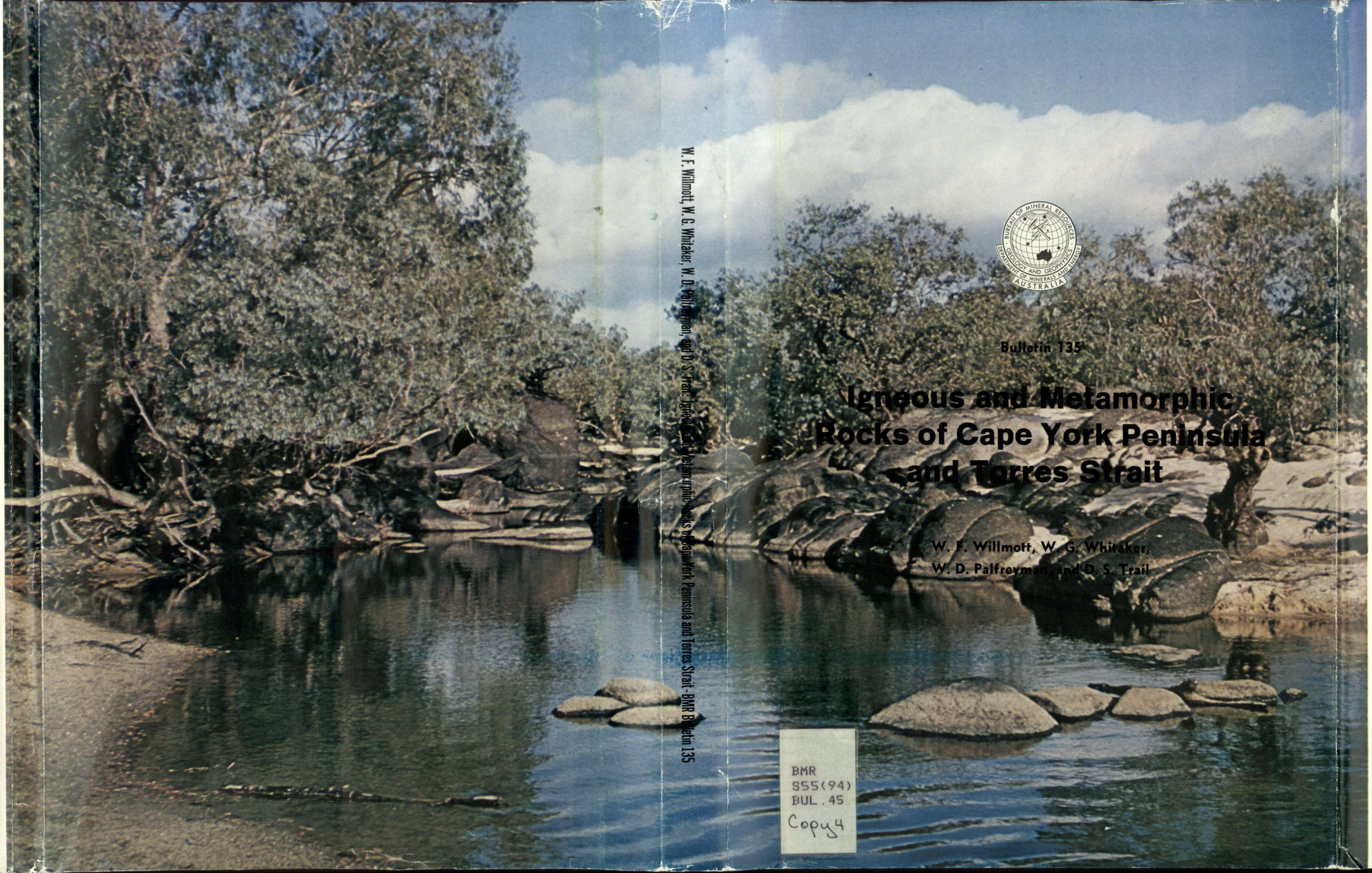

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS
DEPARTMENT OF MINERALS AND ENERGY
AUSTRALIA

Bulletin 135

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SUMMARY

A broad ridge of Precambrian and Palaeozoic igneous and metamorphic rocks extends for 450 km along the east side of Cape York Peninsula, from the Mitchell River in the south to Temple Bay. From Cape York a submerged ridge of Palaeozoic igneous rocks extends across Torres Strait to Papua.

The metamorphic rocks crop out in four separate areas, but are all probably part of the same Precambrian sedimentary sequence. They have been subjected to high-temperature/low-pressure regional metamorphism, and the metamorphic grade increases eastwards from phyllite of the greenschist facies to gneiss of the amphibole facies. They consist mainly of mica schist and quartzite, with local occurrences of greenstone, calc-silicate rocks, marble, and iron-rich rocks, and are intruded by dolerite in the south.

The Cape York Peninsula Batholith is composed of adamellite and subordinate granodiorite and granite. It is intrusive into the discontinuous belt of metamorphic rocks over a distance of at least 400 km. The age of the batholith is uncertain, but preliminary isotopic analyses indicate that it is probably middle Palaeozoic.

