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The Igneous Rocks of Torres Strait

Queensland and Papua

by

*W.F. Willmott, W.D. Palfreyman, D.S. Trail, and W.G. Whitaker**

**Geological Survey of Queensland*

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SUMMARY

In 1968 a combined field party from the Bureau of Mineral Resources and the Geological Survey of Queensland mapped the igneous rocks of Torres Strait, to complete a three-year survey of the pre-Mesozoic rocks of Cape York Peninsula.

The islands in the west of Torres Strait are composed of Carboniferous or Permian volcanic and granitic rocks, which form a basement ridge extending from Cape York to Mabaduan in Papua. The volcanics consist of great thicknesses of acid welded ash-flow tuffs with minor lavas and interbedded sediments; in the south they have been divided into four members. The volcanics probably extended originally from at least Cape York across Torres Strait into the southwest of Papua. They have since been intruded by a number of bodies of biotite granite, adamellite and minor granodiorite; near the contacts extensive areas of hornfels have been developed. Both the granite and the volcanics have been intruded by dykes and small bodies of porphyritic microgranite, as well as acid and intermediate dykes. In places in the south of Torres Strait the volcanics have been altered and mineralized by late stage hydrothermal activity.

The volcanics and granites are overlain by Mesozoic sediments to the south of Cape York, in the southwestern region of Papua, and in the northeast of Torres Strait. In the last two areas, the Mesozoic sediments are overlain by Miocene shelf limestone and Pliocene to Pleistocene mudstone, sandstone and gravel. In Pleistocene times a number of small centres of basic vulcanism developed in the northeast of Torres Strait; three well preserved cones are present at the Murray Islands.

In the acid volcanics in the south of Torres Strait minor mineralization occurs in a discontinuous zone of alteration extending from Hammond Island southeast to Cape York. Pyrite, galena, chalcopyrite, cassiterite and gold are associated with quartz veins in the altered rocks. Gold was produced from quartz veins on Horn and Possession Islands in the 1890's, and small quantities of cassiterite have been produced from lodes and alluvium near Cape York since 1952. Small quantities of wolfram were produced from quartz lodes in granite and hornfels on Moa Island. Bauxite occurs on Turtle Head Island and nearby on the mainland.

INTRODUCTION

This Record describes the results of the 1:250,000 scale mapping of the igneous rocks of Torres Strait, which are exposed in the Torres Strait, Boigu, Daru and Maer Island 1:250,000 Sheet areas. The mapping was carried out between July and September, 1968, by a combined party from the Bureau of Mineral Resources and the Geological Survey of Queensland consisting of four geologists, D.S. Trail, W.D. Palfreyman, W.F. Willmott (B.M.R.) and W.G. Whitaker (G.S.Q.).

The project was the continuation of mapping undertaken in 1966 and 1967 which covered the pre-Mesozoic basement rocks that extend in a north-trending ridge along the eastern side of Cape York Peninsula. In Torres Strait igneous rocks form a second basement ridge which extends from Cape York to Mabaduan in Papua. It is intended to publish the combined results of the three-year survey in a Bureau of Mineral Resources Bulletin.

The stratigraphic names of the units described in this Record have been defined previously by Whitaker and Willmott (1969). During the survey the Mesozoic and younger rocks of Cape York Peninsula were not examined in any detail, but they will be included in the mapping of the Carpentaria Basin at present being undertaken by the Bureau of Mineral Resources and the Geological Survey of Queensland. The Cainozoic sediments inland from the Papuan coast also were not examined.

The majority of the Torres Strait islands and an adjacent area of the mainland south of Cape York are Aboriginal Reserves under the administration of the Queensland Department of Aboriginal and Island Affairs, which is locally based on Thursday Island, the main centre of population (approximately 3000). Daru, on an island of the same name off the southern coast of Papua, is the only other town in the area, and is the centre of administration for the Western District of Papua. Many of the larger islands in Torres Strait are inhabited by Torres Strait Islanders who live in small villages. A large Government community has been established at Bamaga, 15 miles south of Cape York, to re-settle mainland Aborigines and Islanders from some of the less productive islands. Thursday Island is served by frequent air and shipping services from Cairns. The outer islands are serviced by small Government vessels at irregular intervals. At present the main industries of the area are pearl culture, prawn fishing and processing, and some timbergetting.

Exposure of the rocks is very good, with excellent outcrops occurring around the shorelines of the islands. Inland on the larger islands the country is hilly to mountainous and exposure is also generally good. The larger islands in the west are covered with poor soil which supports only low and sparse eucalypt forest, except on Moa Island, where rain forest is present on the higher mountains. The annual rainfall at Thursday Island averages 68.45 inches but its highly seasonal nature results in a pronounced dry season. The eastern islands (Stephens, Darnley and the Murray Islands) are more fertile and support open grassland, coconut groves, and some rainforest.

The islands were mapped using two dinghys operating from a 45-foot chartered launch, the M.V. Sapphire, owned and skippered by Mr A. La Cava of Cairns. Transport on the mainland was provided by the Department of Aboriginal and Island Affairs at Bamaga. Air photography was available for the islands, except for Stephens, Darnley and the Murray Islands, the shapes of which are consequently uncertain on the accompanying maps. For the Torres Strait Sheet geology was plotted on photoscale maps (1:50,000) made by the Royal Australian Survey Corps, and later reduced to 1:250,000 scale. For the Daru-Maer Island Sheet the geology was plotted directly at 1:250,000 scale. In this Record the term Torres Strait is used in its broadest sense, meaning the stretch of water between Cape York and the Papuan coastline.

Acknowledgements

We gratefully acknowledge the assistance given to the party in Thursday Island by the Deputy Director, Department of Aboriginal and Island Affairs (Mr Riordan); officers of the Department at Bamaga Community; government school teachers and village chairmen on a number of islands; officers of the Church of England, Diocese of Carpentaria, on Moa Island; and the officer in charge, Department of Civil Aviation, Horn Island airport.

Mr A. La Cava of the M.V. Sapphire contributed greatly to the success of the mapping programme.

Names of Islands

The names of islands used in this report, and on the accompanying maps, are those in most common use in Torres Strait. English or Indigenous equivalents for some names are given in brackets. The names conform essentially with those of the standard 1:250,000 topographic maps except in a few cases where the Indigenous equivalents are used in preference to the English name. For Goods Island, the spelling "Goode" on recent topographic maps is incorrect.

HISTORY AND PREVIOUS INVESTIGATIONS

The first European to sail through Torres Strait was the Spaniard Torres in 1606, but the discovery remained a military secret for over a century, and it was not until Cook's voyage of 1770 that the existence of the Strait was finally confirmed. Captain Bligh sailed through the Strait in 1789 and 1792 and named many of the islands; he was followed by Flinders in 1802. In the period between 1790 and 1850 in which merchant ships first began using the Strait, many vessels were wrecked on the treacherous reefs and a number of their crews were massacred by the islanders. The first detailed survey of the shipping channels and the islands were carried out by H.M.S. Beagle (1839), H.M.S. Fly (1843-45) and H.M.S. Rattlesnake (1850-52). In 1864 the settler-magistrate Jardine established Somerset, a Queensland government settlement near Cape York which was to provide a refuge for shipping using the Strait, (it was moved to Thursday Island in 1877) and in 1870 the first missionaries arrived. During the 1870's the potential

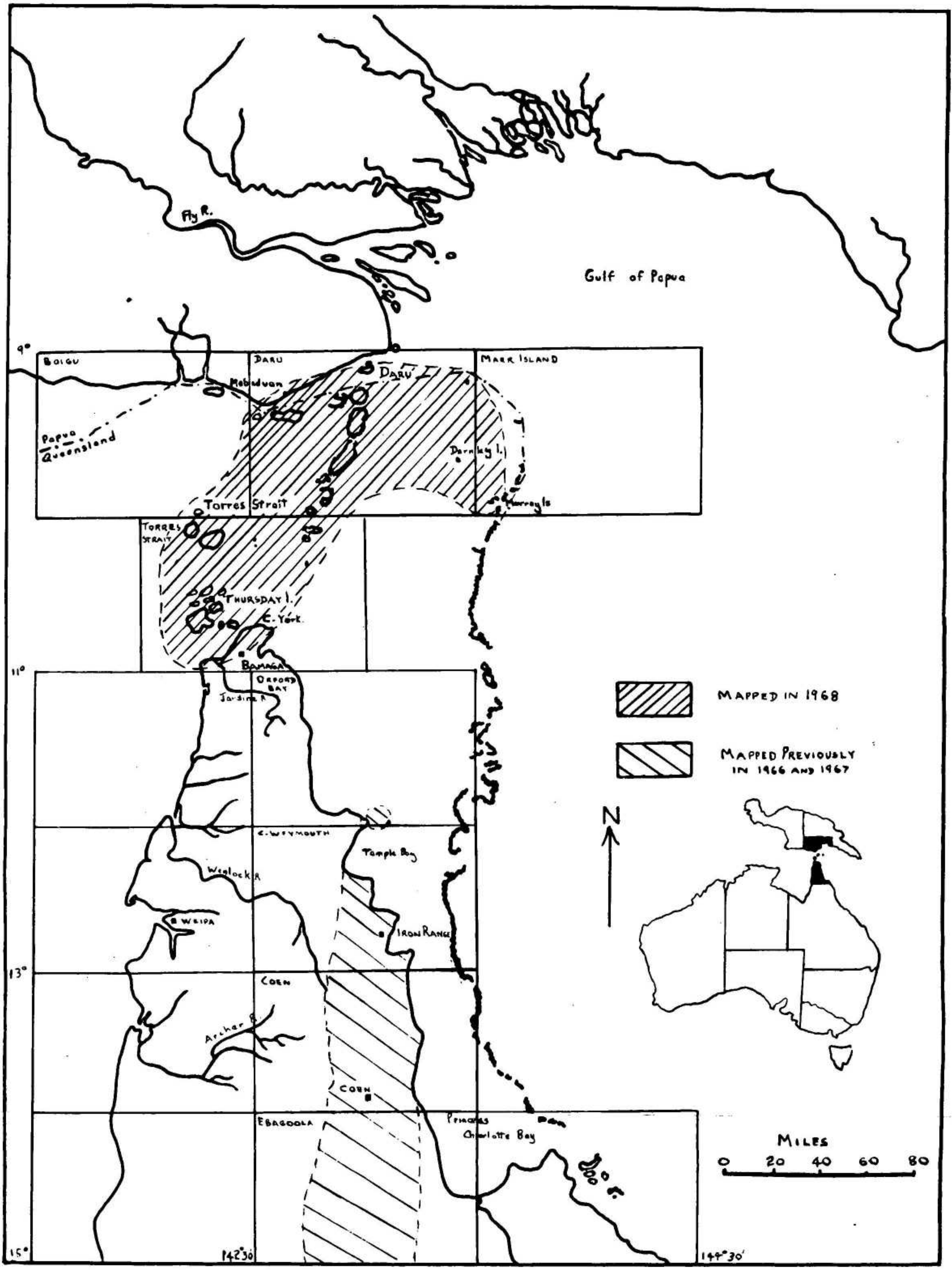


FIG. I LOCALITY MAP

Plate 1. Thursday Island; looking southwest towards Prince of Wales Island.

Plate 2. M.V. Sapphire; amongst islands on the west coast of Badu Island.

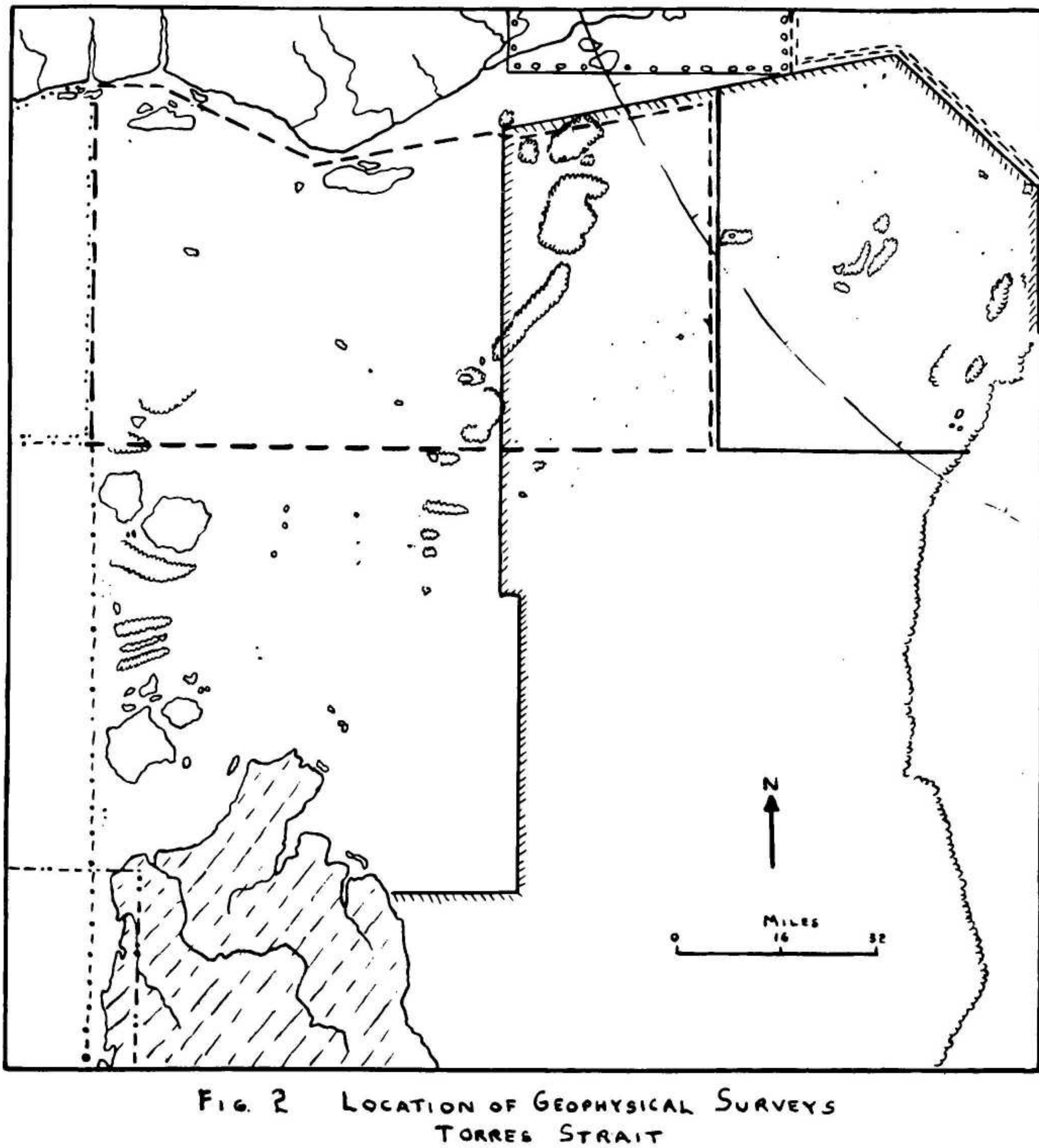
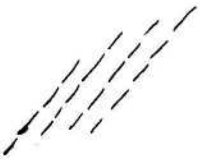
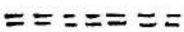


FIG. 2 LOCATION OF GEOPHYSICAL SURVEYS
TORRES STRAIT

LOCATION	TYPE OF SURVEY	REFERENCE
	(Aeromagnetic (Marine seismic	Gulf (1962) Gulf (1965)
	(Marine seismic (and shipborne (magnetometer	Tenneco, 1967
	Aeromagnetic	Aust.Aquit.Pet. (1964)
	Aeromagnetic	Delhi (1962)
	Marine seismic	Marathon (see Vind and Harwood 1965)
	Marine seismic	Marathon Petroleum (1966)
	Marine seismic	Phillips (1965, 1968)
	Marine seismic	Tenneco (1968)
	Marine seismic	Amer. Overseas Pet. (1968)
	Aeromagnetic	Amer. Overseas Pet. (1969)
	Aeromagnetic	Comp.Gener.de Geophys. (1969)
Whole Area	Helicopter gravity	Shirley (in prep.)

Reference to Fig. 2

of pearling was realized, and the industry developed rapidly, often using forced Kanaka labour. Conditions on board some of the pearling ships were so violent and inhumane that in 1880 the Queensland Government annexed the Torres Strait islands and introduced some controls into the industry. After that time the influence of the government and the church gradually brought stability to the islands.

The first geologist to visit Torres Strait was Jukes (1847), on board H.M.S. Fly. He described Darnley and the Murray Islands in some detail and mentioned the granitic rocks of the larger islands further west. The naturalist MacGillivray (1852) described briefly the rocks around Cape York and Prince of Wales Island, and Maitland (1892) described granite at Dauan Island and Mabaduan on the coast of Papua. A comprehensive report on the geology of Torres Strait by Haddon, Sollas and Cole (1894) gives an excellent description of the eastern islands (Stephens, Darnley, and Murray Is.) with a brief mention of the rocks of the larger western islands. In 1898 the Cambridge Anthropological Expedition visited Torres Strait and later published six volumes of reports. The last (the general introduction) was compiled by Haddon in 1935.

Rands (1896) described the Horn Island goldfield, where gold was discovered two years previously. Jackson (1902, 1903) also described the Horn Island workings, as well as those on nearby Possession Island. Jack (1922) in his book "Northmost Australia" described a journey he made in 1880 up Cape York Peninsula as far as Somerset, and Richards and Hedley (1925) described a geological reconnaissance to north Queensland and Torres Strait. Very detailed accounts of the basic volcanics at Bramble Cay, Black Rocks and Darnley Island were given by Jardine (1928a,b).

Wolfram mines on Moa Island, first worked by Islanders before and during the second World War, were described by Shepherd (1944) and Andersen (1944). Jones (1951) also described the wolfram workings on Moa Island (Banks Island) as well as some small tin mines near Cape York on the mainland; Carter and Porter (1952) reported on the latter area for Mount Isa Mines Limited. Fleischman (1952, 1953) inspected and reported on the wolfram mines on Moa Island and the tin mines near Cape York.

A general report on the geology of the islands of Torres Strait was produced by Jones and Jones (1956). It was based on the specimens collected by Richards and Hedley (1925) and dealt mainly with the welded tuffs and granites of the western islands. Since 1957 a number of mineral exploration companies have undertaken reconnaissance surveys of the Torres Strait islands and the tin deposits near Cape York. (Spratt, 1957; Mineral Deposits, 1957; Wilson, 1961; Rowell, 1962; Hughes, 1962; Tennent, 1964; Webb and Fitzpatrick, 1965; and Whitcher, 1966). In a warden's report Robertson (1959) described the activity around the Cape York tin deposits.

A brief description of the geology of Torres Strait was given in Hill and Denmead (1960); it is essentially a summary of Jones and Jones (1956) and Haddon, Sollas, and Cole (1894). The results of oil company investigations in southwestern Papua are summarized by Australasian Petroleum Company (1961), Stach (1964), Thompson (1967) and Rickwood (1968). Geophysical surveys undertaken in Torres Strait and northern Cape York Peninsula are shown in Fig.2. Meyers (1969) has reviewed the sediments and structure of the Carpentaria Basin. Shallow bore holes in sediments on Daru Island which may be Pliocene to Pleistocene in age were described in a report by Macgregor (1967) on the Daru town water supply.

In September 1968 a party from the Bureau of Mineral Resources marine geology section carried out sampling and shallow marine profiling in the Gannet Passage and Prince of Wales Channel, in a brief investigation into the possibility of dredging these main shipping passages (Dr H.A. Jones, pers. comm.). An exploratory oil well, Anchor Cay No.1 (150 miles northeast of Thursday Island), was drilled early in 1969 by Tenneco Australia Incorporated (Oppel, 1969).

PHYSIOGRAPHY AND BATHYMETRY

The islands of Torres Strait and the adjacent mainland of Cape York Peninsula and Papua fall into a number of physiographic divisions (Fig.3).

Torres Strait Islands

The islands of Torres Strait can be divided into three types; the western islands, the central and eastern sand cays, and the volcanic islands. The western islands occur in a north-trending belt extending from the coastline of Cape York to Dauan Island and the hill of Mabaduan on the Papuan coast. Their eastern limit is delineated by a line joining Yama, Saddle and Mount Adolphus Islands. The islands rise steeply from the sea and are generally over 300 feet high, although some reach considerably greater heights, such as Moa Island (Mt. Augustus 1310') Dauan Island (720') and Prince of Wales Island (806'). The interiors of the larger islands contain broad areas of rugged hills separated by sand-covered plains and valleys. The islands are composed of granite and acid volcanics of the pre-Mesozoic basement which weather to a poor soil that generally supports only open eucalypt forest. However, greater rainfall on the higher peaks of Moa Island has allowed patches of rain forest to develop.

The central and eastern sand cays are composed of coral sand and shingle which have accumulated on isolated coral reefs. They occur in an area extending eastward from Dungeness, Sassie and Warraber Islands as far as Anchor and East Cays on the Barrier Reef. The larger cays are about 15 to 20 feet high and are vegetated with coarse grass, low thorn scrub and groves of coconut palms. The interiors of Sassie and Dungeness Islands are low and swampy.

The volcanic islands (Murray Islands, Darnley and Stephens Islands) are five high islands composed of basalt and bedded tuff which occur in the northeast of the region of sand cays discussed above. Small patches of basalt and bedded tuff are also visible

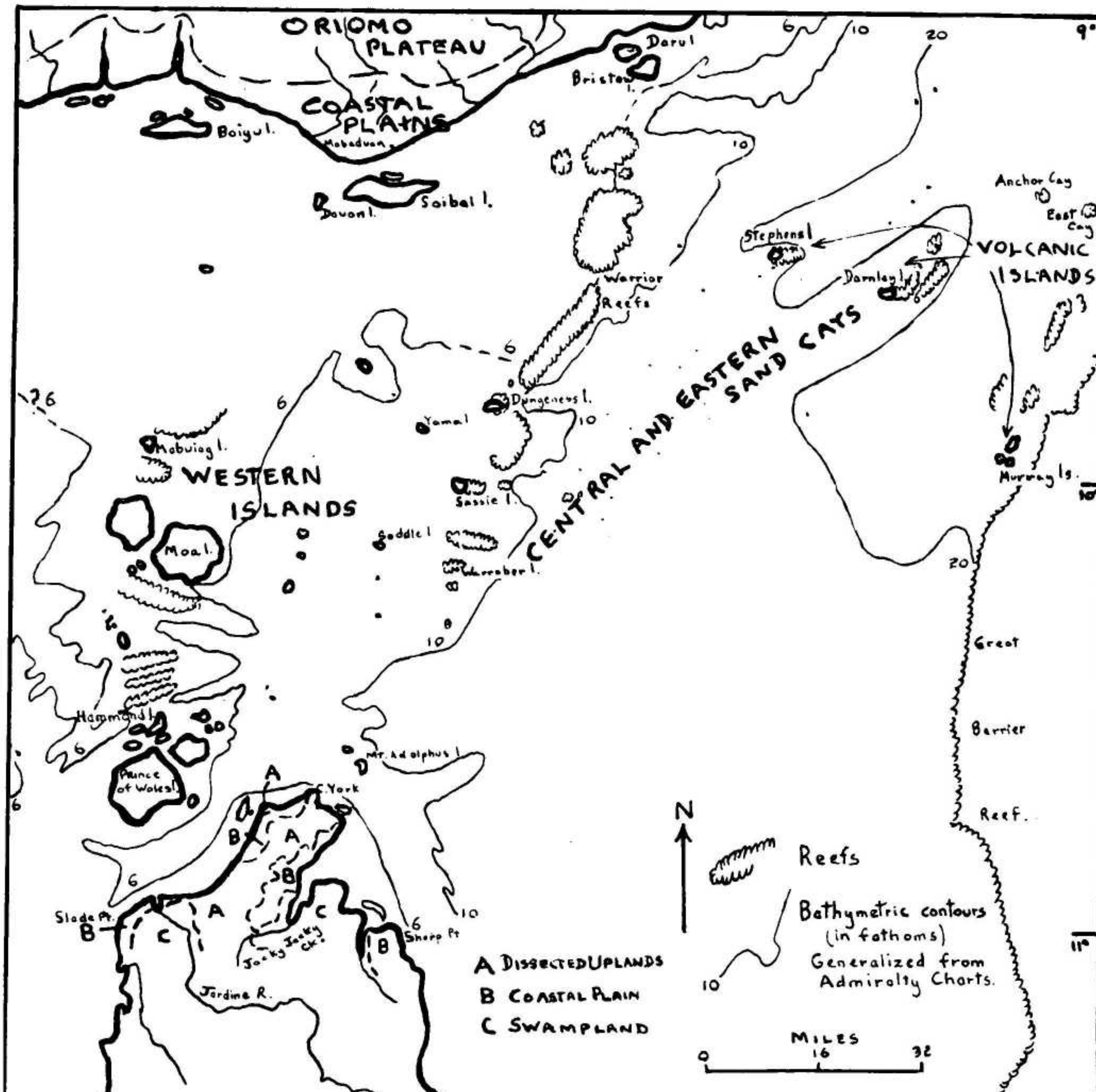


Fig. 3 PHYSIOGRAPHY AND BATHYMETRY
TORRES STRAIT

above the reef at Bramble Cay and nearby Black Rocks. The eastern volcanic islands are the most fertile of the islands in Torres Strait and support thick grass, many coconut groves and some rainforest. The three Murray Lslands are well preserved volcanic cones, and are probably as young as Pleistocene or Recent. The physical characteristics of the craters are described below in the section on the Maer Volcanics.

Mainland south of Cape York

Cape York Peninsula north of latitude 11°S can be divided into three physiographic units. The centre of the Peninsula is formed by northeasterly-trending dissected uplands which are bounded on the west, north and east by sandy coastal plains. Swampland borders the estuaries of the larger streams.

The dissected uplands lie between the Jardine River and Cape York. Their surfaces are relatively flat and dip gently to the southeast; south of Bamaga they are approximately 100 feet high while in the north summit heights are up to 460 feet. There is little dissection in the south and east but dissection is pronounced along the western margin where Paterson and Laradeenya Creeks have separated Galloway's Hill and Mount Paterson from the uplands. The most rugged relief is formed on volcanics north of Lockerbie outstation, and contrasts with the flatter country formed on the gently dipping Mesozoic sandstone to the south and east.

The coastal plain is narrow and discontinuous in the west and north, where it is best developed along the lower reaches of Cody, Paterson and Laradeenya Creeks. West of the Jardine River around Slade Point there is a belt of well defined beach ridges, one mile at its widest, narrowing northward to form an arcuate spit ending at Van Spoult Point. The coastal plain in the east is broader and less well defined merging with the upland area to the west.

Along the east coast north of Wasp Creek ill-defined longitudinal dunes have been formed by the prevailing southeast onshore wind. Similar dunes are extremely well developed south of Sharp Point in the far southeast where they are up to 6 miles in length and reach heights of over 200 feet. In a number of places two dunes meet at a low angle forming an attenuated parabolic dune. Small round or elongate lakes commonly form in the depressions between the dune ridges. Two sets of beach ridges are found north of Higginsfield, near the mouth of Woomera Creek.

Swampland. Mangrove swamps have developed in the estuaries of the larger creeks and rivers and in an extensive area between Jacky Jacky Creek and Escape River. Freshwater swamps are present between the Jardine River and the beach ridge system of the west coast; they cover an area of sparsely vegetated alluvium and are periodically inundated after the wet season.

Mainland of southwest Papua

The area of southwest Papua immediately north of Torres Strait has overall very low relief. Coastal plains, swamps and stream valleys extend for some miles inland before rising to a better drained low plateau which rarely rises higher than 150 feet - the Oriomo Plateau (Blake and Ollier, 1969). Flat swampy islands such as Boigu, Saibai and Bristow are similar to the country forming the coastal plain. Vegetation types both on the coastal plain and the plateau include mangroves along the coast and rivers, open grassland and forest, rain forest, and dense areas of palm trees.

Coral Reefs

Coral reefs are well developed in Torres Strait, and three main types have been recognized. The Great Barrier Reef extends into the Torres Strait area from farther south and terminates in a few scattered reefs north of the Murray Islands.

West of the Great Barrier Reef the water is much shallower and numerous platform reefs have developed. Some are only exposed at low tide, but on others debris has accumulated to form cays. Platform reefs are best developed in the region of the central and eastern cays described above. They are also present in channels between the western islands and are noticeably elongated in an east-west direction. The elongation is probably a streamlining effect caused by the swift tidal currents flowing through the channels. Many platform reefs are also present in a poorly charted shallow area north of Mabuiag Island. The Warrior Reefs and smaller reefs immediately south of them are broad platform reefs which have an unusual north-easterly trend. They are so large and continuous they could perhaps be considered as a subsidiary barrier reef.

Fringing reefs surround most of the rocky islands in Torres Strait, but are only sparsely developed around the coastline of Cape York Peninsula. Although Dauan Island, just off the Papuan Coast, is surrounded by a well developed reef, fringing reefs are generally absent or poorly developed along the coastline of Papua, probably as a result of the suspended sediment in the water which has been brought down by the sluggish Papuan rivers.

Bathymetry

The depth of water between Cape York and Papua is remarkably shallow (Fig.3). Most of the western islands from the mainland of Cape York Peninsula to Mabuiag Island, are emergent parts of an underwater ridge which is generally less than 6 fathoms deep. A number of slightly deeper channels which cut this ridge are probably the result of the scouring action of the swift tidal currents, (up to 8 knots) which prevail in Torres Strait. The main shipping route passes through one of these, the Prince of Wales Channel, north of Hammond Island. North of Mabuiag Island the ridge merges into a broad flat platform which extends across to the Papuan Coast. Although poorly charted, it is probably considerably less than 6 fathoms deep.

To the west of the shallow 6 fathom ridge the bottom deepens very gradually, but to the east it is flanked by a lower platform 8–10 fathoms deep, with a few small rocky islands such as Yama and Saddle Islands, rising above the surface. To the east of this 8–10 fathom shelf, especially in the north near the Warrior Reefs, the bottom drops fairly sharply to between 13 and 14 fathoms. This region of sudden deepening of the bottom (represented approximately by the 10 fathom contour) has a remarkably straight northeasterly trend and suggests that some structural feature may delineate the edge of the 8–10 fathom platform, especially in the north; no basement rocks are exposed east of the platform. The northeast trending Warrior Reefs, and smaller reefs to the south, such as Dungeness Reef, Sassie Island Reef, and Warraber Reef may have developed on or near to the structurally controlled edge of the platform.

Between the 8–10 fathom platform and the Barrier Reef the bottom is generally less than 20 fathoms deep. In the northern part of the area however, the bottom is rather irregular, and the 20 fathom line extends farther westwards. The many small platform reefs in the region of the central and eastern sand cays rise abruptly from the deep water in this area. The eastern volcanic islands with their surrounding fringing reefs also rise abruptly from deep water. South of the Murray Islands the Barrier Reef marks the edge of the continental shelf, and east of the reef the bottom plunges to depths of over 100 fathoms.

GEOLOGICAL HISTORY

The igneous rocks in the western part of Torres Strait form a pre-Mesozoic basement ridge which extends northwards from Cape York to southwestern Papua. The oldest rocks exposed on the ridge are ?Carboniferous or Permian volcanics, but presumably older Palaeozoic or Precambrian rocks similar to those of Cape York Peninsula (Trail et al., 1969) underlie them at depth.

Violent acid volcanic activity occurred during the Carboniferous or Permian over an area which extended from at least as far south as Cape York northwards across Torres Strait into southwestern Papua. Great thicknesses of acid ash-flow tuffs of slightly varying composition, and some lava flows were erupted from a number of centres. Between the periods of more violent volcanic activity thin beds of localized tuffaceous sediments were laid down in some areas.

The volcanic pile was intruded at some time during the Upper Carboniferous or Permian by many bodies of high level granite, and hornfels was extensively developed in the volcanics around their margins. Shortly after, the granite and the volcanics were intruded by dykes and small bodies of porphyritic microgranite, as well as acid and intermediate dykes. Late stage hydrothermal activity related to this magmatic cycle is thought to have been the cause of alteration and mineralization of the volcanics in some areas in the south of Torres Strait.

From Permian to Jurassic times Torres Strait and southwestern Papua remained stable, presumably as an emergent landmass. However, during the Upper Jurassic and Lower Cretaceous the shallow Carpentaria Basin began to form, the southwestern region of Papua began to be depressed as a relatively stable shelf, and farther to the northeast more pronounced subsidence led to the formation of the Papuan Basin. Continental and shallow marine sediments were deposited in the Carpentaria Basin and over the Southwest Papuan Shelf, but in the deeper waters of the Papuan Basin marine muds were more common. In the northeast of Torres Strait, the Cretaceous sediments of the Papuan Basin wedged out against the older ?Carboniferous and Permian rocks, but a narrow connection with the Carpentaria Basin may have existed.

