerals

Note: All rocks contain accessory apatite, sphene and iron ores (commonly titaniferous). Sphene constitutes up to 3% of some of the hybrid rocks.

younger than the granodiorite, but older than some of the microdiorite dykes. The main minerals are quartz and plagioclase in crystals up to 3 inches across; potash feldspar is present in variable amount; micas (biotite and muscovite) are a minor constituent, and are lacking in some specimens. Rutile and tourmaline are rare, but in places form crystals up to an inch long. Amblygonite and cassiterite specimens have been found (Pritchard, 1960) which have probably been shed from the pegmatite; neither was found on this survey.

The pegmatite does not appear to have any economic potential. The few quartz crystals found are not of piezo-electric quality. Micas are generally in small books about an inch across and several millimetres thick, and very rarely up to 3 inches across and 1/4 inch thick; they are too sparsely distributed for economic mining. Amblygonite and cassiterite are probably very rare.

Mailolo Block

Pegmatite crops out in all parts of the Mailolo Block as irregular, transgressive veins, and thin conformable stringers in the gneiss. It is particularly prevalent in the eastern third, notably in Wavuna and Gaveta Creeks, which cut deeply into the block. In Wavuna Creek, near Atugamona, it is locally the predominant rock type; here it contains scattered but oriented xenoliths of garnet amphibolite. Floaters south of Atugamona include an imperfect quartz crystal three inches across and several three-inch books of mica.

In Wauda Creek, on the northern flank of the block, quartz and calcite crystals have developed in small cavities in the gneiss. The cavities are elongated normal to the strike of the gneiss, and are probably tension joints induced by folding. The crystals may have developed from solutions which introduced pegmatite into the adjacent gneiss. The quartz crystals are not of piezo-electric quality.

On Tomagabuna Island, south-west of the Mailolo Block, pegmatite intrudes massive granodiorite. In the low hills south-east of the Block pegmatite is associated with, and probably intrusive into, massive granodiorite and leucocratic gneissic granite.

Oiatabu Range

Pegmatite is especially common in the core of the Oiatabu Range, and relatively rare on the flanks of the range. The best exposures are in upper Omara Creek, Bwagura Creek, and Ama'wa Creek (a tributary of Magoa Creek). Pegmatite in the Oiatabu Range is probably related to the Omara Granodiorite, and may have formed from late-stage solutions emanating from the pluton. The best exposures of pegmatite are within a mile of the granodiorite outcrop. The two rocks are similar in mineral composition, in that the main minerals are quartz and plagioclase, with minor mica and variable percentages of potash feldspar; in both the potash feldspar is either late stage or secondary. The main differences are the presence of rare secondary rutile and more sodic plagioclase (albite) in the pegmatite.

Of four pegmatite specimens examined in thin section three (R10941, R11028, and R11030) contain less than 2% potash feldspar, and the fourth (R11045) contains approximately equal quantites of potash feldspar, albite, and quartz. In all four the potash feldspar appears to have replaced plagioclase.

In Bwagura Creek, pegmatite dykes in the metamorphics have a consistent 340^{o} strike. The pegmatite intrudes granodiorite dykes, but is in turn intruded by microdiorite.

In Ama'wa Creek, pegmatite is gneissic in places owing to parallel orientation of mica flakes and rare elongated vugs. Partly assimilated basic xenoliths within the pegmatite consist of hornblende, augite, andesine-labradorite, sphene, biotite, chlorite, and epidote. Pegmatite is also exposed in lower Magoa Creek, and in Mwaduie Creek on the north-eastern flank of the range. Floaters near Mwaduie Creek include small (about 1 inch) imperfect quartz crystals.

Other parts of Fergusson Island

Pegmatite is relatively rare elsewhere on Fergusson Island. There is an isolated exposure south of Lake Lavu, where pegmatite intrudes granitic gneiss. In the south-eastern Salakadi area, east of Iagila Creek, much pegmatite is developed near the contacts between granodiorite and ultramafic inliers; this pegmatite contains small, well-formed quartz crystals. Floaters and creek boulders on the southern coast, between Wealana and Faiaiana Creeks, include rare prisms of rutile up to an inch long; in some boulders the rutile is associated with quartz and feldspar. The boulders have probably shed from pegmatite veins, but no pegmatite outcrop was found in this area.

Goodenough Island

Pegmatite outcrop was noted in only two localities on Goodenough Island. One is Aliali Creek, in the west, where minor pegmatite intrudes granitic gneiss. The other is in Luboda Creek, in the south-west, where amphibolite inliers in granodiorite are reticulated by pegmatite veins. A pegmatite boulder near Bilolo Creek, in the north-east, contains 3/4 inch crystals of black tourmaline (probably schorlite).

DYKE ROCKS

The Omara Granodiorite and the metamorphics of both islands are intruded by fine-to medium-grained dykes, most of which are of intermediate composition (microdiorite). A few are basic - dolerite - and a few are acid - typically microgranodiorite. Mapping did not establish any pattern of distribution except, perhaps, that the dykes are more prevalent towards the outer margins of the metamorphic masses.

The dykes vary greatly in age. A few appear to have intruded before the period of regional metamorphism, but most are younger. Some are clearly younger than the Omar Granodiorite, and others are contemporaneous with Quaternary volcanic activity. The latter are obviously part of the volcanic suite, and are discussed on p. 36; ft. pegmatites, which are younger than the granodiorite, have already been discussed, as have the microgranodiorites, thought to be contemporaneous with the acid plutons.

Pre-metamorphic dykes

Dykes intruded before the time of regional metamorphism were found in only two localities, both within a few miles of the eastern margin of the Omara Granodiorite. One (R10928), exposed in Wapera Creek, is a quartz-biotite-hornblende-andesine schist which was probably derived from a microdiorite; the other (R11045) in Bwagura Creek is an andesine-biotite-hornblende amphibolite which was probably derived from dolerite.

Post-metamorphic dykes

Dykes intruded after the period of regional metamorphism are by far the most numerous; their age relationship to the granodiorite is not known. They intrude the metamorphics of both islands. Most are porphyritic microdiorites with 50-60 percent plagioclase (usually andesine), between 5 and 45 percent hornblende, and between 1 and 20 percent hornblende, and between 1 and 20 percent biotite. A few contain quartz (up to 10 percent) and rarely potash feldspar. Iron oxide, sphene, and apatite are normal accessories. One dyke (R10962) in lower Seliselina Creek, west of Salamo, is an altered porphyritic leucocratic granodiorite. Another probable dyke (R11011) exposed in Dagua Creek, in north-western Fergusson Island, is a sheared leucocratic trondhjemite or, possibly, altered andesite.

Post-granodiorite dykes

A few dykes clearly intrude the Omara Granodiorite. Most are porphyritic microdiorite, but a few are microgranodiorite, and one is quartz diorite. In some places severe deuteric alteration has produced a rock which resembles pyritic chert in hand-specimen; these rocks consist of fine chlorite, calcite, sericite, quartz, and pyrite, and some contain relict plagioclase and pseudomorphs of chlorite and calcite after biotite and hornblende.

Petrography

The mineral compositions of the various dyke rocks are summarized in Table 4. Textures are generally porphyritic: phenocrysts of plagioclase, hornblende, and biotite are set in a fine-grained groundmass composed of the same minerals. Exceptions are the amphibolite (R11045), which is medium-grained to coarse-grained. In some of the more altered porphyries the minerals of the groundmass are chlorite and probable altered plagioclase.

The most common plagioclase is andesine (around An_{40}); one specimen contains calcic oligoclase (An_{27}), and several others contain labradorite (An_{50} to An_{60}). In almost all specimens the plagioclase is zoned, twinned, and moderately or severely altered. Potash feldspar was identified in only four specimens, but may well be present in others, perhaps in the fine-grained groundmass. It typically replaces plagioclase; in R10980, for example, it forms a network of irregular veinlets within the labradorite phenocrysts.

There are at least three varieties of amphibole, namely green hornblende, brown hornblende, and tremolite. The hornblendes are pleochroic as follows :

(i)	Pale brown	brownish green	dark green
(ii)	pale brown	dark brown	brownish green

Laths of brown hornblende invariably have green rims not apparent in cross-sections. Many phenocrysts of green hornblende contain irregular blebs of the brown variety. The two types are denoted by 'g' and 'b' in Table 4. In R10958 all three types of amphibole are present. They occur in clusters of grains up to 2 mm across; the core of a typical cluster is fibrous tremolite, and the rim is green hornblende mottled with brown in places; small euhedra and subhedra of brown hornblende surround the amphibole cluster. In this and some of the other hornblende-rich rocks the hornblende may have formed at the expense of pyroxene.

Biotite is pleochroic to very dark brown, and is usually associated with hornblende where both are present. In some rocks it appears to be a metasomatic derivative of hornblende. Chlorite, sericite, epidote, calcite, and some quartz are alteration-products. Chlorite is pleochroic from colourless to pale green.

VOLCANIC ROCKS AND THERMAL AND SEISMIC ACTIVITY

Volcanic Rocks

Volcanic rocks crop out on most of the islands of the D'Entrecasteaux Group. Volcanic activity extended from late Tertiary or early Quaternary to Recent time, and is now apparently in the dying solfataric stage. Some of the older volcanics are folded and sheared. Although there have been no eruptions in historic time, cones on Dobu, south-eastern Fergusson, and Goodenough Islands are so well preserved that they should not be considered extinct.

There appear to be three volcanic provinces :

(i) South-eastern and south-western Fergusson Island: predominantly calc-alkaline and sodic, acid and intermediate fragmental rocks, minor lava, and rare dolerite. Typical rock types are pumice, obsidian, flow-banded lava, and welded ash-flow tuff. There is no pumice in the south-western area.

(ii) Goodenough Island: predominantly calc-alkaline, basic-intermediate lava (typically andesitic olivine basalt), minor andesite or trachyte, and rare dacite.

(iii) Amphlett Group and Uama and Tewara Islands: predominantly calc-alkaline, and possibly sodic, intermediate lava and agglomerate, with minor andesitic olivine basalt.

South-eastern Fergusson Island and adjacent islands.

Volcanic rocks form the south-eastern part of Fergusson Island and the neighbouring islands of Sanaroa, Dobu, Neumara, and Oaiobe. The total area of volcanics is about 90 square miles: 70 on Fergusson, 16 on Sanaroa, 3-4 on Dobu, and about a third of a square mile on each of the other two islands.

The area is dominated by three volcanic cones, two on Fergusson Island (Lamonai and Oiau), and one forming Dobu Island. They are between 1000 and 1600 feet high, are roughly aligned north to south, and are spaced 6 and 4 miles apart. There are a number of small thermal areas in the low hills between Lamonai and Oiau, and a few on Dobu Island. West and north-west of Lamonai and Oiau, volcanic rocks form low hills which are bounded by the metamorphics of the Oiatabu-Morima Arc. East of the cones volcanic rocks form the low-lying islands of Sanaroa, Oaiobe, and Neumara.

In this survey no attempt was made to examine the volcanic rocks in detail, and many of the following data are taken from reports by Maitland (1892), Stanley (1920), Taylor (1955a), and Reynolds (1956).

The volcanics are almost wholly of acid and intermediate composition; dolerite is rare. The cones and adjacent hills are predominantly fragmental rock, ranging in grain-size from ash to agglomerate. Rock types in the low-lying hills and islands away from the cones include dacitic ash-flow tuff, andesite, and dolerite.

Lamonai Cone: Lamonai cone is about 2 1/2 miles wide at the base and rises to a height of about 1600 feet. The crater is about 700 feet deep, and has almost vertical walls to the west, north, and east. It appears to have been breached to the south-west, where the crater rim is lower (1100 feet), and a recent lava flow extends south-south-west from the crater (interpretation from air-photograph 36X/92V).

TABLE 4

APPROXIMATE MINERAL COMPOSITIONS OF SPECIMENS OF DYKE ROCKS

Specimen No.	Locality	Plagioclase %	Plagioclase Ave. An	Plagioclase Zoning An	K-feldspar %	Quartz %	Biotite %	Hornblende %	Hornblende Var.	Remarks
Pre-metamorphic dykes										
R10928	Wapera Creek	50	40	45-18	-	10	20	20	g	Schist of quartz microdiorite composition
R11045	Bwagura Creek	5	36	None			10	75	g	Also sphene (5%), apatite (5%), amphibolite formerly dolerite.
Post-metamorphic dykes										
R10939	Bwagura Creek	50	43		-	-	1	45	g	Also minor epidote; hornblende is pale coloured
R11044	Bwagura Creek	75	35	35-25	-	-	20	5	g	Hornblende is pale coloured
R10942	Wadelei	60	27	?-15	-	-	1	35	g	Also some fibrous tremolite (3%)
R10958	Faiaiana Creek	45	50		-	3	3	40	g&b	Also some fibrous tremolite (7%)
R11023	Marasi Creek	45	30	32-20	15	10	18	10	g	
R10991	Lilahi Creek	65	63	87-?	-	10	3	22	g&b	Also rare calcite
R11011	Dagua Creek	70	38		-	7	3	-	-	Also calcite (10%), chlorite (3%), pyrite (5%).
R10962	L. Seliselina Creek	Plagioclase (An_{40}) phenocrysts in a fine-grained groundmass of plagioclase, quartz, chlorite and biotite.								Sheared leucocratic trondhjemite or andesite.
Post-granodiorite dykes										
R10943	Totoboia Creek	60	40	54-30	-	1	-	-	-	Also calcite (15%), chlorite (20%)
R10980	Waliboalina Creek	50	55		15	-	-	30	b	Also epidote and calcite; hornblende is pale coloured
R10985	Bwaiea Creek	60	40		10	15	10	5	b	Porphyritic microgranodiorite
R10944	Totoboia Creek	Minor relict plagioclase (An_{30}) in a fine-grained groundmass of quartz, chlorite, calcite, sericite and pyrite.								
Omara Granodiorite for comparison										
Limits		30-60	28-44	60-20	1-30	15-35	5-12	0-15	g	Also chlorite (6-7%)
Typical		60	32	40-20	10	20	10	-	-	Derived from synthesis of petrographic analyses.

Note:

1. All rock types are quartz microdiorite unless otherwise stated
2. Apatite, sphene, and iron oxides (some titaniferous) are the typical accessories
3. All localities are on Fergusson Island; similar rocks are present on Goodenough Island.
4. The varieties of hornblende are green (g), brown (b), green and brown (g & b).

Lamonai has been described by Taylor (1955a), who entered the crater from the south-eastern side. The north-western wall of the crater appears homogeneous and shows no sign of bedding; it is thought to be part of a former massive plug. Taylor infers that the present crater formed by a powerful explosive eruption slightly eccentric to the massive plug which had completely sealed up the original crater. 'The south-eastern part of the cone appears to be made up essentially of fragmental material which is generally finely divided. On the top of the rim small angular blocks of trachytic lava are common, but for the most part the ash is fine-grained and non-vesicular. On the lower slopes large blocks of black volcanic glass are common; these obsidian blocks appear to be an older lava.' The north-western flank of the cone is probably composed of similar fragmental material.

Oiau cone: Oiau cone lies on Bwaioa Peninsula, 6 miles south-by-west of Lamonai. The crater is filled with lava which has spilled over and flowed to the coast on the western side (Pl. 1, fig. 2) and is drained by a small creek which flows to the east. South of the crater an arcuate ridge rises to about 1000 feet.