In the Lower Carboniferous coal-bearing sediments were laid down in small basins. The thick sheets of acid welded tuff and subordinate lavas in Torres Strait, which are intruded by large bodies of granite and porphyritic micrograno, are probably Carboniferous, and the acid pyroclastics and associated high-level granites south of Temple Bay are Carboniferous or Permian.

In the Mesozoic, coarse sandstone and conglomerate followed by finer sediments were laid down in the trough between the two basement ridges. Tertiary uplift on faults along the east side of the peninsula resulted in the deposition of poorly consolidated sandstone and conglomerate. A plug of olivine nephelinite was emplaced near the faults, and in the Pleistocene olivine basalt lava and pyroclastics were erupted from small volcanoes in the northeastern part of Torres Strait.

Most of the main structures in the peninsula, such as the fold axes and foliation in the metamorphics, the faults, and the long axis of the batholith, have a northerly trend. The Palmerville Fault is a major structure which has been active from Silurian time onwards.

Alluvial and reef gold were mined extensively in Cape York Peninsula and in Torres Strait late in the 19th century, and small quantities of wolfram and alluvial tin have also been won. The deposits of iron and manganese near Iron Range and the silica sand on the Mesozoic sediments north of Temple Bay have not yet been exploited.

Traces of antimony, arsenic, copper, lead, zinc, and molybdenum have been reported, and occurrences of bauxite, coal, mica, heavy-mineral beach sand, and limestone are known.

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INTRODUCTION

Cape York Peninsula is situated in far north Queensland, between the Gulf of Carpentaria and the Coral Sea. It extends northwards for over 600 km from about the latitude of Cairns to Cape York, its northern extremity. It is separated from the Papuan mainland by Torres Strait, a stretch of shallow water, about 150 km wide, dotted with numerous islands and reefs (Fig. 1).

This Bulletin describes the Precambrian metamorphic rocks in the central and northern parts of the peninsula, and the Palaeozoic igneous rocks which penetrate them. The Cainozoic basic igneous rocks are also described. The Precambrian rocks in the Chillagoe area to the south and the Palaeozoic sediments of the Hodgkinson Basin to the east have been described by de Keyser & Lucas (1968), and the upper Palaeozoic igneous rocks in the same region have been described by Branch (1966). The Mesozoic and Cainozoic sediments are mentioned only briefly: the Laura Basin has been described by de Keyser & Lucas (1968) and the Papuan Basin by the Australasian Petroleum Co. (APC, 1961). The Carpentarian Basin is now being mapped by the Bureau of Mineral Resources and the Geological Survey of Queensland.

The pre-Mesozoic basement rocks crop out between latitude 9°00′S and 16°30′S, and longitude 142°00′E and 144°10′E in three separate inliers, called the Yambo Inlier, the Peninsula Ridge, and the Cape York/Oriomo Ridge (Fig. 4). The regional mapping was carried out between 1966 and 1968 by a combined party from the Bureau of Mineral Resources and the Geological Survey of Queensland. Geologists who took part in the project, under the leadership of D. S. Trail, were the four authors of this Bulletin, and I. R. Pontifex and R. F. Spark of the Bureau of Mineral Resources. The preliminary results of each year's mapping have been described by Trail et al. (1968, 1969) and Willmott et al. (1969).

The area described comprises parts of the Mossman, Cooktown, Walsh, Hann River, Ebagoola, Coen, Cape Weymouth, Orford Bay, Torres Strait, Boigu, Daru, and Maer 1:250 000 Sheet areas. The topographic maps available include the 1:250 000 Sheets, distributed by the Division of National Mapping, the Four Mile Series published by the Queensland Department of Lands, and a small number of war-time 1:63 360 Sheets of the southern part of Torres Strait and the north-eastern part of Cape York Peninsula. The area is covered by 1:50 000 or 1:80 000 air-photographs, except for the far northeastern part of Torres Strait.

The geological maps produced during the survey include the accompanying 1:500 000 map, and preliminary editions of the above Sheet areas, except for the Mossman and Cooktown Sheets, which were published earlier, and the Boigu and Maer Sheets, parts of which were included with Torres Strait and Daru respectively. The First Edition 1:250 000 Geological Sheets and Explanatory Notes will be published later when the mapping of the Mesozoic sediments of the Carpentarian Basin has been completed.

Nomenclature

Most of the stratigraphic names have been defined by Whitaker & Willmott (1968, 1969a,b). The nomenclature used for the igneous rocks is based on Joplin (1964).

The names used for islands in Torres Strait conform with those on the 1:250 000 topographic maps, except in a few cases where the indigenous equivalent is in more common use than the English name.