From the end of the Lower Cretaceous to the Lower Miocene Southwestern Papua was emergent, but during the Miocene transgressive shelf limestones were deposited on the eroded surface of Mesozoic sediments. In the northeast of Torres Strait the limestone deposition commenced in the Eocene, but a break occurred before the Miocene limestones were laid down. In southwestern Papua and the Gulf of Papua the limestones were buried by Pliocene and Pleistocene sandstones, mudstones and gravels, but in northeastern Torres Strait limestone deposition continued through the Pliocene and Pleistocene till the present day. However it was probably not until the Quaternary that the present seaway of Torres Strait formed across the basement rocks in the west of the Strait.

Extensive areas of ferricrete and some bauxite were formed on Mesozoic sediments on the mainland south of Cape York, probably during the Tertiary. Quaternary sediments were deposited along the coast and rivers of southwestern Papua and on the mainland of Cape York Peninsula.

In the Pleistocene the northeast of Torres Strait was part of a province of basic vulcanism whose main development may have been to the north in western Papua. In Torres Strait a number of small cones of ash were built up and basalt was erupted from them.

DESCRIPTION OF ROCK UNITS

Table 1 summarizes the rock units mapped in Torres Strait.

TABLE 1

SUMMARY OF ROCK UNITS, TORRES STRAIT

		AGE	ROCK UNIT OR SYMBOL	LITHOLOGY	THICKNESS	ORIGIN AND RELATIONSHIPS
CAINOZOIC	QUATERNARY	Recent	Qra	Silt and clay		On coastal plain along southern coast of Papua.
			Qrt	From air photo interpretation only; probably silty alluvium		In terraces; forms slightly older elevated coastal plain behind coast of Papua.
		Pleistocene to Recent	Qa	Silt and clay; some sand		In stream valleys; extensive area south of mouth of Jardine River. Mixed with residual sand on larger islands.
			Qs	Quartz sand		Residual sand overlying Mesozoic sandstone/thinly developed on volcanics. Mixed with silty alluvium in valleys.
			Qd	Quartz sand		Dune sand on Mesozoic sandstones on east coast Cape York Peninsula.
			Qm	Silt and mud; Quartz and coral sand;		Estuarine and coastal mud; beach sand.
			Qmc	Coral sand and shingle		Sand cays on reefs.
		Pleistocene(?)	Maer Volcanics Qv	Basic tuff, basalt	Variable at different centres; 500 feet of basalt at Darnley Is.	Intrude Pleistocene-Recent coral reefs. Three well preserved craters at Murray Islands.
		Pliocene-Pleistocene	TpQp	Mudstone; some sandstone and gravel; limestone in northeast Torres Strait	<400 feet in southwestern Papua. 2700 feet in northeast Torres Strait	Reported to overlie Miocene limestone.

AGE			ROCK UNIT OR SYMBOL	LITHOLOGY	THICKNESS	ORIGIN AND RELATIONSHIPS
CAINOZOIC	TERTIARY	Miocene	Tm	Limestone	Average 3000 feet	Deposited on stable shelf of Southwest Papua. Exposed west of Oriomo and Daru; and at depth beneath N.E. Torres Strait. Unconformable on Mesozoic sediments.
		Eocene	Te	Limestone	1000 feet	Overlies Mesozoic sediments in northeast Torres Strait.
		Tertiary(?)	Not mapped	Poorly consolidated sandstone and conglomerate	10-15 feet	Small deposits of poorly consolidated weathering detritus of underlying basement rocks. Underlie sand plain on Moa and Wednesday Islands.
			Not mapped	Ferricrete	2- 10 feet	On Mesozoic sandstone south of Cape York; on volcanics on Moa and Mt. Adolp hus Islands.
MESOZOIC		Cretaceous(?)	Mz	Coarse sandstone with conglomerate lenses and siltstone	>190 feet.	Unconformable on Torres Strait Volcanics, south of Cape York. surface ferruginized.
		Jurassic-L. Cretaceous	Mz	Basal sediments are continental sandstone in Papua but deep water pyritic shales in Torres Strait, overlain by shallow marine sandstone and siltstone.	Average 3000 in southwest Papua.>5000 feet in northeast Torres Str.	Present at depth beneath Tertiary sediments in southwest Papua and in northeast Torres Strait. Complexly faulted.

	AGE	ROCK UNIT OR SYMBOL	LITHOLOGY	THICKNESS	ORIGIN AND RELATIONSHIPS
PALAEOZOIC	Permian(?)	Pzup	Porphyritic microgranite		In dykes and small bodies; intrudes Torres Strait Volcanics, Badu Granite; intruded by acid dykes.
		Badu Granite Pzub	Leucocratic biotite granite, porphyritic biotite granite and adamellite, hornblende-biotite adamellite and granodiorite		Intrudes Torres Strait Volcanics. Intruded by porphyritic microgranite, acid and intermediate dykes.
	Carboniferous-Permian(?)	Torres Strait Volcanics: Undivided Pzut	Welded tuff, hornfels		Intruded and hornfelsed by Badu Granite, porphyritic microgranite, acid and intermediate dykes.
		Torres Strait Volcanics: Muralug Ignimbrite Pzum	Brownish grey welded tuff, some rhyolite volcanic breccia and rare intermediate welded tuff	>500 feet	Faulted against Endeavour Strait Ignimbrite.
		Torres Strait Volcanics: Goods Island Ignimbrite Pzug	Dark grey or black welded tuff, with abundant phenocrysts and some rock fragments; some carbonaceous and tuffaceous siltstone and sandstone	>250 feet	Probably overlies Endeavour Strait Ignimbrite. Intruded by Badu Granite and porphyritic microgranite (Pzup).
		Torres Strait Volcanics: Endeavour Strait Ignimbrite Pzun	Greenish-grey welded tuff; minor rhyolite, andesite and agglomerate. Some hornfels.	Several hundred feet	Probably overlies Eborac Ignimbrite. Intruded by porphyritic microgranite (Pzup).
		Torres Strait Volcanics: Eborac Ignimbrite Pzue	Light-grey welded tuff with abundant phenocrysts. Some rhyolite.	>300 feet	Probably overlain by Endeavour Strait Ignimbrite.

CARBONIFEROUS TO PERMIAN(?)

Torres Strait Volcanics

Acid and intermediate pyroclastics and lavas occur on many islands across the width of Torres Strait. They consist of crystal-rich welded tuffs with small variations in composition, and minor andesite, rhyolite and interbedded sediments. Until isotopic ages are available it is assumed that they were erupted at approximately the same time as the Carboniferous or Permian volcanics near Iron Range, 150 miles to the south in Cape York Peninsula (Trail et al., 1969). The volcanics have been intruded by high-level granite, and in places the accompanying thermal metamorphism has produced hornfels. In some areas the volcanics have been hydrothermally altered and mineralized. The base of the volcanics is not exposed, but the sequence is probably less than 2000 feet thick.

The most extensive area of outcrop is in the south of Torres Strait, and includes Hammond, Goods, Friday, Thursday, Wednesday, Tuesday, Prince of Wales, and Horn Islands, the islands of Endeavour Strait, the western coastline of the mainland from Mutee Head to Peak Point, the northern coastline from Peak Point to Albany Island, Mount Adolphus, Little Adolphus and adjacent islands, and Alpha Rock. Similar volcanics also crop out on the Wallis Islands, Booby Island, West Island, the Duncan Islands, Clarke, Browne and Barney Islands, Badu, Moa, Mabuiag, Gabba and Saddle Islands, Ninepin and Harvey Rocks, Dauan Island, and near Mabaduan on the southern coast of Papua. Many of the small outcrops of volcanics are included within granite and have been intensely recrystallized.

The welded tuffs have been previously named the Torres Strait Ignimbrite by Jones and Jones (1956). However, as four separate units of welded tuff can be recognized, and as other rock types are present, we consider that a more general name, the Torres Strait Volcanics, should be applied to all the Carboniferous or Permian (?) volcanic rocks in Torres Strait, including those that have been thermally metamorphosed by the granite.

In the large area of volcanics in the southern part of Torres Strait, four units of crystal-rich welded tuff of different compositions have been recognized. They are named the Eborac Ignimbrite, the Endeavour Strait Ignimbrite, the Goods Island Ignimbrite and the Muralug Ignimbrite. Each of the units probably represents a number of sheets of welded ash-flow tuff of very similar composition; the name "ignimbrite" is used for convenience in stratigraphic nomenclature, following the Queensland Subcommittee for Stratigraphic Nomenclature, and does not imply that each unit is composed of only one sheet. Table 2 summarizes the petrography of the welded tuffs in these four units. The small patches of volcanic rocks on the islands to the north of this region remain as undivided Torres Strait Volcanics.

Eborac Ignimbrite

The Eborac Ignimbrite is composed of massive, even-grained light-grey welded tuff, and minor rhyolite. The welded tuff contains abundant small phenocrysts of quartz and white or pale pink feldspar; when weathered it is light purple. It crops out along the northern coast of the mainland of Cape York Peninsula from Bay Point to Albany Pass, on Albany Island and neighbouring small islands, on Alpha Rock, and on the group of islands northeast of Adolphus Channel. It is named from Eborac Island, a small island a few hundred yards from the tip of Cape York.

The welded tuff is composed of phenocrysts of quartz, potash feldspar and minor plagioclase set in a devitrified quartzo-feldspathic groundmass. The phenocrysts, which comprise between 25% and 60% of the rocks are euhedral or subhedral and are generally about 5 or 6 mm across. Quartz and potash feldspar are present in approximately equal proportions. Locally, the percentage of phenocrysts present varies considerably. On Albany Island and nearby at Osnaburg Point and Bush Island, and also at the southern end of Mount Adolphus Island, vague bands approximately 6 inches thick are alternately composed of crystal-rich and crystal-poor material.

The groundmass is generally devitrified into a structureless microcrystalline intergrowth of quartz and unidentified feldspar; in some specimens, however, glass shards are visible within the groundmass even though they have been devitrified. They are moderately to densely welded and are distorted around the edges of phenocrysts. On Mount Adolphus Island, the groundmass has apparently been recrystallized to a fine-grained granular mosaic of quartz and feldspar.

Most specimens of the Eborac Ignimbrite contain a few small fragments of pumice. These have been completely devitrified but are easily distinguished from the groundmass by their coarser devitrification products. Pumice fragments are generally rare throughout the unit, but on Albany, Mount Adolphus and Lacey Islands and south of Ida Point the rock contains abundant large pumice fragments up to 3 feet in length. In some of these exposures the pumice-bearing welded tuff can be distinguished as a band within the typical welded tuff. A few rare fragments of devitrified glassy rock are present in places; on Albany Rock they are up to 3 inches in length and contain phenocrysts.

The Eborac Ignimbrite is probably composed of a number of sheets of welded tuff of similar composition, although generally the individual sheets cannot be distinguished. On the eastern side of York Island a few benches occur at vertical intervals of about 60 feet and dip gently southwards. They may represent the contacts between individual sheets of welded tuff, but the only difference observed in the sheets is a slight variation in the overall percentage and relative proportions of the phenocrysts present. The bands of pumice-rich material described previously may possibly represent individual sheets, and at Osnaburg Point a bed of agglomerate 7 feet thick composed of cobbles and boulders of fine grained

TABLE 2

PETROGRAPHIC DETAILS OF WELDED TUFFS OF THE IGNIMBRITE UNITS OF THE TORRES STRAIT VOLCANICS

	Average % Phenocrysts	Average size Phenocrysts (mm)	Mineralogy of Phenocrysts (Average % total of rock) Qtz.	Af.	Pl.	Fm.	Acc.	Fragments	Groundmass
Muralug Ignimbrite	20	4	10	10	<1	<1	-	Some welded tuff. Abundant pumice; completely devitrified and finely crystalline.	Completely devitrified. Glass shards discernible in places.
Goods Island Ignimbrite	45	4	10	10	20	5	All.	Welded tuff and andesite. Pumice completely devitrified and finely crystalline.	Completely devitrified and finely recrystallized in places. Structureless.
Endeavour Strait Ignimbrite	45	6	15	20	10	<2	All.	Welded tuff and andesite. Pumice completely devitrified and finely crystalline.	Completely devitrified and finely recrystallized in places. Structureless.
Eborac Ignimbrite	30	5	15	15	3	-	Mz?	Pumice common; completely devitrified and finely crystalline.	Completely devitrified and finely recrystallized in places. Glass shards rarely discernible.

Abbreviations

Qtz. = Quartz. Af. = Alkali feldspar Pl. = Plagioclase

Fm. = Ferromagnesian minerals Acc = Accessories Mz = Monazite

All. = Allanite.

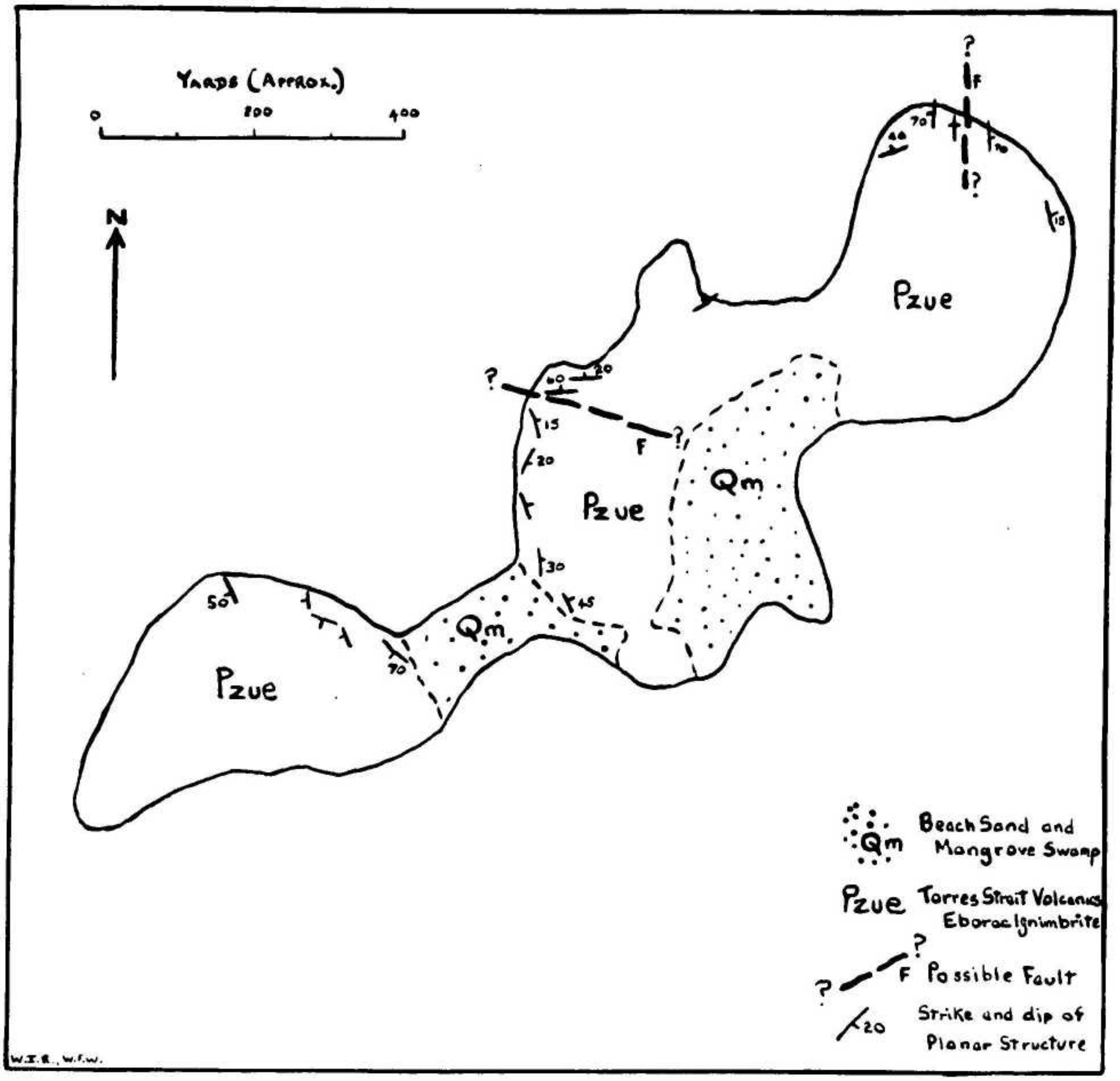


FIG.4. VARIATION OF PLANAR STRUCTURE DEFINED BY PUMICE FRAGMENTS
EBORAC IGNIMBRITE, LACEY ISLAND.

welded tuff is present underlying the normal rock. On Mount Adolphus Island a distinct band 70 feet thick of welded tuff containing pebbles and cobbles of rhyolite, and pumice fragments, is apparently interbedded with the normal welded tuff. Probable flows of rhyolite are present in the Eborac Ignimbrite on Little Adolphus Island and at the southern end of Mount Adolphus Island.

The attitude of the Eborac Ignimbrite is uncertain, as no true bedding was observed and contacts with other units of the Torres Strait Volcanics were not seen. However, the planar structure defined by the orientation of pumice fragments which is probably due to compaction during welding is thought to be parallel to the surface of deposition or bedding surface. Thus, on the mainland, from Cape York to Albany Island, the unit appears to dip between 5° and 10° to the southwest, but in places it is practically flat. On Bush Island near Albany Island, the alternating bands 6 inches thick of crystal-rich and crystal-poor material also dip gently southwest. The agglomerate band at Osnaburg Point appears to dip at 5° to the south. On Mount Adolphus Island the structure defined by the pumice fragments is complicated, probably owing to faulting and the intrusion of bodies of porphyritic microgranite. In general, it dips to the northwest at angles up to 20°. On Lacey Island also, the planar structure is complicated and dips steeply in various directions (Fig.4). It is uncertain whether the steep dips indicate that the unit has been folded or whether they merely developed during extrusion or compaction of the welded tuff.

Endeavour Strait Ignimbrite

The Endeavour Strait Ignimbrite consists of welded tuff and minor rhyolite, andesite and agglomerate. The unit is exposed on the north and west coasts of Cape York Peninsula between the old Cape York Post Office and Mutee Head; on the islands of Endeavour Strait, and on Horn, Prince of Wales, Thursday and Wednesday Islands. The Endeavour Strait Ignimbrite is named from Endeavour Strait which separates Cape York Peninsula from Prince of Wales and Horn Islands.

The welded tuff consists of pale pink or white alkali feldspar and plagioclase phenocrysts and quartz phenocrysts set in a light greenish-grey microcrystalline groundmass. The phenocryst minerals make up on the average 45 percent of the rock; small flakes and crystals of biotite and an amphibole (hornblende or actinolite) pseudomorphed by chlorite are found in subordinate amounts. Rock fragments up to several feet across are common, and many small pumice fragments are present although they are rarely discernible in hand specimen.

From thin section examination quartz phenocrysts are seen to make up from 10 to 30 percent of the welded tuff. They are generally anhedral or subhedral and are commonly slightly embayed and corroded by the groundmass. Some quartz phenocrysts are strained and some rare crystals are fractured or brecciated.

Alkali feldspar, generally anorthoclase, is also present in all specimens examined and ranges from 15 percent to 30 percent of the rock. Microcline is present in some slightly recrystallized specimens. The feldspar crystals are anhedral or subhedral, and are generally partially or completely altered to clay minerals; a few are altered to sericite or a carbonate. There is some corrosion of the margins and in places the laths are fractured and brecciated.

Oligoclase phenocrysts form up to 15 percent of the rock as subhedral laths and small angular fragments. They are strongly zoned and are partially or completely altered to sericite and clay.

Biotite makes up to 2 percent of the rock either as rare, large, scattered flakes or as irregular or rounded aggregates of chloritized flakes up to 3 mm across. Phenocrysts of amphibole, possibly replacing pyroxene and in turn replaced by chlorite and carbonate, are also found rarely. Chlorite also forms very small flakes which are scattered through the groundmass. Allanite is a common accessory phenocryst mineral as enhedral crystals up to 0.5 mm in size.

The most abundant type of rock fragment is a greenish-grey welded tuff which contains large phenocrysts of quartz and feldspar. One block approximately 20 feet square was found in welded tuff south of Red Island Point. Less common are small dark grey fragments of rocks of (?)andesitic composition which are usually surrounded by a narrow reaction zone. In addition, thin section examination of the welded tuff shows small irregular or rounded aggregates several millimetres across of intergrown plagioclase and amphibole or chlorite. These fragments of intermediate composition are closely similar in appearance to andesite exposed within the unit near Cowal Creek, and may represent fragments of this rock.

The groundmass of the welded tuff consists of a microcrystalline or finely crystalline mosaic of quartz and feldspar with minor chlorite and opaque minerals. Rarely the outlines of glass shards are discernible, though the rocks have been completely devitrified. Recrystallized pumice fragments form elongate slightly coarser patches within the groundmass; they make up from 20 to 30 percent of the rock.

Agglomerate, rhyolite, andesite are found in small amounts in the Endeavour Strait Ignimbrite and appear to be concentrated near the base of the unit (Fig.5). An irregular bed of agglomerate about 50 feet thick is interbedded with welded tuff at the southern end of Dayman Island. It consists of abundant welded tuff fragments which generally range from one inch to 3 inches in length and rarely are as much as 18 inches long. Agglomerate is also exposed on the shore at Mutee Head and between Mutee Head and Cowal Creek. It is made up of angular welded tuff fragments up to 4 inches across set in a weathered tuffaceous groundmass. Massive volcanic breccia occurs on a headland just to the north of Red Island Point and extends one mile inland. It is formed by angular fragments of fine-grained andesite and welded tuff set in a fine dark brown groundmass.

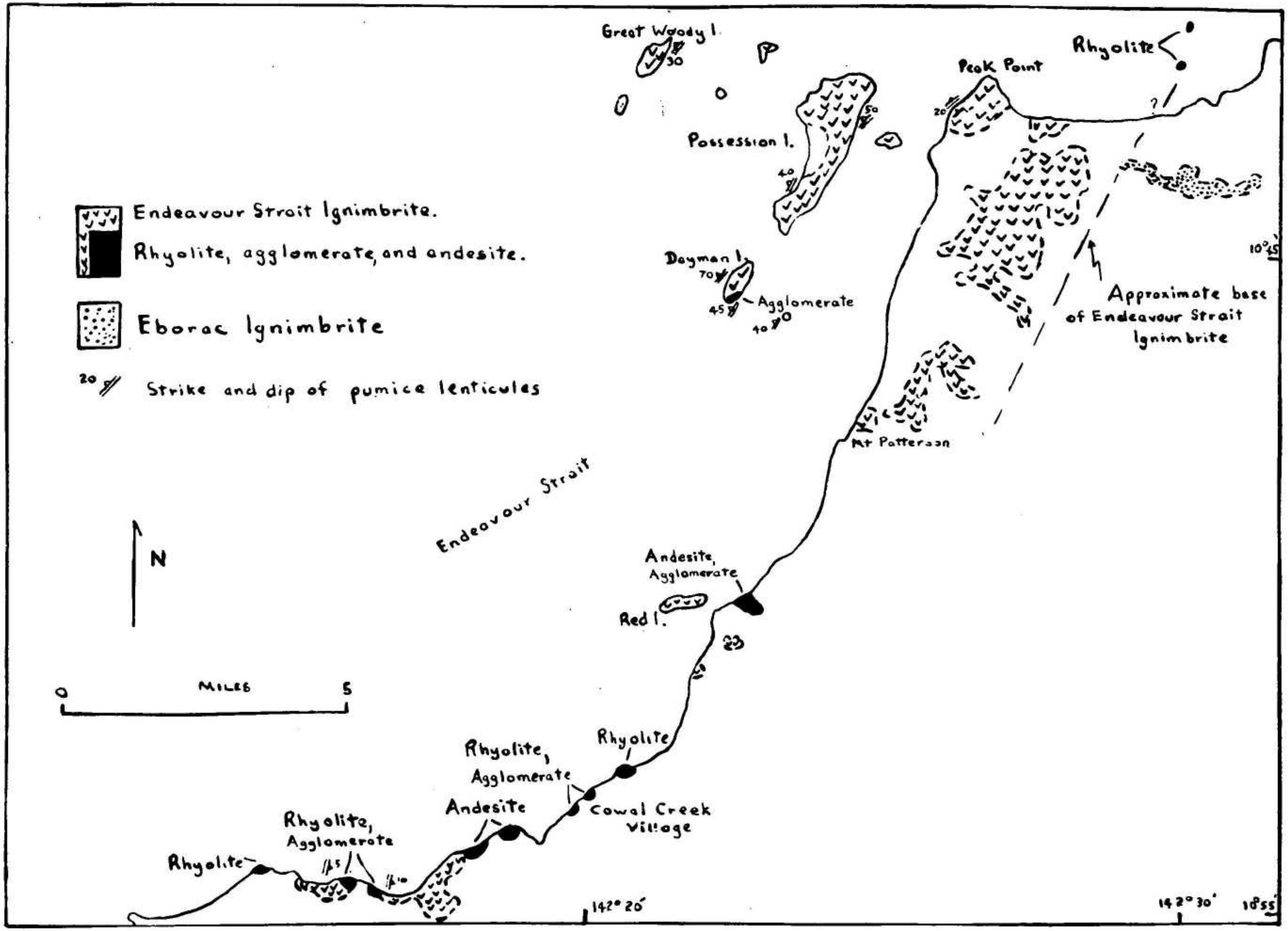


FIG 5 DISTRIBUTION OF RHYOLITE, AGGLOMERATE AND ANDESITE, ENDEAVOUR STRAIT IGNIMBRITE

Rhyolite is exposed together with welded tuff beneath the Mesozoic sediments between Mutee Head and Red Island Point. At Mutee Head a weathered agglomerate is cut by ½-inch-thick veins of grey rhyolite containing small feldspar phenocrysts. Pink rhyolite with quartz phenocrysts is interbedded with agglomerate south of Cowal Creek, and to the west 40 feet of flow banded rhyolite is overlain(?) by an agglomerate formed by rounded rhyolite fragments up to 6 inches long. Rhyolite is also found on Murangi Island and Mona Rock off the north coast of the mainland. On Murangi Island prominent steeply dipping flow banding wraps around numerous spherical bodies similar to spherulites but ranging from one inch up to 6 feet in diameter. These are composed of fine aphanitic material containing rare, small glassy quartz crystals. The larger bodies are cut by radiating tension cracks.

Andesite crops out immediately to the south of Cowal Creek and also east of Red Island Point. It is a fine, even-grained, mid-grey rock composed of interlocking euhedral labrodorite laths and minor hornblende, set in a groundmass of chlorite and opaque minerals. Dumaralug Island off the south coast of Prince of Wales Island is composed of similar but coarser andesite.

The attitude of flattened pumice lenticules suggests the unit has a general northwesterly dip, steepening from 20° at Peak Point to 75° on Dayman Island, and decreasing to 20° again on Little Woody Island. Between Cowal Creek and Mutee Head it is flat or has a gentle westerly dip. The steep dips in the north of Endeavour Strait may in part be due to faulting. The contact with the Eborac Ignimbrite to the east was not seen, but the Endeavour Strait Ignimbrite probably disconformably overlies the Eborac Ignimbrite.

Goods Island Ignimbrite

The Goods Island Ignimbrite consists of sheets of crystal-rich welded tuff and minor interbedded sediments. It is exposed on Goods, Prince of Wales, Friday, Wai-weer, Hammond and Thursday Islands.

The welded tuff is a dark-grey or black rock containing small white feldspar phenocrysts and less common quartz phenocrysts set in a fine groundmass. Rock fragments are common and range up to several inches in size. Most abundant are fine dark greenish-grey or black fragments containing scattered rounded quartz phenocrysts; less common are angular autoliths. At several localities on Hammond and Friday Islands rock fragments form up to 70 percent of the rock.

Thin sections show that the predominant phenocryst minerals are plagioclase, quartz, alkali feldspar, hornblende, and chlorite, which together make up from 45 percent to 70 percent of the rock; accessory minerals are allanite and pyroxene. Quartz, which ranges from 5 to 15 percent of the rock, forms anhedral or rarely subhedral crystals. The larger crystals are usually fractured, and slightly corroded by the groundmass, and some are embayed. Andesine makes up from 10 percent to 35 percent of the rock and forms subhedral or euhedral laths which are partly or completely replaced by clay, sericite, or rarely, by a carbonate mineral. The larger crystals are strongly zoned. Alkali feldspar forms up to 15 percent of the rock as anhedral or subhedral laths up to 3 mm in length which are partially or completely altered to clay. Rarely the laths are multiple-twinned, suggesting that the feldspar is anorthoclase.

The amphibole which is dark brown in colour, is probably hornblende and makes up from 3 to 5 percent of the rock as subhedral or euhedral prismatic crystals partially replaced by chlorite or actinolite. Allanite is a common accessory mineral and forms stubby, dark brown euhedral zoned crystals. One euhedral crystal of pyroxene was identified.

The rock fragments are composed of rounded or elongate aggregates up to 6 mm in size, of intergrown subhedral plagioclase and actinolite or chlorite. These resemble the andesite of the Endeavour Strait Ignimbrite and are identical to fragments found in the welded tuff of that unit.

The groundmass of the welded tuff has devitrified to a finely crystalline mosaic of quartz, feldspar, and brown or green amphibole or chlorite. Pumice lenticules are represented by patches of slightly coarser intergrown quartz and feldspar.

Carbonaceous and tuffaceous siltstone and sandstone are interbedded with welded tuff on Hammond and Thursday Islands (Fig.6) and has also been reported from Goods Island (Jones & Jones, 1956). Mid-grey or dark-grey carbonaceous siltstone is the most common rock type. Interbedded with this are thin bands from ¼ inch to 6 inches thick, of black, poorly sorted tuffaceous sandstone which in places shows graded bedding (Jones & Jones, 1956). Poorly preserved plant remains have been found in the finer beds.

The carbonaceous siltstone consists of small angular quartz grains (5 percent of the rock) set in a very fine grained matrix containing from 5 percent to 10 percent of dark brown or black opaque carbonaceous(?) material. With an increase in the percentage of quartz, feldspar, and rock fragments, the siltstone grades into tuffaceous siltstone and sandstones. In these rocks the quartz and feldspar form angular grains from 2 mm to 3 mm in size which resemble phenocrysts from the surrounding welded tuff; they are concentrated in small discontinuous lenses throughout the rock. The rock fragments range up to 3mm in size and closely resemble the surrounding welded tuff. A thin band of limestone has been reported from the west end of Goods Island (Mr P. O'Rourke, pers. comm.). The strike and dip of these sediments vary considerably and on both Hammond and Thursday Islands, small-scale folds are visible.

The structure of the Goods Island Ignimbrite was determined by the orientation of flattened pumice lenticules; it is flat or dips gently to the northwest, except along the north coast of Goods Island where steep southwesterly dips are found. Near the granite contact on Hammond Island dips range between 20° west and 70° east. The Goods Island Ignimbrite appears to overlie the Endeavour Strait Ignimbrite on Thursday Island, where there is a compositional gradation between the two units.

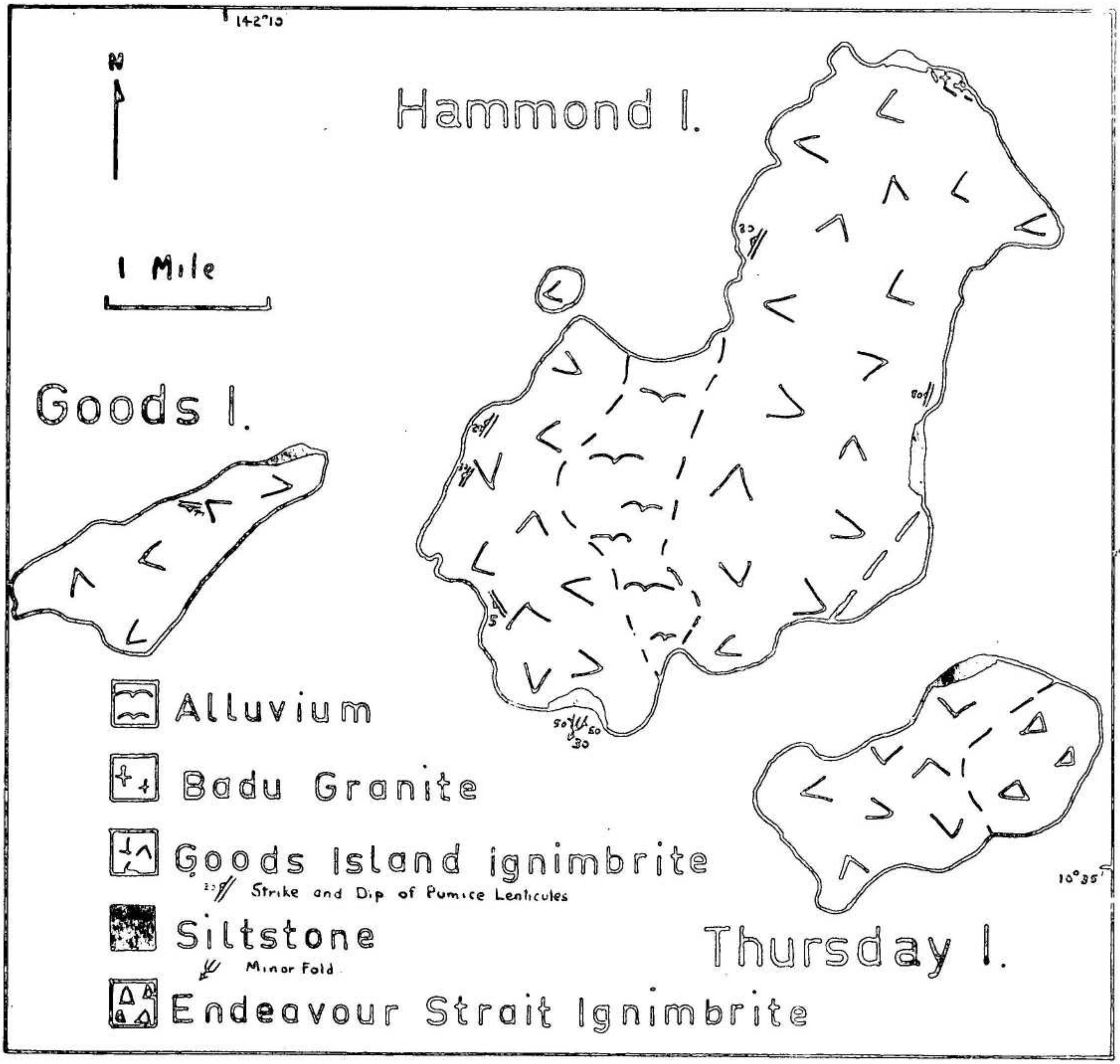


Fig.6. Distribution of sediments within Goods I. Ignimbrite

Muralug Ignimbrite

The Muralug Ignimbrite is composed of massive acid welded tuff, containing phenocrysts of quartz and dark pink feldspar set in a medium-grey to brownish-grey groundmass, and minor volcanic breccia, rhyolite and intermediate welded tuff. It forms the rough hilly country of Prince of Wales Island, south of a line joining Red Point and Hochepied Head, and also forms Entrance Island. Similar rocks on the Wallis Islands probably belong to this unit and have been included in it. The name is derived from Muralug, the Indigenous name for Prince of Wales Island.