Maitland (1892), Stanley (1920), Reynolds (1956), and Pritchard (1963) have described Oiau and the following data are taken from their reports. The cone is composed of predominantly fragmental intermediate and acid rock, ranging in grain-size from ash to agglomerate. Pumice is the major component, though there are some obsidian and lava fragments. Pritchard reports cliffs of fragmental pumice up to 200 feet high in the walls of the crater. He states that the size of the pumice fragments ranges from dust to six-inch blocks, and estimates that more than 50 percent by volume are fragments larger than 1/4 inch across.

Reynolds (1956) postulates that Oiau cone originated with a period of violent explosive activity which produced the cone of fragmental material and the large crater. A later phase of less violent activity is indicated by the presence of lava flows near the top of the section. He measured the following section in a cliff south-east of the crater lava flow:

20' finely-banded light and dark grey lavas with colourless plagioclase phenocrysts.

15' indurated pumice dust and agglomerate consisting of light green pumice dust, green-grey pumice fragments, and rare obsidian fragments.

6' finely-banded brown-grey vesicular lava with colourless plagioclase phenocrysts.

Underlain by fragmental rocks.

The lava which has filled the crater apparently consists of both obsidian and vesiculated trachyte or rhyolite. Maitland (1892) and Stanley (1920) both described it as obsidian or, more strictly speaking, porphyritic pitchstone with translucent sanidine phenocrysts. A representative specimen, collected by O.N. Warin, of the Bureau of Mineral Resources, in 1958, is a flow-banded vesicular trachyte or rhyolite with translucent anorthoclase phenocrysts. Probably the 'sanidine' noted by the earlier workers is actually anorthoclase.

Dobu cone: Dobu, a strato volcano, probably in the dying solfataric stage (Fisher, 1957), forms the greater part of Dobu Island, 4 miles south of Oiau. The cone is about 2 miles across at the base and has a maximum elevation of about 1000 feet. There is one major crater in the southern central part of the island and a smaller double crater in the south-eastern part.

The main crater is south of the centre of the cone, and is open to the south. It appears that, as in the case of Lamonai crater, it may have formed by powerful explosive eruption slightly eccentric to a massive plug which had sealed the original crater.

Reynolds (1956a) postulates that there was explosive activity from a number of vents extending from the main crater to the small bay on the south coast of the island. A cluster of three small vents in the floor of the crater can be discerned on the air photograph. He also noted mild thermal activity in the northernmost of the two eastern craters, and Taylor (1955a) reported warm springs on the northern and north-western coasts.

The main cone is composed of fragmental material, most of it reportedly pumice. Maitland (1892) noted brown stratified sand and gravel, containing glassy pebbles and pumice, in a cliff section on the northern coast. Taylor (1955a) noted fragments of trachytic lava and black volcanic glass in a coastal cliff near Murisia village. A lava flow which forms the south-eastern tip of the island may have originated from the southernmost of the two south-eastern craters (Reynolds, 1956a). There may be another flow on the north-eastern flank of the main cone. Chemical analysis of pumice from Dobu Island indicates a rhyolitic composition (Maitland, 1892).

Other craters and cones: Stanley (1920) reports another major cone, Mount Masai'ia, on Fergusson Island south of Lamonai, and several other small vents south-east of Masai'ia. No other observers have confirmed the existence of these cones and they are not apparent on the air-photographs; but the air-photographs are of poor quality and the area has not been mapped in detail. However, it seems most likely that Stanley's cones are actually small peaks.

Several sections of coast-line on south-eastern Fergusson Island may be old crater rims. One is a near-circular bay 3 miles south-east of Lamonai; another is a more open bay which forms the northern part of the Numanuma Bay. The latter is rimmed by steep cliffs; gentle slopes inland from the cliffs may be the flanks of a former cone. Boulders of flow-banded rhyodacite or trachyandesite occur at the foot of the cliffs.

Low-lying area west of Lamonai. A low-lying area west of Lamonai extends from Salamo in the south to the Gamabila and Galea districts in the north. Exposure is poor, but the few outcrops seen are of flat-lying volcanics. Welded ash-flow tuff of dacitic composition crops out in Sebutuia Bay, on the Ni'eli River near Wagarai, and on the Salamo River in the Gamabila district. Welding is more complete in the tuff at Sebutuia than in specimens from Gamabila; this suggests that the source is nearer Sebutuia, and is perhaps Mount Lamonai. The Gamabila exposure is at an elevation of between 200 and 400 feet, and is about 60 feet thick. The Sebutuia exposure is at sea-level, and is of unknown thickness. If it is assumed that the tuff flowed westward from Sebutuia to Gamabila the original thickness in the Sebutuia area must have been 200 to 400 feet or more.

A few tuff boulders in lower Mebulibuli Creek indicate the presence of remnant tuff cover on parts of the Mebulibuli Peninsula. Vesicular dolerite crops out in the lower reaches of the Salamo River; it appears to form a succession of horizontal flows.

Sanaroa Island: Sanaroa Island has low relief similar to that of the low-lying area west of Lamonai. The island consists almost entirely of volcanic rocks; some alluviated and swampy areas are also present. At one point on the north-west coast flow-banded andesite crops out; the banding dips at 35° to the north-north-west.

Neumara and Oaiobe Islands were not visited.

Petrography

The trachyte which occurs as angular blocks on the southern rim of Lamonai crater is described in an appendix to Taylor's (1955) report. It consists of phenocrysts of orthoclase, green pyroxene, and rare plagioclase in a finely felted groundmass of orthoclase, lamprobolite (with sodic rims), and interstitial quartz.

Obsidian or porphyritic pitchstone, which Stanley collected from the crater flow in Oiau cone, consists of black volcanic glass with phenocrysts of translucent sanidine ((?) anorthoclase) and crystallites which show fluxional arrangement (Stanley, 1920). Maitland (1892) collected a specimen of what was probably the same rock, for which he quotes the following chemical analysis :

SiO_2	71.27
Al_2O_3	9.10
Fe oxides	10.13
MnO	trace
CaO	0.89
K_2O	3.14
Na_2O	5.18
Loss on ignition	0.25

The anomalously low alumina and high iron oxides indicate that the analysis is unreliable. If the silica content is near correct the rock is of acid composition.

Vesicular and flow-banded trachyte or dacite collected by O.N. Warin from the same flow consists of scattered phenocrysts of translucent anorthoclase and rarer phenocrysts of aegirine-augite in a crypto-crystalline groundmass without any distinguishable quartz (W.B. Dallwitz, pers.comm.).

Maitland (1892) quotes a chemical analysis of pumice from Dobu Island:

SiO_2	69.62
Al_2O_3	15.26
Fe oxides	3.05
MnO	trace
CaO	0.94
K_2O	5.20
Na_2O	2.36
Loss on ignition	3.69

If this analysis is reliable it indicates a composition equivalent to rhyolite with high potash content.

Boulders of flow-banded rhyodacite or trachyandesite occur at the foot of the cliffs which form the supposed crater walls on the north shore of Numanuma Bay (R10453). They consist of phenocrysts of anorthoclase, albite, aegirine-augite, and lamprobolite in a crypto-crystalline groundmass. Quartz may be present in the groundmass.

Flow-banded andesite on the north-west coast of Sanaroa Island contains phenocrysts of oligoclase-andesine and (?) lamprobolite (R10452).

In hand-specimen (R10922) the welded ash-flow tuff from the Gamabila area consists of small translucent crystals, rock fragments, and obsidian lenses in a brown matrix which weathers readily; the obsidian lenses have feathered ends. In thin section the rock is found to consist of phenocrysts of anorthoclase (with quadrille twinning) and plagioclase, and glass shards which give an illusion of flow-banding. The rock fragments are andesite, and the groundmass is devitrified iron-stained glass.

Welded ash-flow tuff (R10451) from the head of Sebutuia Bay is yellow and grey in hand-specimen. It consists of small phenocrysts of anorthoclase, albite, hypersthene, and greenish amphibole and glass shards (some devitrified) in a matrix of devitrified glass. The rock shows axiolitic texture indicating devitrification of glassy lenses. Ash-flow tuff origin is indicated by the absence of true flow-banding and the presence of glass shards and obsidian lenses with feathered ends; fragments of andesite are also present. The obsidian lenses have been formed by the welding of tuffaceous material. The Sebutuia specimen (R10451) appears to have been more completely welded than the Gamabila specimen (R10922); it is probably nearer the vent. The rocks are of dacite or andesite composition.

Vesicular dolerite from the lower reaches of the Salame River consists of labradorite (40), titanaugite (25), iron-stained devitrified glass (25), and vesicles (10). Some of the vesicles contain aragonite.

South-western Fergusson Island

In south-western Fergusson Island volcanic rocks cover an area of about forty square miles. They extend from south of the Mailolo Block (Iamelele area) southward to the south coast, westward to the tip of Kukuia peninsula, and eastward to the Salakadi area. They are folded on the Kukuia Peninsula, flat-lying in the Iamelele-Fagululu-Matau Creek area, and form 'plugs' in the Salakadi area and small cones and probable lava domes in parts of the Iamelele area. The rock types range from basalt to andesite, rhyolité, dacite and welded ash-flow tuff.

The solfatara field in the Iamelele area is discussed on p. 45.

Folded volcanics are exposed on the south coast of Kukuia Peninsula near its western tip and as far east as Matau Creek. They commonly dip at about 50°, and form a series of strike ridges on the south-western part of the peninsula. They apparently represent an earlier stage of vulcanism, but are probably no older than late Tertiary, as the rock types are similar to those of the younger volcanics, and are not noticeably more weathered. The most common rock type is flow-banded rhyolite or dacite which, in one exposure, is underlain by agglomerate consisting of blocks of vitric tuff up to 15 inches across.

Sharp peaks about 2000 feet high, near Mapamoiwa, may represent a dissected plug or neck related to the folded volcanics (Pl. 6, fig. 2).

Flat-lying volcanics form several plateaux, and probably also form many of the low hills in the Iamelele area. The largest plateau is between Fagululu and Matau Creek; it has an area of about 7 square miles and an elevation of between 1500 and 2000 feet, and consists of an estimated thickness of 300 to 500 feet of volcanics overlying metamorphic rocks. The northern margin of the plateau coincides approximately with the line of the Lavu Fault, and the southern margin is marked by steep cliffs above the Matau valley. The plateau was not visited. Rocks shedding from it are predominantly biotite dacite and obsidian. Sills of biotite dacite, obsidian, andesite, and basalt intrude the steeply-dipping metamorphics underlying the plateau, and are exposed in Matau Creek. Andesite and dolerite cap some of the higher peaks of metamorphics to the east of the plateau, and are probably outliers of the plateau. Stanley (1920) reports a thin veneer of olivine dolerite overlying metamorphics to the west of the plateau, and this may also be an outlier. Tributaries of Matau Creek which drain the plateau are milky with suspended matter, probably clay derived from the biotite dacite, which weathers rapidly.

Two smaller plateaux in the central Iamelele area, on either side of Awavula Creek, have a total area of about 2 1/2 square miles and an elevation of about 100 feet. Two specimens collected from the eastern plateau were identified as massive hornblende andesite and welded ash-flow tuff of intermediate composition.

Most of the low hills in the Iamelele-Fagululu area are probably composed of flat-lying volcanics, but some outcrops of metamorphics were seen in low hills immediately north of the Debawala selfatara area. Stanley (1920) and Reynolds (1956) report floaters of obsidian, pitchstone, and banded acid lava.

Mount Ebadidi in the Salakadi area is a 'plug' or sub-elliptical dyke of leucocratic olivine dolerite which rises almost sheer for several hundred feet above the surrounding metamorphics. It is about half a mile long (north-south) and a quarter of a mile wide (east-west) and has a maximum elevation of about 1600 feet. Two miles north of Ebadidi near Niubuo a smaller 'plug', several hundred yards across, stands about 200 feet above the alluvial plain. It is composed of pink dacite porphyry with strong vertical joints which strike at 030^{o}.

Several isolated rounded hills which project to a height of about 500 feet above the Iamelele plains are possibly lava domes. One is near a small thermal area and lake, midway between Iamelele and Iewata; another is on Unumagiai Creek, south-east of Iamelele and north of Fagululu. Another 500-foot hill immediately south of the Mailolo Block near Gaveta Creek appears to be a small cone with central vent (interpretation of air-photograph 36X/80V). Weathered vesicular andesite crops out nearby.

Petrography

Folded volcanics: A specimen of the folded flow-banded dacite (R11006) consists of phenocrysts of oligoclase and rare lamprobolite with apatite needles and some iron oxide in a cryptocrystalline and glassy groundmass. The groundmass includes chalcedonic bands and a few patches of palagonite.

On the south-western tip of Kukuia Peninsula the banded dacite is underlain by an agglomerate which consists mainly of 15-inch blocks of black vitric tuff. The vitric tuff (R10915) is a puzzling rock; it is composed of sub-spherical grains of clear obsidian and equant crystals of zoned andesine, biotite, and magnetite, in a groundmass of grey glass with perlitic cracks and lines of minute inclusions. The rock has apparently been stressed and granulated, as the lines of inclusions have a different orientations in each grain.

Flat-lying volcanics: Biotite dacite (R11257) from Matau Creek consists of phenocrysts of dark brown biotite (black in hand-specimen) and oligoclase in a fine-grained groundmass of plagioclase, quartz, and rare iron oxides. Quartz is chalcedonic in places, and shows some myrmekite-like textures indicating that potash feldspar may be present, though scarce. The dacite weathers rapidly.

Hornblende andesite (R11022), which caps a peak of metamorphics east of the plateau, is a fine-grained rock consisting of equal amounts of hornblende and andesine. Leucocratic dolerite (R10950) from nearby consists of phenocrysts of bytownite (An72-76) and augite in a fine-grained matrix of chlorite, plagioclase laths, augite, and iron oxides.

The only sill rock sectioned is R11262, which is a porphyritic lamprobolite-augite-labradorite basalt with patches of xylotile after olivine; phenocrysts are up to 3 mm long.

Andesite (R11018) from the plateau near Awavula Creek consists of phenocrysts of oligoclase (An_{28}) and biotite in a fine-grained groundmass of feldspar and glass. A welded ash-flow tuff (R11259, collected from the same plateau by P.W. Pritchard) consists of sub-rectangular rock fragments and phenocrysts in a partly devitrified glassy matrix. A rock fragment in the thin section is a fine-grained (?)andesite with porphyritic plagioclase and (?)pyroxene. Phenocrysts in the glassy matrix are labradorite (An_{50}), red-brown biotite, and (?)pyroxene. The glass forms small lenses and contains margarite crystallites which are aligned parallel to the elongation of the lenses. The glassy lenses probably represent collapsed and welded pumice fragments.

'Plugs': The Mount Ebadidi 'plug' is composed of leucocratic, porphyritic olivine dolerite (R10952) which contains large euhedra (up to 3 mm) of olivine and smaller subhedra of augite in a medium-grained groundmass of felted labradorite laths. The 'plug' near Niubuo is of pink dacite porphyry (R10947) with oligoclase and biotite phenocrysts.

Lava domes and small cones: No spécimens were examined in thin section.