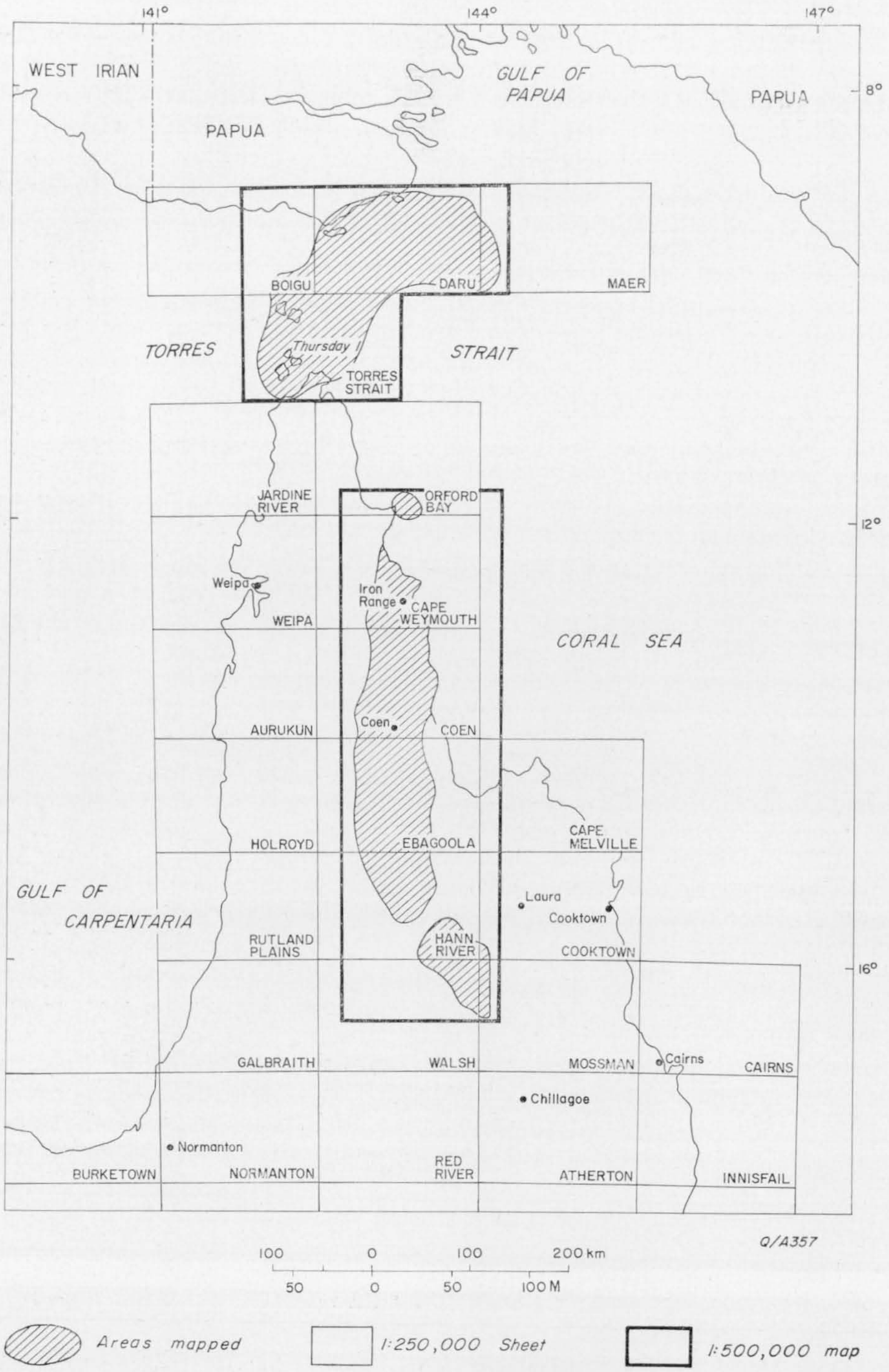

Fig. 1. Locality map and Sheet index.

Relief and exposure

The south-central part of Cape York Peninsula is an area of low relief, except for some ridges of resistant rocks. It is generally less than 300 m above sea level and slopes gently westward to the Gulf of Carpentaria; in the east it is bounded by rugged hilly country formed by the folded sediments of the Hodgkinson Basin. The rocks are poorly exposed, and outcrops can generally be found only in the beds of the larger streams.

Farther north, on the east side of the peninsula the basement rocks form a series of rugged plateaux and ranges up to 800 m high, which extend from south of Coen to north of Iron Range. Despite the thick cover of soil and dense vegetation, the rocks are moderately well exposed. The islands in the western part of Torres Strait rise to 400 m above sea level, and the numerous headlands along the coast provide excellent exposures. Most of the islands farther east are low sand cays, but in the far northeast there are several hilly volcanic islands.

Climate and vegetation

The climate ranges from dry tropical in the south to humid tropical in the northeast. Rainfall is high but markedly seasonal, the bulk of the rain falling between November and April. In the north the rainfall is almost twice as great as in the south, and the ranges between Coen and Iron Range receive rain throughout the year. During the dry season most of the streams are dry, and water is obtainable only in some of the larger rivers.

Most of the peninsula is covered by open tropical eucalypt forest which becomes progressively thicker towards the north. The eastern ranges between Coen and Iron Range support dense tropical rain forest, with open patches of eucalypt forest and grass. In the Janet Ranges near Iron Range acid volcanics support low vegetation. The western islands of Torres Strait are covered with open eucalypt forest similar to that on the mainland; the higher peaks of Moa Island are covered with rain forest. The volcanic islands in the northeast are more fertile and support open grassland, coconut groves, and rain forest.