In the acid welded tuff the phenocrysts are mostly small (3-4mm), and, in contrast with the other units of the Torres Strait Volcanics, generally make up only between 10 to 20 percent of the rock, although they are slightly larger and more abundant on the Wallis Islands. Euhedral quartz and subhedral alkali feldspar crystals are present in approximately equal proportions; the feldspar in most specimens is probably anorthoclase. Minor plagioclase is present in some places as smaller broken grains. A few clumps of chlorite, biotite, opaque minerals, and a carbonate mineral are present in some specimens, pseudomorphing crystals which were either amphibole or plagioclase.

The groundmass is devitrified to a structureless microcrystalline intergrowth of quartz and feldspar with, in some specimens, small flecks of chlorite or mica. Devitrified glass shards are still visible in many specimens, and are best seen in plane polarised light. In the specimens examined they are only moderately compacted and welded. On Red Wallis Island, the groundmass has been recrystallized to a fine-grained mosaic of quartz, feldspar, biotite and opaque minerals.

Compressed pumice fragments are common and generally range up to 2 inches long, although some elongate fragments up to 1 foot long were seen. In some outcrops the pumice is very abundant; in others it is rare or absent. The fragments are completely devitrified to an intergrowth of quartz, feldspar, pale green chlorite and carbonate. Some of the larger pumice fragments have phenocrysts included in them. The planar structure defined by the orientation of the pumice fragments is flat lying or dips gently in the southwest of Prince of Wales Island, but along the northern coastline the structure is vertical or dips steeply to the south and southwest. Rare fragments of devitrified acid glassy rocks containing quartz phenocrysts are present in places, and a few basic rock fragments less than 3 inches long were seen in some outcrops. Rock fragments are more common than usual on the Wallis Islands; on the group of rocks 2 miles south of Woody Wallis Island they make up 10 percent of the rock.

The Muralug Ignimbrite probably consists of a number of welded ash-flow tuff sheets of similar composition, but in only a few places has more than one sheet been recognized. Probably over much of Prince of Wales Island only one massive welded tuff sheet at least 500 feet thick is present. However, on the southeast corner near Rattlesnake Point and on Turtle Island a bed of volcanic breccia 150 feet thick occurs in the welded tuff, showing that at this locality there must be at least two sheets of welded tuff (Fig.7). The volcanic breccia is composed of sub-rounded to sub-angular boulders of welded tuff and flow-banded rhyolite set in a tuffaceous matrix. The boulders are mostly between 6 inches and 2 feet across, but they range up to 6 feet across. The volcanic breccia dips southeastwards at 30° to 40°; on nearby Entrance Island, and immediately opposite on Prince of Wales Island, it is represented by a confused zone of flow-banded rhyolite and volcanic breccia.

On Woody Wallis Island a number of thin sheets of welded tuff are apparently present. Most are similar to the welded tuff of Prince of Wales Island, but one is composed of dark greenish-grey welded tuff and contains abundant white feldspar and quartz phenocrysts. A bed of agglomerate composed of blocks of flow-banded rhyolite up to 1 foot across set in a tuffaceous matrix is also present.

Along the northeastern margin of the Muralug Ignimbrite on Prince of Wales Island a number of separate thin sheets of welded tuff have been recognized. They probably underlie the main massive welded tuff to the west, and are similar to it in composition, except for one sheet of dark-grey welded tuff which is probably intermediate in composition. This rock contains more than 70 per cent of small fragments of crystals of plagioclase, alkali feldspar and ferromagnesian minerals, set in a devitrified groundmass with a streaky texture that may indicate densely welded glass shards were originally present.

On aerial photographs the thin sheets of welded tuff appear vertical and occur on a prominent linear feature that may indicate a fault. On a continuation of this line just south of Red Point a breccia present in the welded tuff may in fact be a fault breccia. The linear feature or fault separates the Muralug Ignimbrite from the Endeavour Strait Ignimbrite; the steep dips of the sheets of welded tuff may suggest it is a bounding fault of a cauldron subsidence area (cf. Branch, 1966, p.19). The steep dips of the structure defined by pumice fragments along the northwestern coast of Prince of Wales Island may indicate the northern edge of the cauldron subsidence area was nearby.

The relationships between the Muralug Ignimbrite and other units of the Torres Strait Volcanics are uncertain. As described the rocks of the unit may have formed in a cauldron subsidence area which cuts, and is therefore younger than, the Endeavour Strait Ignimbrite.

Relationships Between the Four Ignimbrite Units

The structural relationships and relative ages of the four welded tuff units are not well known. Around Cape York the Eborac Ignimbrite is relatively flat; it appears to have a fairly abrupt contact with the Endeavour Strait Ignimbrite to the west. On

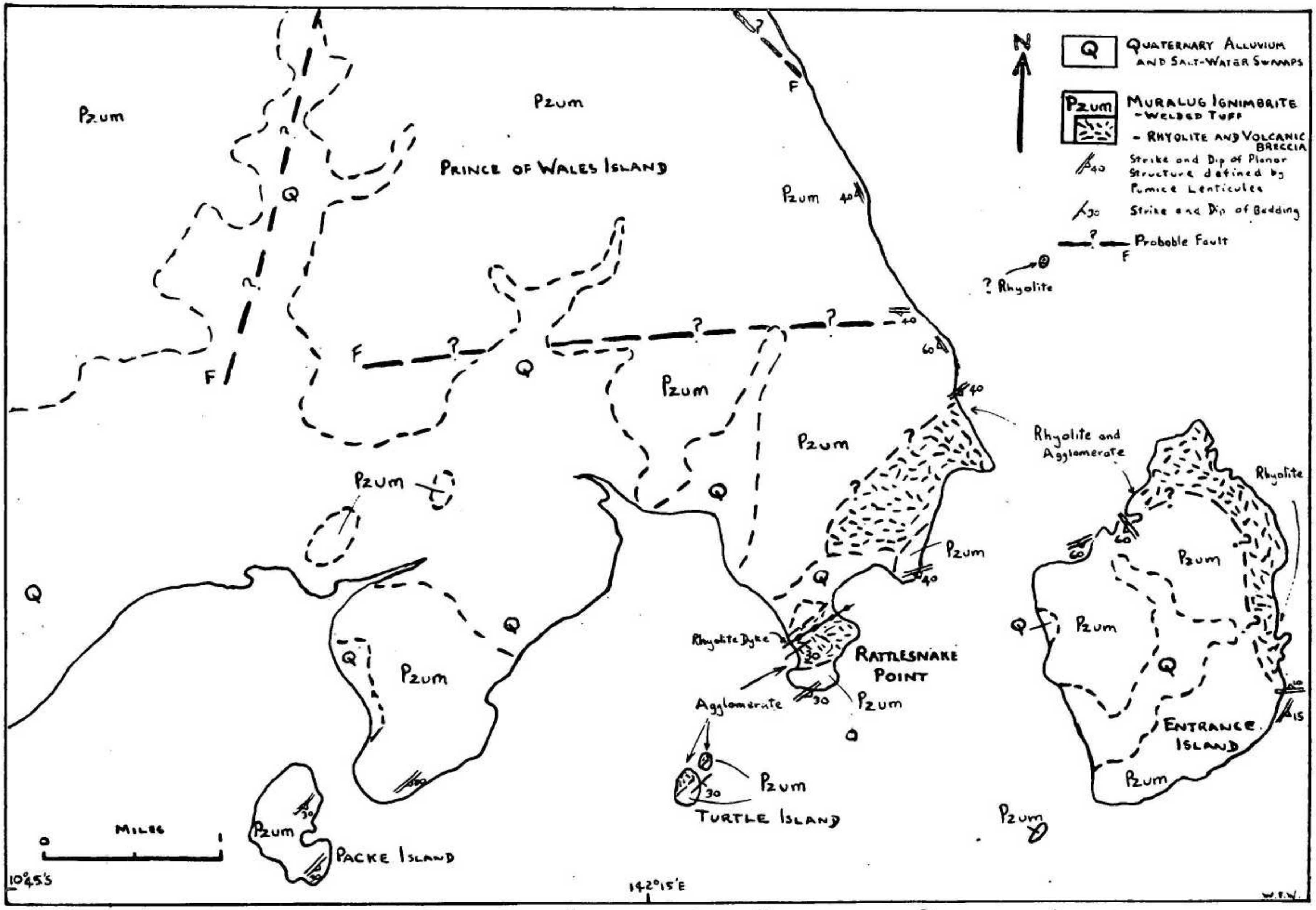


Fig. 7. Geological Map South-East Prince of Wales Island and Entrance Island

some islands in Endeavour Strait this latter unit dips at moderate angles to the northwest, and consequently is thought to overlie the Eborac Ignimbrite. The junction between the two units may be marked by agglomerate, and flows of andesite and rhyolite. The contact between the Endeavour Strait Ignimbrite and the Goods Island Ignimbrite is probably gradational; presumably the successive individual welded tuff sheets gradually changed in composition. On the west coast of Hammond Island the Goods Island Ignimbrite appears to dip to the northwest, and consequently may be overlying the Endeavour Strait Ignimbrite. The relationship of the Muralug Ignimbrite to the other units is uncertain; it has a faulted contact with the Endeavour Strait Ignimbrite on its northeastern margin, but no other contacts are exposed. It may have formed in a cauldron subsidence area cutting the Endeavour Strait Ignimbrite.

Undivided Torres Strait Volcanics

Areas of pyroclastic rocks of the Torres Strait Volcanics which cannot be assigned to the four ignimbrite units discussed above occur in the northern part of Torres Strait. In many of the areas, including the largest on Moa Island, the pyroclastics have been intruded and hornfelsed by later granitic rocks. The recrystallized and hornfelsed rocks are described separately below in the section on thermal metamorphism.

West Island is composed of several sheets of welded tuff of similar composition which have been intruded by biotite granite, aplite, and porphyritic microgranite dykes. The welded tuffs have a dark grey to black groundmass which contains small fragments of plagioclase, quartz and minor alkali feldspar crystals 2 to 4 mm across which together form between 10 and 40 percent of the rock. Some plagioclase fragments are altered to carbonate and chlorite. The groundmass is devitrified to very fine-grained quartz and feldspar, and contains a few small patches of chlorite and opaque minerals. In plane-polarized light poorly preserved devitrified glass shards are still visible in places and appear to be moderately or densely welded. Devitrified pumice fragments and fragments of devitrified glassy rocks are present in places. In one specimen, a fragment ½ inch in length composed of large plagioclase and hornblende(?) crystals was seen. The hornblende(?) is altered to chlorite, carbonate and opaque minerals. The fragment is similar to others seen in the Goods Island and Endeavour Strait Ignimbrites. At one outcrop a sheet about 12 feet thick of light coloured welded tuff containing abundant long stretched pumice fragments is interbedded with the dark welded tuff. The two types of welded tuff merge with each other at the contact, suggesting they were welded together in a compound cooling unit. On the northwest side of the island a sheet of volcanic breccia composed of angular fragments of white or pale pink welded tuff set in a tuffaceous matrix, is also interbanded with the welded tuff sheets.

The welded tuffs of West Island are similar in appearance, and probably in composition, to those of the Goods Island Ignimbrite on Hammond and Goods Islands, but the distance between the two areas makes any correlation uncertain.

On the northeast side of Badu Island a small body of pyroclastics is included within granite. Near the contact the pyroclastics are slightly recrystallized but generally they are not thermally metamorphosed. Varying rock types indicate that a number of sheets or beds are present; the two main types are brown welded tuff containing small (1mm) fragments of quartz and feldspar crystals and abundant fragments of pumice, and black welded (?) volcanic breccia or xenolith-rich acid lava. The (?) volcanic breccia contains a few small (2 mm) fragments of quartz crystals and abundant angular fragments of welded tuff up to 1½ inches in length. Devitrified glass shards are present in the welded tuff fragments; in some they are densely welded, but many are only moderately welded. The groundmass of the breccia is microcrystalline and is faintly flow banded; glass shards are not present.

The southern end of Mabuiag Island is composed of massive pinkish-grey welded tuff containing abundant phenocrysts of quartz and alkali feldspar forming between 30 and 40 percent of the rock. The phenocrysts appear to have been fractured and broken; they range in size from 5 to 8 mm. The alkali feldspar is probably anorthoclase. The groundmass is devitrified to a microcrystalline intergrowth of quartz and feldspar and is generally structureless. However, in places in plane-polarized light faint outlines are visible which may have been glass shards. Lithic fragments are absent except in one or two outcrops where a few rhyolitic fragments, up to 1 inch long, and one basic fragment are present. Pumice is also absent except in one outcrop where a number of leucocratic bands 5 feet long and 2 inches wide may represent large compacted and stretched pumice fragments. The welded tuff has some resemblance to welded tuff of the Endeavour Strait Ignimbrite, but the distance is too great to allow correlation. It has been intruded by the Badu Granite, by a body of porphyritic microgranite, and by rhyolitic and basic dykes, but shows little evidence of recrystallization. Even right at the granite contact, which is exposed on the southern coast of the island, the welded tuff appears unrecrystallized. The contact is very sharp, with no faulting or brecciation; the granite has a chilled margin about 1 inch wide.

The southeastern half of Gabba Island is composed of dark grey welded tuff containing small white feldspar phenocrysts, fragments of pumice, and abundant lithic fragments. The feldspar phenocrysts weather to a dark pink colour and are probably anorthoclase. They make up between 10 and 20 percent of the rock and range up to 2 mm in size. Quartz phenocrysts are rare. The groundmass is only very finely devitrified and incipiently welded glass shards are still clearly visible. The lithic fragments form up to 30 percent of the rock and are generally between ½ and 1 inch in length, but in places they range up to 6 inches. Most of the fragments are composed of devitrified welded tuff and rhyolite, but a few fragments of basic rocks are also present. A few small fragments of pumice up to 10 mm long are present in most specimens, and in places larger fragments up to 1½ inches are abundant. In the north of the island the welded tuff is intruded by the Badu Granite and is hornfelsed for about 15 feet from the contact.

Saddle Island is composed of two types of welded tuff. Light-grey, fine-grained, incipiently-welded tuff lacking phenocrysts forms the the westernmost hill. It is composed of very small angular fragments of quartz and feldspar, which make up 40 percent of the rock, set in a devitrified groundmass of very fine-grained quartz and feldspar. Many patches are altered to carbonate minerals. In plane-polarized light glass shards are still visible and appear to have formed the bulk of the groundmass. They are uncompressed and retain their original shape. Small devitrified fragments of other pyroclastic rocks are present in places. At some outcrops a few large blocks up to 2 feet across of black, fine-grained siltstone are present in the welded tuff. In the larger blocks bedding is still visible in the siltstone which has been hardened or slightly recrystallized. The siltstone was probably derived from volcanic material and is similar to siltstone exposed on Hammond Island.

Greenish-grey welded tuff containing abundant quartz and feldspar phenocrysts up to 5 mm in size forms the eastern half of the island and overlies the welded tuff described above. In some localities pumice fragments are abundant and in places the rock contains large blocks of dark, very fine-grained siltstone similar to those in the underlying welded tuff. The contact between the two types of welded tuff dips gently to the southeast. The welded tuff in the eastern half of the island has a very strong resemblance to welded tuff of the Endeavour Strait Ignimbrite, but although the two may be contemporaneous, the intervening distance is too great for correlation.

Harvey Rocks are composed of massive greenish-grey welded tuff containing abundant phenocrysts of quartz, alkali feldspar, and plagioclase set in a structureless devitrified groundmass. No pumice or rock fragments are visible in hand specimens, but under the microscope a few small devitrified pumice fragments were seen. The rock is similar to that on the eastern end of Saddle Island and to welded tuff of the Endeavour Strait Ignimbrite.

To the north of the Oriomo area of southwest Papua, rhyodacite and pyroclastics have been encountered in the Iamara and Wuroi oil wells (Fig.13), as basement to the overlying Mesozoic and Tertiary sediments, (Oil Search, 1963, 1965). These volcanics may indicate that Carboniferous to Permian acid volcanism extended a considerable distance north of Torres Strait.

Thermal Metamorphism

Across the width of Torres Strait the volcanics have been intruded and thermally metamorphosed by later granitic rocks. The main areas of recrystallized and hornfelsed rocks are shown in Fig. 8; small patches of hornfels also occur on the west coast of Dauan Island, and at Augaramuba Point and Marakara Island near Mabaduan on the Papuan coast (Fig. 9).

The rocks range from recrystallized welded tuff in which there is no major mineralogical change to hornfels containing garnet, andalusite or cordierite. The recrystallized welded tuff has a blastoporphyritic texture with only a general coarsening of the groundmass. Most hornfels is granoblastic, but a few corroded phenocrysts survive in some specimens. Most hornfels has the assemblage biotite-muscovite-feldspar-quartz which is indicative of the albite-epidote hornfels facies or lower hornblende hornfels facies of contact metamorphism (Turner and Verhoogen, 1960). The highest grade of metamorphism is represented by assemblages containing andalusite, cordierite or garnet; these belong to the hornblende-hornfels facies. In many places the hornfels has a weak foliation defined by thin layers of biotite. At one locality recrystallized but undistorted pumice fragments parallel this foliation, which thus is likely to result from a primary flow or pyroclastic structure which has been emphasized on recrystallization.

On Horn Island (Fig.10) hornfels occurs in a narrow strip along the south and east coasts, where it partly surrounds a body of porphyritic microgranite which intrudes it. There is a general decrease in degree of recrystallization from east to west, where it appears to pass into unmetamorphosed welded tuff of the Endeavour Strait Ignimbrite.

The least affected rocks are in appearance identical to the welded tuff of the Endeavour Strait Ignimbrite, but thin sections show that the groundmass has been considerably coarsened. With increasing metamorphism these rocks pass into medium-grained pink hornfels still preserving the larger quartz and feldspar phenocrysts, which are however, considerably corroded by the groundmass. Elongate fine-grained aggregates of ragged biotite give the rock a streaky appearance. In the southeast and east fine granoblastic hornfels is exposed. This consists of quartz (40%) and andalusite (40%) together with small amounts of microcline, biotite, muscovite, garnet, and hercynite spinel. Irregular and ill-defined patches of banded mica-rich rock are interspersed in the hornfels. In places on the south coast the hornfels and small intrusive patches of porphyritic microgranite have been hydrothermally altered and penetrated by quartz veins.

Recrystallized welded tuff is found on the east coast of Prince of Wales Island between Red Point and Heath Point. The extent of recrystallization decreases to the west.

Near Turtle Head on Hammond Island, welded tuff and tuffaceous and carbonaceous siltstone of the Goods Island Ignimbrite have been thermally metamorphosed. The welded tuff has been little affected; the groundmass has been coarsened and the phenocrysts are corroded around the margins. The matrix of the siltstone however has been finely recrystallized and is dotted with small elongate aggregates of randomly orientated muscovite flakes. A small exposure of Badu Granite is found near Turtle Head but does not appear to have been responsible for the metamorphism as there is no increase in metamorphism towards the contact. However, it is possible that the granite underlies the hornfels to the west of the contact.

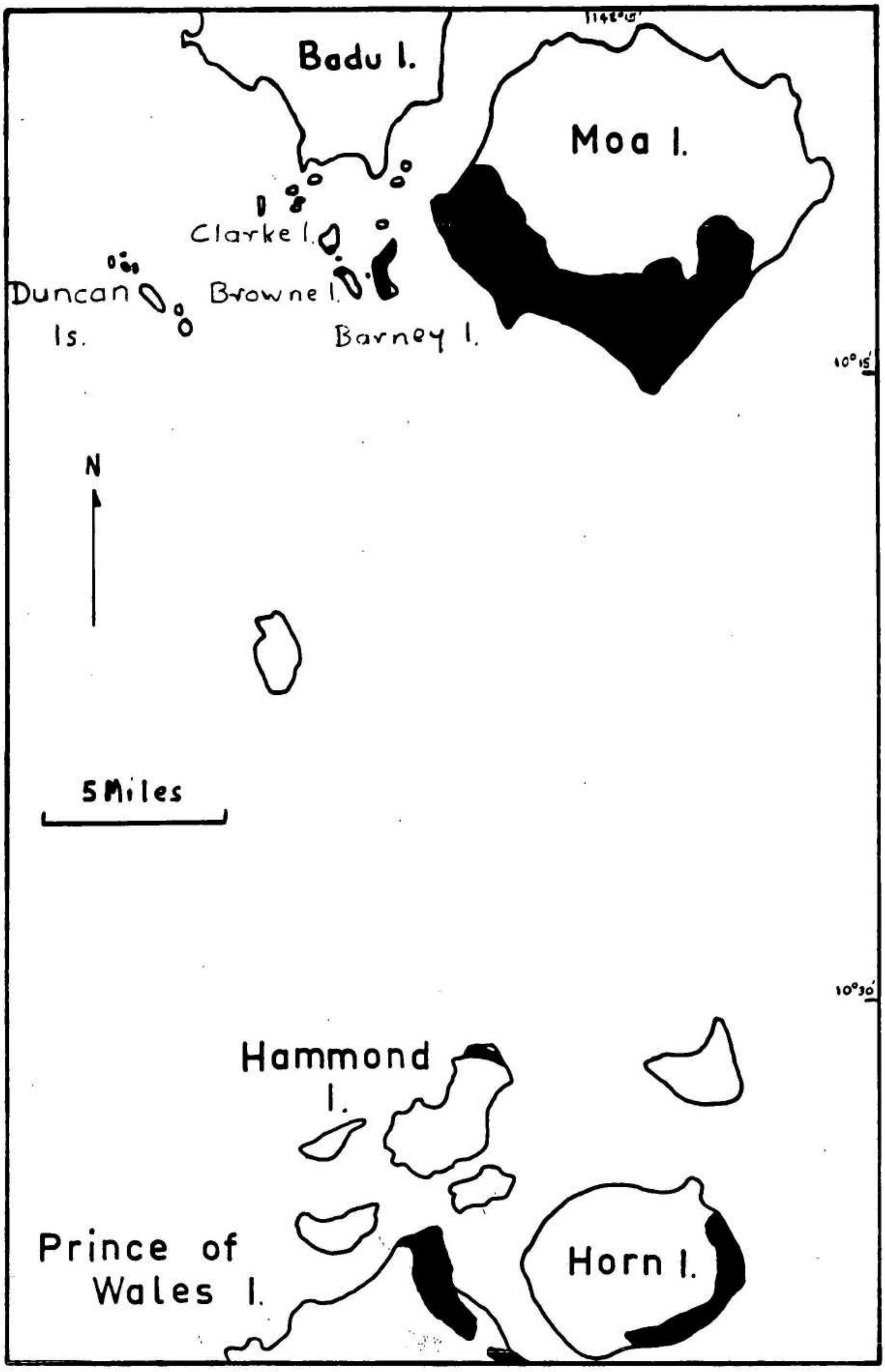


FIG 8. MAIN OCCURRENCES OF RECRYSTALIZED WELDED TUFF AND HORNFELS, TORRES STRAIT

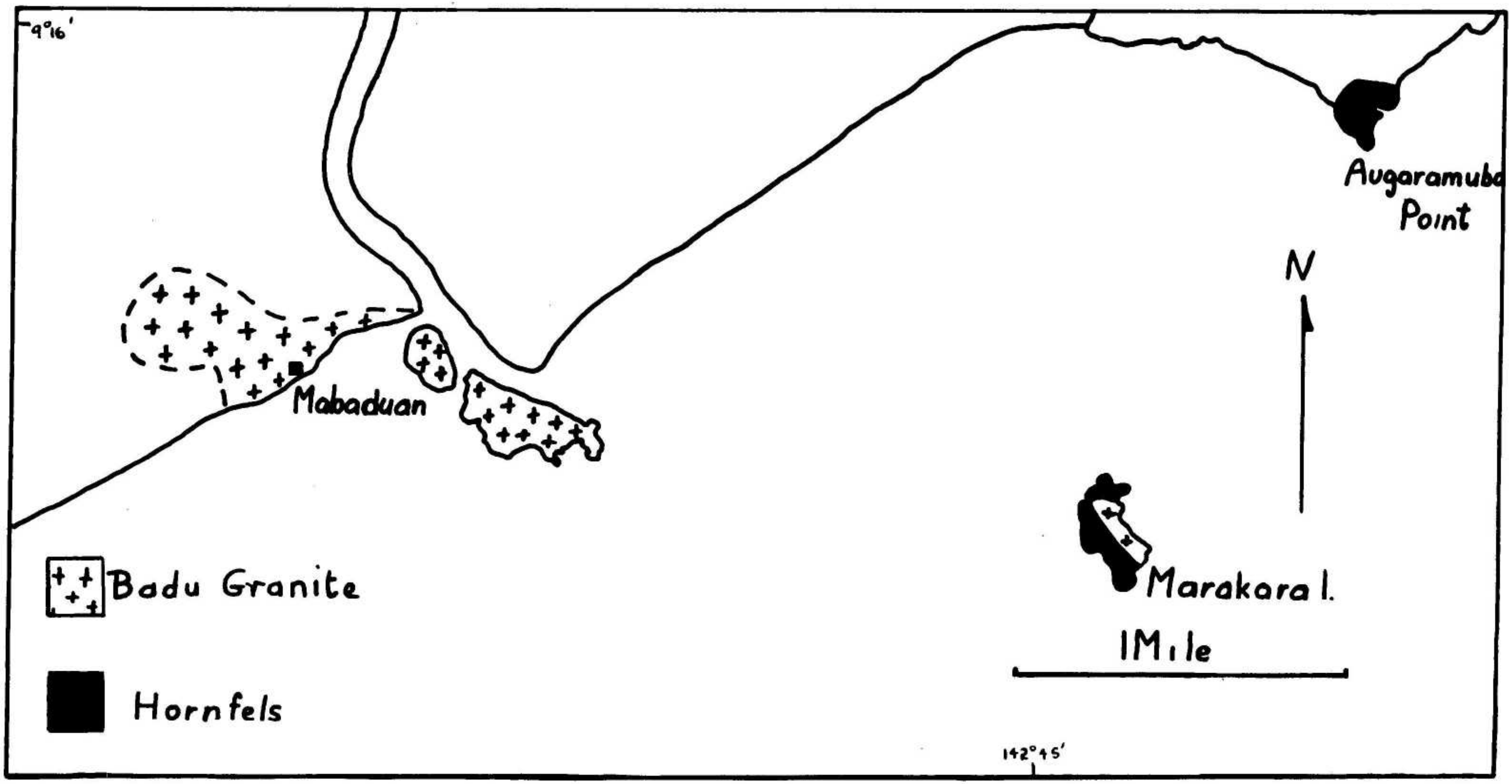


Fig 9. Distribution of Hornfels Mabaduan, Papua

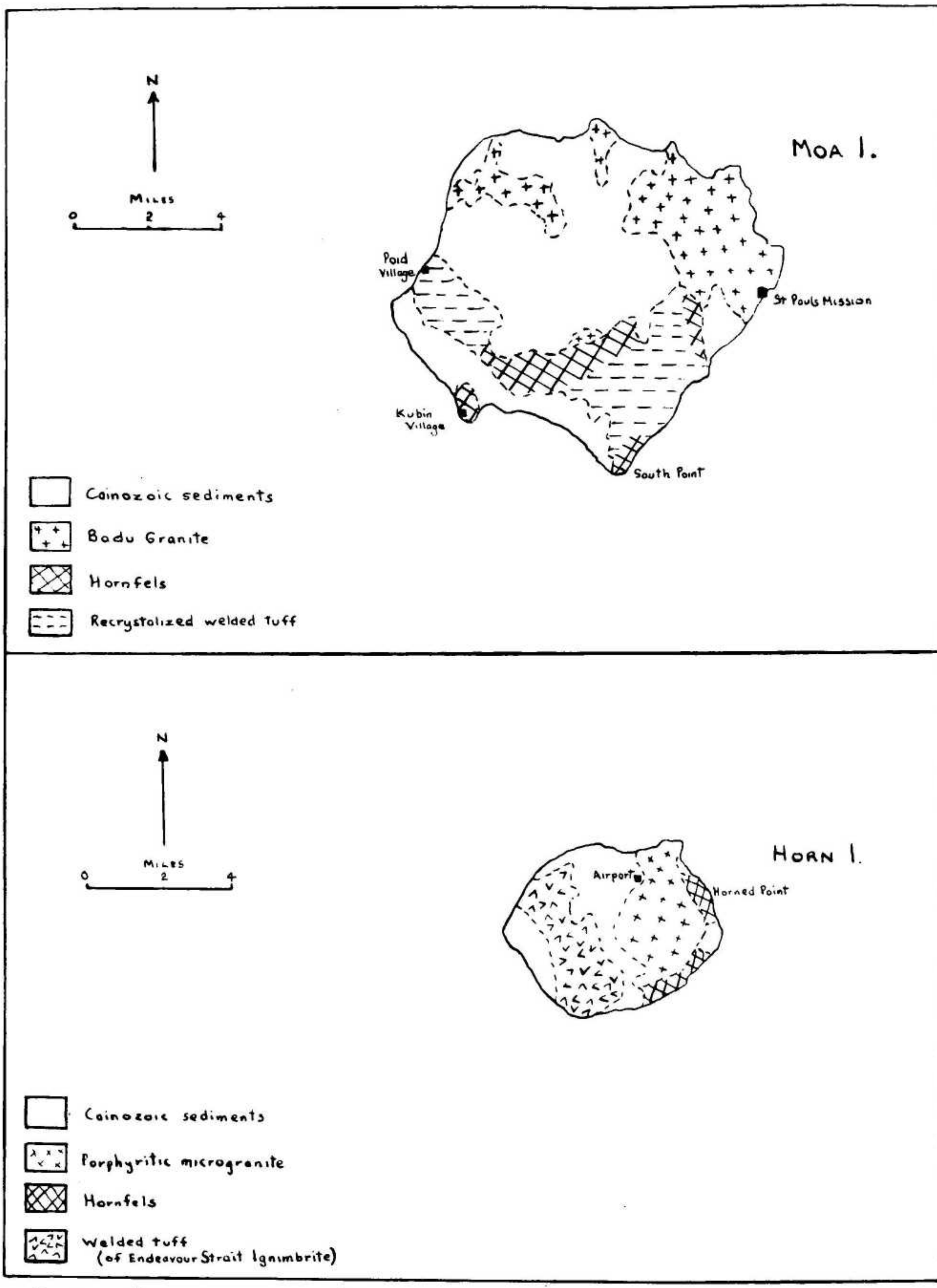


FIG 10. DISTRIBUTION OF RECRYSTALLIZED WELDED TUFF AND HORNFELS, MOA AND HORN IS.

Recrystallized welded tuff and hornfels form the southern half of Moa Island and are bounded on the north by Badu Granite. The bulk of the volcanics have been recrystallized but do not possess a new mineral assemblage. They contain corroded quartz and feldspar phenocrysts set in a fine quartzo-feldspathic groundmass. Some specimens have a small amount of muscovite and biotite as small aggregates within the groundmass. At Poid village, near the contact with the Badu Granite, the phenocrysts have been completely replaced by a mosaic of quartz and feldspar.