Northern central Fergusson Island

Immediately east of the Mailolo Block near Masi Masi a dissected volcanic cone rises to about 300 feet from the alluvial plain. This might be correlated with the cone near Gaveta Creek, as both are on the periphery of the Mailolo Block. The rock is vesicular porphyritic olivine basalt (R11014); it consists of phenocrysts of olivine, augite, and labradorite-bytownite (An_{70}), in a groundmass of fine plagioclase laths.

Goodenough Island

The volcanics of Goodenough Island are generally more basic than those of Fergusson Island, and are mostly of basic-intermediate composition. Andesite basalt predominates; less common rock types are pinkish dacite, purple (?)trachyte, and greenish brown trachyte or andesite. Fragmental rocks are rare. Obsidian, pumice, and flow-bended acid lava, which are so common on Fergusson Island, are rare or lacking on Goodenough.

Volcanics crop out on all flanks of the Goodenough Block, but the most extensive development is in the east and south-east. Volcanic cones on the south-eastern tip of the island are aligned with several small cones and flows which have developed on the Wakonai Fault on the north-eastern margin of the Goodenough Block. Small cones and flows on the south-western, western, and north-western flanks of the Block have probably developed over faults which bound the block on these sides. A probable lava dome and low hills and cones of volcanics project from the alluvial plain which forms the northern part of the island.

South-eastern part of the island: Volcanics cover an area of about 18 square miles in the south-eastern part of the island, and extend from Gunawala Creek in the north to the Kilia coast in the south-west and Wagipa Island in the south-east. The northern and western part of the area is a plateau, between 500 and 1000 feet high, divided by the valley of Niubula Creek. It consists of lava flows and rare agglomerate, up to 1000 feet thick, overlying metamorphic rocks. Coarsely porphyritic andesitic olivine basalt is common on the eastern part of the plateau. In the west vesicular basalt predominates; accompanying it are some basaltic agglomerate and rare greenish brown porphyritic trachyte or andesite.

Most of the area south and east of the plateau is moderately dissected, and contains peaks rising to 1300 feet; some of these may be volcanic plugs and necks. Coarsely porphyritic andesitic olivine basalt crops out on the southern shore of Mud Bay. Near Abolu, on the south coast, a lava flow of vesicular basaltic olivine andesite dips at 20^{o} to the south-south-east.

Four well-preserved cones in the extreme east of the area probably represent a more recent phase of volcanic activity. They range in height from 200 to 600 feet, and the largest forms the island of Wagipa (Pl. 7, fig. 1). Wagipa cone is probably composed of flows of basaltic lava; dark vesicular lava with plagioclase phenocrysts and disseminated pyrite crops out in the south coast, and Reynolds (1956) found olivine basalt on the northern slopes. A low ridge of agglomerate on the north-western coast of Wagipa Island may be part of an old crater rim. The agglomerate consists of basalt fragments in a matrix of pumiceous dust (Reynolds, op.cit).

Flows and cones peripheral to the Goodenough Block: Small flows and cones occur on all margins of the Goodenough Block, but are most prevalent in the east and north-east.

Inland from Nuatutu, volcanics cover an area of about 6 square miles. In the southern part of the area a fan-shaped lava flow extends to the sea from a probable vent half a mile east of the Wakonai Fault (Pl. 7, fig. 2). The lava is pink porphyritic (?)trachyte (P.W. Pritchard, pers.comm.), and is underlain by red-black vesicular basalt up to 500 feet thick; the basalt, in turn, is underlain by pinkish white (?)dacite. Baker (Baker & Coulson, 1948) has described a pinkish dacite from the northern part of the area near Bolu Bolu. The rock contains small shears filled with quartz veins and limonite, and thus appears to belong to an earlier phase than the other lavas (Baker & Coulson, loc.cit.). Similar pinkish white dacite crops out three miles to the south-west, on Gunawala Creek.

About three miles north-north-west of the Nuatutu area, between Bilolo and Aligabou Creeks, there is a fan-shaped flow of completely silicified and carbonated volcanic breccia, which appears to have issued from the Wakonai Fault. Another mile to the north-west there are some concentric ridges of vesicular andesite; these may be remnants of a cone. The highest peak is known as Wakala Hill.

Boulders of vesicular basalt were found in Duwau Creek, four miles north-west of Wakala Hill, and in Alua, Lauboda, and Bekala Creeks, on the north-western and western margins of the Goodenough Block. On the accompanying map (Pl. 13) areas of volcanic rock outcrop are shown near these creeks, though in fact no exposure was seen. These supposed areas of outcrop have been deduced from interpretation of air-photographs and from the occurrence of vesicular basalt boulders in the streams. The Duwau Creek volcanic boulders have been shed from near the Wakonai Fault and those in Alua and Bekala Creeks have been shed from the line of the Fakwakwa Fault. The Bekala Creek volcanic boulders crop out less than a mile away from the creek, on the coast near Cape Rawlinson. Vesicular basalt from Bekala Creek is an andesitic olivine basalt similar in composition to the typical basalt of the south-eastern part of the island.

On the south-western flank of the Goodenough Block, west of Fakwaoia Creek, volcanics crop out in two small areas on the line of the Ta'uleleia Fault. Basaltic scoriae predominate, but there is also some massive basalt which may contain small (up to 1/2 inch) fragments of quartzo-feldspathic schist and olivine crystal aggregates. The metamorphic fragments have probably been broken from the walls of the fissure or vent, and the olivine aggregates may be cognate xenoliths.

Two miles south of this area, in the alluvial flats near the village of Diodio, a crescent-shaped lake is bordered to north, east, and south by a low ridge of volcanic material. It is probably an explosion vent (maar). The volcanic rock-type is purplish trachyte (P.W. Pritchard, pers.comm.). Fissures are reported to have developed around the margins of the lake at the time of the severe earth tremors in 1956 (Monthly report for November, 1956 - Rabaul Vulcanological Observatory).

Northern part of the island: Volcanics project from the northern alluvial plain at Mount Oiava'ai and around Wataluma Hill, and form low hills on the off-shore island of Nuamara.

Mount Oiava'ai is a lava dome, cone, or neck, which rises abruptly from gently-sloping alluvial plain, about 1 1/2 miles north of the Wakonai Fault. It is about a mile wide at the base, and its maximum height is about 1400 feet. The flanks are steep, particularly on the south side, where the hill has been partly eroded by Malafua Creek. The steep sides, rounded outline, and absence of vent indicate that it may be a lava dome, though Coulson (Baker & Coulson, 1948) described it as a cone. Whichever is the case the lava must have been very viscous. The rock type is porphyritic olivine basalt, which is rarely vesicular (Baker & Coulson, loc.cit.); the apparent viscosity is probably due to low volatile content in the lava. Vesicular lava, which crops out nearby in Malafua Creek, contains a xenocryst of quartz with a small amount of attached albite (Baker & Coulson, loc.cit.).

Wataluma Hill is the highest peak in a group of low rounded hills, occupying an area of about 3 square miles, which project from the alluvial plain near the north-east coast of Goodenough Island. Three small cones, one of which forms Wataluma Hill, can be distinguished in the eastern part of the group of hills (air-photograph MM112/146). P.W. Pritchard (pers.comm.) collected purplish (?)trachyte from the western end of the group.

On Nuamata Island, off the north coast of Goodenough Island, grey, flow-bended olivine andesite is exposed; the flow-banding dips at 55^{o} to the west.

Petrography

The most common volcanic rock type on Goodenough Island is porphyritic andesitic olivine basalt. The plagioclase is typically sodic labradorite, An_{50-53}. The phenocrysts in five similar specimens are :

R10431 (Abolu coast, south-eastern Goodenough Island): bytownite An_{77}, augite, olivine, phlogopite. R10445 (West of Ufufu, south-eastern Goodenough Island): labradorite An_{50-53}, augite, hypersthene. R10454 (south-west of Ufufu, south-eastern Goodenough Island): labradorite An_{49-53}, augite, olivine. R11260 (Bekala Creek, western Goodenough Island): labradorite An_{52}, hypersthene, augite, olivine. Not numbered - see Baker & Coulson, 1948 (Oiava'ai, northern Goodenough Island): labradorite, olivine.

The olivine is chrysolite, about Fe_{85}. In most of these rocks the groundmass is predominantly plagioclase; pyroxene is subordinate, and iron oxide is accessory. Specimens R10445 and R10454 are coarsely porphyritic and contain phenocrysts measuring up to 4mm.

Pinkish dacite from near Bolu Bolu consists of embayed and rounded quartz phenocrysts, zoned oligoclase, rare orthoclase, and green to pale yellow-green biotite in a cryptocrystalline to microcrystalline groundmass of quartz, feldspar, and some apatite. Quartz veins and limonite occur in small shears (Baker & Coulson, 1948).

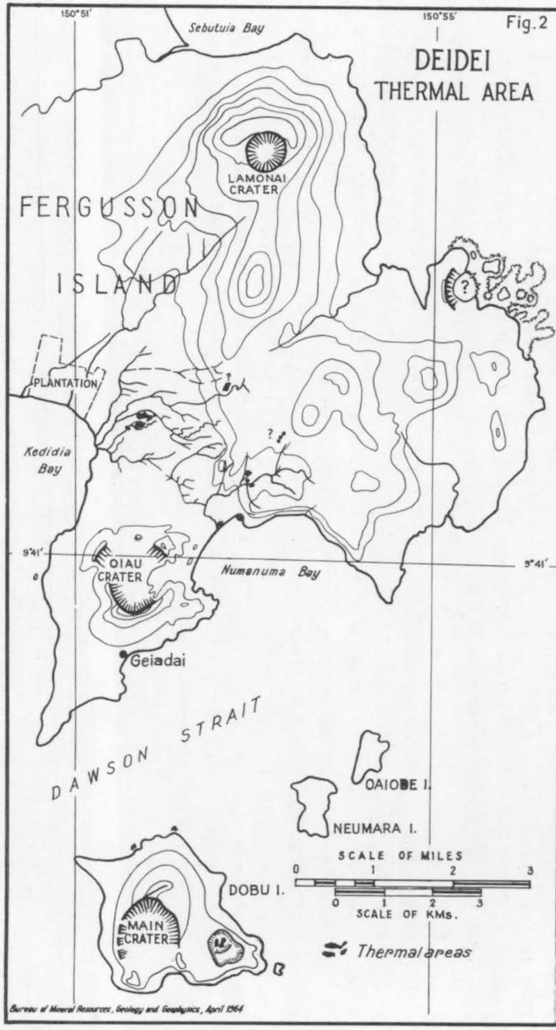
Amphlett Group and Uama and Tewara Islands

These islands, which lie to the north-east and east of Fergusson Island, are composed entirely of lava and agglomerate, most of it of intermediate composition. On Wagabu Island flow-banded andesite dips at 10^{o} to the west. On Watota Island andesite lava and agglomerate are exposed; component boulders of the agglomerate are porphyritic andesitic olivine basalt, similar to the typical lava of Goodenough Island. On Wawiwa Island biotite (?) trachyte lava is overlain by agglomerate of similar composition. On the coast of Yabweia Island there are boulders of andesite. More than 100 feet of agglomerate is exposed on Urasi Island and the neighbouring islands of Tuboa and Pigeon Rock; the agglomerate dips at 5^{o} to the north or north-west and consists predominantly of fragments of biotite andesite or trachyte. Coulson collected banded hornblende andesite from Urasi Island (Baker & Coulson, 1948). Massive volcanic rock crops out on Wamea and Wata Islands. On the north coast of Uama Island, olivine andesite is exposed as large boulders in a clay matrix. These boulders may be part of an agglomerate, or merely a product of weathering of massive volcanics. The topography of Uama and Tewara Islands suggests that they are composed of strata which dip at 10^{o} to north-east and north, respectively.

Petrography: Flow-banded andesite on Wagabu Island (R10448) consists of phenocrysts of andesine (An_{40-43}), quartz, augite, hypersthene, and red-brown biotite in a cryptocrystalline groundmass. Andesitic basalt in agglomerate on Watota Island (R10449) consists of phenocrysts of andesine-labradorite (about An_{50}), hypersthene, augite, olivine, and lamprobolite in a cryptocrystalline groundmass. Banded andesite from Urasi Island consists of phenocrysts of andesine, red-brown hornblende, hypersthene, and augite in a cryptocrystalline groundmass. The hornblende has reaction rims of hematite and limonite. Colour-banding is due to weathering which has caused the leaching and re-deposition of dissolved materials, mainly iron hydroxide (Baker & Coulson, 1948).

THERMAL AREAS

Thermal activity occurs in two large areas on Fergusson Island, and at scattered points on Dobu and Goodenough Islands. The two areas on Fergusson Island are : (i) The Deidei area, at the base of Bwaioa Peninsula, in the south-east, and (ii) the Iamelele area, inland from Seymour Bay in the west.


150°51'
150°55'
Fig. 2
Sebutuia Bay
DEIDEI
THERMAL AREA
LAMONAI
CRATER
FERGUSSON
ISLAND
PLANTATION
Kedidia
Bay
9°41'
9°41'
OIAU
CRATER
Numanuma Bay
Geiadai
DAWSON STRAIT
OAIOBE I.
NEUMARA I.
SCALE OF MILES
0 1 2 3
0 1 2 3
SCALE OF KMs.
DOBU I.
MAIN
CRATER
Thermal areas
Bureau of Mineral Resources, Geology and Geophysics, April 1964


SALT LAKE
Fig. 3
IAMELELE
THERMAL AREAS
SCALE OF MILES
0 1/4 1/2 3/4 1
ONE KILOMETRE
500
400
300
200
100
50
9°30'
9°30'
FERGUSSON ISLAND
SULPHUR
LAKE
IAMELELE
No. 1
VILLAGE
Seymour Bay
AREA No. 1
AREA
No. 2
AREA
No. 3
AREA
No. 4
Reference
Lakes
Thermal areas
Swamp
150°31'
BUREAU OF MINERAL RESOURCES
GEOLOGY & GEOPHYSICS · APRIL 1964

The following information is taken from reports by Stanley (1920), Taylor (1955 and 1958), and Reynolds (1956), and a summary by Fisher (1957).

Deidei area (Fig. 2)

The Deidei thermal area is made up of six small thermal areas at the base of Bwaioa Peninsula between Numanuma Bay and Gomwa Bay. The principal thermal area, about a mile east of Kedidia Plantation, near Deidei village, consists of two parallel areas 150 yards apart, each about 300 yards long from east to west, and about 50 yards wide. Both consist of boiling springs, small geysers, hot pools, mud pots, and white sinter terraces. Temperatures range up to 108 ^{o}C. The Atunapara thermal area is at the head of Numanuma Bay at the foot of cliffs which may be the rim of an old crater (see p.). It consists of several hot springs at 95 to 98 ^{o}C. The Mararau'eira area, about half a mile north of Numanuma Bay, is a solfataric area emitting steam and some sulphur. The Anadu'u Du'u area, about 2 miles north of Numanuma Bay, is also solfataric. The area of steam and sulphur emission extends about 100 yards along a steep slope which is covered with sulphur and other sublimation products.