Population and industry

The population of Cape York Peninsula is thinly spread, and is almost entirely engaged in cattle raising; most of the cattle properties are in the south, with only a few north of Iron Range. The main town is Coen (pop. 175). The small settlement of Laura (pop. 30) lies a short distance to the southeast of the map area, and Weipa (pop. 750), a bauxite-mining centre, to the west. In the Iron Range/Portland Roads district a few people are settled on small holdings, and 200 to 300 Aborigines live in the nearby Lockhart River Community.

The islands of Torres Strait are inhabited by several thousand Torres Strait Islanders who live on Thursday Island, the main centre of population (3000), and in small villages on the outlying islands. At Bamaga, 25 km south of Cape York, a large Government community has been established to re-settle mainland Aborigines and Islanders from some of the less productive islands. Daru, an island off the southern coast of Papua, is the centre of administration for the Western District of Papua. The main industries in Torres Strait are pearl culture, and prawn fishing and processing.

Access and communications

In the past access to the peninsula has been particularly difficult, and even now few roads and tracks exist (Fig. 2). Most are suitable for four-wheel-drive vehicles only, and all are impassable during the wet season. The main access route is the unsealed Kennedy Road, or Peninsula Development Road, which connects Portland Roads and Laura with the gravelled Mulligan Highway between Cooktown and Cairns. In the far southwest, west of Mount Mulgrave homestead, the most convenient access is by the well formed road from Chillagoe. The Kennedy Road north of Coen is a rough track which is frequently washed out during the wet season. North of the Archer River, a track branches off to Weipa on the west coast, and a very rough track continues northwards along the telegraph line as far as Cape York, although the ford on the Jardine River is usually impassable.

In the south, tracks to station homesteads branch east and west from the Kennedy Road, but north of Coen few other tracks exist, particularly in the ranges between Coen and Iron Range. Two little used and overgrown tracks branch off the main road near Coen airport and lead eastwards to the old mining areas at Leo Creek and Buthen Buthen. A very poorly defined route also connects Buthen Buthen with the track linking Iron Range and the old Lockhart River Community. Most of the roads constructed by the Broken Hill Pty Co. Ltd in 1957-60 in the Iron Range area are overgrown.

A regular shipping service operates between Cairns, Portland Roads, and Thursday Island, and small government vessels serve the outer islands of Torres Strait at irregular intervals. Scheduled air services call at Coen, Iron Range, Weipa, and Thursday Island, and light aircraft serve a number of cattle stations. Daru is connected both by sea and air to Port Moresby. A telegraph line links Thursday Island, Coen, and Cairns, but other settlements and stations rely on radio networks based on Cairns or Thursday Island.

Most of the Torres Strait Islands and parts of the mainland south of Cape York and in the Pascoe River/Lockhart River district are Aboriginal Reserves under the administration of the Queensland Department of Aboriginal and Island Affairs, locally based on Thursday Island.

The use of Land Rovers was generally restricted to roads and tracks because the vegetation is usually too thick to traverse by vehicle, and most of the stream beds are difficult to cross. The ranges between Coen and Iron Range were mapped by small parties working on foot or on horseback, with Land Rover or helicopter support. An inflatable dinghy was used to traverse the Pascoe River. The coast of the peninsula and the Torres Strait Islands were mapped from a 13.5-m launch, MV *Sapphire,* on charter from Cairns.

Acknowledgments

We wish to acknowledge the great assistance provided by the Broken Hill Pty Co. Ltd and Australian Aquitaine Petroleum in freely supplying geological information of the Iron Range district. C. D. Branch, formerly of the Bureau of Mineral Resources, helped to elucidate the structure of the Janet Ranges Volcanics near Iron Range. Throughout the survey invaluable help was received from the inhabitants of Cape York Peninsula and Torres Strait and from the Department of Aboriginal and Island Affairs, Thursday Island. Mr A. La Cava of MV *Sapphire* contributed greatly to the success of the mapping in coastal areas and Torres Strait.