With an increase in metamorphic grade adjacent to some granite contacts (Fig.10) the rocks are thoroughly recrystallized to hornfels containing mica, garnet, andalusite and cordierite. The mica in places forms aligned elongate aggregates up to 15 mm in length which define a weak foliation. The most intensely metamorphosed rocks, containing knots of mica and andalusite, occur on the coast to the northeast of South Point, and adjacent to the granite contact west of St. Pauls Mission. These rocks are blastoporphyritic, containing remnants of phenocrysts of quartz and feldspar together with porphyroblasts of andalusite, muscovite, and biotite which are set in a fine groundmass of cordierite, quartz, and feldspar. The andalusite porphyroblasts range up to 5 cm in size. They tend to be ovoid and are roughly aligned and concentrated in bands up to 4 feet in width. The hornfels is considerably fractured and sheared along faults and is cut by a number of small ptygmatic quartz veins, or feldspar-quartz pegmatite veins.

Barney Island, which lies to the west of Moa Island, is formed by medium-grained light-grey hornfels, except for a small exposure of Badu Granite in the southeast. The hornfels consists dominantly of quartz and feldspar, together with a small amount of muscovite and biotite which is concentrated in bands up to 2 inches in width, and which defines a poorly developed foliation. In the southwest the hornfels is blastoporphyritic, containing feldspar phenocrysts up to 5 cm. in length which are aligned to form a weak lineation. In the north large recrystallized but undistorted pumice lenticules 6 inches in length parallel the foliation. The hornfels is cut by veins and dykes of muscovite-granite, pegmatite, and aplite.

The hornfels on Browne Island is a fine-grained muscovite-feldspar-quartz rocks which in places contains rounded aggregates of tourmaline 2 mm in diameter. Less common is weakly foliated biotite-bearing hornfels.

Hornfels also crops out on the south coast of Clarke Island and on the small island immediately to the southeast. The bulk of the hornfels is fine-grained, dark grey, and is composed mainly of quartz and feldspar with minor amounts of biotite and garnet. In places bands alternately rich in biotite and in quartz and feldspar define a foliation (Plate 3). Near the granite contact the banding is more pronounced; some biotite-rich bands contain patches up to 6 inches in size composed entirely of biotite and garnet. The banded hornfels is penetrated by small granite dykes.

Recrystallized welded tuff

occurs on two small islands north of Wilson Island in the Duncan Islands. On the larger and southernmost island fine or medium grained welded tuff is in contact with a body of pink granite (Plate 4). The original quartz and feldspar phenocrysts have been corroded during the development of a fine grained granoblastic groundmass. Similar rocks crop out on the smaller island to the northwest.

Recrystallized welded tuff and hornfels are found over a distance of several hundred yards on the west coast of Dauan Island. The bulk of the welded tuff retains the original porphyritic texture and rock fragments can be recognized in a few places, although the groundmass has been recrystallized. Small aggregates of biotite are common. Towards the granite the welded tuff becomes progressively finer and more even grained, and within a few feet of the contact it is a fine grained dark-green hornfels consisting of quartz (60%) and cordierite (40%), with accessory amounts of biotite and muscovite.

Small patches of hornfels are found near Mabaduan on the south coast of Papua (Fig.9). The main exposure is on Marakara Island 2½ miles east-southeast of Mabaduan Village, where welded tuff has been recrystallized to a grey, medium-grained, granoblastic, or weakly foliated hornfels. The foliation is defined by aligned elongate fine-grained aggregates of biotite. Garnet porphyroblasts up to 5 mm in size are common. Dykes of pegmatite, aplite and irregular pods of quartz cut the hornfels and are especially prevalent near the granite.

Similar metamorphics are found at Augaramuba Point 3½ miles northeast of Mabaduan. Here a well developed foliation has formed with the alignment of biotite aggregates and feldspar porphyroblasts. The rock is cut by small granite-pegmatite veins.

Origin of Thermal Metamorphism

On the northern islands of Torres Strait and at Mabadnan it is clear that the Badu Granite has been responsible for the metamorphism of the volcanics; the hornfels is in contact with the granite, and the highest grade of metamorphism is found at or near the contact. However, on Hammond, Horn, and Prince of Wales Islands there is no unequivocal source of heat. On Horn Island the hornfels flanks the southern and eastern margins of an intrusion of porphyritic microgranite and has probably been metamorphosed by this body. However, there are no intrusive rocks exposed on Prince of Wales Island which could account for the recrystallized rocks exposed there. It is possible that a mass of porphyritic microgranite or possibly Badu Granite underlies the strait between Prince of Wales and Horn Islands. The hornfels on Hammond Island is near a small exposure of Badu Granite which probably underlies the hornfels at depth and has been responsible for the metamorphism and mineralization in this area.

Plate 3. Banding developed in hornfelsed volcanics near granite contact on Clarke Island.

Plate 4. Contact of hornfelsed volcanics (foreground) with granite, Duncan Islands.

Alteration and Mineralization

In many places the Torres Strait Volcanics have been altered to pale green, purple, or white rocks in which the original textures are destroyed. Most of the alteration has occurred in irregular patches in a zone extending from Goods and Hammond Islands through Horn Island and Endeavour Strait to the vicinity of Peak Point on the mainland (Fig.11). Small areas of alteration also occur on Booby Island, West Island, Black Rock (north of Moa Island), Mabuiag Island and Ninepin Rock. In places a gradation can be seen between the altered material and unaltered rock, but in others the contact between the two is sharp. In rocks where alteration is only slight, quartz and feldspar phenocrysts, and pumice and lithic fragments, are still visible, but in the intensely altered rocks only the quartz phenocrysts can be recognized.

The alteration appears to have taken place by the replacement of the feldspar phenocrysts and the feldspar in the groundmass by a clay mineral. In the more intensely affected areas the alteration has been accompanied by fracturing, silicification, and penetration by quartz veins, averaging about 2 inches in width. The quartz veins are closely spaced and intersect to form irregular boxworks which are more resistant to weathering than the surrounding altered rock. Large lodes of quartz also penetrate the areas of alteration; some are formed by zones of closely spaced small quartz veins, but others, such as that forming the hill behind Horned Point on Horn Island, are single large intrusive bodies.

In many places the alteration of the volcanics has been accompanied by minor mineralization. Commonly it is only seen as malachite, azurite, and limonite staining on the weathered surface and in the penetrating quartz veins, but in some areas the ore minerals are more abundant and conspicuous. On Horn Island pyrite, galena, and chalcopyrite were recognized; gold has been mined in the past, and wolfram has been reported. On Possession Island pyrite, galena and malachite were seen, and gold has been worked in the past. A few miles southeast of Peak Point cassiterite associated with pyrite and other sulphides is present in the altered welded tuff. The ore minerals generally occur in small amounts in the penetrating quartz veins, but in places they are present in thin stringers unaccompanied by quartz, between 1/16 inches and 2 inches wide, which cut the altered country rock.

The alteration and mineralization have probably resulted from late stage hydrothermal activity associated with the intrusive granitic rocks, probably mainly the porphyritic microgranite. On the southern coast of Horn Island, hornfels derived from thermal metamorphism of the volcanics, a large body of intrusive porphyritic microgranite, and a rhyolite dyke which cuts the hornfels, have all been altered.

Age and Regional Relationships

The Torres Strait Volcanics are thought to have been extruded during a period of (?) Upper Carboniferous acid vulcanism, that occurred over an area of at least 200 square miles stretching from south of Cape York to at least as far as the Papuan Coast. If they are Carboniferous they form part of an extensive province of continental acid vulcanism which developed in northern Queensland in Middle to Upper Carboniferous times. This province is now known to extend as far south as Mackay and Mount Coolon and includes the volcanics near Iron Range in northeast Cape York Peninsula (Trail et al. 1969); the volcanics developed in many cauldron subsidence areas and ring complexes in the Georgetown Inlier (Branch, 1966); the volcanics in the coastal strip from Cairns to north of Townsville (de Keyser, 1964, 1965; Wyatt et al., 1969); and the Bulgonunna Volcanics southwest of Bowen and Mackay. (Malone et al., 1964, 1966, Paine et al., in prep.).

While all these volcanics are approximately the same age, differences exist in the rock types which predominate in the various areas. In the volcanics of the Georgetown Inlier, the majority of the rocks are massive rhyodacite welded tuffs containing only small quantities of phenocrysts. Near Iron Range in the Janet Ranges Volcanics, Kangaroo River Volcanics, and Cape Grenville Volcanics flow-banded rhyolite and pumice-rich welded tuff are the most common rock types. The Torres Strait Volcanics are composed predominantly of crystal-rich welded tuffs.

The relation of the Torres Strait Volcanics to the Badu Granite is uncertain. The volcanics may be co-magmatic with the granite or the granite may be considerably younger. If co-magmatic, it is perhaps likely the volcanics are not Carboniferous but Permian, as an Upper Permian date has been obtained from granite basement in the Aramia No.1 bore, 150 miles north of Torres Strait in Papua (Harding, 1966).

PERMIAN(?)

Permian(?) intrusive rocks in the Torres Strait area consist of three units: 1. The Badu Granite, which varies from granite to granodiorite in composition and which is exposed north of latitude 10°30'S. 2. Four bodies of porphyritic microgranite, three of which intrude the volcanics in the southern part of the area, 3. Acid and intermediate dyke rocks, which are most numerous in the Badu Granite.

All the intrusive rocks appear to belong to the same intrusive episode and post-date the Torres Strait volcanics.

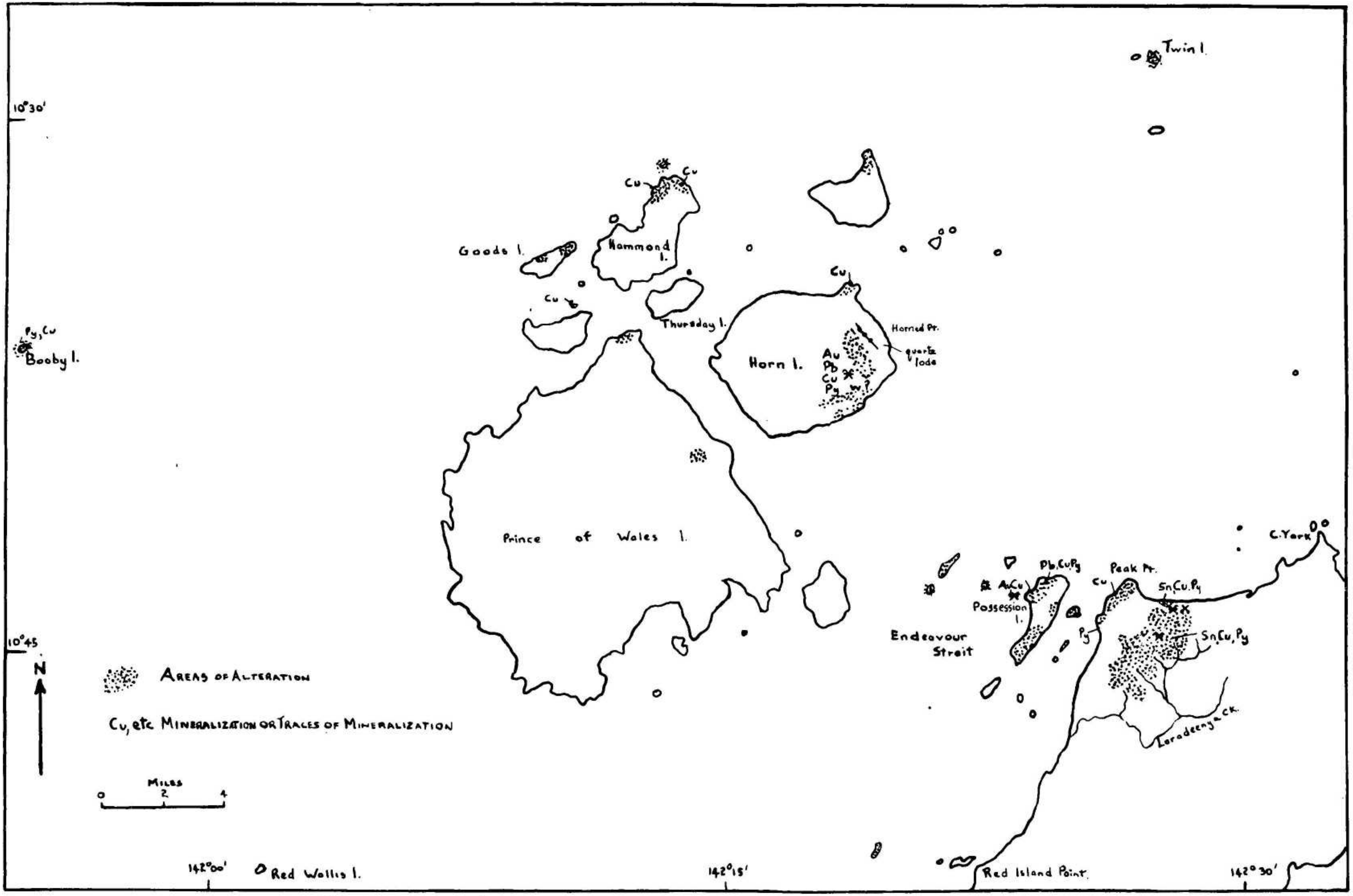


Fig. 11. Areas of Alteration, and Accompanying Mineralization, Torres Strait Volcanics

Badu Granite

The Badu Granite forms all or part of many of the islands of Torres Strait north of 10°30'S. latitude, and also crops out at Mabaduan on the Papuan coast. The total area of outcrop is about 100 square miles, principally on Badu and Moa Islands. The name Badu Granite is used collectively for a number of granitic types which are thought to be of a similar age. The name is taken from the third largest island in Torres Strait, Badu Island, which is situated approximately 50 miles northwest of Cape York.

The granite intrudes and has recrystallized acid volcanics of the Torres Strait Volcanics, and is high-level in character. To the north of the area mapped it is overlain by Mesozoic and Tertiary sediments of western Papua, but granite basement which may be similar to the Badu Granite was met in four wells drilled for petroleum in this region. Biotite granite was encountered at 6614 feet in the Aramia No.1 well; pink granite was met at 9750 feet in Komewu No.2; weathered granite was met at less than 2000 feet in the Oriomo wells and at 4406 feet in the Mutare No.1 well (see Fig. 13, A.P.C., 1961, Oil Search, 1964).

The principal rock type is biotite granite, but adamellite and minor granodiorite also occur; some specimens are hornblende-bearing. The granite is generally well exposed, especially along the coasts of Badu and Moa Islands and on the many smaller islands. On Moa Island the granite forms peaks up to 1300 feet high in the northeast of the island, but is partly covered by superficial deposits in the centre of the island. The coastal exposures, as wave-eroded pavements or as piles of boulders, are generally very fresh although the more deuterically altered leucocratic granites (e.g. on Badu Island) are susceptible to subaerial weathering.

Lithology and Petrography

The Badu Granite includes many different rock types which differ texturally and compositionally from one another. Because of this, and of the scattered nature of the outcrop, the various rock types are difficult to describe as a unit. However, there are sizeable areas in which the Badu Granite is fairly homogeneous; in these the main rock types recognized are leucocratic biotite granite, porphyritic biotite granite, and hornblende-biotite adamellite and granodiorite (Fig.11A).

Leucocratic biotite granite. The greater part of Badu Island and nearby small islands to the southwest, west and north, and islands near Mabuiag Island are composed of leucocratic biotite granite with minor hornblende in places. The colour varies from cream to shades of pink and red. The deeper colours are generally a surface feature only and appear to be in part due to weathering of the feldspar. The rock varies in grainsize from very fine grained to coarse grained. It is generally porphyritic in quartz and to a lesser extent in potash feldspar. Small miarolitic cavities partly infilled with quartz and potash feldspar, and aplitic patches are found in places in the finer grained zones of the granite.

Quartz (30% to 40% of the rock) is generally anhedral in thin section and may be a little embayed. It is almost everywhere intergrown with potash feldspar. The intergrowth is either micropegmatitic (in the fine-grained varieties) or a coarse intergrowth (in the medium-grained or coarse-grained varieties). The potash feldspar (40% to 45%) is orthoclase microperthite. Overall it is coarser than the other minerals, and it is generally anhedral with irregular margins, though phenocrysts may tend to be subhedral. The plagioclase (20% to 25%) is sodic or calcic oligoclase which in some specimens exhibits good oscillatory zoning and narrow sodic rims, especially where the plagioclase percentage is highest. In some specimens where plagioclase is only 10 to 15 percent of the rock the potash feldspar is seen to be exsolving patches of albite.

The mafic minerals - largely biotite (1% to 5%), with some hornblende (up to 2%) are variably altered to chlorite and leucoxene. On some of the small islands east of Mabuiag Island the mafic mineral appears to have altered to quartz and iron oxide or to quartz and epidote. The mafic minerals are everywhere fine grained and form no more than 5% of the rock.

In many places the granite is cut by quartz veins up to a few centimetres thick and, in places, by narrow mylonitic zones. Pyrite occurs in accessory amounts in some exposures.

<u>On Tobin and North Possession Islands</u> and on the north coast of Moa Island the granite is similar to that on Badu Island. It is leucocratic and variable in grainsize and in places contains small dark xenoliths. It is cut by dykes of pink leucocratic microgranite.

<u>On Gabba, Cap, and Yama Islands</u> to the northeast of Moa Island, the granites are essentially of the same type as those on Badu Island. They are pink-grey to red, leucocratic, massive, medium-grained or coarse-grained rocks with scattered cream to pink orthoclase phenocrysts in places. On Yama Island there are numerous rounded, fine-grained biotite-hornblende granodiorite or tonalite xenoliths up to three feet by one foot in size. The xenoliths have been partially absorbed by the granite. Accessory pyrite, galena, and chalcopyrite are seen in the granite as small specks, often in narrow, steep micro-shears. In the western part of Gabba Island the granite, which here is almost an alaskite, has a sharp contact with unmetamorphosed welded tuff.

<u>Porphyritic biotite granite</u>. Between <u>Clarke and Hawkesbury Islands</u> the rock is a grey, medium-grained or coarse grained granite, typically porphyritic in pink feldspar. The phenocrysts are up to 15 mm in size and are subhedral or euhedral. Biotite is the only mafic mineral. The rocks are massive and poorly jointed.

Small pink aplite dykes cut the granite and contain miarolitic cavities up to 4 cm across partly infilled with quartz. Small bodies and dykes of aplite intrude volcanics on West Island. The contacts are sharp. The porphyritic granite also intrudes bodies (perhaps roof pendants) of recrystallized volcanics on Clarke and

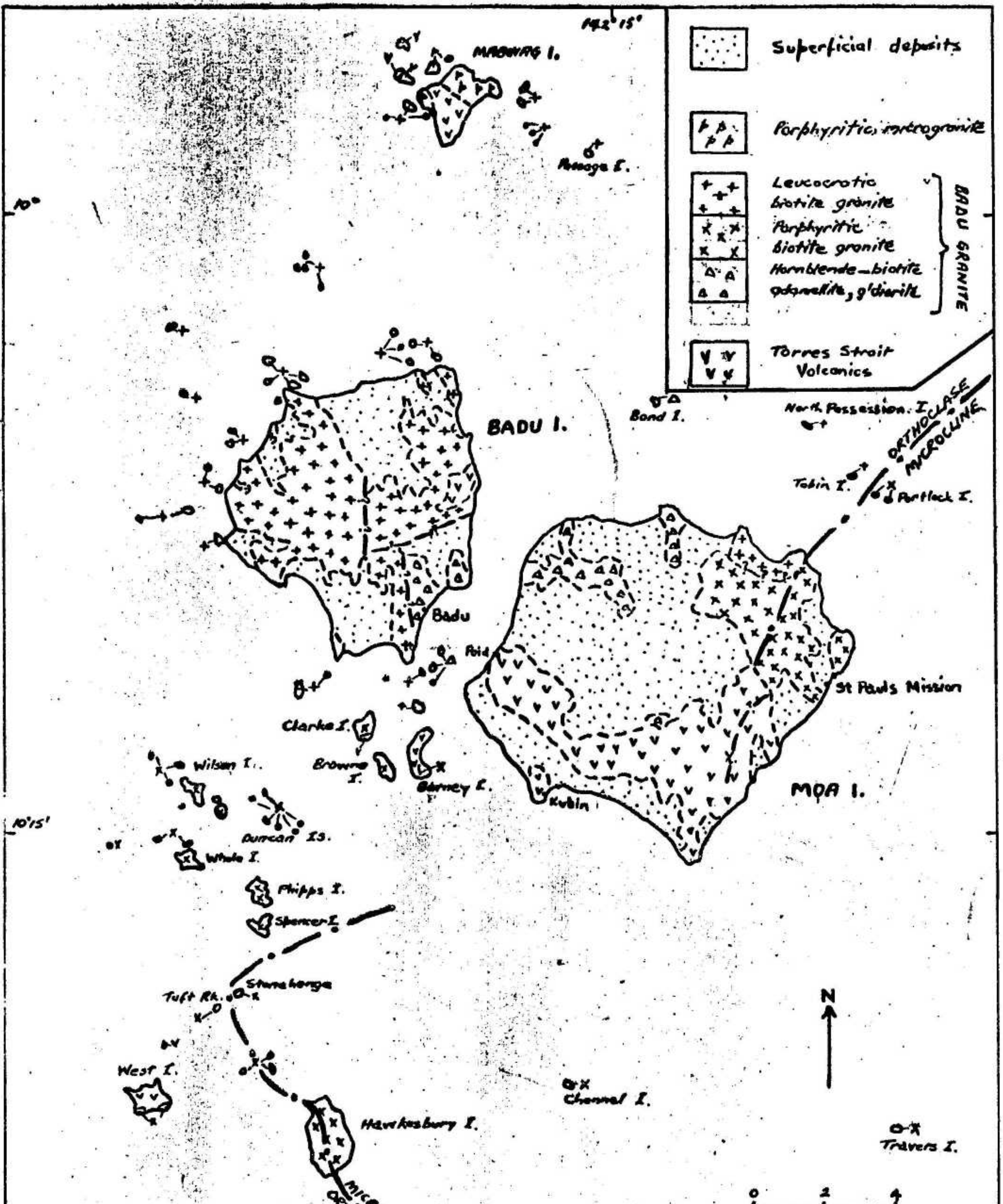


Fig. 11A BADU GRANITE — MAIN ROCK TYPES.

Barney Islands, and on two of the Duncan Islands. The granite at White Rocks, nine miles southwest of Hawkesbury, is essentially similar to the porphyritic biotite granite, although it is somewhat altered.

In thin section the porphyritic biotite granite is a coarser grained and less deuterically altered variety of the leucocratic biotite granite on Badu Island. The quartz and potash feldspar are coarsely intergrown. The potash feldspar is generally orthoclase and is in part microperthitic, although in the porphyritic granite on Stonehenge, Tuft Rock, and Hawkesbury Island it is microcline.

On the western side of Hawkesbury Island the porphyritic biotite granite is apparently intruded by an even grained biotite granite composed of small aggregates of quartz crystals and pink feldspar crystals and scattered flakes of biotite. Near the contact the even grained granite is finer grained, and biotite granite-pegmatite sheets up to 3 feet thick intrude the porphyritic biotite granite.

In the vicinity of Mount Augustus on Moa Island the rock is a grey coarse-grained biotite granite with generally pink orthoclase-microperthite phenocrysts, and is essentially similar to the porphyritic biotite granite in the Clarke Island-Hawkesbury Island area. On the western slopes of Mount Augustus small bodies of a fine-grained grey biotite or hornblende-biotite granite appear to intrude the coarser grained granite.

The granite on the eastern coast of Moa Island in the St. Pauls Mission area, and on Portlock Island is grey, medium-grained or coarse grained with pink potash feldspar phenocrysts. It is similar in hand specimen to the granite in the Clarke Island-Hawkesbury Island area, but differs in that the potash feldspar is microcline-microperthite, and in that where the phenocrysts are relatively few in number, the rock is an adamellite in composition. The rock also lacks any quartz-potash feldspar intergrowths. The phenocrysts average 15 by 10 mm in size and are in variable concentrations throughout the rock. They are in places aligned in a preferred direction over short distances. The rock shows faint compositional banding in some exposures.. A few miles northwest of St. Pauls Mission a belt of pink leucocratic microgranite or adamellite is exposed, but its relationships with the surrounding porphyritic granite is unknown.

At Mabaduan on the Papuan coast the rock is a massive, grey, medium-grained or coarse-grained porphyritic biotite adamellite containing pink euhedral microcline-microperthite phenocrysts 10 mm to 30 mm in size. The rock contains some veins of pink aplite and a few patches of fine-grained or medium grained altered alaskite. The granite is in places fractured and partly recrystallized.

On nearby Dauan Island the rock is similar to that at Mabaduan, though overall it is finer grained. It is hornblende bearing, and contains a number of coarser-grained patches with irregular margins. A small number of intermediate dykes intrude the granite.

Hornblende-biotite adamellite and granodiorite. Hornblende-bearing biotite adamellite and granodiorite crop out in the western half of Moa Island and in a small area opposite on Badu Island. The rocks are grey to pinkish grey and medium grained, with a few pink potash feldspar phenocrysts in places. Hornblende, as irregular laths up to 5 mm in size, is in most exposures less common than biotite. There is a minor amount of intergrowth between quartz and orthoclase-microperthite in the more acid varieties. Granodiorite crops out near Badu village and on one of the small islands to the south; it has in places a speckled appearance caused by small clots, up to 15 mm in diameter, of small laths of hornblende and plagioclase. The granodiorite also contains dark grey xenoliths up to one foot across, which are of a fine grained or medium grained intermediate rock composed of laths of mafic mineral interspersed with white feldspar. At one locality a patch or body of an altered, dark brown, coarse grained quartz-biotite-hornblende-oligoclase rock has a sharp contact with the normal rock and may intrude it.

The hornblende bearing rocks appear to have a faulted contact with the leucocratic granite to the west of Badu village.

Other varieties and areas of granite. The three islands to the east of Moa Island - Burke, Getullai, and Mount Ernest - are composed of pink, fine-grained to coarse-grained leucocratic biotite granite with some patches and dykes of aplite and, rarely, pegmatite. The biotite generally occurs as small clumps and on Burke Island streaks and patches of biotite-rich material are found. The potash feldspar is microcline, which is strongly poikilitic and slightly microperthitic.

The western end of Travers Island is composed of a massive dark grey, fine-grained equigranular muscovite-biotite granodiorite which is intruded by a light grey, medium-grained, porphyritic muscovite-biotite adamellite or granodiorite. The phenocrysts (up to 30 mm) are of microcline and are usually few in number. They are concentrated in some areas but are virtually lacking from the eastern end of the island. Near the contact with fine-grained granodiorite, the medium-grained rock is banded and slightly foliated. Vertical bands of alternately biotite-rich and biotite-poor material up to one foot wide are approximately parallel to the contact. Irregular dykes and patches of aplite and muscovite-quartz-feldspar pegmatite cut the medium-grained rock near the contact. Both rock types are similar in composition, and are moderately recrystallized, sheared, and micro-fractured.

Channel Island is composed of pink, leucocratic, medium-grained biotite-muscovite granite, which is aplitic or pegmatitic in places. The muscovite is coarse-grained; the biotite tends to form small clots. The quartz is strained and recrystallized.

Twin Island is composed of a grey, medium-grained, massive biotite granite with pink potash feldspar phenocrysts up to 20mm in size. It grades in places into a muscovite-biotite or muscovite granite. The muscovite-bearing phases are either penetrated by, or intimately banded with coarse pegmatitic material which consists of large clumps

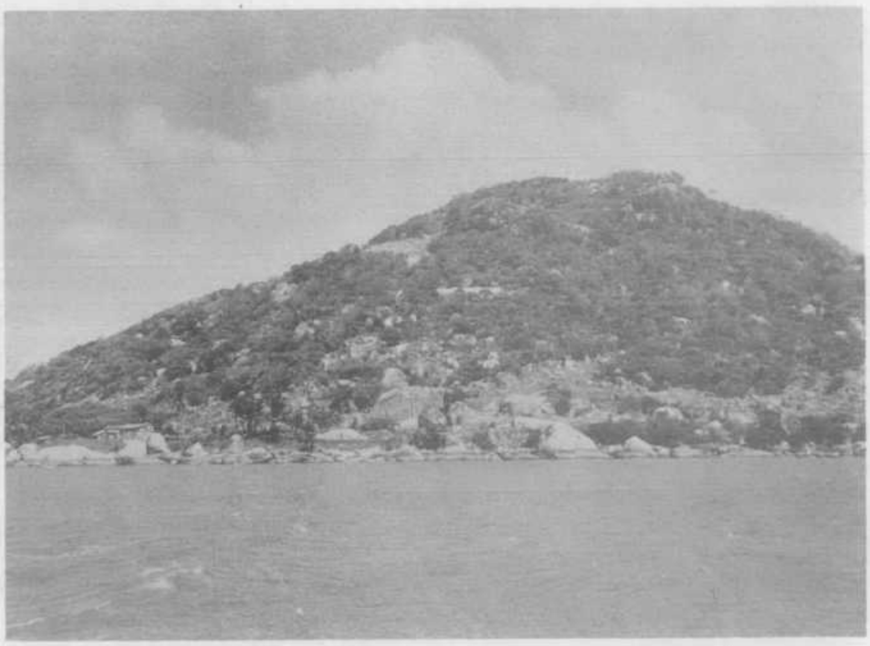


Plate 5. Typical exposure of Badu Granite, Dauan Island.

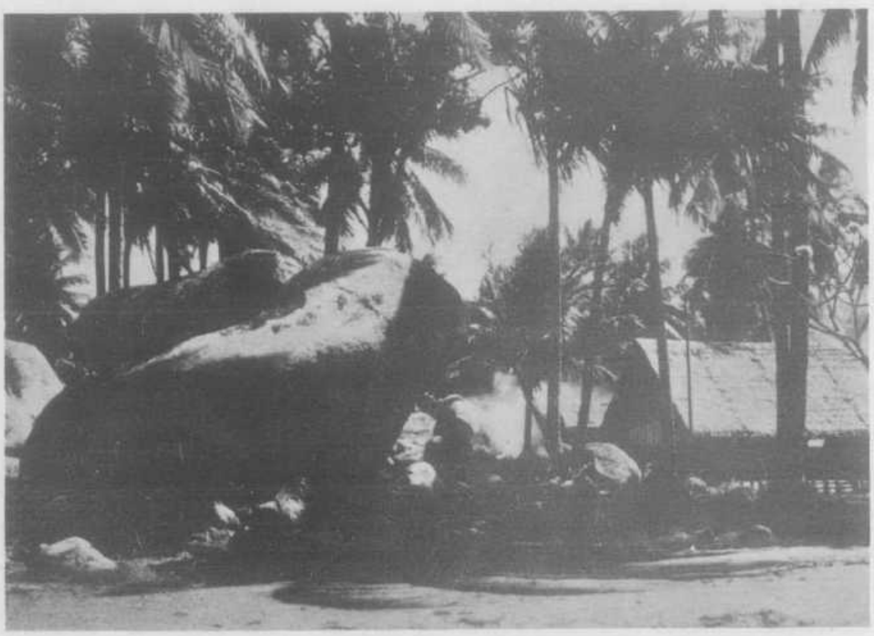


Plate 6. Boulders of Badu Granite, Mabaduan village, Papua.

or bands of pink potash feldspar set in a granitic matrix. Some large crystals of muscovite are present. The granite is sheared and altered in places, and is intruded by quartz veins up to two feet thick. An altered andesite dyke up to 60 feet wide and a small banded rhyolite dyke also intrude the granite.

Two miles to the south on East Strait Island the granite is a medium-grained or coarse-grained, leucocratic, pink to red biotite granite. The potash feldspar is microcline-microperthite and the biotite is irregularly distributed in clumps up to 5 mm across. An extensive horizontal sheet of pegmatite one foot thick is composed of intergrown crystals of quartz and potash feldspar up to 10cm long. Similar rocks are exposed on Strait Rock near the Tuesday Islets.

Hammond Island, a small body of tonalite or granodiorite intrudes altered and recrystallized welded tuff of the Goods Island Ignimbrite. It is a grey, medium-grained muscovite-biotite tonalite or granodiorite and contains rare patches of pegmatite rich in muscovite. The contact with the volcanics is sharp and almost vertical. Near the contact the tonalite is mineralized with small spots of chalcopyrite in a zone up to 20 feet wide.

Summary of Petrography

Quartz: Anhedral. In places slightly to moderately strained, recrystallized in some specimens. Tends to form phenocrysts in some areas, especially Badu Island. In places in coarse intergrowth with potash feldspar.

Potash feldspar: Generally forms phenocrysts. Subhedral. Mostly orthoclase (some microperthitic); microcline in southeast and near Mabaduan. In groundmass, where orthoclase, almost invariably in intergrowth with quartz, but where microcline, very rarely in intergrowths. Rare myrmekite - only in microcline granites (e.g. Mabaduan, Mount Ernest, St. Pauls Mission); phenocrysts here are significantly poikilitic.

Plagioclase: Subhedral or anhedral. Generally poorly zoned sodic oligoclase; cores perhaps calcic oligoclase; some sodic rims. Recrystallized in some specimens. Generally well twinned (albite, rare pericline).

Biotite: Brown to green ragged flakes, often tending to form groups of crystals. Invariably altered, but to varying extent.