Iamelele area (Pl. 8; Fig. 3)

The Iamelele area is made up of six or more small solfataric areas within a belt trending north-north-west; the belt is about 4 1/2 miles long and a mile wide. The principal area (Areas 1 and 2 on Fig. 3), about a mile south of Iamelele village, is known as Debawala. Area No. 1 measures about 400 by 200 yards, and consists of hot springs, mud pools, and small vents surrounded by mounds of sinter. Temperatures do not exceed 100 ^{o}C. Area No. 2 measures about 400 by 400 yards, and contains numerous solfataras, around which mounds of sulphur and siliceous sinter have formed. Area No. 3 consists of boiling springs, mud pools, and steam vents, and Area No. 4 contains sinter terraces, mud pools, hot springs, and small steam vents. Other small areas exist near Areas 3 and 4, and thermal activity is also taking place east of Sulphur Lake and south-east of Salt Lake.

Other areas on Fergusson Island

Natives report the existence of warm springs near Nade, on the south coast. Maitland (1892) noted solfataric activity near Cape La Billardiere, in the north-west, but this has not been found by later investigators.

Dobu Island

Decadent solfataric activity exists in the northernmost of the two craters on the south-eastern part of the island (Reynolds, 1956). Taylor (1955a) reports two small warm springs near Murisia village on the north coast, and an ebullition point in the sea off the most northerly point of the island (see Fig. 2).

Goodenough Island

Hot springs occur about a mile north-west of Nou Nou and immediately south-west of Wakala Hill, and are reported on the coast east of Bolu Bolu (Taylor, 1955a) and about 2 miles north of Bolu Bolu.

Seismic Activity

Volcano-seismic phenomena in eastern Papua were discussed in a detailed report by Reynolds (1957). Between 1919 and 1939 no major earthquakes or other unusual phenomena occurred in the area, but since 1939 there have been a number of earthquakes and two Pelean type eruptions on the eastern Papuan mainland.

Epicentres of three of the major earthquakes were in or near the D'Entrecasteaux Group:

Date	Strength	Epicentre
7. 6.1940	6 1/4 (Gutenberg & Richter)	25 miles east of Esa'ala
31. 7.1955	4 1/2 (" ")	Gomwa Bay
22.10.1956	4 (Mod. Mercalli)	Ward Hunt Strait, about 10 miles south-west of Goodenough Island.

After-shocks from the earthquake in July 1955 continued until the following September, and the October 1956 earthquake caused fissures to appear around Diodio Lake on south-western Goodenough Island.

In addition to the major earthquakes many local tremors, often accompanied by rumbling noises, have been felt in the islands. Since 1957 shocks have been felt on south-eastern Normanby Island (5-6.8.'58, 27-29.10.'58, 5-7.3.'59) and at Esa'ala (21.8.60); these ranged in strength between 2 and 5 on the Modified Mercalli scale, and were all accompanied by rumbling noises (various Monthly Reports, Rabaul Vulcanological Observatory).

Discussing seismic activity in the area between 1939 and 1957, Reynolds (1957) concluded that the most logical inference to be drawn from the increased activity is that another eruption might be expected in eastern Papua, probably in the Lamonai - Oiau - Dobu area. However, he pointed out that the activity might also be due to (i) strain adjustments in the eastern part of the region after release of energy by eruptions in the western part (eruption of Mount Lamington in 1951-2), or (ii) gas-liquid differentiation in subterranean magma and variations in gas pressure on overlying strata occasioned by rise and fall of the magma. Reynolds drew the latter theory from Perret (1939), who invoked it to explain the 'volcano-seismic crisis at Montserrat, 1933-1937'.

Reynolds noted that many of the seismic events in eastern Papua have occured during the periods of maximum luni-solar influence, which are late February-March, June, late September-October, and December. Luni-solar influence might be expected to cause rise and fall in the level of subterranean magma and consequent variations in gas pressure on overlying strata. Resulting gas movements could cause seismic activity, and could explain the rumbling noises which have accompanied most of the shocks felt in the D'Entrecasteaux Islands.

RAISED CORAL

Raised coral occurs at several places on both Goodenough and Fergusson Islands, and forms the nearby Barrier Islands. None of it is more than about 50 feet above sea level.

At Mapamoiwa, on Kukuia Peninsula, raised coral covers a little more than a square mile, and forms low rounded hills whose maximum elevation is about 50 feet. A coral bench about 8 feet above sea level forms the north-western coast of Fergusson Island, around Deba, and the adjacent Barrier Islands. Inland from Deba there are a few low spurs of coral about 50 feet above sea level. Rare blocks of coral standing 20 to 30 feet above sea level were noted on the south coast west of Nade, and Stanley (1920) reported raised coral on Warua Island, west of Oiau, and at the head of Gomwa Bay, where it is interbedded with volcanic sediments. Coulson (Baker & Coulson, 1948) reported raised coral in Hughes, Seymour, and Sebutuia Bays, and near Salamo.

On Goodenough Island, coral raised to about 3 feet above high water mark is exposed near the mouth of Abolu Creek, and forms the small island of Gunuva, near the mouth of Abolu Creek, and forms the small island of Gunuva, near Kilia, on the south coast. The flat area around Wailagi Mission in Mud Bay is a bench of coral about 8 feet above sea level.

Living coral is extensively developed only off the north-western coast of Goodenough Island, a lee shore for much of the year. There are narrow, discontinuous, fringing reefs around the coasts of both islands.

TALUS

Fans of talus and alluvium up to 500 feet thick occur at the foot of the steep flanks of the metamorphic blocks, especially on the northern flanks of the Goodenough and Mailolo Blocks and both flanks of the northern Oiatabu Range. Talus with little or no alluvium covers two large areas on the southern flank of the Morima Range.

The talus consists of large angular blocks of gneiss and schist in a matrix of smaller fragments and some clay, and is the product of large landslips. A characteristic hummocky topography is developed over the talus of the southern Morima Range. The Morima landslips have possible been activated by fault movement, as the suggestion of a fault trace may be seen on air-photographs near the head of the landslips. However, no evidence of the supposed fault was found in the field.

ALLUVIUM AND BEACHES

Alluvium consisting predominantly of rounded boulders of metamorphic rocks, gravel, and sand forms gentle slopes and broad plains flanking the metamorphic blocks. The largest alluvial plain is that on northern Goodenough Island; others are situated on the western, southern, and south-eastern flanks of the block, and similar plains occur inland from Seymour, Hughes, and Sebutuia Bays on Fergusson Island.

South-west of Augana, on the western flank of the Goodenough Block, the alluvial plain dips gently to the south and is strewn with large boulders. The presence of this extensive boulder-covered plain could be explained by the breaching of a landslip dam in Bekala Creek. The valley of this creek, along the line of the Fakwakwa Fault, is constricted, and if a dam did exist at some time and was later breached the released waters would have been capable of carrying large boulders down the valley, leaving a chaotic deposit such as is seen now. The present drainage system of the immediate area is not extensive enough to have formed the plain in a simple manner.

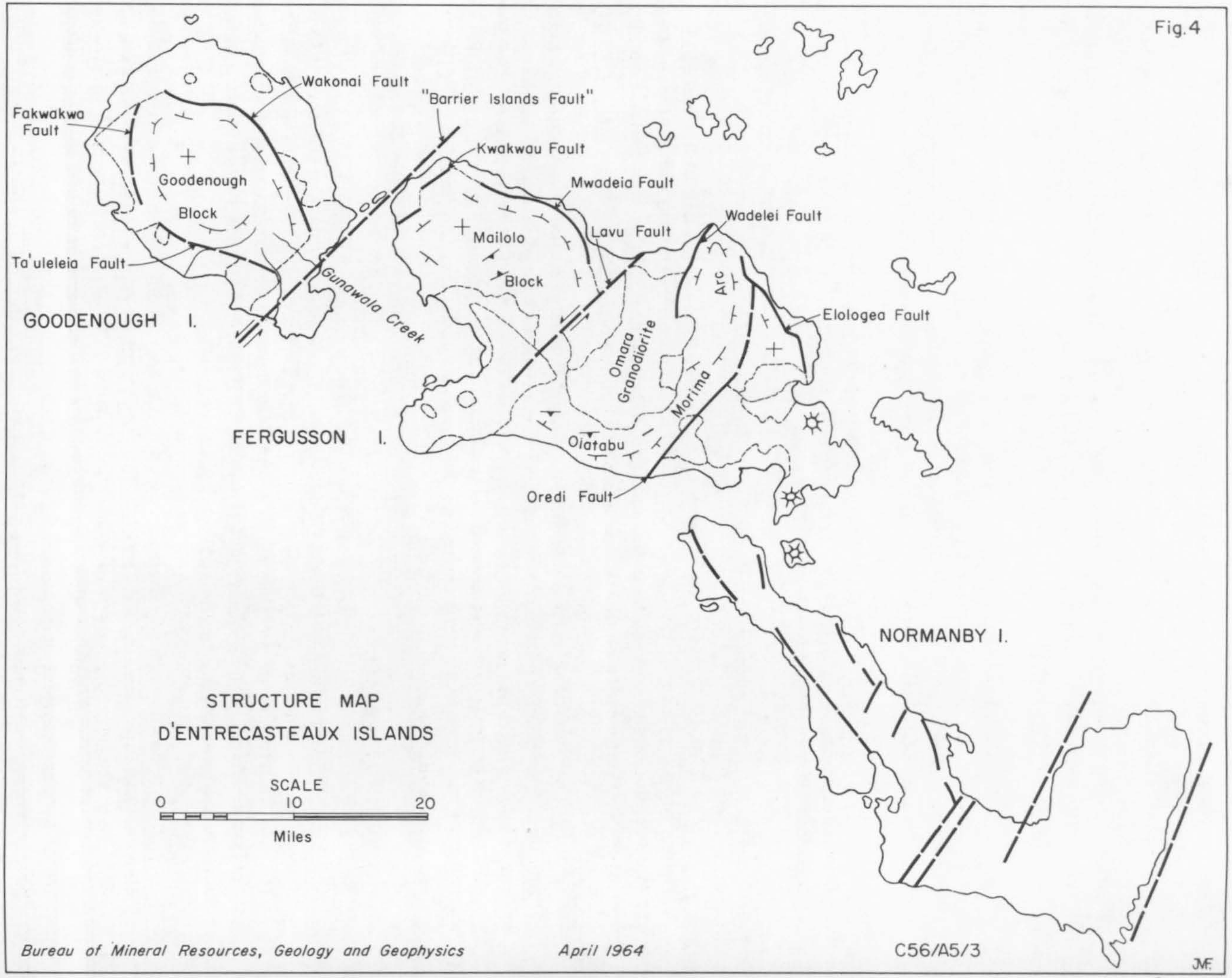


Fig. 4
Wakonai Fault
"Barrier Islands Fault"
Fakwakwa Fault
Kwakwau Fault
Goodenough Block
Mwadeia Fault
Mailolo Block
Lavu Fault
Wadelei Fault
Ta'uleleia Fault
Gunawala Creek
Arc
Elologea Fault
GOODENOUGH I.
Omara Granodiorite
Morima
FERGUSSON I.
Oiatabu
Oredi Fault
NORMANBY I.
STRUCTURE MAP
D'ENTRECASTEAUX ISLANDS
SCALE
0 10 20
Miles
Bureau of Mineral Resources, Geology and Geophysics
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C56/A5/3
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Beaches are composed of mud, sand, boulders, or shell and coral fragments, according to local conditions. Beaches on the steeper coasts, such as the Morima-Basima coast, are made up of boulders. Parts of Gomwa, Hughes, Seymour, and Mud Bays are very muddy, and are fringed with mangrove swamp in places. Sandy beaches near Gwabe, north of the Mailolo Block, near Iewata, south of the Mailolo Block, and west of Kilia on southern Goodenough Island are remarkable for their reddish colour, caused by the concentration of garnet. Other minerals in the sands are iron oxides, rutile, apatite, sphene, and less commonly, chromite.

STRUCTURE

Fergusson and Goodenough Islands consist of domes of metamorphic rocks with granodiorite cores, and ultramafic and volcanic rocks on the faulted margins of the domes. Anticlockwise transcurrent faulting appears to have displaced the domes. Faulting of the same nature on a large scale may have displaced the metamorphic rocks of the D'Entrecasteaux Islands from a position immediately south-east of the Gorupu Mountains of the Papuan mainland (see Fig. 6).

Domes

There are two or possibly three domes, one forming the Goodenough Block, one partly preserved in the Mailolo Block, and, possibly, another partly preserved in the Oiatabu - Morima arc. The Mailolo Block and Oiatabu - Morima arc may be parts of the one original dome, which once covered the Omara Granodiorite; this dome will be referred to as the Omara Dome. The form of the domes is described on p. 12, ft. and is only briefly recounted here.

The Goodenough Dome is about 17 miles long (north-west to south-east) and 11 miles wide. It is bounded to north and east by the Wakonai Fault and to south and west by Ta'uleleia and Fakwakwa Faults. It is made up of layered metamorphics overlying contorted metamorphics which are intruded by massive granodiorite. The dip of the layered metamorphics on the flanks of the dome is about 40 degrees.

The Mailolo dome is about 14 miles long (east-west) and 9 miles wide, and is bounded by the Mwadeia Fault to the north and east, and the Lavu Fault in the south-east. It is made up of layered metamorphics overlying contorted metamorphics, which are probably intruded by massive granodiorite, though this is not exposed. On the western, northern, and eastern flanks the layered metamorphics dip at about 20° to 40°; on the southern flank they are not present, and have probably been removed by erosion.

The Oiatabu - Morima arc is thought to represent the south-eastern half of the Omara Dome. The north-western half of the dome has probably been displaced by movement on the Lavu Fault, and is possibly now represented by the Mailolo Block. The arc has a radius of about 10 miles; so the former dome may have been about 20 miles across. At present it has the form of an arcuate mountain range about 4 miles across and 28 miles long. It is made up of predominantly layered metamorphics which dip outwards from the Omara Granodiorite at about 30° except (i) at the northern end of the arc, where they are folded into a northerly-plunging anticline (Pl. 9), and (ii) in the north-east where the dip flattens to form Mebulibuli Peninsula.

The arc is bounded by the Oredi and Elologea Faults, and possibly by a fault off the Morima coast. The western flank of the Oiatabu anticline is bounded by the Wadelei Fault.

Faults

The faults may be divided into two types: those bounding the metamorphic domes, and north-easterly trending anticlockwise transcurrent faults.

Faults of the first type generally trend north-west, and are displaced by the transcurrent faults. The fault system compares with that of the Musa River area, on the Papuan mainland about ninety miles to the west, where the north-westerly-trending Owen Stanley Fault bounds the metamorphics of the Owen Stanley Range, and is offset by anti-clockwise transcurrent faults.

On the accompanying map (Fig. 4) faults on the three major islands of the D'Entrecasteaux Group are shown. Those on Normanby Island have been interpreted from air-photographs, and some have been verified in the field (J.E. Thompson, pers.comm.).

Faults bounding the metamorphic blocks are commonly arcuate or sinuous, and generally trend north-west, though some trend north and north-east. Movement has been predominantly vertical, and has probably taken place in at least two stages, one when the metamorphics were domed by emplacement of the granodiorite, and the other in Quaternary time, when the domes were raised to form mountain ranges. The later movement was accompanied by vulcanism.