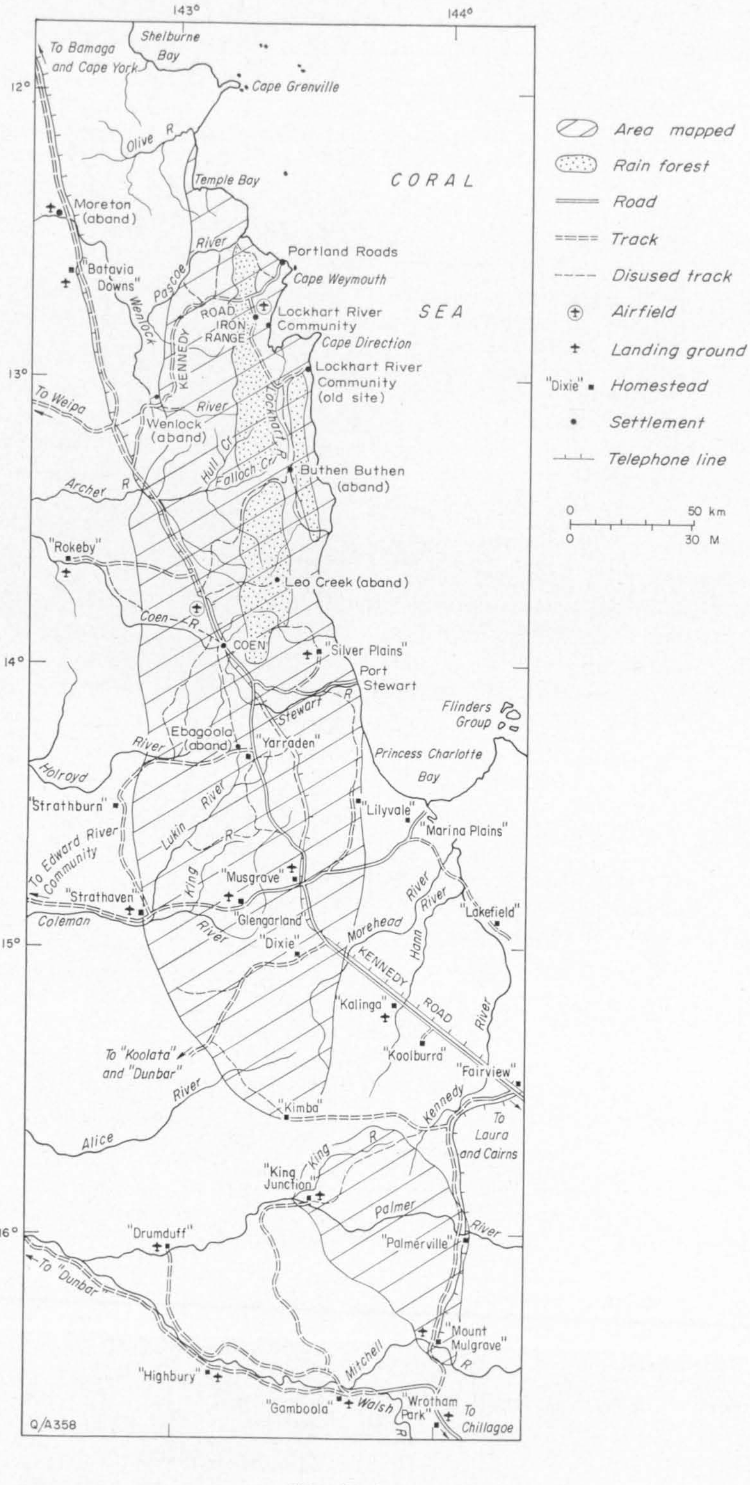
143°
144°
12°
13°
14°
15°
16°
To Bamaga and Cape York
Shelburne Bay
Cape Grenville
Olive R
Temple Bay
CORAL SEA
Moreton (aband)
"Batavia Downs"
Wenlock
Pascoe River
Portland Roads
Cape Weymouth
KENNEDY ROAD
IRON RANGE
Lockhart River Community
Cape Direction
Lockhart River Community (old site)
To Weipa
Wenlock (aband)
Hull Cr
Lockhart R
Falloch Cr
Archer R
Buthen Buthen (aband)
"Rokeby"
Leo Creek (aband)
Coen R
COEN
"Silver Plains"
Port Stewart
Stewart R
Flinders Group
Ebagoola (aband)
"Yarraden"
Holroyd River
Princess Charlotte Bay
"Strathburn"
Lukin River
"Lilyvale"
"Marina Plains"
To Edward River Community
King River
"Musgrove"
"Strathaven"
"Glengarland"
Coleman
Morehead River
Hann River
"Lakefield"
"Dixie"
KENNEDY ROAD
"Kalinga"
"Koolburra"
To "Koolata" and "Dunbar"
"Fairview"
Alice River
"Kimba"
Kennedy
To Laura and Cairns
"King Junction"
King R
Palmer River
"Drumduff"
"Palmerville"
To "Dunbar"
"Mount Mulgrave"
Mitchell
R
"Highbury"
"Gamboola"
Walsh R
"Wrotham Park"
To Chillagoe
Q/A358
Area mapped
Rain forest
Road
Track
Disused track
Airfield
Landing ground
"Dixie" Homestead
Settlement
Telephone line
0 50 km
0 30 M

Fig. 2. Access.

History and previous investigations

European exploration of Cape York Peninsula began early in the 17th century with visits by Spanish and Dutch vessels to the west coast and Torres Strait. The first recorded passage of the Strait was made by Torres in 1606, but it was not until Cook's voyage in 1770 up the east coast of Australia that its existence was finallly publicized.

In the period between 1790 and 1850 some merchant ships passed through Torres Strait and along the east coast of Cape York Peninsula, but many vessels were wrecked on the treacherous reefs. Bligh (in 1789 and 1792) was one of the more famous early navigators. The first detailed survey of the shipping channels was made by Flinders in 1802, and subsequent surveys were carried out by HMS *Beagle* (1839, 1841), HMS *Fly* (1843-45), and HMS *Rattlesnake* (1850-52).

Overland exploration began in 1848 with Kennedy's ill-fated expedition up the east coast of the peninsula (Jack, 1922). The western side was first traversed in 1864-65 by the Jardine brothers, who drove cattle to the newly established government settlement of Somerset, which provided refuge for ships passing through Torres Strait. This settlement was moved to Thursday Island in 1877.