Hornblende: Minor, except in xenoliths and in granodiorite near Badu village. Green/brown, altered.

Accessory minerals: Zircon (largely in biotite) and opaques ubiquitous. Allanite as subhedral grains, with zoned metamict appearance in larger (up to 1 mm) grains; mostly in biotite. Apatite common. Sphene in some areas (e.g. Cap, Yama, Hawkesbury Islands). (?)Monazite rare.

Alteration

Most of the granites, especially the more leucocratic rocks as on Badu Island, show moderate to strong deuteric alteration of feldspar and mafic minerals. Typically potash feldspar is altered to a clay mineral imparting a cream to pink colouration. Plagioclase is altered in part to a whitish clay mineral and in part to sericite; the calcic cores are typically altered to the latter and, in places, epidote or carbonate. Biotite is altered to chlorite and leucoxene, and also to epidote in the more altered rocks. Hornblende is altered to actinolite and/or chlorite.

Discussion

Several features of the Badu Granite indicate that it was emplaced at a relatively shallow depth in the epizone (Buddington 1959). These include sharp contacts with the country rock; the development of granophyric textures in much of the granite; and the presence of miarolitic vughs.

The porphyritic granite on the east coast of Moa Island and the scattered granite exposures on the small islands to the east and south, together with the granite at Mabaduan and on Dauan Island appear to have been intruded at a lower level in the crust than the main part of the Badu Granite. This is indicated by their lack of granophyric texture and the presence of microcline instead of orthoclase. In addition, the most severe recrystallization of the volcanic country rocks has occurred where they are intruded by the porphyritic biotite granite. Where cut by the leucocratic biotite granite they are only little affected.

Porphyritic Microgranite

Four distinct areas of porphyritic microgranite intrude the Torres Strait Volcanics on Mabuiag Island, Friday Island, Horn Island, Tuesday Islets, and Mount Adolphus Island.

Mabuiag Island

The porphyritic microgranite which forms the northern part of Mabuiag Island is similar in every respect to the larger of the porphyritic microgranite dykes which intrude the Badu Granite on Badu Island (see below).

The rock apparently intrudes welded tuff lying to the south and west, although no contact was seen. The tuffs are not visibly affected by the intrusion.

The microgranite is massive, poorly jointed, and red-brown in colour. It contains phenocrysts of altered orthoclase up to about 1 cm in size and smaller embayed quartz phenocrysts which may have corroded margins. There is little granophyric intergrowth in the groundmass. The groundmass contains occasional grains of an altered mafic mineral which is heavily ironstained.

A small number of flow-banded felsite dykes intrude the microgranite.

Friday Island

A small body of porphyritic biotite microgranite intrudes the Goods Island Ignimbrite in the eastern part of Friday Island. The rock is massive and pale pink with medium-sized quartz and feldspar phenocrysts set in a microgranitic groundmass with small clots of fine-grained biotite.

The quartz phenocrysts are 2 mm to 4 mm in size and are rounded and fractured. They have corroded margins. Albite phenocrysts of composition An_4 are up to 7mm in size and are subhedral, well zoned, and moderately altered to a clay mineral and sericite. Some have slightly corroded margins. Anhedral orthoclase phenocrysts are moderately altered and have a poorly developed microperthitic texture. They are also slightly corroded. The ragged biotite flakes are largely altered to chlorite with some epidote. The groundmass is of microcrystalline quartz and alkali feldspar. Sphene is an accessory.

The microgranite is fractured and several breccia or minor fault zones occur near the contact with the volcanics. Near the contact several xenoliths of recrystallized welded tuff up to 20 feet across occur in the microgranite, and a number of small dykes and veins of pink aplite intrude the volcanics.

Horn Island-Tuesday Islets

Coarsely porphyritic microgranite has apparently intruded and hornfelsed the Endeavour Strait Ignimbrite in the eastern part of Horn Island, and is exposed in the Tuesday Islets to the northeast. A small body of porphyritic microgranite 60 feet across was seen to intrude the hornfels on the south coast of Horn Island. A small area of similar porphyritic microgranite apparently intrudes the volcanics near the northeast coast of Prince of Wales Island, opposite Horn Island.

The microgranite is fairly uniform in appearance throughout. It is grey with phenocrysts of cream to pale green plagioclase (up to 20 mm), cream to pale pink alkali feldspar (up to 25 mm), clear quartz (up to 10 mm), and dark green to black mafic clots (up to 10 mm). In thin section the quartz (15% to 40% of the phenocrysts) is euhedral to subhedral and embayed. Oligoclase (30% to 50%) is subhedral and altered in part to sericite with some calcite. Albite (0% to 25%) is subhedral, and well twinned, and has quartz inclusions. Alkali feldspar (10% to 30%) is subhedral with poorly developed cross-hatch twinning; it is microcline or perhaps anorthoclase. The mafic minerals generally occur in patches composed of small ragged crystals of hornblende altered to actinolite and epidote. Accessory minerals are zircon, apatite, opaques, and allanite. The groundmass is very fine-grained and is composed of intergrown quartz and microcline, with some oligoclase.

In the east-central part of Horn Island the rock is hydrothermally altered to a variable degree, veined by quartz, and contains gold and iron, lead, and copper sulphide mineralization.

Mount Adolphus Island

A small body or bodies of quartz-potash feldspar microgranite intrude welded tuffs of the Eborac Ignimbrite on Mount Adolphus Island, 9 miles northeast of Cape York.

The rock is massive and grey, with white to greenish white subhedral feldspar phenocrysts and a lesser number of small rounded quartz phenocrysts. The feldspar phenocrysts are untwinned sanidine or perhaps anorthoclase, and in part exhibit granophyric intergrowth with quartz. They are partly altered to calcite. The quartz phenocrysts have corroded margins and are optically continuous with quartz in the groundmass for a short distance. The groundmass is finely crystalline (0.1 mm) quartz and feldspar, with dusty opaques, minor calcite and chlorite, and accessory sphene.

The shape and relationships of these microgranite bodies have not been ascertained. They crop out on a small headland in Blackwood Bay and near the summit of Mount Adolphus. Although it is possible that the microgranite may be a severely recrystallized welded tuff, its texture and relative percentage of phenocrysts are considerably different from those of the welded tuffs of the surrounding Eborac Ignimbrite. If the rock is intrusive it may have been the cause of the recrystallization of the groundmass of the nearby welded tuffs.

Dykes

Three types of dykes intrude the granites and volcanics in Torres Strait: flow-banded and massive felsite dykes, intermediate dykes, and porphyritic microgranite dykes. Aplite, pegmatite, and microgranite dykes which are comagmatic with and intrude only the granitic rocks, or volcanics close to granite contacts, are described with the Badu Granite above. In general only flow-banded felsite dykes intrude the volcanics in the southern part of Torres Strait.

In some areas where there are numerous dykes the sequence of intrusion of the three types of dykes can be ascertained. The order of intrusion appears to be consistent throughout. In the southwest part of Badu Island the order is: intermediate; porphyritic microgranite; and at least two ages of felsite. A few narrow intermediate dykes of a second age intrude the microgranite dykes in some exposures. Near St. Pauls Mission, on the east coast of Moa Island, there are no porphyritic microgranite dykes, but the order is otherwise the same as on Badu Island.

Intermediate

Intermediate dykes occur throughout the Badu Granite but are most common in the southwest part of Badu Island and in the eastern part of Moa Island. The dykes are up to 50 feet wide but are generally much narrower.

The dykes are greenish black in colour and generally contain a few small plagioclase phenocrysts up to 3 mm in size (average 1 mm). They range in composition from (?) dacite, through hornblende andesite and hornblende-augite andesite, to augite andesite. Alteration is strong, and plagioclase (andesine, rarely sodic labradorite) is altered to sericite and minor epidote. Hornblende is variably altered to actinolite, chlorite, or tremolite. The augite is titaniferous. Minor minerals include calcite, opaques, apatite, and occasionally sphene.

One 1.5 foot dyke near East Point on Moa Island has a 3 or 4 inch wide margin which has a spherulitic texture. In thin section this margin is seen to be composed of calcite, chlorite, and opaques in a sparse microcrystalline quartzo-feldspathic groundmass. Spherical patches of the rock a few millimetres across are rich in radiating crystals of siderite. Amygdules up to 2 mm across of quartz, calcite, chlorite and some siderite are scattered throughout the rock.

Porphyritic Microgranite

A number of dykes of a distinctive porphyritic microgranite with abundant large phenocrysts of potash feldspar intrude the Badu Granite between Canoe Island and Badu Island. A body of similar rock occurs on Mabuiag Island. Overall, these dykes are less common but larger than the other dyke types. They range in size up to several hundred feet in width and perhaps 2 miles in length.

The dykes are grey through brown to reddish-brown aphanitic to fine-grained rocks with phenocrysts of pink or, more rarely, white euhedral feldspar up to 10 mm, and clear quartz up to 3 mm. Small 1 to 2 mm clots of dark green mafic mineral are scattered throughout the groundmass. In general, the narrower dykes are dark grey and aphanitic, while the wider ones are brown and finely crystalline.

The phenocrysts are of orthoclase-microperthite, quartz, and also usually plagioclase. The orthoclase occurs as altered subhedral or euhedral grains, some of which are poikilitic; others have corroded margins, or have secondary potash feldspar overgrowths. Quartz phenocrysts are subhedral, embayed and in the coarser grained dykes have recrystallized margins. The plagioclase phenocrysts (oligoclase, or more rarely albite) are subhedral and have sodic rims or potash feldspar overgrowths.

In thin section the groundmass varies from a microcrystalline intergrowth of quartz and feldspar, through a microgranophyric intergrowth of quartz and potash feldspar with occasional plagioclase grains, to microgranitic quartz and potash feldspar in which the larger potash feldspar grains are poikilitic. Small grains and clots of chlorite, biotite, and hornblende are present. Clinopyroxene, in one of the larger dykes, is partly altered to hornblende and actinolite.

At Coconut Point in southwest Badu Island, patches of quartz-tourmaline rock up to 2 feet across, and quartz vughs and veins up to 1 foot wide containing minor wolfram and arsenic and copper sulphide mineralization, are present in and near the margin of a large dyke. Xenoliths of granite country rock up to 2 feet across are also present near the margin of this dyke.

Felsite

Felsite dykes are more abundant than the other two types. Numerous flow-banded felsite dykes up to 30 feet wide, but generally much narrower, intrude the Torres Strait Volcanics, especially on the small islands in Endeavour Strait and in, or close to areas of hydrothermal alteration. The dykes are vertical or nearly so and strike approximately parallel to the strike of the volcanics (020°to 060°). They are cream, pink, or green in colour with small (up to 1.5 mm) embayed quartz phenocrysts and a lesser number of sericitized potash feldspar phenocrysts in a microcrystalline quartz-feldspar groundmass. The flow banding is often very contorted, especially along the margins of the dykes. The largest dykes are fairly massive towards their centres. Narrow quartz veins are common in and near many of the dykes.

Felsite dykes which intrude the Badu Granite to the north are essentially the same, though they are generally banded in narrow marginal zones only, and some are massive throughout. The massive dykes generally have a coarser groundmass. Plagioclase and quartz, or just plagioclase phenocrysts (up to 2 mm) occur in some of the massive felsite; others contain quartz and potash feldspar phenocrysts. The quartz phenocrysts often have slightly corroded margins. Small cloritized biotite flakes are a minor constituent of these rocks.

The dykes have no preferred general direction. However, in certain areas groups of dykes are approximately parallel (e.g. in the southwest part of Badu Island).

Mineralization

The Permian(?) intrusive rocks in Torres Strait have been accompanied by minor mineralization. Three types or styles of mineralization have been recognized.

On and near Badu and Moa Islands wolfram occurs in quartz veins within or near Badu Granite, in places associated with felsite and porphyritic microgranite dykes.

In the south of Torres Strait the mineralization is associated with hydrothermal alteration, fracturing, and quartz penetration which has affected areas of the volcanics and also the body of porphyritic microgranite on Horn Island. Gold, cassiterite, pyrite, galena and chalcopyrite occur in minor amounts. It is thought that the hydrothermal activity was probably connected with the porphyritic microgranite which may be more extensive at depth.

Finely disseminated chalcopyrite occurs in the small body of tonalite exposed in the northeast of Hammond Island.

Age

The age of the Badu Granite and other intrusive rocks in Torres Strait has not been determined isotopically. However, a sample of biotite granite from 6623 feet in the Aramia No.1 well in western Papua (see Fig.13) has been dated by the K/Ar method on biotite at 236 million years, an Upper Permian age (Harding, 1966).

The relationships between the granitic intrusive rocks and the Torres Strait Volcanics is uncertain. They may be co-magmatic, in which case the volcanics may be as young as Upper Permian, or the granite as old as Carboniferous. Alternatively there may be a considerable time break between the two, with the volcanics Carboniferous and the intrusives Permian in age. Work on samples of the Badu Granite collected in 1968 for age determination is planned.

MESOZOIC

Mesozoic Sediments of Cape York Peninsula

Coarse ferruginous sandstone caps the hills which extend southwestwards from the coast near Albany Island to Bamaga Settlement, and westwards from there to the coast again at Muttee Head. The sandstone rests unconformably on the Torres Strait Volcanics and dips gently southeastwards under Quaternary sediments fringing Newcastle Bay. It is the northernmost exposed sedimentary unit of the Carpentarian Basin, and bears a close resemblance to the Mesozoic sandstone in the Coen and Cape Weymouth 1:250,000 Sheet areas (Trail et al., 1969). Whitehouse (1954) records that lower Aptian marine fossils have been found a few miles south of Cape York; a location which, though uncertain, lies within the outcrop of the sandstone. The sandstone was not mapped in any detail or named during this survey, but will be included in the mapping of the Carpentaria Basin at present being undertaken by the Bureau of Mineral Resources and the Geological Survey of Queensland. The sediments and structure of the Carpentaria Basin have been reviewed by Meyers (1969).

The outcrop of the sandstone is almost entirely covered by a layer of ferricrete, and under this layer, in cliffs at Albany Island and Muttee Head, it has been leached and ranges in colour from brown through pink to white. Where it is least affected by leaching the sandstone is brown or dark grey and is composed of quartz grains ranging in size from medium to very coarse; quartz granules are abundant and pebbles of quartz are scattered through the rock. The grains and granules are angular and sub-angular and resemble strongly the quartz phenocrysts of the underlying welded tuffs; the quartz pebbles are generally sub-angular and sub-rounded.

In places quartz-pebble conglomerate forms poorly defined beds and lenses up to 1 foot thick in the sandstone; a few of the pebbles are siltstone and fine sandstone and a few others are weathered ferruginous volcanic rocks. At Muttee Head the sandstone also contains a few beds up to 6 inches thick composed of clayey siltstone or fine sandstone, and according to Australian Aquitaine Petroleum (1965), similar beds are present in the sandstone near Albany Island.

Exposures of the sandstone generally appear to be sub-horizontal, though current bedding is common in places; overall the sandstone dips very gently southwards. The pebbly quartz sandstone commonly rests directly on leached and weathered volcanic rocks with no intervening conglomerate. At Muttee Head at least three resistant rhyolite dykes protrude 10 feet or more upwards into the sandstone. Up to 80 feet of sandstone is exposed in cliffs on Albany Island, and a minimum thickness of 190 feet has been estimated by Australian Aquitaine Petroleum near Somerset homestead.

A helicopter reconnaissance regional gravity survey carried out by the Bureau of Mineral Resources in 1966 and 1967 (Shirley, in prep.) has revealed a trough trending east-northeast across Cape York Peninsula about 50 miles south of Newcastle Bay and the Mesozoic sediments presumably thicken southwards into it.

Mesozoic Sediments of Southwest Papua

Mesozoic sediments have been encountered in wells drilled for oil at depth beneath younger rocks in southwest Papua, but no outcrops are known. They are described in detail by A.P.C. (1961), Stach (1964), Thompson (1967), Rickwood (1968), and Phillips Australian Oil (1968). The sediments consist of Jurassic continental arkosic sandstones with coal and lignite bands, and Lower Cretaceous near-shore marine glauconitic quartz sandstones and silty mudstones. They were deposited on a relatively flat shelf formed by the slowly subsiding northern extension of the Australian continental platform. In the Aramia No.1 (APC, 1961) and Iamara No.1 wells (Oil Search, 1963) (Fig.13), 2764 ft and 2894 ft of Mesozoic sediments were encountered above the basement. In the far southwest subsidence was somewhat greater and the small Morehead Basin developed; in the Morehead No.1 well about 5,000 feet of Mesozoic sediments are present (APC, 1961). In the southeast in the Oriomo area the sediments thin considerably over a basement ridge which existed during the Mesozoic. Wuroi No.1 (Oil Search, 1965) passed through 1,800 feet of Mesozoic sediments, and in two bores near Oriomo, only 100 ft and 400 ft of Mesozoic sediments were encountered.

Seismic and magnetic work of Gulf (1965), Tenneco (1967) and Phillips Australian Oil (1968) indicates that Mesozoic sediments continue southwards into the northeast of Torres Strait. The Anchor Cay No.1 well passed through approximately 5000 feet of Jurassic deep water pyritic shales and Lower Cretaceous sandstones before approaching basement (Oppel, 1969). The sediments apparently onlap against basement rocks to the west and south, but there may be a narrow connection with the Carpentaria Basin. The sediments are draped over irregularities in the basement and are complexly faulted; a number of possible structural traps have been delineated by the oil companies.

In the centre of the Gulf of Papua and in the area north of the Gulf, the continental platform subsided more rapidly and thicker sequences of sediments were deposited; they were mainly deep water mudstones. Farther east again the sediments thin out somewhat over the Erave-Wana Swell before thickening to an unknown depth in the Papuan Geosynclinal Zone.

Deposition of Mesozoic sediments in the southwest of the Papuan Basin commenced at the beginning of the Jurassic and continued without a major break into the Lower Cretaceous. However, in the Upper Cretaceous, much of the area of Figure 13 was emergent and sedimentation continued probably only in the Morehead Basin. There was probably widespread cessation of deposition over all of the area at the end of the Cretaceous, and parts of the region were subject to erosion.

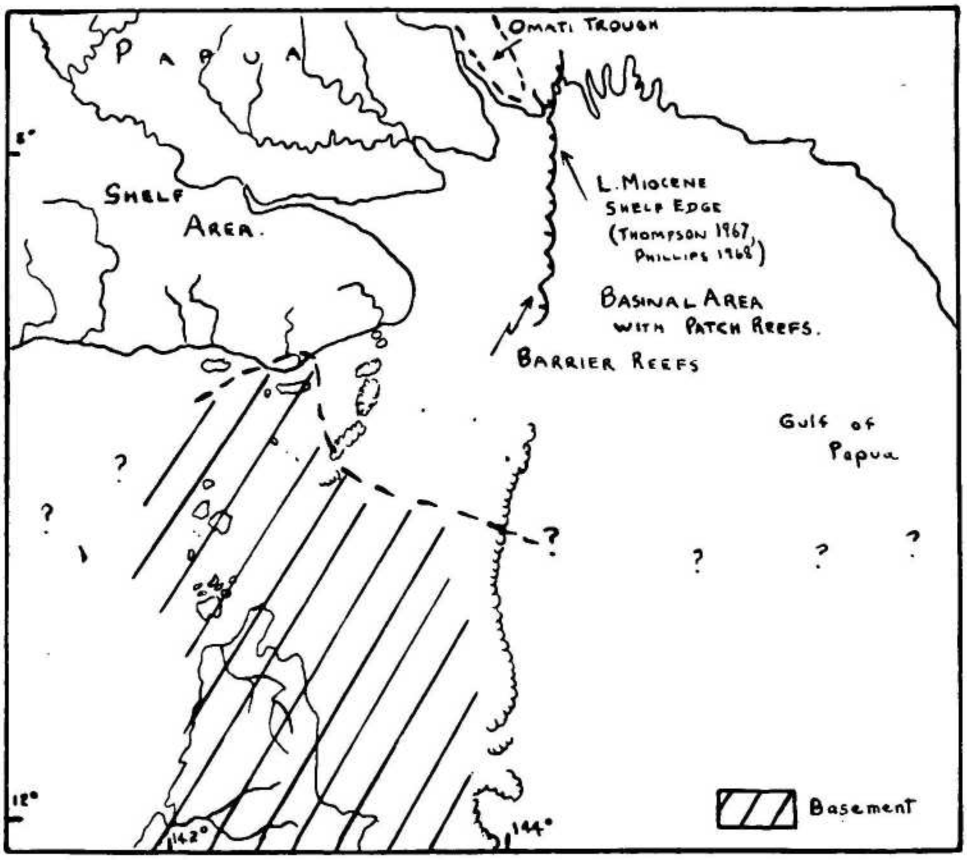


FIG. 12 EXTENT OF LOWER MIOCENE TRANSGRESSION

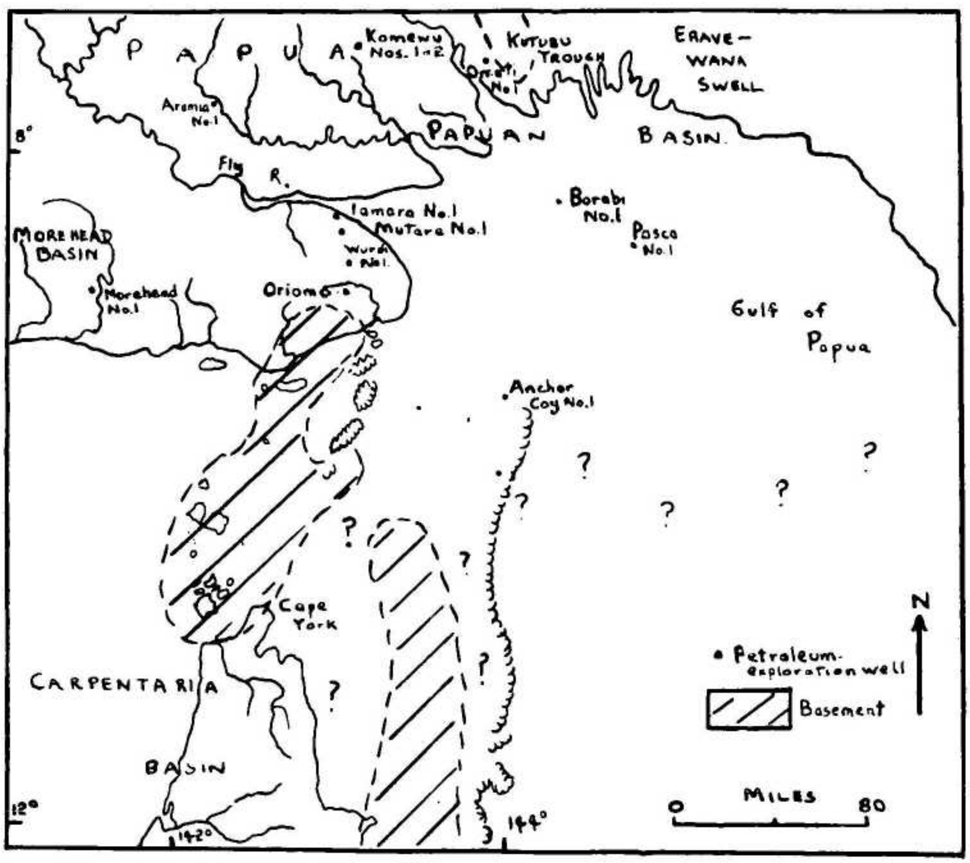


FIG. 13 EXTENT OF LOWER CRETACEOUS SEDIMENTATION

TERTIARY

Tertiary Sediments of Southwest Papua

Tertiary sediments were deposited over extensive areas of southwest Papua and the Gulf of Papua, (APC, 1961; Stach, 1964; Thompson, 1967; Rickwood, 1968; Phillips Australian Oil, 1968) and extended southwards into northeastern Torres Strait (Gulf 1965 Tenneco 1967, Oppel 1969). They were not examined during this survey.

Sedimentation commenced during the Eocene, with the deposition of argillaceous shallow water limestone or calcarenite on the eroded Mesozoic surface in the central and eastern area of the present Gulf of Papua. The Eocene is only 200 feet thick in the Omati area, but thickens eastward to about 3000 feet in the eastern Gulf. It is absent west of Omati, where apparently an emergent shelf area was present./However in the south 1000 feet of Eocene limestones (Te) were encountered in the Anchor Cay No.1 well (Oppel, 1969). The top of the Eocene is bounded by an unconformity and no Oligocene strata are known.

During the early Miocene, subsidence of the Gulf of Papua resumed, and the sea transgressed westward across the stable shelf of southwest Papua (Fig.12). On the shelf moderate thicknesses of shallow water limestone (Tm) were deposited on the eroded Mesozoic surface. In the Morehead and Aramia wells, 3100 feet and 2700 feet of limestone are present. The basement ridge in the Oriomo area persisted with the result that the limestone is much thinner in this area. The Lower Miocene limestone is at present exposed over a broad area west of Oriomo. The area of outcrop shown on the Daru 1:250,000 Sheet is based on air photo interpretation carried out for oil companies. In the Anchor Cay area in the northeast of Torres Strait over 3000 feet of Lower Miocene limestones were deposited above the Eocene limestones.

Thompson (1967) and Phillips Australian Oil (1968) consider the eastern edge of the Lower Miocene Shelf (Fig.12) to be marked by a number of buried coral reefs forming a barrier-reef chain. In the deepening waters east of the shelf edge, pelagic limestone was deposited, except in areas of local uplift where offshore platform reefs developed. In the Omati area, a small trough contains over 9000 feet of Lower Miocene limestone (APC 1961). Presumably it developed just west of the barrier reef chain (Thompson, 1967). In the eastern Gulf the pelagic limestone gives way to a thick sequence of mudstone, greywacke, and volcanics.

In the Middle Miocene the rate of sedimentation in the central and eastern areas of the Gulf increased rapidly, probably following uplift of mountainous areas to the north and west. The limestone was buried under vast thicknesses of argillaceous sediments, the deposition of which probably continued uninterrupted throughout the Middle and Upper Miocene, Pliocene, and Pleistocene, up to the present day.

In contrast, the western shelf remained stable and limestone deposition continued until the Upper Miocene; only thin deposits of Pliocene to Pleistocene (Tp Qp) argillaceous sediments were laid down over the shelf. APC (1961) report Pliocene (?) clays overlying the Miocene limestone northwest of Oriomo, and other Pliocene (?) sediments up to 400 feet thick have been encountered in the Morehead, Aramia and Oriomo wells. Blake and Ollier (1969) describe Pleistocene and Pliocene sediments in the Morehead area, and clays and sandstones intersected in water bores at Daru (MacGregor, 1967) are probably Pleistocene to Pliocene in age.

On the southeastern edge of the shelf in the Anchor Cay area limestone deposition continued throughout the Pliocene and Pleistocene, and 2750 feet of these limestones were encountered in the Anchor Cay well. This may indicate that a barrier reef complex has existed in this region from the Miocene to the present day.

Unnamed Tertiary(?) Deposits of the Torres Strait Islands and the Mainland of Cape York Peninsula

Small areas of poorly consolidated and poorly sorted soft clayey sandstone containing cobbles of the nearby basement rocks are exposed on Moa and Wednesday Islands. They are too small to be shown on the 1:250,000 scale map. The sandstone is up to 15 feet thick and has probably resulted from consolidation of weathering debris of the underlying granitic and volcanic rocks with little or no transport. It is essentially similar to the Lilyvale Beds to the south in Cape York Peninsula (Trail et al., 1968; 1969), and may be Tertiary in age.

On the mainland just south of Cape York the Mesozoic sediments are capped by extensive areas of ferricrete which is probably Tertiary in age. The ferricrete is not mapped because it is difficult to detect on aerial photographs. It normally forms a crust about 2 or 3 feet thick composed of dark brown cemented pisolitic material which overlies leached sandstone. However in many places it consists of a conglomerate of large blocks up to 1 foot across of ferruginized sandstone set in a honeycombed ferruginous matrix. On Albany Island this conglomerate is up to 40 feet thick. Here, and along the northwest coast of Newcastle Bay, where the ferricrete is well developed, an underlying mottled leached zone is present beneath the ferricrete in some exposures. The ferricrete may be similar in origin to the aluminous lateritic profile to the south on Turtle Head Island and at the mouth of the Escape River, (Hill and Denmead 1960, pp. 385,386). The ferricrete is generally developed on the Mesozoic sandstone, but where the sandstone is very thin the underlying volcanics have been leached immediately beneath the sandstone. In a few places, such as Galloways Hill, poorly developed ferricrete lies directly on the volcanics and presumably has been derived from them. The only occurrence of ferricrete observed on any of the islands of Torres Strait is a capping on hornfelsed volcanics in the southeast of Moa and on volcanics on Mt. Adolphus Island. In some areas near ferricrete cappings the ferricrete appears to have been eroded, deposited, and recemented at a lower elevation. This is the case on the southern margin of the central sand plain of Moa Island, in the valley of Laradeenya Creek on the mainland, and in a low area on Mt. Adolphus Island. Apparently redeposited conglomeratic ferricrete containing cobbles of volcanics is also present on the beach of Dayman Island in Endeavour Strait.

QUATERNARY

Maer Volcanics

Tuff and olivine basalt which form the Murray Islands, Darnley Island, Stephens Island, the Black Rocks, and small exposures at Bramble Cay, in the northeastern part of Torres Strait, are grouped together in this report and named the Maer Volcanics after Maer Island, the largest of the Murray Islands. Calcareous tuff and tuffaceous sediments forming Daru Island in Papua were probably deposited at the same time as the Maer Volcanics and have been included in them.

Each of the three Murray Islands (Maer, Dauar, and Waier) is a recognizable volcanic cone composed of ash consolidated to tuff; the cone of Maer is breached by basalt flows.

Darnley Island is a pile of basalt, several hundred feet thick, resting on bedded tuff which was probably part of a volcanic cone. Stephens Island is a small plateau of basalt about 100 feet high, and basalt forms two small exposures at the east end of Bramble Cay. The Black Rocks, 4 miles southwest of Bramble Cay, are composed of tuff, according to Jardine (1928a). Haddon, Sollas, and Cole, (1894) give a particularly detailed description of the Murray Islands, and Jardine (1928a,b) describes the volcanic rocks at Darnley Island and Bramble Cay in detail.

Tuff

Tuff forms the three Murray Islands, each of which is a well-preserved ash cone. It is also well exposed in Treacherous Bay on Darnley Island, where it crops out beneath basalt, and it forms the Black Rocks near Bramble Cay. Tuffaceous sediments are exposed on Daru Island in Papua.

In the Murray Islands (Figs 14,15) Maer Island consists of a breached ash cone whose elliptical rim outlines a crater about one and a half miles long by three-quarters of a mile across. At the west end of the island the rim rises to a rounded peak about 700 feet high known locally as Gelam. The eastern part of the rim is much lower (less than 200 feet) and has been breached by basalt flows which have an aggregate thickness of more than 100 feet. The bedded tuff forming the cone at Maer dips radially outward from the crater rim at angles steepening from 10 degrees at the crest to about 30 degrees around the coast of the island. In a few places dips range up to 60 degrees as a result of slumping during the accumulation of the ash.

In the centre of the crater about half a mile east of Gelam a small cone over 100 feet high rises from the crater floor. The surface of the cone is mainly covered by friable red soil which contains blocks of highly vesicular basalt, but horizontal coarse tuff or agglomerate crops out on its south side. It may be a small spatter cone and could represent the latest phase of volcanic activity on Maer. It lies near the apex of the triangular outcrop of basalt forming the eastern end of the island, possibly at the site of the vent from which the basalt was erupted.

Dauar Island is an ash cone which reaches about 600 feet above sea-level at its western end. The sea has breached the crater rim on its north and south sides and has left a high western hill and a very much lower eastern hill separated by the floor of the crater on which native gardens flourish. Dips on Dauar are also radial and range from 10 degrees on the crest of the western hill, to 30 degrees and more on the very steep dip slopes of the western part of the island. Where the sea has breached the crater rim, bedded tuff in the central part of the island has a sub-horizontal dip and at one point on the north coast lies unconformably on beds of coarse tuff dipping outwards at 30 degrees, in conformity with the nearby rim.

Waier Island represents the western half of an ash cone, the eastern half of which was probably prevented from building up by the strong prevailing southeast winds. Dips are radial in the preserved part of the cone and range from horizontal around the summit of the crater rim, to dips of 30 or 40 degrees on the outward flanks; dips are even steeper than this in a few places. On the steep slopes inside the rim slumps up to 50 yards across, which probably formed before the ash consolidated, dip inwards at angles up to 40 degrees (Plate 14).

It is notable that the rims of all three islands are highest on their western sides, probably because the prevailing southeast wind has caused the erupted ash to accumulate mainly west of the vent.

All three ash cones are composed of weathered yellow-brown bedded tuff in which lapilli and small bombs of glassy basalt and round fragments of white limestone are set in a matrix of small fragments of brown altered basaltic glass. Beds of coarse-grained tuff up to 2 feet thick alternate with and grade sharply into beds of medium-grained or fine-grained tuff which are generally a few inches thick. In many places the fine-grained beds predominate and range up to 5 feet in thickness; some of the coarse-grained layers are lenses, several feet long, within the fine-grained material. Cross beds and scours occur in places in the tuff, and probably formed by rainwater scouring and deposition in small ponds.