The major fault planes are not exposed, and no satisfactory information was obtained about their attitudes. However, the attitudes of planes in two of the shear-zones suggest that the faults may dip away from the domes at angles between 20^{o} and 50^{o}.

Wakonai, Fakwakwa, and Ta'uleleia Faults bound the Goodenough Block. Wakonai Fault is on the northern and north-eastern margin; the name is taken from the Wakonai district, through which the fault runs. It is marked by the sharply-defined linear front of the Block, several small patches of volcanics, and rare ultramafics, some of which are brecciated. Any shear-zone is concealed beneath piedmont deposits. Fakwakwa Fault is an interpreted fault which separates low foothills of metamorphics from the western flank of the dome. It is marked by the alignment of the valleys of Alua, upper Bekala, and Fakwakwa Creeks, and a small patch of volcanics near the low saddle between Alua and Bekala Creeks. The valleys are filled with large boulders. Ta'uleleia Fault, on the southern margin of the dome, may be continuous with Fakwakwa Fault. It is expressed in the alignment of upper Niubula Creek and middle Goila Creek and in a lineated belt of low country in the hills between. Volcanics west of Fakwaoia Creek and sheared granite in Ta'ueleleia Creek (a tributary of Niubula Creek) are on the line of the fault. There may be a small parallel fault on the line of Gunawala Creek.

The Mailolo Block is bounded to the north and north-east by Mwadeia Fault, and to the north-west by Wabawe and Kwakwau Faults. Mwadeia Fault is expressed in the sharp linear front of the Block; it is arcuate and swings through about 70^{o}. The shear-zone is exposed on Mwadeia Creek, and contains fragments of quartz, quartzo-feldspathic gneiss, and, less commonly, harzburgite in a schistose matrix of mica, talc, and amphibole. About two-thirds of the rocks in the shear-zone are schist, and the schistosity dips at about 30^{o} to the north-east, conformably with layering in the adjacent metamorphic rocks. A parallel shear-zone enclosing a small body of ultramafic rock in Melewaie Creek may be a sympathetic fault. Kwakwau Fault is expressed in the linear front of the block and in shear-zones exposed in

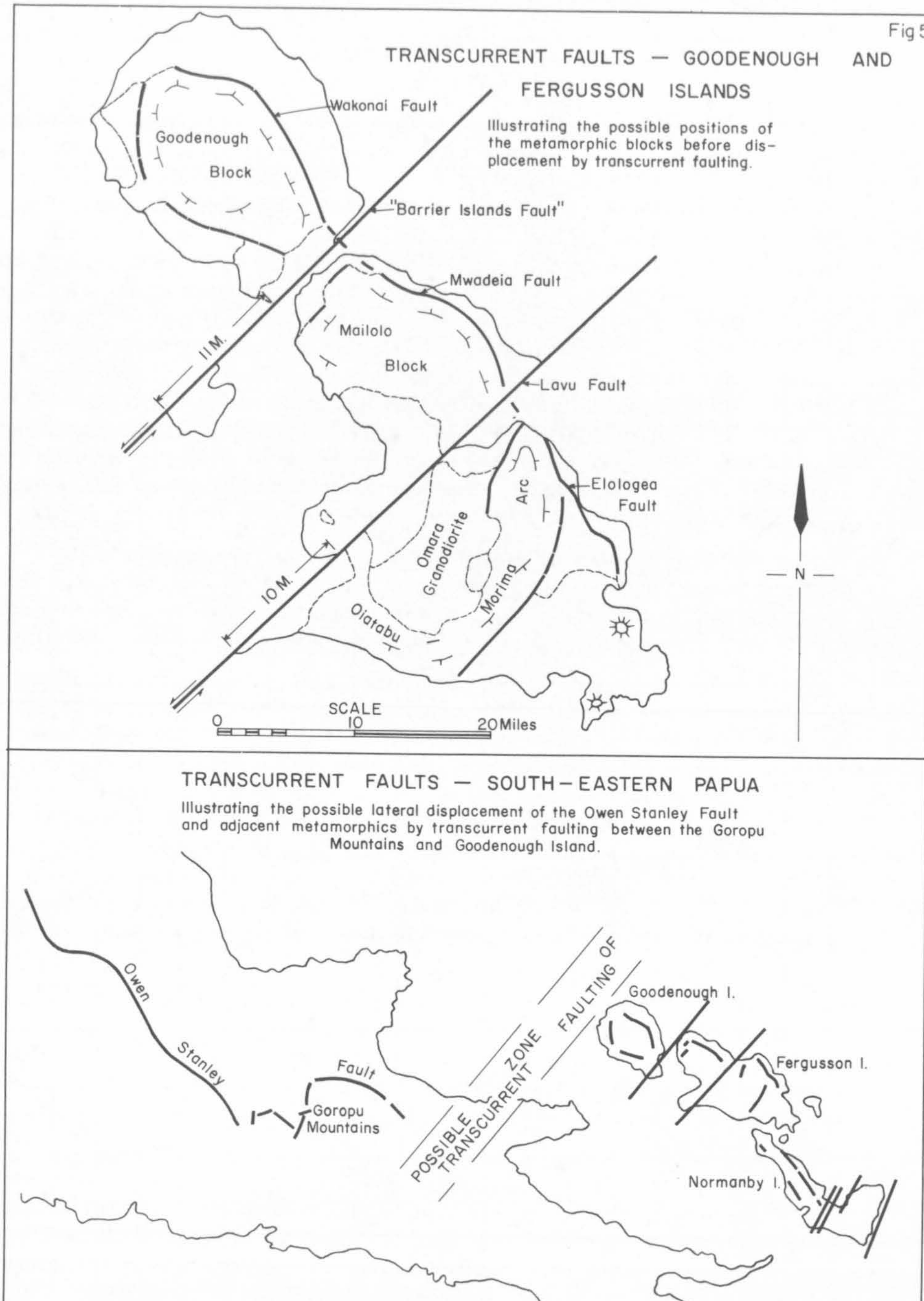
Fig 5
TRANSCURRENT FAULTS — GOODENOUGH AND FERGUSSON ISLANDS
Illustrating the possible positions of the metamorphic blocks before displacement by transcurrent faulting.
Wakonai Fault
Goodenough Block
"Barrier Islands Fault"
Mwadeia Fault
Mailolo Block
11 M.
Lavu Fault
Arc
Elologea Fault
Omara Granodiorite
Morima
Oiatabu
10 M.
N
SCALE
0 10 20 Miles
TRANSCURRENT FAULTS — SOUTH-EASTERN PAPUA
Illustrating the possible lateral displacement of the Owen Stanley Fault and adjacent metamorphics by transcurrent faulting between the Goropu Mountains and Goodenough Island.
Owen Stanley Fault
Goropu Mountains
POSSIBLE ZONE OF TRANSCURRENT FAULTING
Goodenough I.
Fergusson I.
Normanby I.
SCALE
0 40 80 Miles
Bureau of Mineral Resources, Geology and Geophysics
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Kwakwau Creek. The shear-zones consist of chloritic mica schist containing some amphibolite. Wabawe Fault may be an offset part of Kwakwau Fault. It is expressed in the linear front of the range, and some silicification of gneiss on Wabawe Creek.

The Oiatabu-Morima Arc is bounded to the south-east by the Oredi Fault, to the north-east by Elologoa Fault, and to the north-west by the Wadelei Fault. There may be another fault off the Morima Coast. Oredi Fault is expressed in the linear front of the range between Nade and Galea, and in the alignment of the Ni'eli and Magoa valleys between Galea and Ulua. On Oredi and Seliselina Creeks it is marked by a zone, about half-a-mile wide, of opalized and carbonated serpentinite breccia with some pug on the north-western margin of the zone. Elologea Fault is expressed in part in the line of the Basima coast. It separates layered amphibolite from ultramafic rocks on Mebulibuli Peninsula, and, as on the Oredi Fault, there is a zone of opalized and carbonated serpentinite breccia and some serpentine pug near the contact. Finely laminated basic gneiss near the contact has mylonitic texture (see Pl. 10). Planes in a shear-zone exposed in Elologea Creek dip at 20° to the north-east, roughly conformably with layering in the adjacent metamorphic rocks. Slickensides on one plane plunge at 30° to the north. Wadelei Fault is expressed in the linear front of the Oiatabu Range behind Wadelei. It may have existed before the emplacement of the granodiorite, as it is aligned with the valley of the upper Salamo River and the margin of the Koradidia ultramafic body to the south.

There are two possible north-easterly trending transcurrent faults in the area - one, the Barrier Islands Fault, on the line Nuatutu - Barrier Islands - Deba between Fergusson and Goodenough Islands, the other, the Lavu Fault, on the line Lake Lavu - Boselewa in central Fergusson Island. These post-date the normal faults which bound the metamorphic blocks.

The supposed Barrier Islands Fault may have displaced the Mailolo Block eleven miles to the north-east from a position immediately south-east of the Goodenough Block. The Lavu Fault may have displaced the Oiatabu-Morima arc ten miles to the north-east from a position south and south-east of the Mailolo Block. If these movements have, in fact, taken place it is possible that the Wakonai, Mwadeia, and Elologea Faults are actually the one fault, and that the Mailolo Block and Oiatabu-Morima arc are the remnants of the Omara dome. The possible configuration of the metamorphics before transcurrent faulting is shown in Figure 5. There is little evidence for the Barrier Islands Fault beyond the alignment of the Deba coast, Barrier Islands, and Nuatutu - Faiava coast. Wabawe and Kwakwau Faults on the north-western margin of the Mailolo Block may be sympathetic faults.

The Lavu Fault is concealed by alluvium and volcanics for the greater part of its length. Sub-parallel alluvial valleys and minor shears in the south-eastern part of the Mailolo Block are thought to indicate sympathetic faulting. These valleys transgress foliation in the metamorphics. The south-western part of the fault is concealed by volcanics, but coincides approximately with the north-western edge of the Fagululu-Matau volcanic plateau; this coincidence may be fortuitous.

Regional extrapolation

On a regional scale transcurrent faults may have displaced the D'Entrecasteaux metamorphics 65 miles north-eastwards from a position immediately south-east of the Gorupu Mountains on the Papuan mainland. Similar displacement has taken place immediately north-west of the Gorupu Mountains, where the Owen Stanley Fault has been displaced about 28 miles to the north-east (Smith & Green, 1963). Thus, to take this speculation to its limit, the Wakonai - Mwadeia - Elologea Fault may actually be part of the Owen Stanley Fault.

The Owen Stanley and Wakonai - Mwadeia - Elologea Faults are similar in habit. They strike generally north-west, but are sinuous, and their strike ranges from due west to due north. South-west of the faults metamorphic rocks dip towards the faults; to the north-east are ultramafic rocks, and scattered volcanoes rise from alluvial plains. On the line of the fault, there is some volcanic activity, examplified on the mainland by Mount Gorupu or Waiowa, which erupted in 1943. The only difference between the rocks adjacent to the faults is the higher grade of metamorphism of the D'Entrecasteaux metamorphics (amphibolite facies) as opposed to the Gorupu metamorphics (greenschist facies).

The main objection to the hypothesis is that it requires transcurrent fault movement of the order of 65 miles in, probably, Quaternary time (see Fig. 6).

GEOLOGICAL HISTORY

The postulated order of events in the formation of the D'Entrecasteaux Islands is :

1. Deposition of sediments and volcanics to a thickness of about 10,000 feet; these were possibly intruded by acid and basic plutons.
2. Deep burial and regional metamorphism to emphibolite facies without folding.
3. Emplacement of ultramafic and gabbroic rocks, possibly along faults.
4. Emplacement of granodiorite plutons, accompanied by
    (a) doming of the metamorphics, and
    (b) faulting on the dome margins.
5. Elevation of the metamorphic domes by faulting, accompanied by extrusion of volcanics on the faults.
6. Transcurrent faulting and continued extrusion of volcanics.
7. Decline of vulcanism to solfataric activity.

Sediments were probably first laid down in Palaeozoic time. The sediments were predominantly quartzo-feldspathic (arenites or acid volcanics), but towards the top of the section basic tuff and lava and limy sediments were interbedded with the arenites or acid volcanics. Pelitic sediments were very scarce. The lower quartzo-feldspathic parts of the section are now represented by metamorphics of groups I and II, and the upper more basic part by group III. Possible gabbroic intrusions are now represented by two large transgressive bodies of massive amphibolite and many smaller 'sills', some of eclogite or granulite grade.

Granitic rocks may have intruded the quartzo-feldspathic sediments, but if so they cannot now be readily distinguished among the metamorphosed rocks. Baker (Baker & Coulson, 1948) concluded that most of the gneisses from northern Goodenough Island which he examined were derived from granodiorite and granite.

The regional metamorphism is probably a result of deep burial rather than orogenic folding, as any folding in the metamorphics is very simple and broad, and probably post-dates metamorphism. During metamorphism rocks lower in the section were partly mobilized.

Ultramafic and some gabbroic rocks have not been affected by regional metamorphism, and were thus probably emplaced after the period of metamorphism. They are possibly co-magmatic. Alternatively, the ultramafics may have been emplaced before metamorphism, as it has commonly been observed (Dr A.J.R. White, pers.comm.) that they are not affected by regional metamorphism; olivine and pyroxene may be preserved in a metastable state, possibly due to anhydrous conditions. Whether the ultramafics were emplaced magmatically or in a solid state along faults is not shown by any evidence; all exposed contacts are now faulted. The gabbroic rocks occur only within the Omara Granodiorite, and probably represent an earlier basic pluton which may have risen along the same channels as the granodiorite.

Massive granodiorite was emplaced in two or, perhaps, three separate plutons - the Omara Granodiorite, the Luboda Granodiorite, and an inferred pluton in the core of the Mailolo Block. They are high-level plutons with clear intrusive contacts and some contact metamorphic effects, and have played no part in the mobilization of the metamorphics. Their emplacement apparently caused the doming of the metamorphics and normal faulting on the margins of the domes.

The age of the metamorphic and igneous rocks, and of the tectonic events, remains unknown.

Elevation of the metamorphic blocks to their present position probably began in late Tertiary or Quaternary time, as the domes are fairly well preserved despite active erosion. Elevation on a broad scale may have taken place along major suboceanic faults. Elevation on more local scale took place along the normal faults which bound the domes. Volcanic rocks have risen along these faults.

North-easterly anticlockwise transcurrent faults post-date the normal faults bounding the domes. The supposed Barrier Islands Fault may have transposed the Mailolo Block about eleven miles to the north-east from a position south-east of the Goodenough Block. The Lavu Fault may have transposed the Oiatabu-Morima Arc ten miles to the north-east from a position south and south-east of the Mailolo Block. On a broader scale similar faults may have transposed the D'Entrecasteaux metamorphics about 65 miles to the north-east from a position immediately south-east of the Gorupu Mountains on the Papuan mainland.

Vulcanism continued through the period of transcurrent faulting into very recent time. Activity consistsed of explosive eruptions on south-eastern Fergusson Island, and extrusion of acid and intermediate lava on south-western Fergusson Island, and intermediate and basic lava on Goodenough. Vulcanism ceased before historical time, except for a little thermal and solfataric activity which continues today. Shallow-focus earthquakes centred on south-eastern Fergusson Island in recent years may portend renewed volcanic activity.