Subsequent settlement of the peninsula was closely linked with the discovery of a number of small goldfields, the development of the cattle industry and, in Torres Strait, with the rise of the pearl shell industry. The isolation of the region inhibited pastoral development and it has remained sparsely settled to this day. A resurgence of gold mining in the 1930s at Wenlock and near Iron Range was terminated by World War II and did not revive afterwards. Wartime saw much military activity at Iron Range and in Torres Strait, but a few airstrips are all that now remain. The pearl shell industry in Torres Strait has declined in the last 25 years and many of the Islanders have moved south. The most significant recent developments are the construction of a gravel road as far north as Coen, the large-scale re-development of cattle properties, and the exploitation of the bauxite deposits at Weipa on the west coast.

The first geological observations on the area were made by Wickham, on board HMS *Beagle* (Stokes, 1846), and by Jukes (1847), on HMS *Fly*. Jukes noted the rocks along the coastline, and in Torres Strait he described the basic volcanics of Darnley Island and the Murray Islands in some detail, and mentioned the granitic rocks of the western islands. Further observations were made in Torres Strait by MacGillivray (1852) and Maitland (1892). A comprehensive report on the geology of Torres Strait by Haddon et al. (1894) gives an excellent description of the volcanic rocks forming Stephens and Darnley Islands, and the Murray Islands.

The first observations on the geology of the interior of the peninsula were made by Taylor, a member of Hann's 1892 expedition to north Queensland (Hann, 1873a, b). This expedition was the first to record gold in the Palmer River, a few kilometres downstream from the present site of Palmerville homestead. Mulligan also recorded gold in 1873 (Jack, 1922), and the rush to the Palmer goldfield followed (Holthouse, 1967).

Alluvial gold was discovered at Coen in 1876, and in 1879-80 Jack (1881, 1922) visited the area for the Queensland Government. He made extensive geological observations during two prospecting expeditions in the area between the head of the Kennedy River in the south and Somerset in the north. He noted many auriferous quartz reefs and patches of alluvium. Jack also visited the Palmer River in 1887 (Jack, 1888). The history of European exploration and early geological and mining activities in the area are summarized in Jack (1922).

Most of the other early investigations were also concerned primarily with the search for gold. One of the most active prospectors in the region was Dickie, who discovered gold at Ebagoola (Hamilton goldfield) in 1900 (Dickie, 1900). Ball (1901) mapped the Ebagoola area and recognized two distinct phases of granite. Dickie also reported gold in the upper Coleman River (Dickie, 1900), between the King and the Kennedy Rivers, northwest of Palmerville (Dickie, 1901), and in the Alice River (Dickie, 1909). Reef mining began at Coen about 1892; the Great Northern mine was the largest producer and operated for several years.

Alluvial gold was discovered in the Rocky River northeast of Coen in 1893 (Jack, 1922), and reef mining began there in 1896. Gold mining began to the north at Hayes Creek (Fig. 5) in 1909 (Shepherd, 1938), although gold had been reported from this area as early as 1880 (Jack, 1922). Alluvial gold was first worked near Wenlock in 1892 (Morton, 1930), and the field was rushed following larger discoveries in 1910; the Main Leader was not located until 1922 (Fisher, 1966). Wolfram was discovered northeast of Wenlock by Bowden in 1892, but mining did not begin until 1904 (Morton, 1924). A geological sketch map of the Cape York gold and mineral fields was published in 1911 (Greenfield, 1911). In Torres Strait, gold was discovered on Horn Island in 1894, and on Possession Island in 1896 (Rands, 1896; Jackson, 1902, 1903).

Later, the general geology of the region was described by Jensen (1923) and Richards & Hedley (1925). Morton (1924) described the Pascoe River district near Iron Range, and Jardine (1928a, b) mapped the basic volcanics of Bramble Cay and Darnley Island in the northeastern part of Torres Strait. The discovery of gold in the Claudie River near Iron Range in 1933 was reported by Shepherd (1939). The wolfram mines on Moa Island were worked by Islanders before and during World War II; they have been described by Shepherd (1944), Anderson (1944), and Jones (1951a). The Aerial, Geological, and Geophysical Survey of Northern Australia (AGGSNA) investigated the gold in the Claudie River and Palmer River areas in the 1930s (Broadhurst & Rayner, 1937; Rayner, 1937; Jensen, 1940a, b).

More recently Jones & Jones (1956) have reported on the igneous rocks in the western part of Torres Strait, and summaries of the geology of the region have been given by Bryan & Jones (1946), David (1950), Hill (1956), Hill & Denmead (1960), and Jensen (1964). The Broken Hill Pty Co. Ltd made a detailed investigation of the iron ore deposits at Iron Range (BHP, 1962; Canavan, 1965a, b), and Australian Aquitaine Petroleum mapped the upper Palaeozoic sediments between the Archer River and Cape York (AAP, 1965, 1967). The small alluvial and lode tin deposits discovered near Cape York in 1949 have been investigated by a number of mining companies. Many other reports and inspections of mineral prospects and mines were made by officers of the Geological Survey of Queensland, AGGSNA, and mining companies.