The bombs are composed of glassy vesicular basalt and range up to 3 feet across; most of them are only a few inches across. The bombs are largest and most abundant in the coarse-grained beds; some large bombs distort the beds for a few inches beneath them, and these beds were evidently soft when they landed. Round fragments of limestone in the beds range from less than one inch to a few inches across. They are generally common in the coarser beds, but on Maer Island at least they appear to be concentrated in particular beds which contain relatively few basalt fragments. They may have been derived from reefs which grew over the submerged mouth of the vent during periods of quiescence. The limestone is light grey with white patches of recrystallized material, and contains fragments of coral, pelecypods, and gastropods, which indicate a Pleistocene or Recent age (D. Belford, pers. comm.). A few thin beds of tuff on Maer Island are almost entirely composed of weathered brown lapilli which are very well rounded.

At Dauar Island the sub-horizontal tuff which crops out within the crater is relatively rich in olivine and pyroxene crystals; elsewhere the tuff is similar to the vitric tuff forming Maer Island. In the tuff forming Water Island basalt bombs are more common than

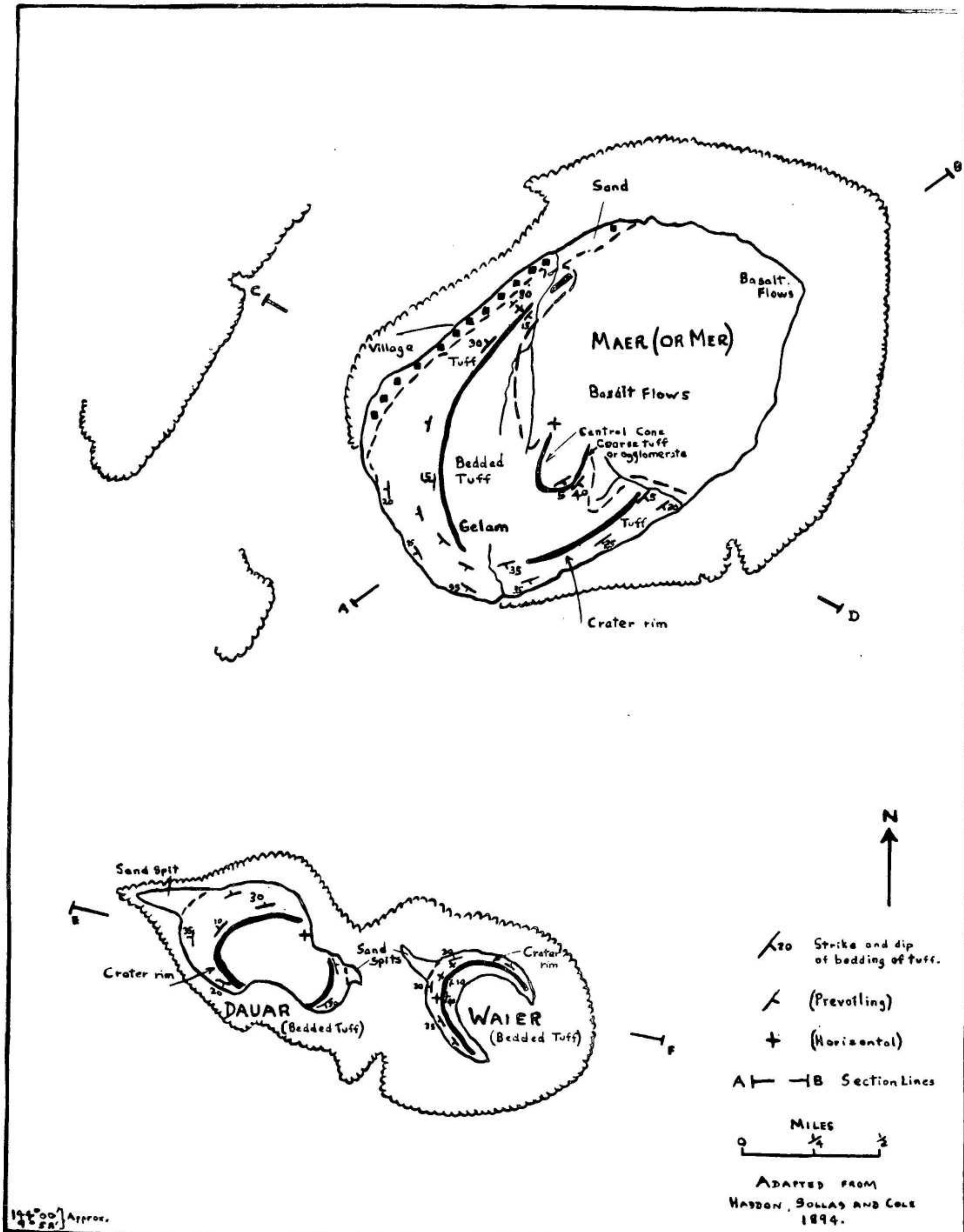


FIG. 14. THE MURRAY ISLANDS

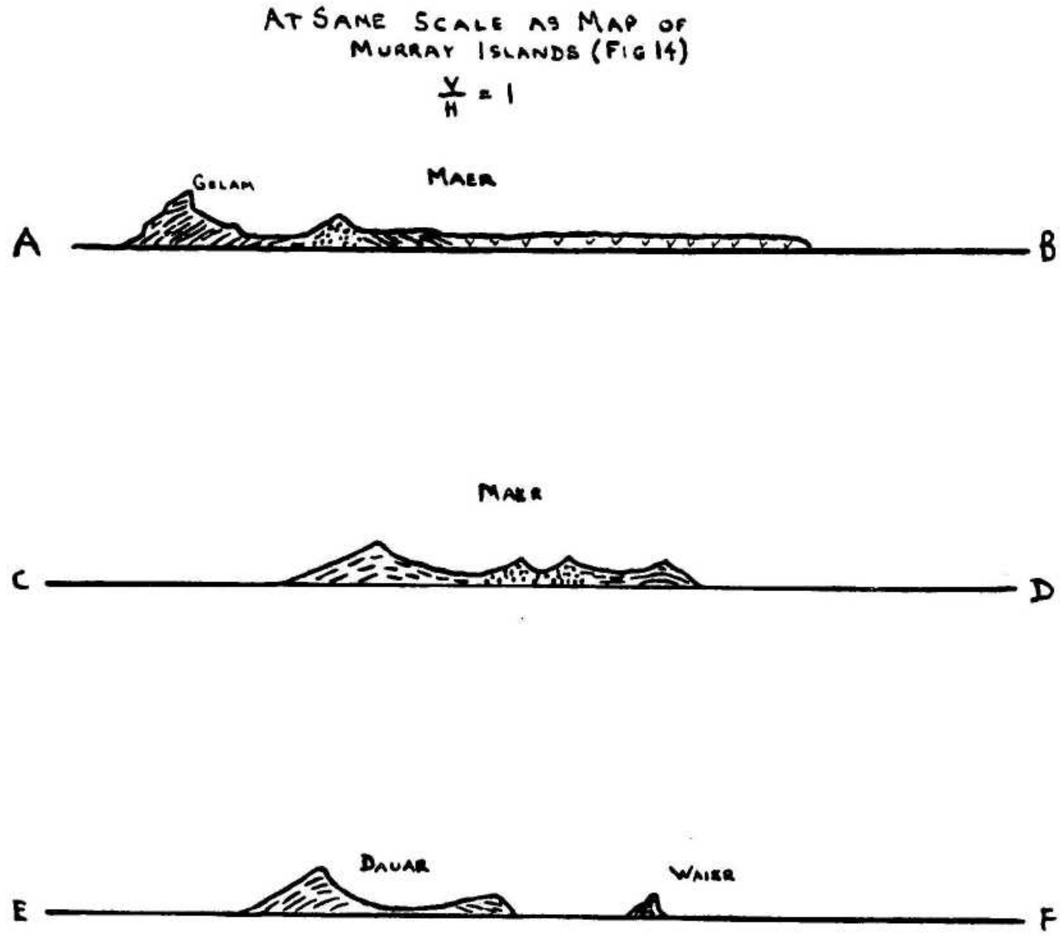


FIG. 15 CROSS-SECTIONS, MURRAY ISLANDS
(FROM HADDON, SOLLAS AND COLE, 1894.)

Plate 7. Maer Island from northwest. Crater rim rising to Gelam (peak on right).

Plate 8. Maer Island from south. Gelam (peak on left); spatter cone (centre); basalt flows breaching crater rim (far right).

Plate 9. Moderately dipping bedded tuff at base of cone of Maer Island; on south coast.

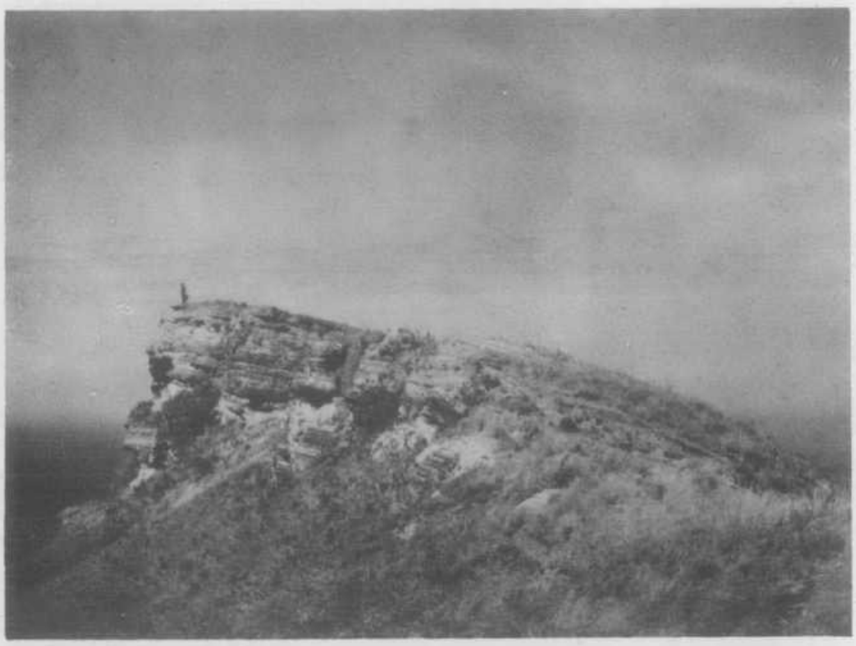


Plate 10. Gently dipping bedded tuff at peak of Gelam, summit of crater rim of Maer Island.

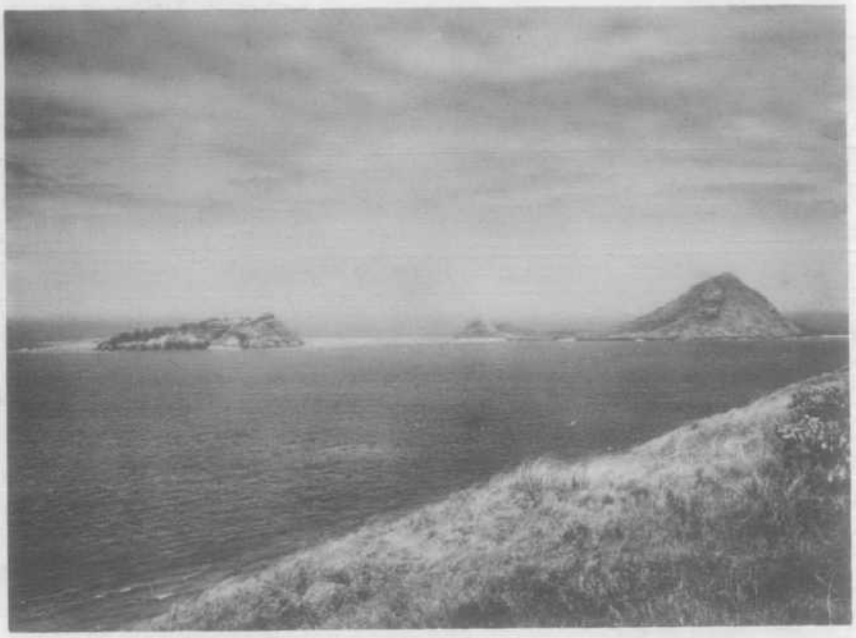


Plate 11. Cones of Waier Island (left) and Dauar Island, looking southeast from Maer Island.

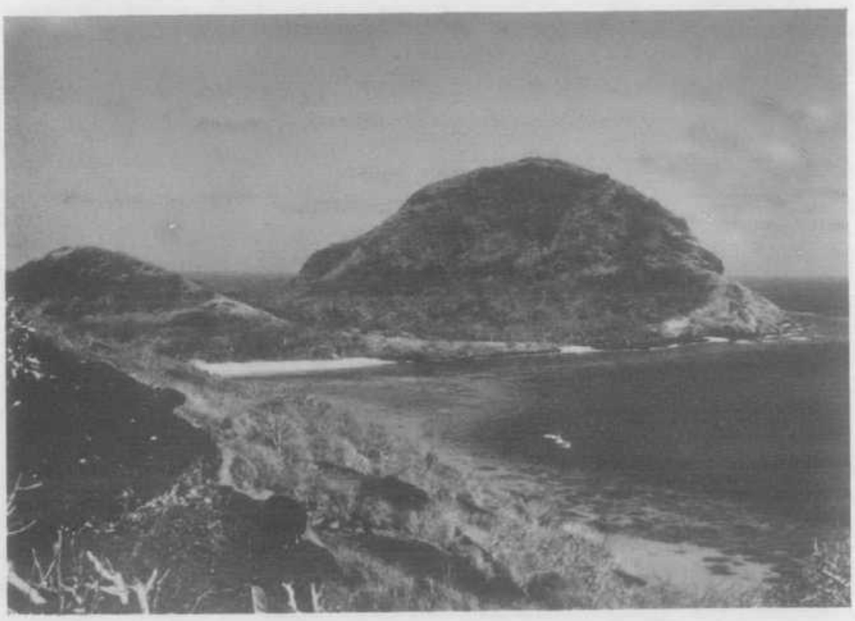


Plate 12. Crater of Dauar Island, looking west from Waier Island.

Plate 13. Exterior of crater rim of Waier Island from northwest showing radially dipping bedded tuff. (Height of island is about 300 feet.)

Plate 14. Interior of crater of Waier Island from north. Note steep inward dips in slumped ash (now tuff), far right.

they are in the tuff at Maer, and form up to 30 percent of some beds. Limestone fragments are also more common on Waier Island.

At Darnley Island a thickness of about 100 feet of tuff, similar to the tuff of the Murray Islands, is exposed in Treacherous Bay beneath the basalt pile which forms the bulk of the island. The base of the tuff is not exposed.

The tuff is well bedded. Typically, beds about 1 foot thick contain bombs of vericular basalt and white recrystallized limestone in a matrix composed mostly of abundant fragments of altered glass, basalt lapilli, and olivine crystals. These beds alternate with thinner beds a few inches thick composed only of the matrix material with a few small rounded fragments of basalt and limestone. Some of the beds of this fine-grained tuff are less than 1 inch thick. Cross-beds and scours are common and dip in the same direction as the tuff beds. Some of the larger basalt bombs have in landing deformed the underlying ash beds for an inch or two. The strike of the tuff beds runs more or less parallel to the curved shore of Treacherous Bay and the beds appear to dip consistently outwards from a point in the sea north of the island, at angles between 10 degrees and 25 degrees. This has led Jardine (1928b) to state that the beds represent the southern part of an ash cone whose centre lay to the north of Treacherous Bay.

In places in Treacherous Bay basalt lies directly on fresh tuff; in other places the contact is marked by a layer about 1 foot thick, of rounded cobbles and small boulders of basalt in a sparse matrix of red clay lying on weathered tuff and overlain by fresh porphyritic basalt with few vesicles. In one exposure basalt in contact with the clay has a chilled margin, between 6 and 9 inches thick, in which round phenocrysts of augite are prominent.

The Black Rocks, near Bramble Cay, were not examined in the course of this survey because of high seas breaking over them. Jardine (1928a) describes them as coarse ash or tuffaceous beds with a well developed banded structure. They are composed of fragments of decomposed olivine basalt in a fine-grained matrix which contains olivine and augite crystals and calcareous material.

At Daru Island, in Papua, tuffaceous sediments crop out in places around the shoreline and on the hill forming the highest point of the island. These sediments were probably deposited at the same time as the Maer Volcanics and have been included in them. MacGregor (1967), reporting on water wells and bores at Daru, states that the "tuffaceous sandstone ... is almost horizontal and ranges from 10 to 50 feet in thickness .... The bottom of the sandstone is found up to 12 feet below sea-level and it is underlain by a thick layer of yellow or blue clay".

The tuffaceous sediments are fine-grained bedded rocks which contain small rounded fragments of basalt and limestone in a matrix composed of lapilli and smaller fragments of altered glass, in an abundant calcite cement. Grains of olivine, pyroxene and iron oxide minerals are also scattered through the matrix.

Petrography of the Tuff

The tuffs at Darnley Island and at the Murray Islands are closely similar. Their average composition is 65 percent altered glass fragments, 12 percent calcite, 12 percent olivine, 10 percent pyroxene, and small amounts of iron oxide minerals and zeolites. The altered glass forms round brown fragments grading from very fine through coarse up to lapilli and bombs of vesicular glassy basalt; vesicles are common even in the smallest fragments. Feldspar microlites are evident in some glass fragments, and patches of clear glass are common within the altered brown glass forming bombs and larger lapilli.

In addition to the limestone fragments in the tuff, calcite commonly forms irregular patches interstitial to the glass fragments of the matrix. Shell fragments are evident in sections of limestone in tuff from the Murray Islands, and the margins of these fragments are commonly recrystallized. Most limestone fragments in the tuff at Darnley Island appear to be completely recrystallized.

The olivine forms small subhedral or broken fresh crystals scattered through the matrix of the tuff, and subhedral olivine crystals of the same size are common in lapilli and bombs. Pyroxene is absent from a few thin sections of the tuff; where present the pyroxene crystals are scattered through the matrix and are commonly broken; some pyroxene crystals in lapilli and bombs are also broken and granulated.

Iron oxide minerals occur in a few thin sections scattered through the matrix of the tuff. Zeolites form rare angular crystals in the matrix and have clearly formed after the deposition of the rock. A few small crystals of brown hornblende occur in the matrix of a tuff from Dauar Island.

The tuffaceous sediments at Daru contain altered glass fragments (45%), crystals of olivine (7%), pyroxene (2%), and small quantities of iron oxide minerals and zeolites. The rocks are similar to those described above, except that at Daru glass and other fragments are less abundant, and the calcareous groundmass makes up 45 percent of the rock.

Basalt

The most extensive and abundant exposures of basalt are present on Darnley Island. The 500-foot thick pile of lava is undoubtedly composed of many flows, but only a few of these can be made out. On the northern slopes of the island, about 150 feet above sea-level, the top of one flow is indicated by elongated and highly vesicular blocks of lava in a matrix of dense, very fine-grained basalt with a flow texture picked out by thin streaks of black glass. About 50 feet higher the top of another flow is revealed by a horizon of red earth, a few feet thick, which contains abundant boulders of weathered, highly vesicular lava, and which is overlain by massive basalt with few vesicles.

On a ridge running south from the summit of the island two prominent steps, each between 30 and 50 feet high, may outline lava

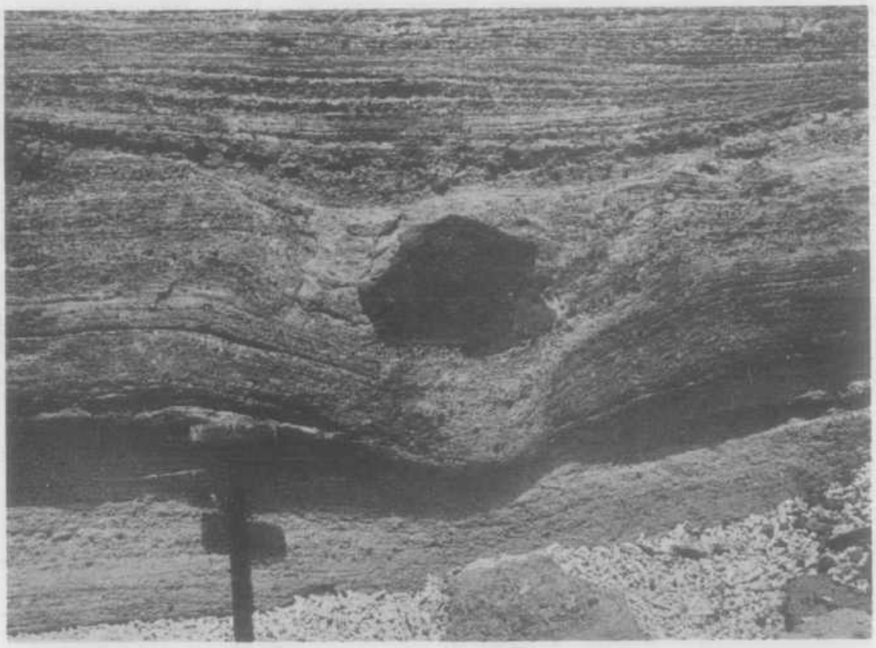


Plate 15. Basalt bomb distorting bedding in
tuff, Treacherous Bay, Darnley Island.

Plate 16. Lenses of limestone fragments in tuff,
Treacherous Bay, Darnley Island.

Plate 17. Bedded tuff, overlain by basalt (top of hill) Treacherous Bay, Darnley Island.

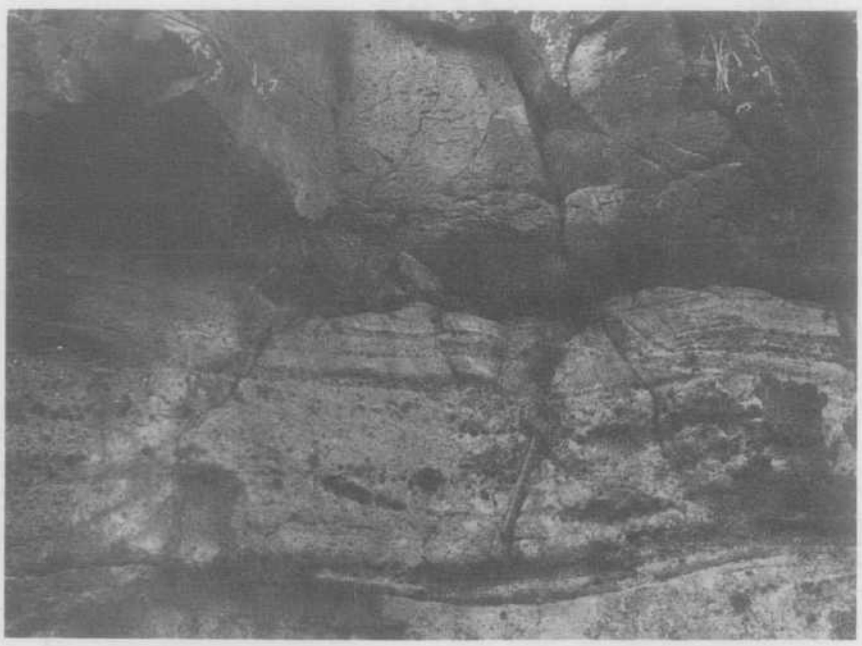


Plate 18. Basalt flow overlying bedded tuff, Treacherous Bay, Darnley Island.

Plate 19. Vesicular basalt, Stephens Island.

flows, but such features are surprisingly rare; the western part of the island, as Jardine (1928b) notes, is probably a dip slope following the surface of one or a few flows. Towards the northeast corner of Darnley Island a ridge of blue clay, in which prominent small gullies have been cut, trends northwestwards across the island, and may be the weathered outcrop of a single, less resistant flow. The clay contains rare small fragments of silica and scattered boulders of weathered basalt.

In the Murray Islands basalt flows are present only on Maer Island, where a group of flows, over 100 feet in total thickness, breaches the eastern side of the crater. Individual flows cannot be distinguished, but variations in the abundance of olivine and augite phenocrysts in the coastal exposures suggest that several flows are present.

Stephens Island is mantled by red soil containing large residual boulders of basalt with prominent feldspar phenocrysts. As the island approaches 100 feet in height, it is almost certainly composed of more than one flow.

Bramble Cay is a sand cay with two small exposures of basalt on the coral flat at its eastern end. In the larger exposure weathered vesicular basalt lies on sparsely vesicular basalt, which is composed partly of bodies that may be pillows up to two and a half feet long, and partly of a compact aggregate of small cubes of massive basalt, each between 1 and 3 inches across. A few of the pillows exhibit concentric banding. The vesicles in the overlying weathered vesicular lava are commonly filled with white phosphatic material derived from guano, which encrusts the nearby sand cay. The smaller exposure of basalt at Bramble Cay is a compact aggregate of rounded fragments of vesicular basalt.

Petrography of the Basalt

The olivine basalt is everywhere a vesicular, dark grey, fine-grained rock spotted by small phenocrysts of olivine and larger aggregates of pyroxene. In places some vesicles are partly filled with zeolite minerals. The basalts exposed at Maer Island and Darnley Island are similar, but the basalt of Stephens Island differs from them in possessing abundant phenocrysts of feldspar. The basalt at Bramble Cay appears to contain more iron oxide mineral than the others.

Six thin sections from Darnley Island indicate the rocks have an average composition of 65 percent labradorite, 15 percent pyroxene, 10 percent olivine, and 10 percent opaque mineral. One of the sections is enriched in opaques (25 percent) and impoverished in labradorite (45 percent); another is predominantly composed of dark brown glass (70%) with small phenocrysts of olivine (5%) and aggregates of pyroxene crystals (25%) similar in appearance to those in the wholly crystalline specimens.

The labradorite generally forms small laths which make up the great bulk of the matrix. These laths are commonly arranged in a flow-pattern around the phenocrysts of dark minerals. The labradorite is remarkably fresh, though the lava is riddled with vesicles and is soft and easily broken. The opaque mineral, which forms the remainder of the matrix, appears to be more abundant than normal.

Olivine forms abundant small phenocrysts, many of which are euhedral. In some sections the olivine is fresh; in others it is altered to serpentine or iddingsite. The pyroxene crystals generally form aggregates, and in some they penetrate each other; some pyroxene crystals contain small crystals of olivine. Very small grains of olivine and pyroxene are also present in the matrix.

Three thin sections of basalt from Maer Island show that the rocks contain up to 40 percent glass, and consequently their content of labradorite (about 40 percent) is significantly less than that of the Darnley Island rocks. The small laths of labradorite in a matrix of glass reveal a marked flow texture, and are associated with small grains of opaque mineral, which makes up between 10 and 20 percent of the rock. Olivine and pyroxene each form about 10 percent of the rocks. The olivine phenocrysts are intensely fractured, and some of the pyroxene aggregates are granulated or broken; in one section microcrystals of pyroxene are abundant in the matrix and form about 10 percent of the rock, which also contains about 5 percent pyroxene phenocrysts. Some fractured olivine crystals occur in aggregates of granulated pyroxene. In one section the edges of broken olivine crystals have altered to iddingsite, but generally the mineral is fresh.

The basalt which forms Stephens Island is similar in composition to the basalt at Darnley Island, but the plagioclase in the former rock forms abundant large laths or phenocrysts in addition to making up the bulk of the matrix as small laths. In contrast to the feldspars at Maer and Darnley, the groundmass feldspar laths at Stephens Island have no evident preferred orientation, and the phenocrysts are slightly altered. The plagioclase is mainly labradorite, and forms about 75 percent of the rock. Opaque mineral forms 10 to 15 percent of the basalt and is intergrown with the plagioclase of the matrix. The olivine is commonly altered to deep red iddingsite and forms about 10 percent of the rock as rounded phenocrysts. Pyroxene crystals form both isolated small phenocrysts and scattered aggregates, the latter commonly associated with large feldspar laths. In places the pyroxene is slightly cloudy and the crystals are broken; it forms about 10 percent of the rock.

The basalt at Bramble Cay is essentially similar to that at Darnley Island, but broken fragments of olivine and augite crystals are present in addition to the large phenocrysts. Granules of opaque minerals are exceptionally abundant in the groundmass, and one thin section shows a sharp but undulating junction between an opaque rich and a more normal rock; the significance of this is not known.

Formation of the Volcanics

The basic volcanic activity in the northeast of Torres Strait occurred at a number of centres, but only small volcanoes were built up at each. The activity appears to have started with the eruption of ash, probably when a gas-rich basaltic magma, containing olivine and pyroxene crystals suspended in a residual liquid, came into contact with sea-water. Later effusion of basalt may have taken place when the vents were closed off from the sea. The presence of feldspar phenocrysts at Stephens Island and of abundant iron oxide at Bramble Cay suggests local fractionation of the magma.

Cross beds and scours are common in the tuff at Darnley Island and their presence suggests that this tuff was deposited in shallow water subject to the influence of currents, probably in the sea. On the other hand the three well-developed cones of the Murray Islands were undoubtedly built up above sea-level.

Most of the limestone fragments at Darnley Island are almost completely recrystallized and appear to have undergone more intense metamorphism than the limestone fragments at the Murray Islands, in which commonly only a thin skin of recrystallized material surrounds unaltered fossiliferous rock. The recrystallized limestone at Darnley Island probably had its source deep in the neck of the volcano, and much of the limestone in the other tuffs doubtless has a similar source. However, the concentrations of limestone fragments in particular beds of the tuff at Maer could be derived from coral reefs growing within the breached crater of the volcano during a period of quiescence, in a similar situation to that which exists at present at Water Island. The reef material would be blown out and concentrated in the tuff bed formed at the beginning of a new eruptive phase.

Age of the Volcanoes

The state of preservation of the volcanic cones forming the Murray Islands suggests that they are relatively young, and almost certainly no older than Pleistocene. However, the volcanoes do not appear to have been active in Recent times; several feet of soil has formed on the basalt flows of Maer, and no unconsolidated pyroclastic material was found. The slopes of the cones at Waier and Dauar are less subdued than those of Maer, and these cones may represent the latest volcanic activity in Torres Strait. The volcanics are probably best regarded as Pleistocene.

The forms of the volcanoes which produced the lavas at Darnley and Stephens Islands and Bramble Cay have been destroyed by erosion and, in view of the thickness of lava preserved at Darnley Island, it is likely that these volcanoes are significantly older than the cones of the Murray Islands, although still probably Pleistocene.

The volcano which produced the tuffaceous sediments at Daru is no longer recognizable, but it probably has an age broadly similar to the volcanoes in Torres Strait. Mr D. Belford (pers. comm.) has determined the age of the limestone fragments in tuff from the Murray Islands, Darnley Island and Daru as Pleistocene or Recent.

APC (1961) describe several large basic to intermediate volcanoes which form part of the Central Highlands of New Guinea and which extend south to the Biwau Hills, about 120 miles north of Daru. Perry (1965) has described glacial deposits from the summit of Mount Giluwe which are younger than the volcanic rocks forming that mountain and which he has ascribed to the Upper Pleistocene. A sample of organic material incorporated in an ash fall near Tari, also in the Central Highlands, has been dated at 46,000 years B.P. by the carbon-14 method (M. Plane, pers. comm.). It is thus likely that the volcanoes in both Torres Strait and in the central highlands were active broadly at the same time, throughout the Pleistocene.

Quaternary Sediments of Southwest Papua

Pliocene and Pleistocene Sediments (Tp Qp)

Thin deposits of undifferentiated Pliocene and Pleistocene sediments overlie Miocene limestone on the Southwest Papuan shelf, and limestones of the same age have been encountered in Anchor Cay No.1 well. These deposits are described in the section on Tertiary sediments of Southwest Papua.

Terraced Alluvium (Qrt)

Photo-interpretation recently carried out for oil companies has delineated a system of river terraces around the mouth of the Fly River and an older, elevated coastal plain west of Mabaduan. Most of these features are probably composed of Recent alluvium.

Alluvium (Qra)

Extensive Recent alluvium has been deposited in the delta and lower reaches of the Fly River and on the present coastal plain along the southern coastline. Deposits of black sand have been reported from the mouth of the Fly River.

Quaternary Sediments of Torres Strait and the Mainland south of Cape York

Residual Sand (Qs) and Alluvium (Qa)

Thick white residual sand overlies Mesozoic sandstone on the mainland, merging with alluvial silt in river valleys and with coastal mud. Sand cover is thin and discontinuous over the Volcanics on the mainland except along the north coast. Sand and silt floor the lowlands on the larger islands; they are most extensive on Banks and Badu Islands.

The only extensive area of alluvium underlies the marshland adjacent to the mouth of the Jardine River. In many areas it is difficult to differentiate between residual and alluvial material, and the deposits are therefore represented on the map by the symbol Qs, Qa.

Dune Sand (Qd)

Longitudinal and parabolic dunes are found along the east coast of the mainland. They have probably formed by the action of the onshore wind during the dry season on thick deposits of residual sand derived from the underlying Mesozoic sandstones. Dunes are poorly developed or absent along the west coast where onshore winds blow only during the wet season.