ECONOMIC GEOLOGY

Gold

Alluvial gold has been worked on a small scale on both islands. On Goodenough Island, Mr 'Brassy' Evenett has worked alluvium in Fakwaoia Creek in the south-west, and in the Eweli-Kalauna areas in the north-east; no details of production are known. On Fergusson Island natives have won about two ounces of gold from Filofiloia Creek in the Salakadi area, and Stanley (1920) reports that a little gold has been won in the Basima area.

The Filofiloia prospect warrants further development by native miners. Filofiloia Creek, a tributary of the Lilahi (Ata'ata) River, has a flow of about 0.03 cusecs, and is reworking old alluvium which consists of silty quartz sand containing rare boulder beds of quartz, gneiss, and schist; the alluvium may mark a former bed of Adeta Creek. The Agamoia village constable, Abitaunina, reports that gold is found in only one section of the creek, about 400 yards long, and that in two weeks' work, between one and two ounces of gold were recovered, including one half-inch flake. A dish panned before one of the authors yielded fifteen pinhead specks of non-abraded gold.

The possible sources of alluvial gold are:

(i) Quartz veins in the metamorphics: A quartz vein in the Basima area, sampled by Stanley (1920), assayed 0.5 dwt gold per ton. However, a likely looking vuggy pyritic quartz vein sampled (A167) on our survey contained no gold.

(ii) Sulphide-bearing opalized and carbonated serpentinite breccia: a specimen (A176) of breccia from Elologea Creek assayed 3 dwt gold per ton, but a similar specimen from Oredi Creek contained no gold.

(iii) Sulphide-bearing amphibolites: they may contain some gold, but two specimens (A116 and A208) collected on the current survey contained none.

Copper

Sulphide mineralization is a common feature of the opalized and carbonated serpentinite breccia and the massive amphibolite and granulite, but the sulphides are predominantly pyrite and marcasite. Chalcopyrite and malachite occur in gossan boulders near Ipwapaia Creek on the Morima coast, and Stanley (1920) reported malachite stains in schist adjacent to 'dark coloured basic dykes' in the Basima area. Rare malachite stains were seen by one of the authors in the Oredi Creek serpentinite breccia.

Selected specimens (A116) of the Ipwapaia Creek gossan assayed 1.3 percent copper and no gold. The gossan is probably developed over a narrow body of sulphide-bearing amphibolite (R10999) which crops out in the creek nearby; an intensive search of the area failed to locate gossan outcrop.

Boulders of garnet amphibolite in upper Wavuna Creek, in the northern Mailolo Block, contain locally up to 70 percent sulphides, but a selected specimen (A208) assayed only 0.07 percent copper and even smaller amounts of lead and zinc. Sulphide-bearing serpentinite breccia (A176) from Elologea Creek assayed 3 dwt gold per ton, but contained only 0.01 percent copper and smaller amounts of lead and zinc.

Nickel, chromium, and asbestos.

Nickel and chromium are disseminated through the ultramafic rocks, nickel probably in the olivine crystal lattice, and chromium as accessory grains of chromite up to 6 mm across. Nickel may be concentrated by weathering and lateritization in soils overlying the ultramafic rocks and as nickel silicate in rock fractures. However, the soil cover on the ultramafics is generally thin, except perhaps over the Koradidia body, and no silicates were seen. One specimen (P398) of opalized serpentinite breccia, collected by J.E. Thompson from Mebulibuli Creek, contains 1.51 percent chromium.

Asbestos occurs in veinlets up to one inch wide within the ultramafics, particularly near contacts with the granodiorite. The veinlets are generally too narrow and sparse to be exploited. A specimen from upper Seliselina Creek (R10933) is asbestiform tremolite, a variety of asbestos which has limited use as a filtering medium, and in heart surgery (Gillson, 1960, p.49).

Quartz crystal, mica, rutile, amblygonite, and cassiterite.

Quartz crystal, mica, and rutile occur in pegmatite veins which are generally between one and two feet wide. Amblygonite and casiterite have been found in the islands and probably occur in the pegmatite; neither mineral was found during our survey.

Crystals, up to three inches long, of colourless clear quartz occur in the Mailolo Block (especially Wauna Creek), the south-eastern Salakadi area, and on the north-eastern flank of the Oiatabu Range. All specimens found were cracked or malformed, and not of piezo-electric quality.

Mica (muscovite and biotite) occurs in thin sheafs about one inch long and 0.1 inch thick, and rarely three inches long and 1/4 inch thick; the flakes are too sparsely distributed and generally too small to be of economic value.

Rutile occurs as rare crystals up to one inch long.

Reports of cassiterite in the alluvium of northern Goodenough Island led to a brief drilling investigation by Bulolo Gold Dredging Ltd in March and April 1952. The investigation was centred on the south-eastern end of Vivigani air-strip. Three holes were drilled, to depths of 5 1/2, 40, and 79 1/2 feet, and all were abandoned because of drilling difficulties. In addition 14 pits were sunk to a maximum depth of eight feet, and river sands and gravels were planned. A small trace of cassiterite was found in one of the pits. The only concentrates obtained in any appreciable quantity were garnet and ilmenite (information extracted by D.B. Dow from a company report).

Pumice, sulphur, and possible bauxite

Pumice forms the greater part of Oiau and Dobu volcanic cones. Pritchard (1963) estimated that at least ten million cubic yards of pumice are available in Oiau alone. He described it as ranging from dust to 6-inch fragments and stated that more than 50 percent by volume of the fragments are larger than 1/4 inch across. Taylor (1962) has defined two likely quarry sites, one on the south-western side of Oiau, and the other on the south coast of Dobu.

The pumice may be suitable for use as light-weight aggregate for cement, as insulation, and as a filtering medium. Samples collected by Pritchard were tested in cement bricks by the Public Works Department, Port Moresby, and other samples have been dispatched to a Darwin building contractor. Results of these tests were not available at the time of writing.

Maitland (1892) quoted the following analysis of pumice from Dobu Island:

SiO_2	69.62%
Al_2O_3	15.26%

FeO, Fe_2O_3	3.05%
MnO	trace
CaO	0.94%
K_2O	5.20%
Na_2O	3.69%

Sulphur deposits in the Iamelele solfatara field on western Fergusson Island are estimated at 1000 tons of clean sulphur and 3000 tons of sulphur contaminated with quartz sand, mica, and clay (Edwards, 1950). The sulphur extends no more than 5 feet below the surface, and appears to be rapidly removed after deposition and replaced by silica (Edwards, op.cit.). This is illustrated in analyses quoted by Stanley (1920) :-

	Sulphur	Silica
Surface sample No. 1	86. 2%	12.0%
" No. 2	86. 1%	13.0%
Sub-surface sample No. 1	46.51%	47.0%
" No. 2	16.13%	74.2%

The sulphur deposit appears to be too small and too erratically distributed to be exploited.

J.E. Thompson (pers.comm.) has suggested that bauxite may be developed over some of the low-lying hills of acid and intermediate volcanics, but none was seen on the current survey. Possible areas for bauxite are on Sanaroa Island, and north of Gomwa Bay on Fergusson Island.

Conclusions

The most likely economic prospect in the islands is the pumice comprising Oiau and Dobu cones. The possibility of commercial conentrations of bauxite on Sanaroa and south-eastern Fergusson Island has not been investigated.

Gold and other minerals are apparently not present in commercial grade or quantity.

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APPENDIX 1

PETROGRAPHIC AND MINERAGRAPHIC EXAMINATION

OF NICKELIFEROUS ROCKS FROM MEBULIBULI CREEK, FERGUSSON ISLAND

by

W.B. Dallwitz and W.M.B. Roberts.

Specimen P190 resembles closely a dark grey volcanic glass (pitchstone), and has a conchoidal fracture. It contains a spongy meshwork of fine-grained sulphide.

In thin section the rock is found to consist mainly of opal and sulphide. Structures remaining in the opal clearly show that the rock was formerly a serpentine, and that this serpentine was probably derived from olivine. In other words, the rock can be genetically referred to as an opalized, sulphide-bearing serpentinized dunite.

Books of talc and a few grains of red-brown chromite are scattered through the slide. Fine-grained doubly-refracting material, possibly talc, forms abundant inclusions in the opal in places. The structures referred to in the previous paragraph pseudomorph those of a serpentine which consisted of antigorite veined by chrysotile. The veinlets of chrysotile have been replaced by more or less clear opal, whereas the antigorite has been made over to murky brownish opal. Black iron oxide, probably magnetite (which is a common by-product of serpentinization), is associated with the clear opal replacing former chrysotile veins.

The polished section showed that marcasite, pyrite, and chromite are present. In crushed rock magnetite can be detected with a magnet, but is invisible under the microscope because of its extremely fine grainsize.

Chromite forms euhedral and subhedral crystals, ranging up to 2 mm in length, which have been fractured and later recemented by marcasite. The crystals are almost invariably surrounded by a 'halo' of marcasite, which, although obviously later in origin, does not replace the earlier chromite.

The marcasite itself is present mainly as spongy masses through which irregular veins of coarser-grained marcasite are emplaced. These veins are clearly controlled by well-developed jointing in two directions about 60° to each other. The spongy masses themselves represent a diffusion outwards from these mineralizing channels.

Pyrite occurs in the same manner as marcasite, although much less abundantly, forming spongy masses as well as diffusion textures resembling liesegang rings. This mineral appears to be moulding irregular granular areas of marcasite, but the evidence is not sufficient to state that it is of later origin.

Specimen P191 is a dark grey, chalcedonic rock containing sulphide. Marginally the rock has been stained brown and red through weathering of iron sulphide.

In thin section the rock is found to consist of chalcedony, sulphide, and fine-grained black opaque material (magnetite - see below). Veinlets of coarser chalcedony traverse the slide; these may contain brown chalcedony showing distinct spherulitic structure. Brown chalcedony in small clots is also scattered through the main body of the rock.

This specimen is similar to P190, but more highly altered and silicified; none of the talc remains and all reliable signs of former serpentinous structure have been obliterated. The presence of chromite in the polished section accords with the idea that the rock is derived from dunite.

The opaque minerals are the same as for section P190, although far less sulphide is present.

Marcasite is the principal sulphide, forming irregular thread-like veinlets which have a random arrangement and distribution; sponge-like areas, which are common in section P190, are not present in this specimen.

Pyrite forms irregular masses composed of euhedral crystals 0.001 mm across, which are only visible at extreme magnification. Chromite occurs as in section P190, but is slightly less plentiful; the largest crystal measures 0.15 mm across.

Magnetite, although quite abundant, could not be identified in polished section because of its extremely finely divided state.

The source of nickel

The sulphides of both rocks were tested microchemically for nickel, and all gave a negative result.

The polished sections were analysed in the X-ray fluorescent spectograph, and the presence of nickel was verified.

The finely-divided magnetite was not apparent as such under the microscrope, and was only identified by its behaviour when the finely crushed rock from specimen P191 was probed with a magnet. Sufficient magnetite was separated to test microchemically with dimethyl glyoxime; a strong reaction for nickel was obtained.

These rocks have been formed by serpentinization and subsequent silicification of dunite, and it is fairly certain that the dusty magnetite is a by-product of the serpentinization (see above). The magnetite has picked up nickel present in the original olivine during its alteration to serpentine.

Nickelian magnetite has been recorded in the literature.

APPENDIX 2

GEOCHEMICAL SAMPLING PROGRAMME

Four hundred and four stream sediment samples were taken from Fergusson and Goodenough Islands; the samples were collected wherever possible, at approximate one-quarter mile intervals along the main streams. The programme was hindered by the rough topography, and the absence of suitable stream sediments (-80 mesh fines) in many areas.

The samples were later analysed at the Bureau of Mineral Resources Laboratory, Canberra, using optical spectrographic methods. The following metals were estimated - nickel, cobalt, copper, lead, zinc, vanadium, tin, chromium, molybdenum, and beryllium.

The results are summarized in the table below. No large-scale anomalies were located, but there are some points of interest arising from the results, and these are discussed below.

Note: figures in ppm.

	Ni	Co	Cu	Pb	Zn	V	Sn	Cr
Normal abundance in igneous rocks	40-200	10-80	60-70	20	130	150-200	40	200/ 500
Maximum value of 90% of the samples	200	20	10	50	0	200	10	300
Absolute maximum value	700	150	100	1000	150	400	50	10,000

Nickel and Cobalt

Nickel and cobalt are associated elements, and were found in the sediment of streams cutting through bodies of ultramafic rocks or through fault zones. The highest nickel and cobalt values were found in samples from Oredi Creek, close to the Oredi Fault, where minor pyrite mineralization was found.

Generally areas of metamorphic and/or granodioritic rocks have negligible nickel and cobalt values. An exception to this was found in samples from Lualua and Iagile Creeks on Goodenough Island, where nickel values ranged from 150-400 ppm, and cobalt values were constant at 20 ppm. It is thought that these values may be indicative of a body of basic rock upstream from the sampling localities.

High nickel and cobalt values may thus be generally useful in outlining bodies of basic or ultrabasic rocks, in areas where exposures are poor.

Chromium

Chromium was commonly present in samples from areas of ultramafic rocks. The highest value recorded was 10,000 ppm in a sample from the Koradidia area, where there is a large mass of ultramafic rocks. Such a high value was not unexpected, as chromite is a common accessory in the ultramafics, and small concentrations of chromite grains were found in small creeks in the Koradidia area.

Copper

Copper values were very low: almost invariably less than 20 ppm. Only two samples gave higher values. One sample from Potai Creek, Fergusson Island., contained 50 ppm Cu. and another sample from Sasoipa Creek, also on Fergusson Island, contained 100 ppm. In both these streams amphibolite containing a little sulphide was found, and the small variation in values is believed to be caused by this. The generally low copper values are due to the fact that copper is quite soluble, and is therefore not held in the stream sediment, especially in areas of heavy rainfall.

Lead

Lead was detected in all samples. The highest value was 1000 ppm from a sample in Auwafwo Creek, Fergusson Is.; nearby samples had values ranging from 20 ppm to 200 ppm. Matau Creek, to the west, had values ranging from 20 -100 ppm. These values, in absolute terms, are low but may indicate the presence of some lead mineralization. No evidence for such mineralization was found in the field.

Zinc

Zinc values less than 200 ppm are difficult to determine by optical spectrography. The few values below this level which were recorded are of doubtful accuracy. Zinc ions are easily removed in solution, and consequently little or no zinc is held in the stream sediment.

Vanadium

Vanadium was present in all samples, and the values are normally in the range 0 - 200 ppm. Slightly higher values up to 400 ppm were found in samples taken from Potai Creek. The higher values may be attributable to a large body of massive amphibolite exposed in the creek.

Tin

Tin is present in only a few samples. The highest value recorded (50 ppm) was from a sample taken in an area where the Omara Granodiorite crops out. Other minor values were associated with the Luboda Granodiorite, and with pegmatite veining near Lake Lavu.

Molybdenum and Beryllium

Molybdenum and beryllium are present only as very rare traces.

Conclusions

The geochemical results do not indicate any areas of economic interest, but it has been proved that sampling of stream sediments can be used under the conditions encountered in Papua and New Guinea, and that different rock types give distinctive values. Large orebodies should similarly also give distinctive values. However, the method needs testing near known ore mineralization in similar topography before its utility can be fully evaluated.

Plate 1.