The three 1:250 000 Sheet areas southeast of the region described in this Bulletin were mapped between 1960 and 1963 (Amos & de Keyser, 1964; Lucas & de Keyser, 1965a, b) by combined parties of the Bureau of Mineral Resources and the Geological Survey of Queensland. This work has been summarized in de Keyser & Lucas (1968) and Branch (1966). De Keyser (1963) described the Palmerville Fault and its possible extension to the north along the western shore of Princess Charlotte Bay. The isotopic age of the granodiorite near Musgrave homestead was published by Richards et al. (1966).

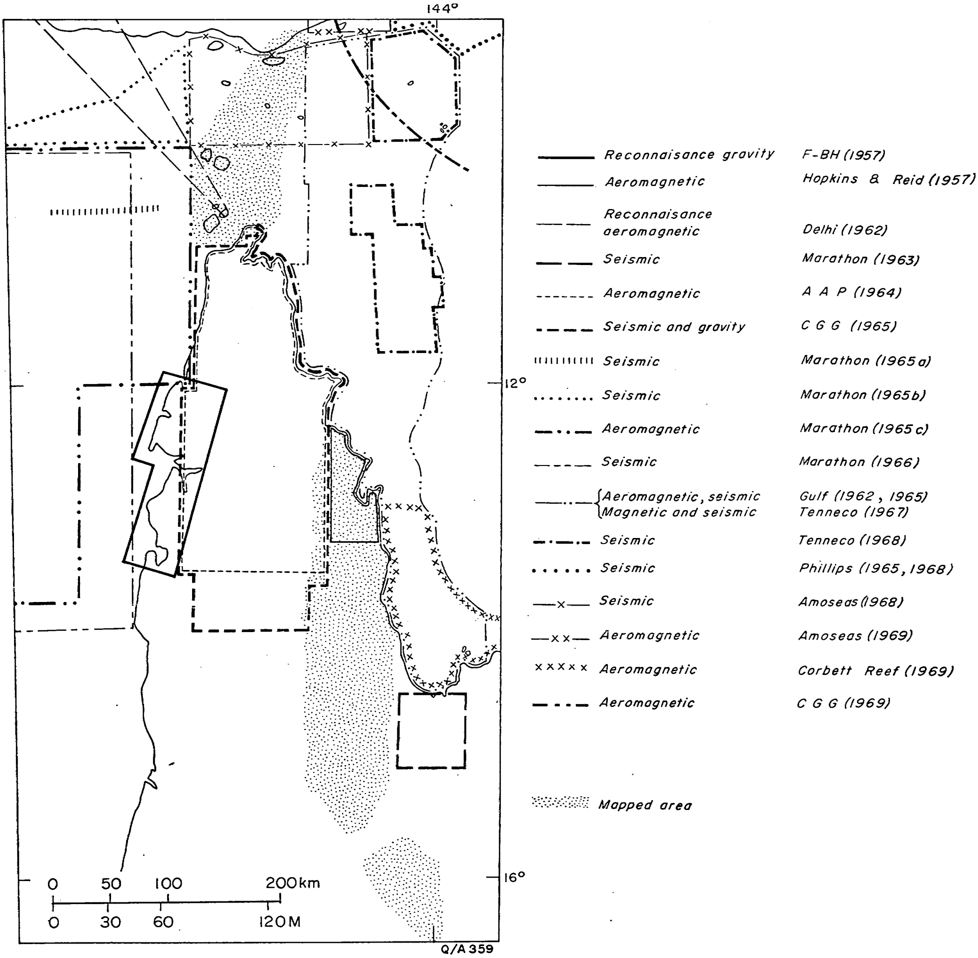

Fig. 3. Location of geophysical surveys.

In recent years the Mesozoic sediments in the Laura, Carpentaria, and Papuan Basins have been investigated (Lucas & de Keyser, 1965b; Meyers, 1969; APC, 1961; Stach, 1964). The geophysical surveys carried out in the region are shown in Figure 3; the area shown in Figure 3 has also been covered by a reconnaissance aeromagnetic survey carried out by Frome-Broken Hill Co. Pty Ltd (F-BH, 1955) and by reconnaissance gravity surveys directed by the Bureau of Mineral Resources (Shirley, in prep.; Goodspeed & Williams, 1959). Two petroleum exploration wells have been drilled; Marina Plains 1, 15 km south of the mouth of the Kennedy River (Minad, 1965) and Anchor Cay 1, 30 km northeast of Darnley Island (Opell, 1969); both were dry holes.