Marine Sediments (Qm)

Beach sand is found along most coastlines either at the head of bays, shoreward of the fringing reef, or in beach ridge systems and sand spits. It is generally composed of a high percentage of organic calcareous detritus, and more pure quartz sand is found only in some beaches on the mainland. Beaches on exposed coasts or where the fringing reef is narrow or absent tend to be narrow and steep; wide flat beaches have formed behind extensive reefs and on sheltered coasts. West of the Jardine River beach sand extends for up to one mile from the coast in the form of vegetated beach ridges. Vegetated ridges are also found north of Jacky Jacky Creek. Sand spits and sand flats fringe a number of the rocky islands, forming mainly on west and north-facing coasts. Coral shingle forms low embankments on storm beaches along exposed coasts. A shingle bank four feet high encloses a shallow lagoon on the northwest point of Mount Ernest Island. Coral sand and shingle connects the two rocky halves of Saddle Island. A narrow beach bordering the south coast of Maer Island is formed dominantly of volcanic material derived from the decomposition of tuff, and is in places rich in olivine.

Coastal muds underlie the mangrove swamps in and near the estuaries of the larger streams and at the head of sheltered bays on the larger islands. The most extensive development lies between Jacky Jacky Creek and the Escape River.

Coral sand cays (Qmc) are present on the down wind ends of reefs of the platform type. They are formed by foraminiferal, shelly, and coral sand and shingle which are commonly cemented in the inter-tidal zone to form beach rock. On the low and swampy Sassie and Dungeness Islands no sandy detritus has accumulated, and the islands are composed only of mud.

REGIONAL STRUCTURE

In far northern Queensland, the Australian continental platform is formed by Precambrian to late Palaeozoic igneous and metamorphic rocks which are overlain by relatively undisturbed late Mesozoic sediments. The pre-Mesozoic basement is exposed in a narrow north-trending ridge along the eastern side of Cape York Peninsula (Trail et al., 1968, 1969) and in a north-northeasterly trending ridge extending across Torres Strait (Fig.16). Recent seismic and magnetic surveys (Gulf, 1965; Tenneco, 1967) suggest that the ridge on the eastern side of the Peninsula - here termed the Peninsula Ridge - may continue northwards at shallow depths under the present sea floor as far as the central area of Torres Strait. The basement ridge extending across Torres Strait - here called the Cape York-Oriomo Ridge - continues north under Tertiary cover into the southern Oriomo area of Papua (A.P.C., 1961; Stach, 1964). East of the tip of Cape York a narrow north-northeasterly trending downwarp - referred to by Tenneco (1967) as the Peninsula Trough - separates the two basement ridges described above, and is believed to contain Mesozoic sediments (Gulf, 1965; Tenneco, 1967; Shirley, in prep.).

On the western side of the Peninsula the basement has been broadly downwarped to form the relatively shallow Carpentaria Basin. The surface of the basement deepens gradually westward from its outcrop on the [illegible] Peninsula Ridge to 2900 feet at Weipa(Zinc Corporation Ltd, 1957) and to an indicated maximum of approximately 6000 feet in the centre of the Gulf of Carpentaria (Marathon Petroleum, 1966).

North of Torres Strait the Australian continental platform extends into the southwest region of Papua as a relatively stable, depressed shelf - referred to here as the Southwest Papuan Shelf - buried under moderate thicknesses of Mesozoic and Tertiary sediments, (A.P.C., 1961; Stach, 1964; Thompson, 1967). At the northern end of the Cape York-Oriomo Ridge the basement is 2000 feet deep, but generally its level undulates at depths between 4000 and 6000 feet. In the far southwest of Papua the small downwarp of the Mesozoic Morehead Basin has depressed the basement to approximately 9000 feet.

Northeast of Torres Strait the pre-Mesozoic basement deepens rapidly to approximately 30,000 feet in the eastern part of the Gulf of Papua. The depression of the basement is thought to have commenced during the Mesozoic; on the western side of the Gulf of Papua it was partly a result of movements along a number of northwesterly trending faults, downthrown to the northeast, which cut the northeasterly plunging nose of the [illegible] Peninsula Ridge (A.P.C., 1961; Gulf, 1965; Tenneco, 1967).

During the Mesozoic, southwest Papua was a stable shelf on which continental sediments were deposited, but the Gulf of Papua was an actively subsiding area in which marine shales were laid down. In the northeast of Torres Strait the sediments are complexly faulted and a number of possible structural traps have been delineated by Tenneco (1967, 1968), and Amoseas (1968).

During the Tertiary, the northeast of Torres Strait as well as southwest Papua acted as a stable shelf, and limestone was deposited over a wide area, draping structures in the underlying Mesozoic sediments. The eastern edge of the shelf was marked by a barrier reef chain, and east of this deeper water basinal conditions prevailed. North of the Gulf of Papua the small but deep Omati Trough developed, presumably behind the barrier reefs (Thompson, 1967). In the late Tertiary and in the Quaternary, the shelf in southwest Papua was largely emergent, and continental deposits covered the limestone. Black and Ollier (1969) describe Quaternary warping of Pleistocene sediments in the Morehead area.

In the basement rocks of the Cape York-Oriomo Ridge little structure is evident due to the scattered nature of the outcrops. Three members of the Torres Strait Volcanics, the Eborac, Endeavour Strait and Goods Island Ignimbrites may strike northeast and dip to the northwest. The Muralug Ignimbrite may have formed in a cauldron subsidence area, one of whose boundaries was a large northwesterly trending fault in the north of Prince of Wales Island.

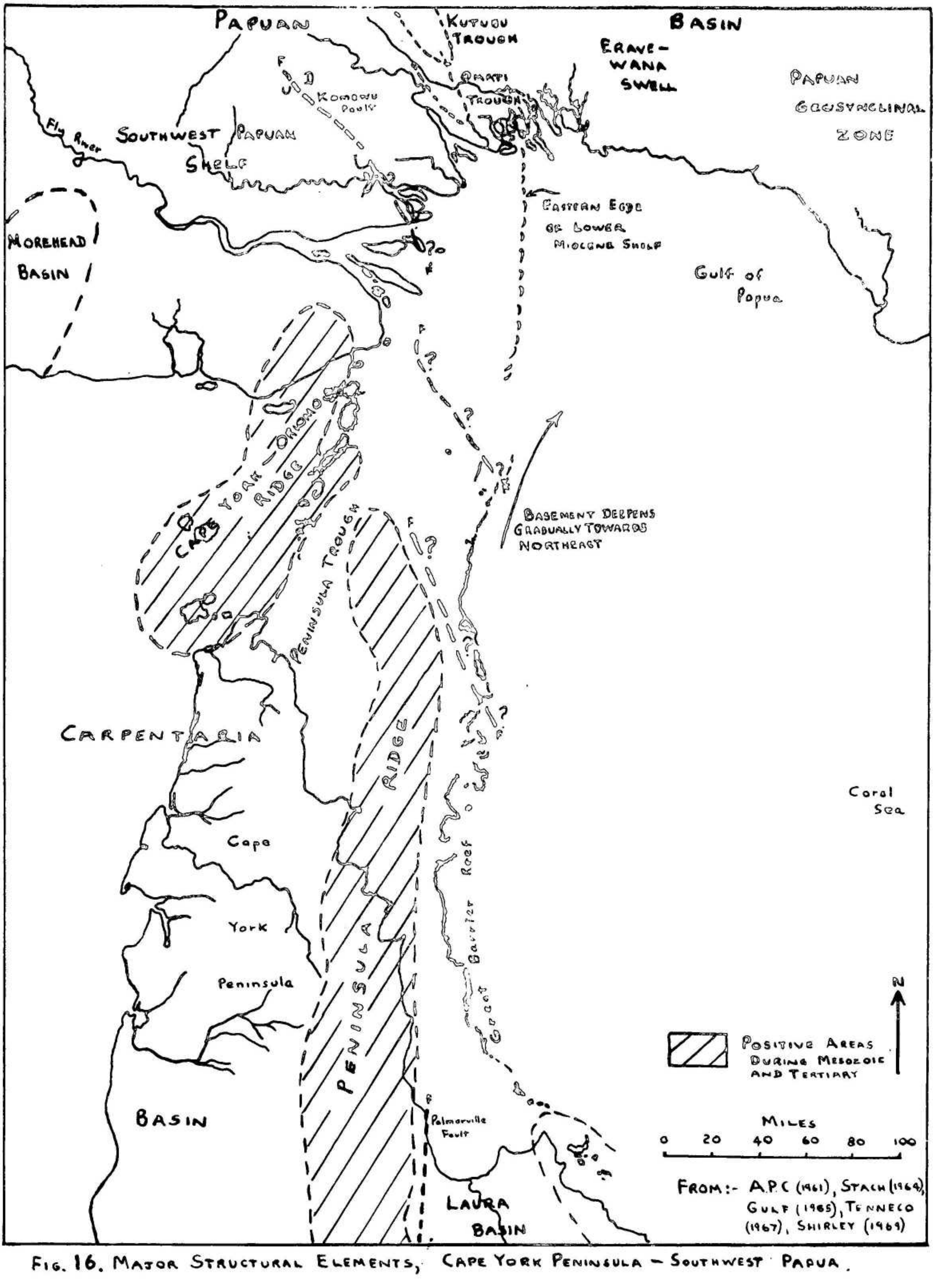


FIG. 16. MAJOR STRUCTURAL ELEMENTS, CAPE YORK PENINSULA – SOUTHWEST PAPUA.

ECONOMIC GEOLOGY

In Torres Strait mineralization is most evident in a discontinuous zone of alteration extending for more than 20 miles northwestwards from the mainland a few miles west of Cape York, to include Possession Island, Horn Island, and Hammond Island. The alteration is described above with the Torres Strait Volcanics. In the alteration zone both volcanics and intrusive rocks are kaolinized, fractured, and silicified and minerals such as pyrite, galena, chalcopyrite, cassiterite, and gold, are associated with quartz veins in the altered rocks.

Gold was produced from the shallow oxidized levels of quartz reefs at Horn Island and Possession Island in the 1890's. Galena is recorded as an abundant contaminant of gold at Horn Island. Traces of copper minerals are most abundant at Hammond Island. Small quantities of cassiterite have been produced from lodes and alluvium on the mainland near Cape York since 1952.

Small quantities of wolfram were produced by gouging and hand-picking at Moa Island during World War II and the Korean War, when prices were high. Bauxite forms a deposit on Turtle Head Island and on the mainland south of it. Lateritic ironstone is abundant near Cape York.

Stone for construction is scarce throughout southwest Papua but is easily available at Dauan Island and at Mabaduan. Lime-sand and coral are particularly abundant in the eastern part of Torres Strait, and quartz sand in the southwestern part. A veneer of guano occurs on Bramble Cay, and small deposits of sand rich in olivine occur at Maer Island.

ALUMINIUM

Connah and Hubble (<u>in</u> Hill and Denmead, 1960) note that "in the Escape River area and on Turtle Head Island bauxitisation is prevalent east of the Great Divide outcropping at elevations between sea level and 150 feet, and apparently underlying the ferruginous material. It is exposed in coastal cliff sections beneath a cover of sand dunes. The bauxite, which is a hard red pisolitic to nodular rock 1 foot to 16 feet thick, overlies a ferruginous nodular band, passing down to partly iron-stained sediments". They conclude by saying that "the bauxite is generally siliceous and of rather low average grade".

COPPER

C.R.A. Exploration Pty Ltd (Whitcher, 1966) undertook a reconnaissance geochemical survey of stream sediments on islands in Torres Strait between Badu Island and Possession Island in a search for porphyry copper deposits. Overall they found very low background values of copper. The values between 5 and 15 ppm (parts per million) obtained generally on the volcanic rocks tended to be a little higher than the values of 5 ppm obtained on the granite. The highest values obtained for copper were 40 ppm on Moa Island and 28 ppm in the central part of Hammond Island.

In the course of the geochemical survey, minor copper mineralization was noted on Goods Island, Hammond Island, Possession Island, Thursday Island, and on the mainland. A reconnaissance survey by Enterprise Exploration Co. Pty Ltd (Spratt, 1957) also noted minor copper mineralization on Goods Island, Hammond Island, Possession Island, and Booby Island. During mapping in 1968 most of the localities with copper mineralization were visited.

On the northeast coast of Hammond Island chalcopyrite grains are disseminated in a zone measuring about 150 feet by 20 feet, within a body of tonalite along its contact with the welded tuff forming the island. Small patches of chalcopyrite up to 1 inch across also occur in the zone. The bulk of the outcrop of the tonalite is concealed by the sea: the tonalite near the contact is chloritized and contains a few quartz veins. Joints and veins in volcanics near the contact are stained by malachite and iron-oxide minerals.

On the west coast of Hammond Island chalcopyrite altering to malachite and azurite in joints and veins occurs in about 20 per cent of the exposures of altered, silicified, and fractured welded tuff over a distance of about 150 yards; breccia and dykes (?) of porphyritic rock also form part of these exposures.

C.R.A. Exploration Pty Ltd and Enterprise Exploration Co. Pty Ltd record malachite on joint planes on the west side of Goods Island, and C.R.A. also record traces of malachite or chrysocolla on Thursday Island. Small patches of malachite occur in a zone of shattered welded tuff, 1 foot thick, on an islet north of Friday Island.

The presence of minor copper mineralization in the vicinity of Hammond, Goods, Thursday and Friday Islands suggests that the area merits further investigation, particularly perhaps the north end of Hammond Island, although the surveys by Enterprise Exploration Co. and C.R.A. Exploration evidently did not yield promising results.

Towards the west end of the beach on the north coast of Possession Island malachite, azurite, and bornite(?) form veins and patches in chloritized and silicified welded tuff, which also contains many veins filled with limonite. Malachite also stains an iron-rich quartz vein near the abandoned gold mines. Enterprise Exploration Co. Pty Ltd note two small areas with copper stains in the southwestern part of Possession Island.

On the mainland coast about 1 mile southwest of Peak Point malachite grains occur in altered and quartz-veined tuff. Malachite stains also occur in welded tuff exposed below the Bluff tin prospect, on the beach about 1 mile southeast of Peak Point.

Jackson (1902) recorded a little copper pyrites among the sulphide minerals abundant in the open cut gold mine at Horn Island and some chalcopyrite was seen in rocks from this area in 1968. Malachite stains siliceous veins in a dyke of porphyritic microgranite at Coconut Point on the southwest coast of Badu Island, where minor wolfram mineralization also occurs.

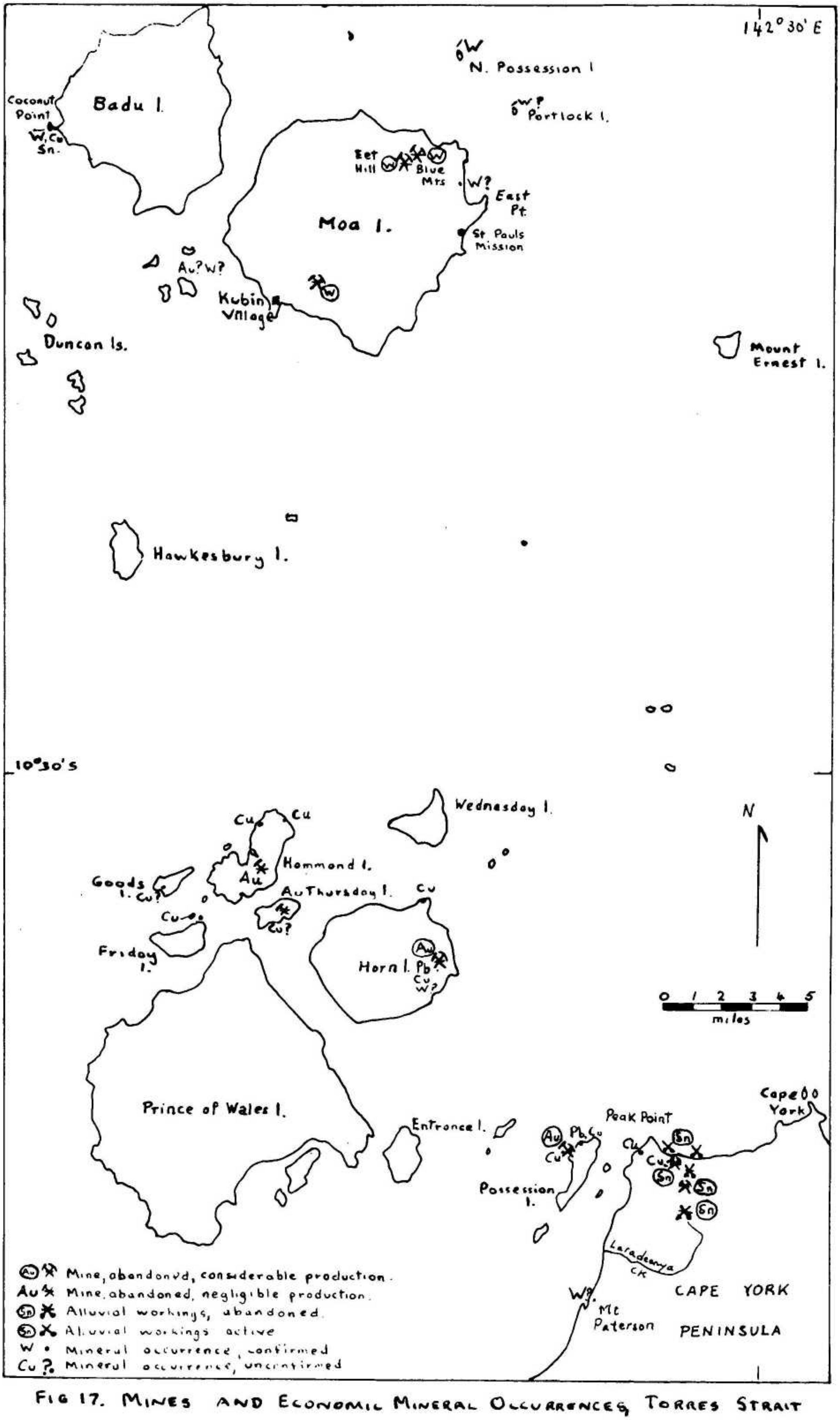


FIG 17. MINES AND ECONOMIC MINERAL OCCURRENCES, TORRES STRAIT

GOLD

Rands (1896) reports that gold had been discovered on Prince of Wales Island and on Hammond Island some time before his visit to Torres Strait in 1896. The Horn Island Gold and Mineral Field was discovered in 1894. In 1897 production began from gold mines on Possession Island and in 1902 Jackson noted that gold had also by then been found on Thursday Island. Annual Reports of the Department of Mines in Queensland reveal that gold was produced at Hammond Island between 1907 and 1909 and possibly until 1918. They also record that unsuccessful prospecting was carried out at Prince of Wales Island in 1922 and that prospecting on Thursday Island in 1931 led to mining on a small scale in the next few years, though lack of water was a hindrance. In 1935 a claim at the rifle range gave 2.21 ounces of bullion from 2 tons 4 hundredweights of ore; no other production is recorded. Islanders claim that gold was mined on an island south of Badu Island, possibly Clarke, Brown, or Barney Island, but no confirmation of this could be obtained, and no sign of mining was seen on these islands.

Most of the gold mined in Torres Strait was won from the mines at Horn Island and Possession Island before Jackson's visit in 1902, and mining activities at these two islands are described in detail below.

Gold production in Torres Strait, as recorded in the Annual Reports of the Queensland Department of Mines, is shown in Table 3.

Horn Island Gold and Mineral Field

The whole of Horn Island was proclaimed a gold and mineral field in 1894, though the abandoned gold mines lie within an area only about half a mile square, about three-quarters of a mile inland from the east coast of the island between Horned Hill and Papou Point. The mines are about 6 miles distant by road from the jetty opposite Thursday Island; the track to the mines is a continuation of the road between the jetty and the airport.

The mines are in altered and silicified porphyritic microgranite, which forms a rise on the south side of a stretch of sandy alluvium. The mines and their history have been described by Rands (1896) and Jackson (1902). Alluvial gold was discovered in 1894 and was worked until 1897 in gullies running into Spring Creek and Smyths Creek. Rands notes that the alluvium along Spring Creek had not been tested for gold in 1896, but he thought it unlikely to contain gold in payable quantities.

Reef mining began in 1895 or 1896. The reefs gave good yields for the first few years but the recovery of gold declined sharply in 1900; by 1901, when Jackson visited the field, it was almost deserted.

Rands described the reefs that were being worked in 1896. Most of them are quartz reefs composed of closely spaced quartz veins penetrating altered microgranite. Most of the reefs trend between east-southeast and southeast and dip steeply towards south-southwest. They range in width from a few inches to 4 feet. In contrast, the Band of Hope reef is described by Rands as a decomposed granite dyke with small veins of quartz running through it; it yielded less than 4 pennyweights of gold to the ton.

Sulphide minerals appeared in most of the reefs only 10 feet below the surface. Rands states that pyrite and galena are most common; some reefs also contain sphalerite and two also carry chalcopyrite. The deepest shaft on the field was sunk to 45 feet below the surface and only a few reefs were worked down to 30 feet. Undoubtedly the shallow occurrence of sulphide minerals led to the early closure of the field, since contemporary methods of treatment could not extract gold in association with sulphides. In 1896 Rands noted that several reefs yielded more than 1 ounce of gold to the ton, and the average yield for reef gold for that year was 19.5 pennyweights to the ton. In the following three years the average yield slipped to 12 or 13 pennyweights and in 1900, when a large quantity of ore, presumably containing sulphides, was treated, the yield was a disastrous 0.15 pennyweights to the ton.

Samples collected by Jackson in 1901 from an open cut on what was probably the Welcome reef were assayed and yielded values ranging from 1 ounce of gold and slightly less than 2 ounces of silver, up to 22 ounces of gold and 11 ounces of silver to the ton. These samples all contained large quantities of sulphide minerals - one of them was 80 per cent sulphides - and would not yield much gold from the treatment methods in use in 1900.

TABLE 3: GOLD PRODUCTION IN TORRES STRAIT

Year	Horn Island Ore (tons)	Horn Island Gold (ozs)	Possession Island Ore (tons)	Possession Island Gold (ozs)	All Torres Strait Ore (tons)	All Torres Strait Gold (ozs)
1894	Alluvial	320				
1895	"	569				
1896	"	110				
1896	1311	1292				
1897	1180	741	780	450		
1898	3794	2559	1185	586		
1899	533	329	492	432		
1900	9819	759	363	751		
1901			545	261		
1902		113		771		
1903					1063	611
1904					1080	423
1905			825	393.5	1225	476
1906					825	363
1907					2714	406
1908	2001	146				
1909					2382	168
1910					138	18
1911						99
1912					30	31
1913						
1914						
1915					25	26
1916					112	69
1917					743	71
1918					380	38
1919	36	28.5	4	2.8		
No recorded production						
1935					2.2	2.21
No recorded production						
1941		31.94				

Note: Gold produced before 1903 is quoted in fine ounces. Gold produced in 1903 and after is, with few exceptions, quoted as mill gold, which had a considerable range in value. For this reason it is not possible to give a total production figure in fine ounces. Production before 1903 amounted to 10,043 fine ounces, and from 1903 onwards the production total of mill gold (of variable value) was 3384 ounces.

Jackson describes the sulphides exposed at the bottom of the open cut as "chiefly galena, mispickel, and iron and copper pyrites. A little zinc blende is also present".

Annual Reports of the Department of Mines reveal that sporadic production of gold from Horn Island continued on a small scale until 1919 and prospecting has gone on at intervals until 1966. Alluvial claims were tested in 1922, without result. In 1940, 100 tons of ore at grass on Horn Island presumably yielded the production of 31.94 ounces of gold and 5.84 ounces of silver recorded for 1941. Samples sent for assay in 1951 were said to give encouraging results.

In 1958 a 40-acre lease was applied for covering the old mines; in 1961 ore was treated to obtain samples for assay, and a concentrate assayed at 24 ounces 3 pennyweights and 5 grains of gold, and 14 ounces 4 pennyweights of silver to the ton. Australian Selection Pty.Ltd. drilled 3 holes to depths of about 250 feet at Horn Island in 1963, but did not consider the prospect payable. In 1965 overburden was removed and 150 cubic yards of alluvium was taken for sampling, the results of which are not known; prospecting and sampling continued into 1966.

A visit to the mines in 1968 revealed a large open cut probably on the Welcome reef, about 300 feet long by 150 feet across and partly filled by water, and a smaller open cut, in the vicinity of the Dead Cat claim as shown by Rands and Jackson, which is about 90 feet long, 60 feet across, and 10 feet deep, with a timbered shaft in reasonable condition sunk in the bottom.

In the smaller open cut the porphyritic microgranite is yellowish green and intensely altered; it is cut and silicified by numerous quartz veins. The altered rock contains small patches of sulphide minerals. In the larger cut the microgranite is less altered and contains fewer quartz veins, and sulphide minerals form small veins within it. The most common sulphides are pyrite and galena; some chalcopyrite was also observed, and a little wolfram(?). No one was working on the field at the time of the visit. A small 5-head battery in reasonable condition is located near the smaller open cut.

Possession Island Provisional Gold and Mineral Field

Following prospecting in 1896, the production of gold at Possession Island began in 1897; Jackson (1902) described the mines, which he visited in 1901. All the workings are located fairly near the shore in the northwestern part of the island, east and northeast of the monument to Captain Cook. Gold production is given in table 3.

Jackson records that the main workings were located on two reefs about 250 yards apart, which trend south-southeast and which are almost vertical. Each reef is composed of quartz veins, up to several inches thick, in a matrix of fractured and altered tuff, which Jackson identified as decomposed porphyritic granite. The veins contain a small quantity of sulphide minerals.

Jackson found several shafts and small cuts. Almost all the workings on one reef were situated on the shore near high-water mark and, as Jackson says, water must have caused considerable trouble. Ore had been stoped from one reef to a depth of 50 feet, and one flooded shaft was about 60 feet deep. Jackson sampled a heap of ore composed of vein quartz with galena and pyrite, and obtained an assay of 1 ounce 17 pennyweights 5 grains of gold and 1 ounce 1 pennyweight 19 grains of silver to the ton.

Jackson noted that the reefs strike towards the gold mines at Horn Island and that the reefs on both islands were in the same mineralized zone.

Annual Reports of the Department of Mines indicate that production from the Possession Island mines continued until 1905, and the mines were abandoned in 1907. A small quantity of gold was recovered from the island in 1918 and 1919. Prospectors were active again in 1932 and shafts were sunk in 1934 and 1935. There is no further record of mining activity on Possession Island.

A visit in 1968 revealed only a trench and three collapsed shafts along a line trending 140 degrees. Mullock nearby is composed of fractured and chloritized welded tuff with quartz veins which are not evidently mineralized. Copper staining associated with limonite was found in outcrops of chloritized and silicified welded tuff northeast and southwest of the abandoned workings, and some galena and pyrite were observed in joints northeast of the workings.

IRON

In many places, particularly along the mainland coast running southwest from Albany Pass into Newcastle Bay, the ferricrete (lateritic ironstone) which caps the Mesozoic sediments is several feet thick and appears to be strikingly free from contaminants, containing only scattered remnant grains of quartz. Specular hematite forms scattered veins, up to a few inches thick, at one locality in granite on the north coast of Gabba Island. Pyrite is the most common sulphide mineral in the zone of alteration which extends from near Cape York to Hammond Island.

LEAD

The mining of gold at Horn Island ceased when the reefs were found to carry abundant sulphide minerals at depths of only 10 feet. Rands (1896) states that pyrite and galena are the most abundant sulphide minerals there, and Jackson (1902) notes that samples from the open cut at Horn Island all contain large quantities of sulphide minerals, "chiefly galena, mispickel, and iron and copper pyrites. A little zinc blende is also present".

C.R.A. Exploration Pty Ltd (Whitcher, 1966) record 197 ppm lead in a stream sediment sample from the centre of Hammond Island and 100 ppm zinc in a sample from the east coast of Hammond Island.

Traces of galena are present in the rare veins of specular hematite in the granite at Gabba Island. A little galena also occurs in the gold reefs on Possession Island.

TIN

The occurrence of lode and alluvial tin near Cape York on the mainland was first noted in 1948 by Messrs Bromage, Holland and Miller. The tin mineralization occurs in the southeastern part of the zone of altered and mineralized welded tuff described above, and appears to be confined to an area of about 4 square miles extending about 2 miles along the coast between the old Cape York Post Office site and Peak Point, and for about 2 miles southwards into the hills behind the coast.

Alluvial tin has been worked in river sands between these hills and Punsand Bay, and south of the hills in the upper reaches of Laradeenya Creek and its tributaries. Most of the tin concentrate produced from these deposits between 1952 and 1962, (recorded in Table 4), has come from small rich pockets in sandy alluvium at the head of the beach in Punsand Bay.

In 1952, following successful trial crushings at Irvinebank of parcels of ore from Hollands Reef, in the hills 2 miles south of the beach, the Queensland Department of Mines erected a small battery on Holland's lease in 1953, and production from that reef and from a few others continued until 1956.

Of the reefs listed in the Annual Reports of the Department of Mines, only Holland's Reef was located in 1968; it is believed to be the reef from which most tin has been won. Robertson (1959) describes it as being made up of 2 to 5 inches of silicified porphyry with visible tin and 1 inch to 2 feet of mineralized quartz, much of it with no tin. The reef strikes about 10° and dips westwards at angles ranging from 10° to 45°. Fleischman (1953) states that the tin occurs in shoots in the reef.

The Booty mine is described by Fleischman (1953) as a shallow trench on a reef between 3 inches and 1 foot wide, striking towards 157° with a flat dip. He describes the lode as quartz porphyry in which tin occurs in irregular and discontinuous sheets. Fleischman records the Northern Mine as a shallow cut on a reef striking 116° and dipping 22° northwards; the width of the reef ranges from 18 to 30 inches, and the tin again occurs in sheets. The Northern Mine is probably Mulhollands Mine, which is 2 miles north of Hollands Mine, and Granite Bar and Barbara's Bar may be other names for the Bluff quarry, described below.

In 1959 Robertson records that Holland's Reef had an open cut on it 80 feet long and a shaft 30 feet deep. In 1968, 3 inclined shafts connected by a flooded drive about 10 feet below the surface were examined. The shafts follow a lode made up of alternating layers of clear and opaque quartz downwards at an angle of 45°. The mullock dump is composed of fragments of white quartz and green silicified welded tuff. The welded tuff is cut by many pyrite-bearing quartz veins about 2 mm thick; pyrite also faces joints and forms thin rusty veins and lenses up to 30 mm by 10 mm. Some chalcopyrite (?) is also present in these lenses.

Lode tin also occurs in scattered outcrops of welded tuff on the coast at Punsand Bay. A small quarry, about 25 feet by 20 feet, has been opened up in one outcrop, known as the Bluff. In 1968 Mr Mulholland, who was mining alluvial tin nearby, said that the tin formed the black veins, about 1 mm thick, which were clearly visible in the altered green tuff forming the outcrop. He stated that the veins generally contain amber tin with some ruby tin. Large grains of tin which form scattered small lenses are fractured and are easily broken down to the same size as the tin in the veins.

Much of the alluvial tin produced has been won by small syndicates which, according to Mr Mulholland, did not work systematically, but concentrated on rich pockets near the beach behind Punsand Bay, where they would win only a few tons of cassiterite before moving away. In 1968 Mr Mulholland was getting tin from poorly sorted alluvial sand with pebbles of welded tuff, at the head of the beach, about three-quarters of a mile east of the Bluff quarry.

Jones (1951) records that alluvial tin was being worked in the headwaters of Laradeenya Creek a few years after the discovery of the other deposits, but the amount produced is not known and is probably small. In 1961 Roonga Tin Pty Ltd spent a few thousand pounds on building a jetty and on obtaining advice on the alluvial deposits, but the company, as far as can be made out, produced little tin.

Both the alluvial and lode deposits have been tested by various companies and individuals since 1949. Almost all have made discouraging reports on the prospects for mining. The first systematic investigation of the tin deposits was made in 1952 by Mount Isa Mines Ltd (Carter and Porter, 1952). After digging 130 pits to an average depth of 9 feet along Laradeenya Creek and its tributaries, the company found that no sample contained more than 1 lb of cassiterite per cubic yard, few samples had more than 0.5 lb per cubic yard,

TABLE 4: PRODUCTION OF TIN NEAR CAPE YORK

Year	Ore treated (tons/type)	Tin concentrates produced (tons)	Locality
1950	Alluvial(43 yds)	0.16	Laradeenya Creek?
1952	Alluvial?	0.12	?
"	39.85	3.4	Holland's Reef
1953	?	?	
1954	100	3.4	Holland's Reef, Granite Bar
"	Hand dressed	0.45	Northern Mine
1955	?	3.7	Holland's Reef, Granite Bar, Northern Mine
"	Alluvial	2.7	Atlas, Beach Lease, Lady Luck
1956	?	3.45	Holland's Reef, Barbara's Bar
"	Alluvial	2.65	Beach Lease, Ocean Lease
1957	Alluvial	0.9	Dreding lease
1958	"	1.0	?
1959	"	5.65	?
1960	"	1.15	?
1961	?	0.25	?
1962	?	0.6	?

and most contained 0.1 lb or less. Jones (1951) records that the first 48 pits encountered for the most part fine sands with hard bands of ferruginous laterite up to 2 feet thick.