Fig. 1. Goodenough Island from Mapamoiwa showing volcanics in foreground and metamorphics of Goodenough Block in background, highest peak Mt Vineuo (8419 feet).

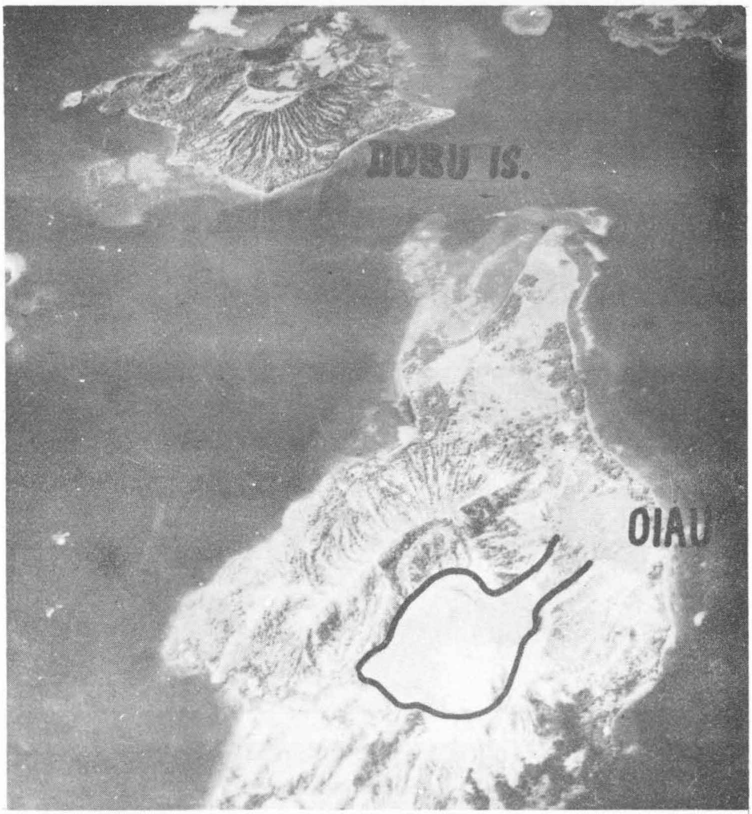

Fig. 2. Oiau cone on Bwaioa Peninsula, and Dobu Island (aerial view from the north). The lava flow which has breached Oiau crater is outlined.

Plate 2.

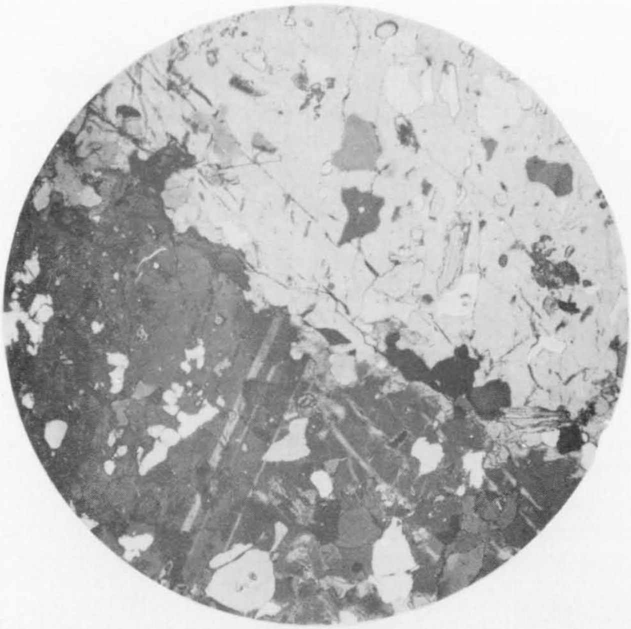

Fig. 1. Typical quartzo-feldspathic layered gneiss from Wabawe Creek, Fergusson Island. Minerals are quartz, plagioclase, biotite, and epidote.

R11039 (x12).

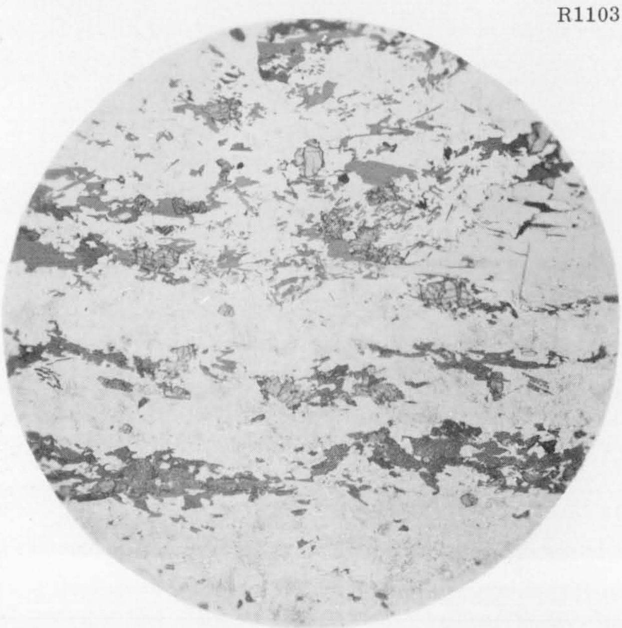

Fig. 2. Hornfelsed gneiss from Kukuia Peninsula showing large porphyroblasts of plagioclase with inclusions of quartz and biotite.

R10957 (x30).

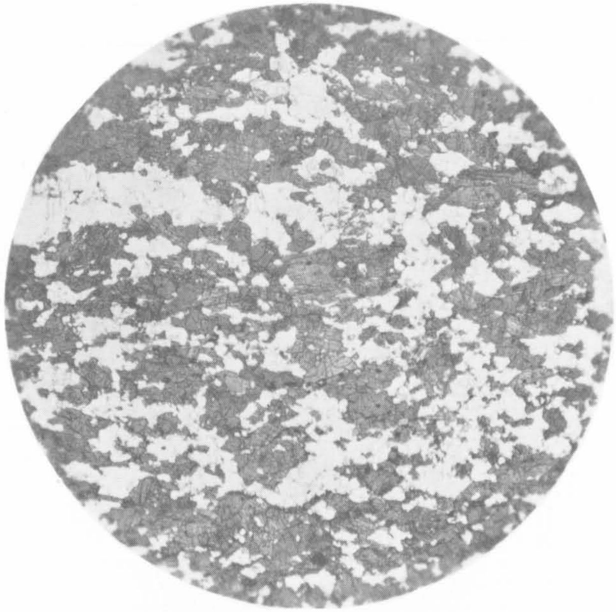

Fig. 1. Amphibole-rich band in layered amphibolite, from Wauda Creek, Fergusson Island.

R11015 (x12).

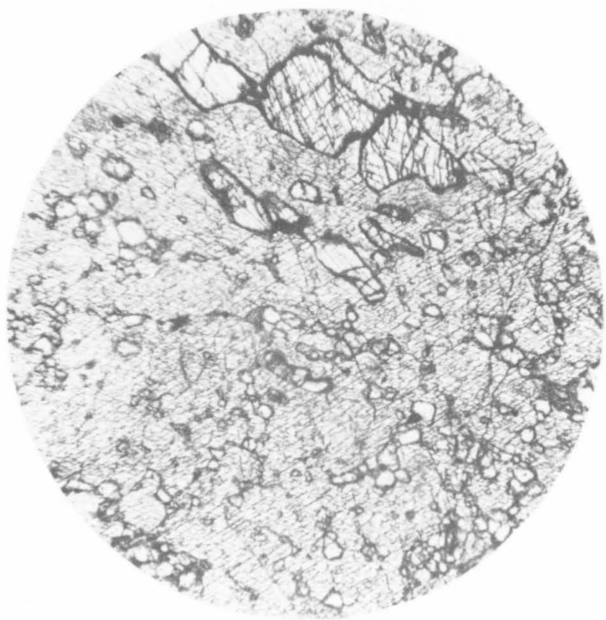

Fig. 2. Fine-grained granulite from Upper Salamo River, Fergusson Island, showing a large porphyroblast of hornblende with inclusions of pyroxene and garnet.

R10976 (x45).

Plate 4.

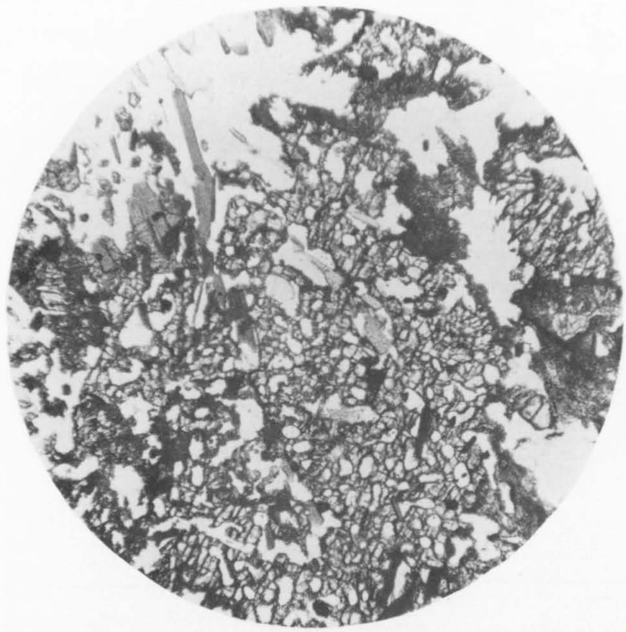

Fig. 1. Coarse-grained granulite from Awavula Creek, Fergusson Island, showing a large pyroxene grain with sieve texture, and plagioclase with inclusions of biotite.

R11038 (x45).

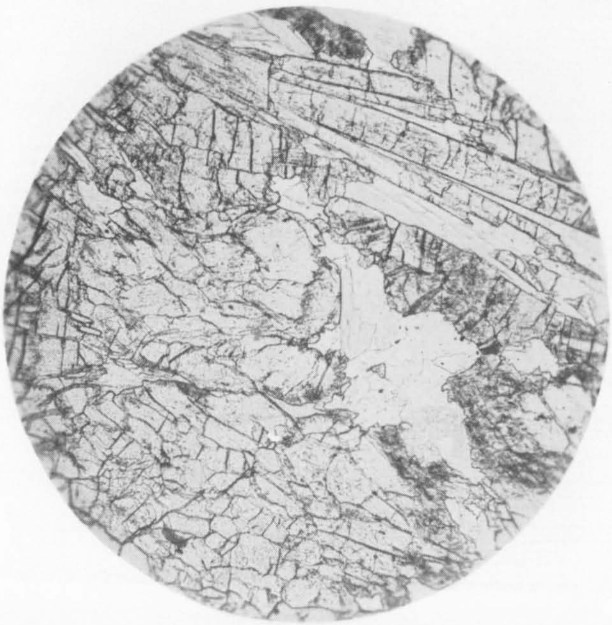

Fig. 2. Talc-tremolite-olivine rock (altered harzburgite) from Potai Creek, Fergusson Island. Pyroxene has been completely altered but olivine is quite fresh.

R11042 (x20).

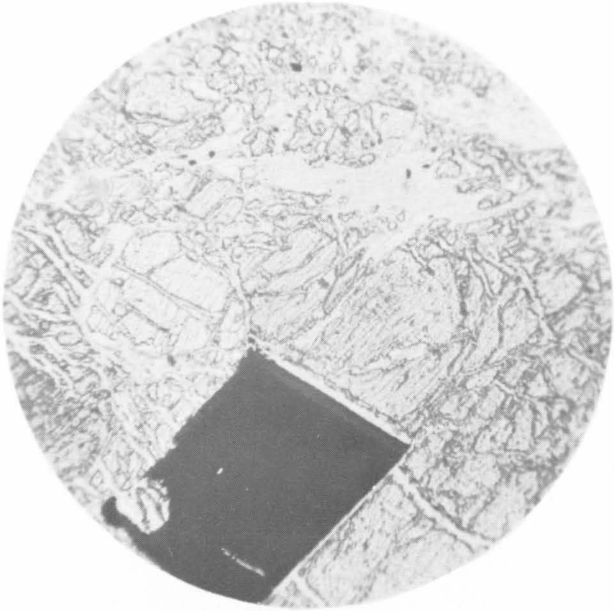

Fig. 1. Altered pyroxenite from the Koradidia body, Fergusson Island. The large opaque rhombic crystal is chromite.

R10968 (x45).

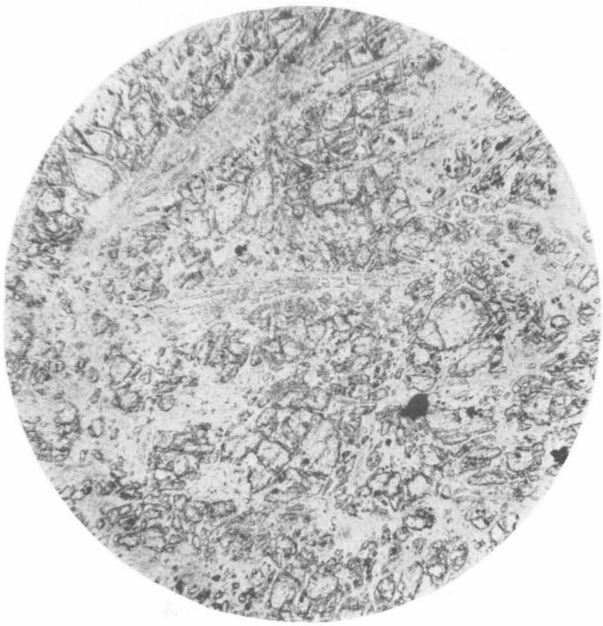

Fig. 2. Altered pyroxenite from the Koradidia body, Fergusson Island.

These figures show the varying degrees of alteration of enstatite in pyroxenite specimens (see text).
The enstatite (high relief material) is altered to serpentine, chlorite, tremolite, and talc.

Plate 6.

Fig. 1. Twinned and zoned plagioclase in the Omara Granodiorite, from near Wogawoga, Fergusson Island.

R10974 (x56).

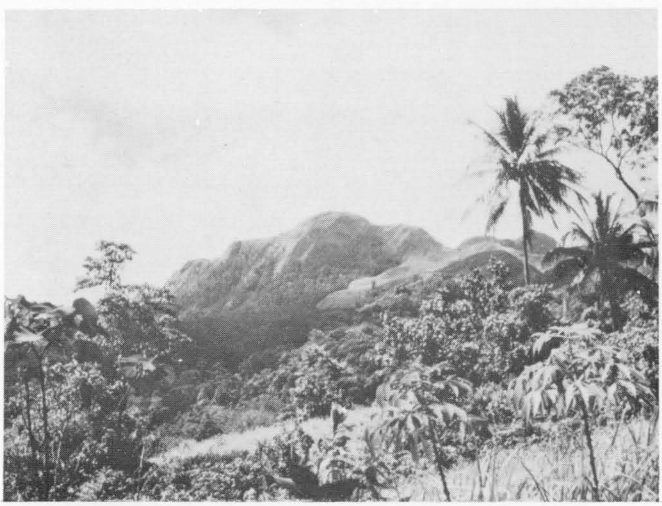

Fig. 2. Sharp peaks of volcanics, possibly a former plug or neck, east of Mapamoiwa.

Fig. 1. Wagipa Island, a volcanic cone off south-eastern Goodenough Island.

Fig. 2. A large lava fan far south of Nuatutu, Goodenough Island; the lava appears to have been entruded from a vent near the eastern end of the Wakonai Fault.

Fig. 1. Part of the Iamelele thermal area, Fergusson Island. The hill is composed of sinter and sulphur.

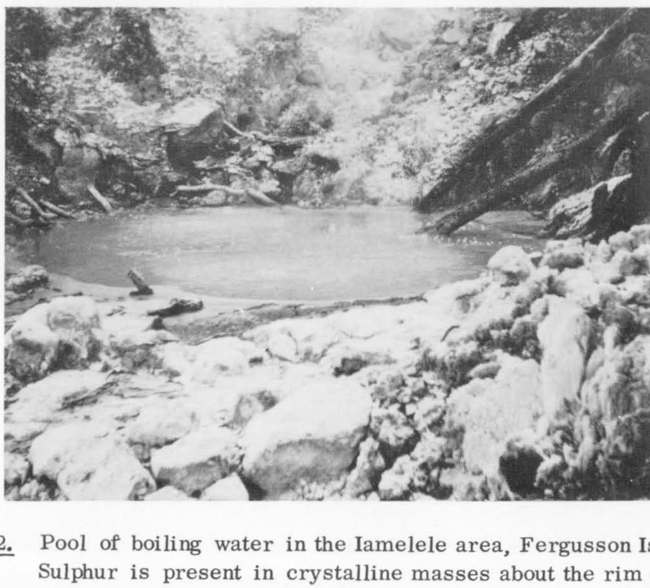

Fig. 2. Pool of boiling water in the Iamelele area, Fergusson Island. Sulphur is present in crystalline masses about the rim of the pool.

Fig. 1. Northerly-plunging anticline forming the Oiatabu Range on Fergusson Island. Some dip slopes are visible on the flanks of the range.

Plate 10

Fig. 1. R11027 (x35).

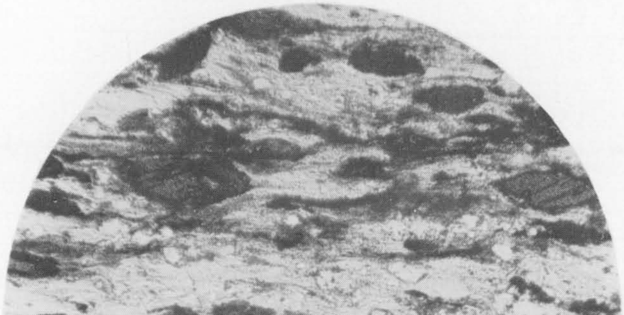

Fig. 2. R11027 (x70).

Figures 1 and 2 show mylonitic texture in basic gneiss close to the Elologea Fault, Fergusson Island.

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Bureau of Mineral Resources, Geology and Geophysics.

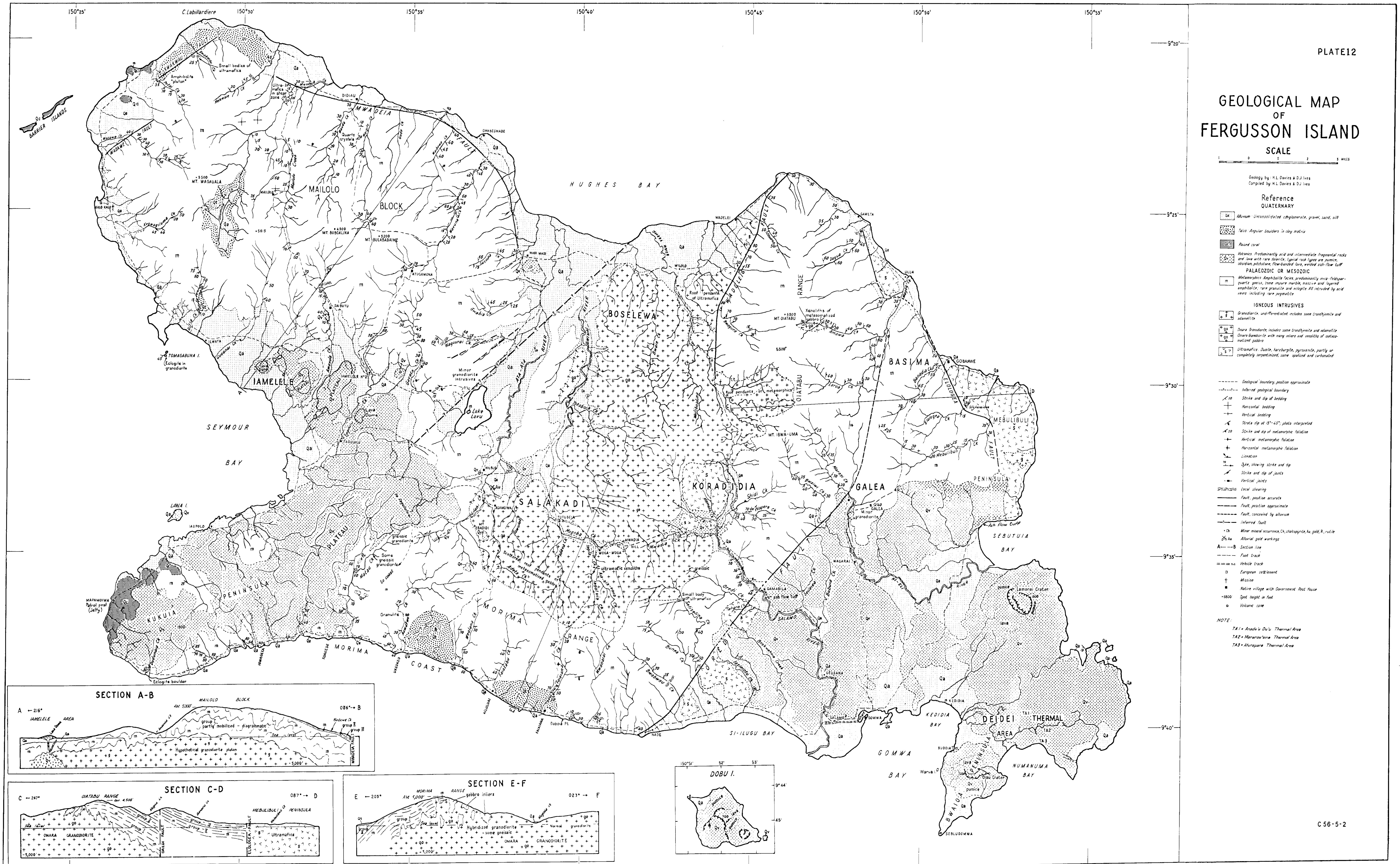
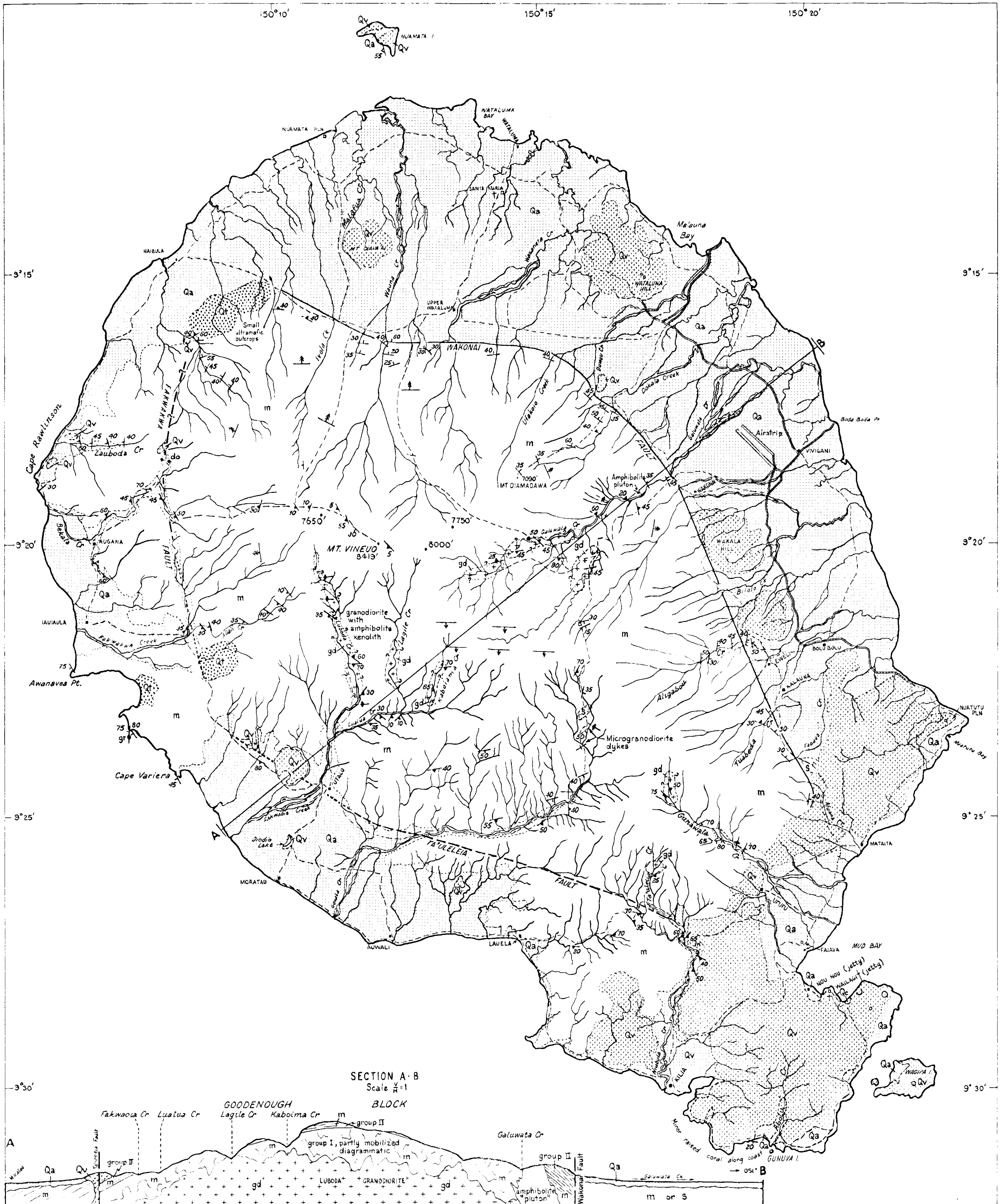


PLATE12
GEOLOGICAL MAP
OF
FERGUSSON ISLAND
SCALE
1 0 1 2 3 MILES
Geology by: H.L. Davies & D.J. Ives
Compiled by: H.L. Davies & D.J. Ives
Reference
QUATERNARY
Qa Alluvium: Unconsolidated conglomerate, gravel, sand, silt
Qt Talus: Angular boulders in clay matrix
Qc Raised coral
Qv Volcanics. Predominantly acid and intermediate fragmental rocks and lava with rare dolerite; typical rock types are pumice, obsidian, pitchstone, flow-banded lava, welded ash-flow tuff
PALAEOZOIC OR MESOZOIC
m Metamorphics. Amphibolite facies, predominantly mica-feldspar-quartz gneiss, some impure marble, massive and layered amphibolite; rare granulite and eclogite. All intruded by acid veins including rare pegmatite
IGNEOUS INTRUSIVES
g Granodiorite, undifferentiated, includes some trondhjemite and adamellite
go Omara Granodiorite, includes some trondhjemite and adamellite
go Omara Granodiorite with many inliers and xenoliths of metasomatized gabbro
s Ultramafics. Dunite, harzburgite, pyroxenite, partly or completely serpentinized, some opalized and carbonated
Geological boundary, position approximate
Inferred geological boundary
Strike and dip of bedding
Horizontal bedding
Vertical bedding
Strata dip at 15°-45°; photo interpreted
Strike and dip of metamorphic foliation
Vertical metamorphic foliation
Horizontal metamorphic foliation
Lineation
Dyke, showing strike and dip
Strike and dip of joints
Vertical joints
Local shearing
Fault, position accurate
Fault, position approximate
Fault, concealed by alluvium
Inferred fault
• Ch Minor mineral occurrence, Ch; chalcopyrite, Au, gold, R; rutile
Au Alluvial gold workings
A—B Section line
Foot track
Vehicle track
European settlement
Mission
Native village with Government Rest House
•6800 Spot height in feet
Volcanic cone
NOTE:
TA1 = Anadu'u Du'u Thermal Area
TA2 = Mararau'eina Thermal Area
TA3 = Afunapara Thermal Area
HUGHES BAY
SEYMOUR BAY
MAILOLO BLOCK
BOSELEWA
SALAKADI
KORADIDIA
BASIMA
GALEA
IAMELELE
PLATEAU
PENINSULA
KUKUIA
MORIMA COAST
MORIMA RANGE
SEBUTUIA BAY
SI-ILUGU BAY
GOMWA BAY
KEDIDIA BAY
NUMANUMA BAY
DEIDEI THERMAL AREA
MEBULIBULI PENINSULA
BARRIER ISLANDS
MT. WASAUALA
MT. BOBOALINA
MT. BULABABAIME
MT. OIATABU
MT. IBWA-UMA
Lake Lavu
Lamonai Crater
SECTION A-B
MAILOLO BLOCK
Hypothetical granodiorite pluton
SECTION C-D
OIATABU RANGE
OMARA GRANODIORITE
SECTION E-F
MORIMA RANGE
Hybridized granodiorite - some gneissic
OMARA GRANODIORITE
DOBU I.
Note: Scale of sections V/H = 1
C56-5-2

PLATE 13.

GEOLOGICAL MAP OF GOODENOUGH ISLAND



Scale

1 0 1 2 3 4 5 MILES

Geology and compilation by : H.L.Davies, D.J. Ives

Reference

QUATERNARY

Qa	*Alluvium : Unconsolidated conglomerate, gravel, sand, silt*
Qt	*Talus : Angular boulders in clay matrix*
	Raised coral
Qv	*Volcanics : Predominantly andesitic olivine basalt, some trachyte, andesite and rare dacite*

PALAEOZOIC OR MESOZOIC

m	*Metamorphics : Amphibolite facies, predominatly mica-feldspar-quartz gneiss, some impure marble, massive and layered amphibolite; rare granulite and eclogi. All intruded by acid veins including rare pegmatite*

IGNEOUS INTRUSIVES

gd	*Granodiorite; includes some granite and adamellite*
s	*Ultramafics : Dunite, harzburgite, pyroxenite, partly or completely serpentinized, some opalized and carbonated*

Geological boundary, position approximate
Inferred geological boundary, position approximate
Strike and dip of bedding
Horizontal bedding
Vertical bedding
Strike and dip of joints
Dip < 15° } *air-photo interpretation*
Dip 15-45°
Strike and dip of metamorphic foliation
Vertical metamorphic foliation
Strike and dip of igneous foliation
Dyke; gd - granodiorite, do - dolerite
Fault, position accurate
Fault, position approximate
Fault, concealed by alluvium
Inferred fault
Local shearing
Au *Alluvial gold workings*
A—B *Section line*
Foot track
Road
Airstrip
European settlement
Mission
Native village with Government Rest House
• 7750′ *Spot height in feet*
Volcanic cone

C 56-5-1