Mineral Deposits Pty Ltd (1957) also evaluated the alluvial deposits and sank 25 pits and 41 bore holes; they concluded that there was little likelihood of a large workable deposit being found, and they felt that the lode deposits were too small.

Wilson (1961) investigated the tin mineralization for Cape York Tin Pty Ltd and considered that it was not likely to be economic. He concluded that much of the alluvial tin was being shed from outcrops of low-grade ore in the hills and not, to a large extent, from the few known lodes.

Rowell (1962) investigated the alluvial tin at Punsand Bay for the Broken Hill Proprietary Company Ltd; generally he found only traces of tin, but one patch contained 3½ to 4 lb per cubic yard; five holes drilled in the sea bed had disappointing results. Tennent (1964), and later Webb and Fitzpatrick (1965) examined both lode and alluvial deposits for P.E. Gault. Webb and Fitzpatrick found overall values of 0.7 lb cassiterite per cubic yard in test pits in two small areas during a survey of the country between Punsand Bay and Hollands Reef. In other areas tested there they found between 0.23 and 0.5 lb per cubic yard. They recommended further testing of the alluvial deposits.

Webb and Fitzpatrick also sampled various lodes and obtained values of 0.7 and 0.8 per cent tin from two of them; they recommended diamond drilling to test some lodes, and noted that the tin mineralization was associated with altered green rhyolite, quartz-sericite rocks, and quartz veins. The analyses of their samples showed that cassiterite was the only mineral worth recovering.

Hughes (1962) reported on the tin deposits for New Consolidated Goldfields (A/asia) Pty Ltd. At the Northern Prospect he found at least one horizontal zone of mineralization throughout which cassiterite was associated with quartz stringers. The rock also contained vugs resulting from the weathering of disseminated pyrite.

In March, 1969 newspapers carried the announcement that Consolidated Mining Industries Ltd had carried out auger drilling in the tin-bearing alluvium to an average depth of 4 feet and had outlined a large area with an average grade of 0.8 lb cassiterite per cubic yard. Further exploration was then in progress.

No tin has been reported from any of the islands in Torres Strait, but a sample collected during this survey, from a mineralized part of a porphyritic microgranite dyke at Coconut Point on Badu Island, was found to contain more than one percent of metallic tin.

WOLFRAM

The production of small quantities of wolfram from Moa Island has been recorded since 1938 in the reports of the Department of Mines, Queensland. Traces of wolfram were found on the west side of Badu Island and on North Possession Island, north of Moa Island. Traces of wolfram are also reported from the vicinity of Badu village (Shepherd, 1944) and from Mount Patterson, about 12 miles southwest of Cape York (Jones, 1951).

The details and the date of the discovery of wolfram on Moa Island are not known. The wolfram produced (Table 5) has been gouged from quartz lodes in granite on the north side of the island and from similar lodes in hornfelsed volcanics on the south side of the island.

Shepherd (1944) described the localities at Eet Hill, Blue Mountains and Kubin at which wolfram was being mined in 1944. Eet Hill rises to 1000 feet above sea level about 5 miles northwest of St. Pauls Mission. Shepherd describes the lode exposed near the summit of Eet Hill as a white quartz lode with an average width of 7 feet and a maximum width of 10 feet, exposed horizontally for 1000 feet along strike, and vertically for about 100 feet in the side of the hill.

Fleischman (1953), as a result of a later visit, suggested that the reef is two or more quartz reefs within a dyke which itself cuts the granite, and that shoots of wolfram also occur in the dyke. The width of the dyke he estimated at between 20 and 30 feet and he noted that wolfram is won over a width of 20 feet in places. Fleischman gave no indication of the composition of the dyke, but it may be an acid dyke related to those which cut the Badu Granite near St. Pauls Mission, on the west coast of Badu and on North Possession Island. Shepherd notes that the lode is vertical and strikes 105°; it is displaced about 30 feet by a fault near the western end of the workings.

Andersen (1944) estimated that patches of ore at Eet Hill would contain from 6 to 20 percent wolfram, but that a large percentage of the quartz in the lode was barren. Jones (1951) estimated that the content of the ore mined at Eet Hill would be "approximately 1 percent wolfram concentrate (70 percent WO_3) to the ton". He adds that "it would be incorrect to take the above figure as representing the value of all lode mined from Eet Hill". Andersen states that the concentrates produced to the end of 1943 (see Table 5) were "all of approximately 66 percent WO_3 grade". Shepherd states that 40,000 tons of lode material is available for every 100 feet of depth to the lode.

A visit to Eet Hill during this survey revealed only shallow pits dug along a quartz reef in the granite. No wolfram was found, but the method of working the deposit, gouging followed by hand-picking, would ensure that almost every piece of wolfram was removed from the surface.

Andersen (1944) records the Gerheim lode "parallel to the Eet Hill lode and some distance south". He describes a shaft sunk to 17 feet on this lode, from which "possibly 76 tons of ore were extracted for a return of 750 lb of wolfram, (as stated by Tanu), approximately 0.5 percent".

TABLE 5: PRODUCTION OF WOLFRAM IN TORRES STRAIT

YEAR	Wolfram concentrates (tons)
1938	1.4
1939	2.3
1940	5.6
1941	14.3
1942	16.6
1943	11.2
1944	3.25
1945	0.2
1946	Nil
1947	Nil
1948	0.1
1949	0.25
1950	0.2
1951	6.0
1952	18.0
1953	3.9
1954	0.2
1955	0.6

Note 1: Anderson (1944) states that the concentrates produced up to the end of 1943 were "all of approximately 66 per cent WO_3 grade".

Note 2: The peaks of production in 1942 and 1952 correspond with World War II and the Korean War, when the price of wolfram was high.

The workings at Blue Mountains are described by Shepherd (1944) as "situated on the east side and towards the foot of a spur from Eet Hill". They lie about 1 mile from the coast. Shepherd describes the lode as iron-stained white quartz cutting granite, and chloritized at its margins. It is 7 feet thick in one cut; it is vertical and strikes 70°. Shepherd saw only small isolated crystals of wolfram in the quartz but was told that 900 pounds of wolfram had been taken from a small cut 2 feet deep. He recommended further prospecting. The Blue Mountains lode was not visited during this survey.

The workings at Kubin are situated about 1½ miles northeast of Gibbes Head, behind which Kubin village is built, and less than 1 mile from the shore. Shepherd (1944) described the workings as being located on a number of quartz lodes which strike due north and dip 20° to 30° east; they are generally 1 to 2 feet wide; one is 5 feet wide. The lodes exposed in 9 places may represent 4 or 5 parallel lodes. Shepherd notes that the lodes occur in quartz porphyry (welded tuff) near its contact with fine-grained grey granite, and that hematite is abundant in the northeastern part of the workings. During Shepherd's visit rich bunches of wolfram were exposed in 4 pits. On one claim 1 ton of ore dug in 3 days was estimated by Shepherd to contain at least 3 hundredweights of wolfram, from a lode exposed over a length of 40 feet.

Referring to Kubin, Shepherd remarked on the absence of minerals commonly associated with wolfram, such as molybdenum, tin, and bismuth. As far as is known, these minerals are also absent from the other wolfram localities on Moa Island, though tin and wolfram were found together at Coconut Point on Badu Island during this survey.

A visit to the Kubin workings in 1968 revealed about 10 shallow pits extending for about 200 feet along a line trending due north and sunk on one or two quartz reefs. The quartz forms vein-like bodies which are generally a few inches thick and range up to a few feet thick in places. These bodies cut sheared, recrystallized welded tuff, composed of a moderate number of medium-size crystals of quartz and feldspar in a very fine-grained green groundmass. Wolfram was seen in a few pits, and appears to occur in lenses up to 5 cm by 1 cm in size.

Wolfram has been found at a few other localities on Moa Island and on adjacent islands. Shepherd (1944) was told that about half a ton of shoad wolfram was recovered about 2 miles north of St. Pauls Mission, but that no lode was exposed. Jones (1951) reports rumours of molybdenite in the hills southwest of St. Pauls Mission, and Fleischman (1953) examined an exposure with a few specks of wolfram, much nearer St. Pauls Mission than Eet Hill, which the islanders believed to contain molybdenite.

Jones (1951) also records rumours of lode material in the hills southwest of the northernmost point of the island, and relates that "Bill Namok stated that he had picked up shoad wolfram from the sea bed whilst diving with goggles off East Point". East Point is a little more than 1 mile north of St. Mauls Mission.

During mapping in this survey wolfram was found at Coconut Point, at the western extremity of Badu Island, in quartz veins in porphyritic microgranite which cuts the Badu Granite. At the northern end of the point where the contact is visible, narrow elongate zones impregnated with tourmaline are present in both the granite and the porphyritic microgranite. In the porphyritic microgranite one hundred yards south of the contact a quartz vug about 3 feet in diameter contains crystals of wolfram $\frac{1}{4}$ inch across, and nearby a round patch of quartz about 18 inches across contains sulphide minerals. Tin is also present, although it was not seen in handspecimen.

Shepherd (1944) records that traces of wolfram had been reported from at least three localities on Badu, but he could not find any. Andersen (1944) noted large quartz blows on "Cuan Island, about 2 miles south of Badu", and was told by islanders that wolfram had been found there. The name Cuan Island cannot be found on any map; a large quartz reef exposed on Barney Island, 2 miles south of Badu, is apparently barren.

The Annual Reports of the Queensland Department of Mines record that in 1951 60 pounds of wolfram were mined at Portlock Island, a small island about 5 miles north-northeast of St. Pauls Mission on Moa Island. No wolfram was found on this island during this survey, but on North Possession Island, about 3 miles northwest of Portlock Island, crystals of wolfram up to $\frac{1}{2}$ inch long occur in a vein of milky quartz at the contact of a fractured acid dyke, about 20 feet thick, which intrudes the Badu Granite that forms the bulk of the island. Another quartz vein at this contact contains metallic sulphide minerals.

During the 1930's, according to Jones (1951), wolfram was discovered at Mount Paterson, on the mainland about 12 miles southwest of Cape York and only a few hundred yards from the shore. Mr Holland, the discoverer, considered that the deposit was not worth working. Mount Paterson was visited during this survey and consists of welded tuff with, on its north side, a large body of white banded quartz, in which some bands are stained by limonite and some contain clusters of muscovite crystals. The quartz contains small crystals of a dark mineral, but no wolfram could be identified.

All who have inspected the wolfram deposits have said that Eet Hill is most worthy of further investigation. As the lodes have everywhere been worked by gouging and hand-picking, wolfram is very rare at the surface both in mullock and in the exposed lode. The lodes could possibly be evaluated most readily by shallow drilling.

COAL

Scattered sub-round and flattened pebbles and cobbles of dull laminated coal, similar to cannel coal or torbanite, were found on the east coast of Horn Island in 1968. As there is no mention of this material in reports by Rands (1896) and Jackson (1902), who both inspected the nearby abandoned gold working, it is likely that the coal was driven ashore from a wreck or was jettisoned by a ship, although such coal would not normally be used for fuel.

The small angular lumps of bright steam coal which litter the beach of Bramble Cay almost certainly come from shipping using the nearby Northeast Channel. A similar origin is envisaged for numerous lumps of coal up to 1 cubic foot, reported from Vicary Bay and nearby points on Albany Island, as no coal seams are known in Mesozoic sediments nearby.

CONSTRUCTION MATERIALS

Stone for use in construction is extremely scarce in southwest Papua and the southeast part of West Irian. At present there is no great demand for stone, but recently the construction of an airstrip at Daru necessitated the shipping of several thousand tons of stone from Port Moresby, over 200 miles away, and any development in this region is sure to create a demand for aggregate and road metal.

The inhabitants of Mabaduan in Papua are considering quarrying and crushing stone from the hill of granite at the village. An even larger quantity of stone could be obtained by quarrying the high and massive granite hill which forms the island of Dauan in Queensland.

Coral blocks, which harden on drying, were used in building t the Anglican cathedral at Thursday Island (Miss G. Warren, pers. comm.); they are present on reef flats throughout Torres Strait. Welded tuff is quarried at Thursday Island, presumably for road metal and aggregate.

Gravel is generally restricted to the upper parts of stream valleys on hilly islands and on the hilly part of the mainland of Cape York Peninsula. Most gravel deposits on the mainland contain a high proportion of ferricrete fragments. All the deposits are generally poorly sorted and contain fragments ranging from fine grains to large boulders. Gravel deposits may also exist on the sea bed in the vicinity of hilly land.

Quartz sand forms large dunes on the northwest side of Newcastle Bay. The extensive shoals which stretch northwards from the mouth of the Jardine River for at least 40 miles to the vicinity of West Island are probably composed predominantly of quartz sand, although they may contain a considerable proportion of calcareous sediment, such as shell and coral fragments.

Pisolitic ferricrete forms patchy deposits on Mesozoic sediments between Cape York and the Jardine River, and also occurs on Moa Island. It has been used for surfacing rocks near Bamaga and for the airstrip at Higginsfield.

GUANO

Bramble Cay has a population of a few thousand birds, which are mainly boobies and these have deposited a layer of guano of unknown but probably small depth, which covers part of the surface of t the highest part of the cay, a small flat area about 10 feet above sea-level.

This area contains several flat pans, about 50 feet in diameter, which are surfaced by a thin crust of white material between one-quarter and one-half inch thick. The crust lies on more than 6 inches of black or dark brown crumbly material which smells of ammonia. Scattered over the sand which separates the pans are small nodules, up to 3 inches long, of white phosphatic material. The present beach sand and the beach rock which crops out within 5 feet of sea-level at the east end of the island are not phosphatized.

The deposit of guano is very small and is of technical interest only. Any attempt to exploit it would almost certainly have a serious effect on the large bird population. Ladd (1968) notes that several hundred tons of guano were shipped from Bramble Cay in 1878.

Richards and Hedley (1925) note that Booby Island in 1924 was covered by a thin film of white amorphous phosphatic material. They state that Moseley, a naturalist who visited Booby Island in 1874, described clouds of boobies hovering over the island, which was white with their droppings. It is likely that guano deposits were removed from Booby Island at about the same time as they were removed from Bramble Cay. The occupation of Booby Island by the staff of the lighthouse may have prevented effective re-establishment of the bird colony.

Many of the boulders forming the White Rocks, an isolated group, are covered by a film of guano up to half an inch thick. In August, 1968 these rocks were occupied by boobies and terns.

LIME

Coral and shell sand are present on coral sand cays, mainly in the eastern part of Torres Strait. Coral reefs are very common throughout the area, but use of them as a source of lime is unlikely to be encouraged.

OLIVINE

Olivine crystals form a high proportion of the sand forming narrow and thin beaches in coves along the southeastern side of Maer Island in the Murray Islands. The beach sands also contain abundant iron oxide minerals and probably also pyroxene. The beaches themselves are too small to constitute useful deposits, and though the sand may also have been deposited offshore, the growth of coral among these islands is so prolific that it seems unlikely that any sizeable bodies of olivine-bearing sand will exist.

PETROLEUM

The northeast of Torres Strait is underlain by up to 12,000 feet of Mesozoic and Tertiary sediments similar to those underlying the Gulf of Papua to the northeast, where gas flows have been obtained in a number of wells. Seismic and magnetic surveys carried out in Torres Strait indicate a number of positive structures which developed by faulting in Mesozoic sediments, and which persisted during the Tertiary period of deposition. (Gulf, 1965; Tenneco, 1967; 1968;

Amoseas, 1968.) The Anchor Cay No.1 well, recently drilled by Tenneco on one of these structures, did not encounter any traces of hydrocarbons (Oppel, 1969). Further seismic surveys are to be carried out by Amoseas (now Texaco) in 1969.

WATER

Ogilvie and Weller (1949) reported on the water resources of Torres Strait, but this report has not been seen. The reservoir at Thursday Island is not large enough to supply plentiful water to the 3000 or so inhabitants of the island throughout the dry season. Although a small, little-used reservoir exists on Horn Island, and additional reservoirs could be built on Prince of Wales Island, the laying of an undersea pipeline would be made difficult and expensive by the swift tidal currents which flow between the islands. Macgregor (1967) has rejected the concept of an undersea pipeline to supply the island of Daru with water from the Papuan mainland, and favours increasing the rain-water tank capacity of private and public buildings to augment the town water supply. Although the average annual rainfall at Thursday Island is 69 inches, compared to over 80 inches at Daru, the provision of additional tank storage also on Thursday Island might alleviate the water shortage considerably.

Domestic water on other islands is obtained commonly by catching rainwater, though Maubiag and Maer Island have small reservoirs and at St. Pauls Mission water is pumped from a number of small wells in sandy alluvium.

Water appears to be used at present almost exclusively for drinking and washing. An irrigation scheme is scheduled to begin at Bamaga in the near future and will use water piped from the Jardine River, which flows throughout the year. The country between Bamaga and Cape York is well supplied with water in Laradeenya and other creeks and in the lakes in the sandy country along the northwestern side of Newcastle Bay. If a water supply was assured, the soil on the ferricrete between Bamaga and Cape York may be suitable for agricultural development.

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NEW GUINEA 1:250000

DARU - PART MAER

TERRITORY OF PAPUA AND QUEENSLAND

SHEET SC 54-8 - PART SHEET SC 55-5

Reference

CAINOZOIC	QUATERNARY		Qm / Qmc	Coastal mud, beach sand; coral sand and shingle on sand cays
	RECENT		Qra	Alluvium, mainly silty
			Qrt	Alluvium, in terraces
	PLEISTOCENE(?)	Maer Volcanics	Qr	Basic tuff, basalt
	PLIOCENE TO PLEISTOCENE		TpQp	Limestone, mudstone, sandstone, gravel
	MIOCENE		Tm	Limestone
	EOCENE		Te	Limestone (section only)
MESOZOIC			Mz	Sandstone, siltstone, pyritic shale, some conglomerate (section only)
PALAEOZOIC	PERMIAN(?)	Badu Granite	Pzub	Leucocratic biotite granite, porphyritic granite and adamellite
	CARBONIFEROUS TO PERMIAN	Torres Strait Volcanics	Pzut	Welded tuff, hornfels

Geological boundary

Fault

Where location of boundaries, folds and faults is approximate, line is broken; where inferred, queried; where concealed, boundaries and folds are dotted, faults are short dashes

Prevailing strike and dip of strata

Vertical banding in hornfels

Strike and dip of planar structure defined by pumice fragments

Oil well, dry hole abandoned

Basic volcanic vent, extinct

Dyke: i - intermediate

Shoal

Coral

Fathom line

Road

Track

Airport

Landing ground

Town

Hut or building

Trigonometrical station

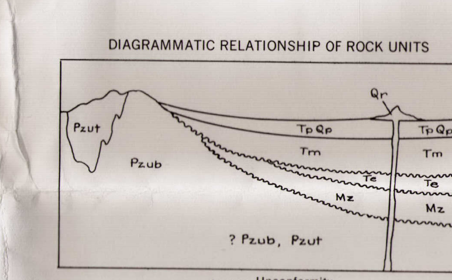
Elevation in metres, approximate

Rocks exposed

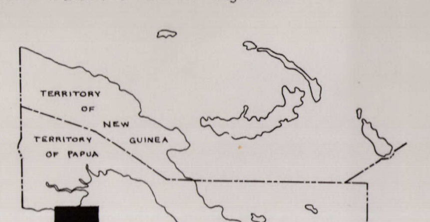
Rocks submerged

Lighthouse

DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS

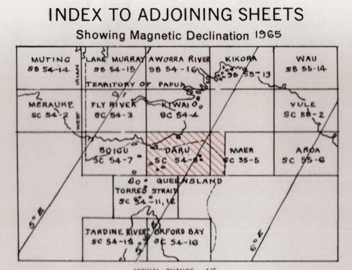


Compiled by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development, in conjunction with the Geological Survey of Queensland. Issued under the authority of the Hon. R.W. Swartz, M.B.E., E.D., Minister for National Development. Base map compiled by the Corps of Engineers, United States Army, 1965, 1966, with corrections by the Bureau of Mineral Resources. Royal Australian Air Force aerial photography 1965, partial vertical coverage at 1:50,000; United States Navy aerial photography at 1:60,000 over some areas
Universal Transverse Mercator Projection



INDEX TO ADJOINING SHEETS

Showing Magnetic Declination 1965



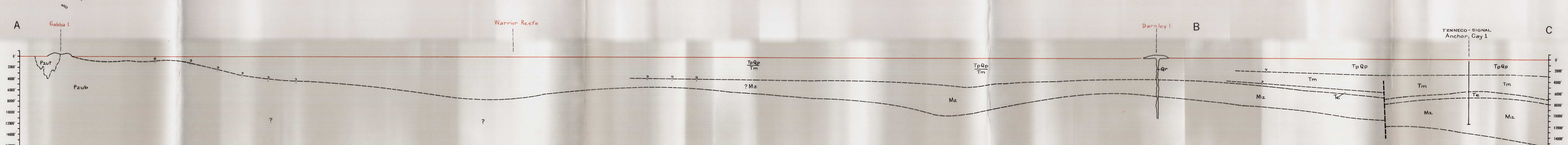
Scale 1:250,000

5 0 5 10 15 MILES

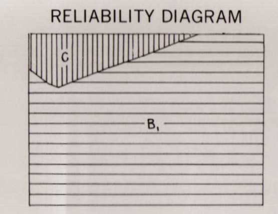
5 0 5 10 15 20 25 KILOMETRES

Section

Scale: V/H = 2



RELIABILITY DIAGRAM



Geology B1 Detailed reconnaissance and air photo interpretation.

C Air photo interpretation (by oil companies)

Geology 1968 by W.F. Willmott, W.D. Palfreyman, D.S. Trail (B.M.R), W.G. Whitaker (G.S.Q)
Compiled 1969 by W. F. Willmott, including information supplied by oil companies
Cartography by Geological Branch, B.M.R.
Drawn by L. Kerslake

PRELIMINARY EDITION, 1969
SUBJECT TO AMENDMENT

DARU - PART MAER

SHEET SC 54-8 - PART SHEET SC 55-5

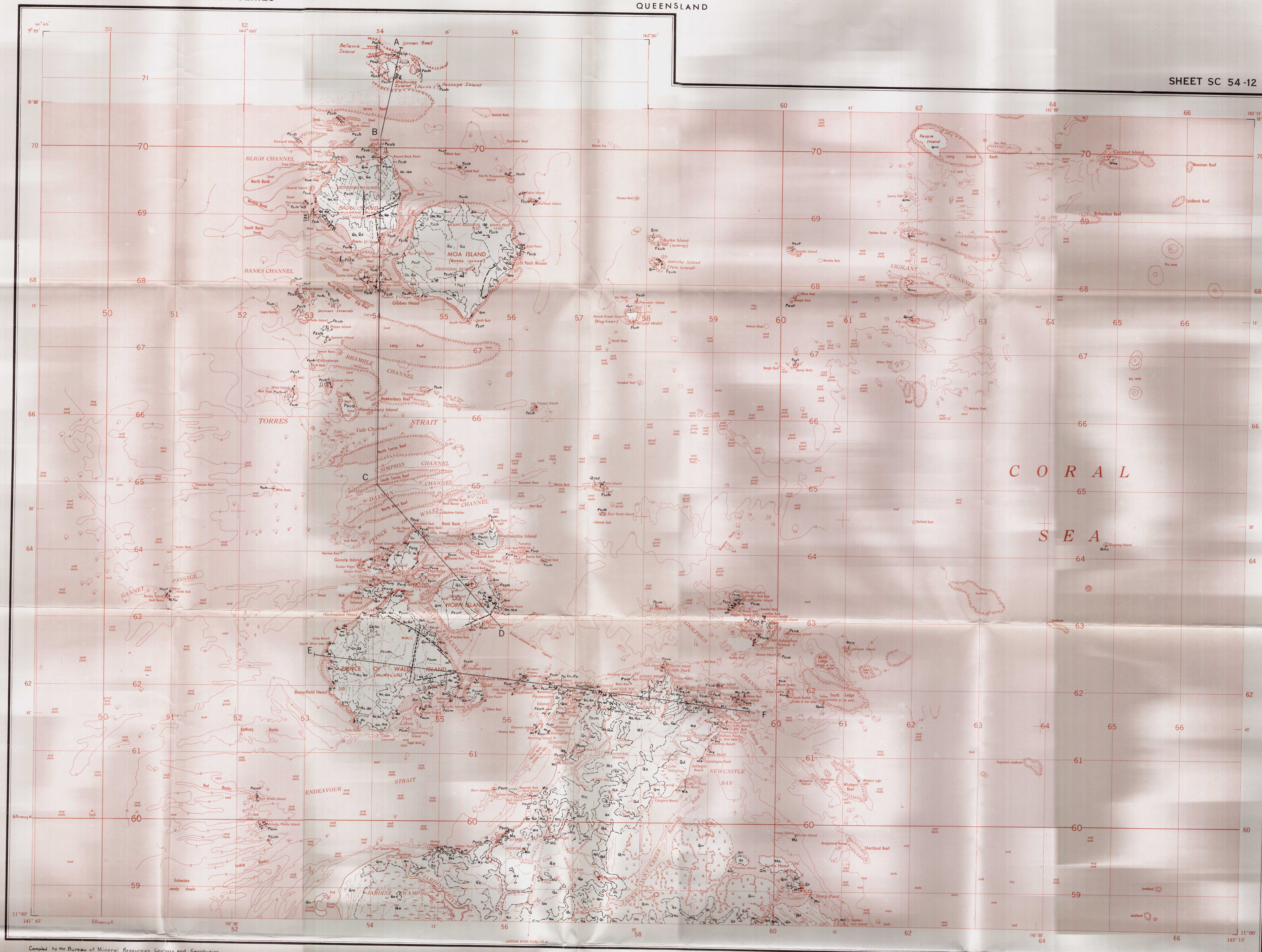
Complimentary

AUSTRALIA 1:250,000 GEOLOGICAL SERIES

TORRES STRAIT AND PART BOIGU

QUEENSLAND

SHEET SC 54-12



Reference

CAINOZOIC	QUATERNARY		Qm / Qmc	Estuarine and coastal mud, beach sand; coral sand and shingle on sand cays
			Qa	Alluvium, mainly silty
			Qs	Sand, mainly residual
			Qd	Sand, mainly in dunes
MESOZOIC			Mz	Coarse sandstone, capped by ferricrete
PALAEOZOIC	PERMIAN (?)		Pzup	Porphyritic microgranite
		Badu Granite	Pzub	Leucocratic biotite granite, porphyritic biotite granite and adamellite, hornblende biotite adamellite and granodiorite
	CARBONIFEROUS TO PERMIAN(?)	Torres Strait Volcanics Muralug Ignimbrite	Pzum	Brownish grey welded tuff, some rhyolite and volcanic breccia, rare intermediate welded tuff
		Goods Island Ignimbrite	Pzug	Dark grey welded tuff, some interbedded siltstone and sandstone
		Endeavour Strait Ignimbrite	Pzun	Greenish grey welded tuff, some rhyolite, andesite and agglomerate; some hornfels
		Eborac Ignimbrite	Pzue	Light grey, welded tuff, some rhyolite
		Undivided	Pzut	Welded tuff, hornfels

Geological boundary

Plunge of minor anticline

Fault

Where location of boundaries, folds and faults is approximate, line is broken; where inferred, queried; where concealed, boundaries and folds are dotted, faults are shown by short dashes

Strike and dip of strata

Horizontal strata

Dip <15°
Dip 15°-45°
Dip >45°
Joint pattern
} Air-photo interpretation

Strike and dip of banding, streaking or foliation in hornfels

Vertical banding in hornfels

Strike and dip of planar structure defined by pumice fragments

Vertical banding in granite

Dyke; a - acid, i - intermediate, p - porphyritic microgranite
q - quartz

Mine not worked

Alluvial workings

Alluvial workings not worked

Battery not operating

Unworked mineral deposit

Minor mineral occurrence

- As Arsenic
- Au Gold
- Bx Bauxite
- Cu Copper
- Pb Lead
- Py Pyrite
- Sn Tin
- W Wolfram

Dam

Swamp

Mangrove

Shoal

Coral reef

Fathom line

Sand ridges and sand dunes, air-photo interpretation

Road

Vehicle track

Airport

Landing ground

"Lockerbie" Homestead

Hut or building

Town

Built up area

Power transmission line

Trigonometrical station

169′ Elevation in feet, accurate

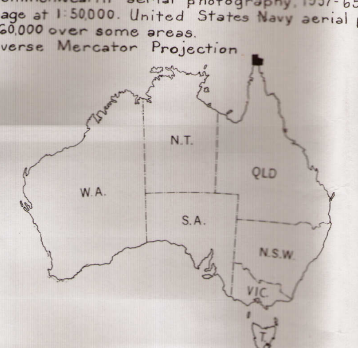
102′ Elevation in feet, approximate

Rocks exposed

Rocks submerged

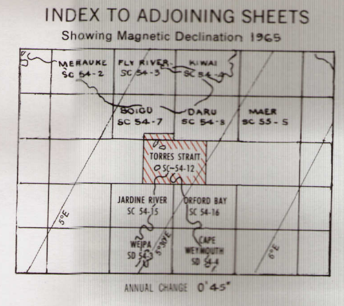
Lighthouse

Compiled by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development, in conjunction with the Geological Survey of Queensland. Issued under the authority of the Hon. David Fairbairn, Minister for National Development. Base map compiled by the Royal Australian Survey Corps, 1966. Royal Australian Air Force and Commonwealth aerial photography, 1957-65; complete vertical coverage at 1:50,000. United States Navy aerial photography 1964 at 1:60,000 over some areas.
Transverse Mercator Projection

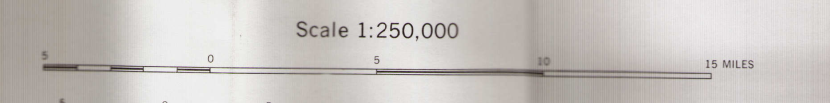


INDEX TO ADJOINING SHEETS

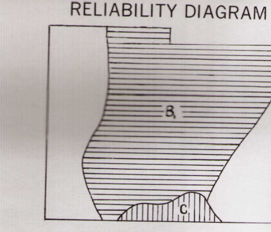
Showing Magnetic Declination 1965



Scale 1:250,000



RELIABILITY DIAGRAM



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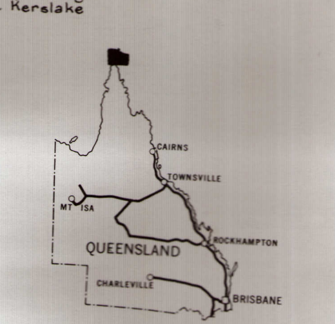
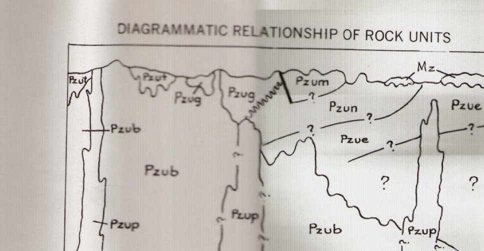
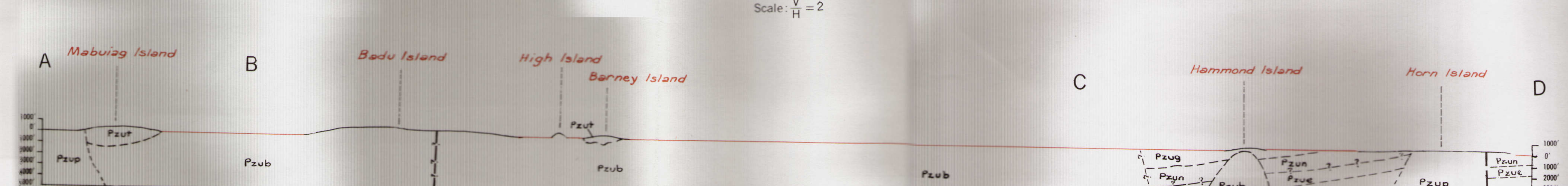


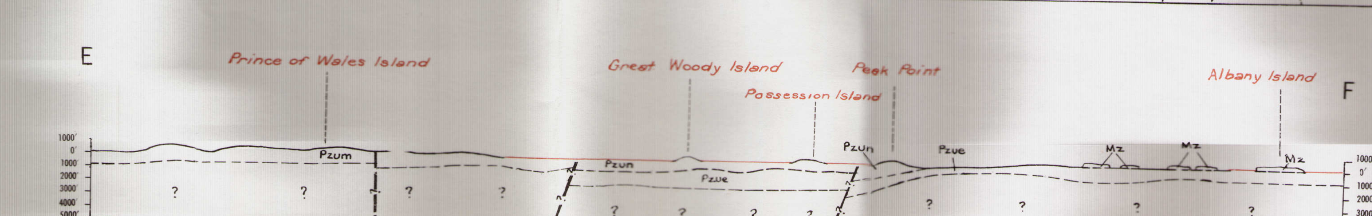
DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS



Sections

Cainozoic sediments omitted from section





TORRES STRAIT AND PART BOIGU
SHEET SC 54 12

Complimentary