PHYSIOGRAPHY

The main topographic features are shown in Figure 4. Cape York Peninsula consists of a northerly trending axis of high ranges and plateaux, flanked by plains

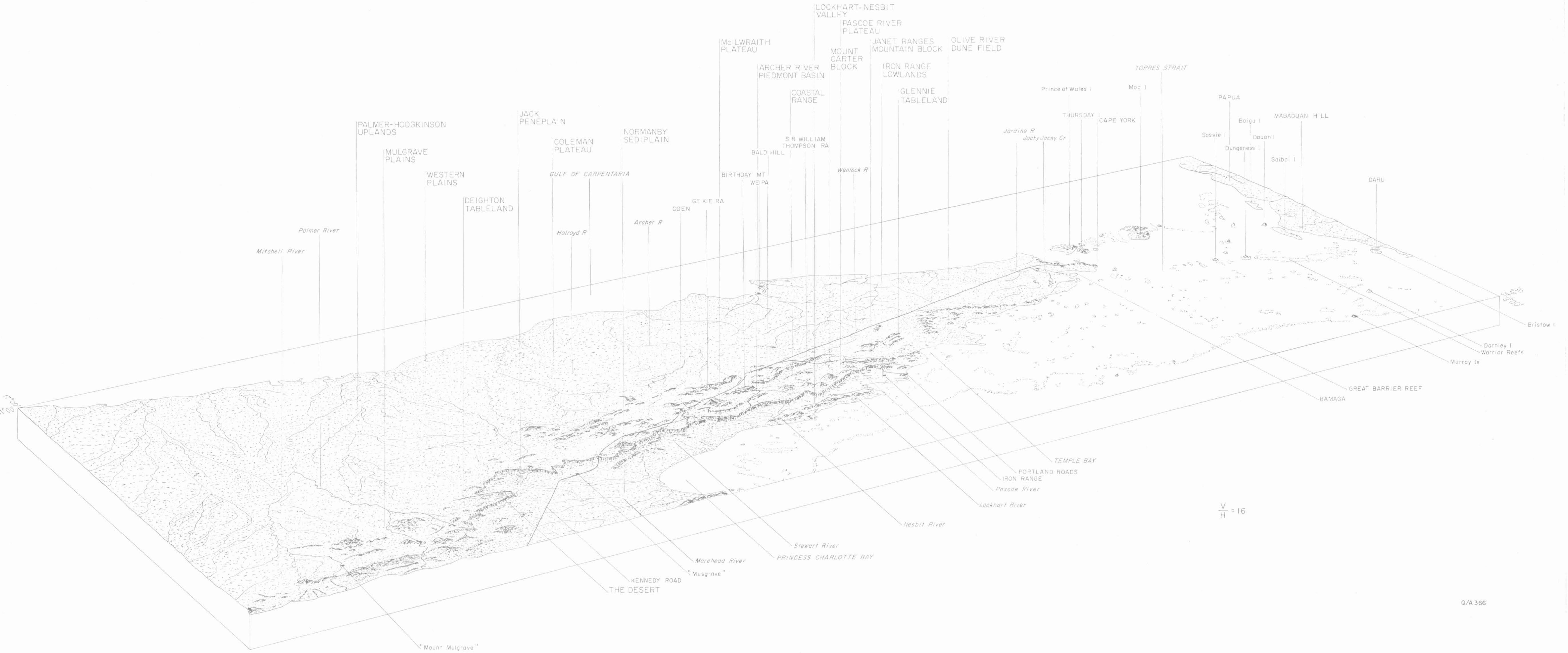

Fig. 4. Physiographic block diagram.

underlain by the flat-lying sediments of the Carpentaria and Laura Basins. The axis is near the eastern side of the peninsula, and continues below the sea at Temple Bay. It is composed predominantly of pre-Mesozoic igneous and metamorphic rocks, although high plateaux of Mesozoic sediments form part of the axis in the north. The axis is relatively low in the south, but rises to a height of 800 m east of Coen before sloping down to about 250 m north of Iron Range.

The islands in the western part of Torres Strait are the peaks of a drowned ridge of pre-Mesozoic igneous rocks, which extends from Cape York to the Papuan coast. The ridge lies to the west of the northern continuation of the main axis of the peninsula, and is separated from it by a trough of Mesozoic sediments. Several of the islands in the northeastern part of Torres Strait have been built up by Quaternary volcanic activity.

The axis

The southern part of the axis between the Palmer and Mitchell Rivers is referred to as the Yambo Inlier. It consists of gently undulating hills of granitic and less resistant metamorphic rocks, and some rugged ridges of quartzite. This gently undulating country was called the *Mulgrave Plains* (Fig. 4) by Amos & de Keyser (1964). In the east, the plains are separated abruptly by the Palmerville Fault from the folded Palaeozoic sediments forming the rugged *Palmer-Hodgkinson Uplands* of Amos & de Keyser. In the west and south, the Mulgrave Plains merge into the plains of the Carpentaria Basin.

The Yambo Inlier is separated from the main belt of igneous and metamorphic rocks to the north (the Peninsula Ridge) by a plateau of Mesozoic sediments between the Laura and Carpentaria Basins. This plateau is referred to by de Keyser & Lucas (1968) as the western margin of the *Deighton Tableland.* On topographic maps the plateau is named *The Desert,* because it lacks surface water, although it is capped by red soil supporting a thick cover of tall trees. The eastern and southern edges of the plateau are dissected, but to the southwest it merges with the plains of the Carpentaria Basin.

The *Coleman Plateau* to the north of The Desert is a large sand-covered plateau, underlain mainly by granitic rocks, which extends for 130 km from the headwaters of the Morehead River to the Stewart River south of Coen. It is less than 120 m high in the south, but rises to about 220 m near Coen. De Keyser & Lucas (1968) include this plateau in the Coleman Peneplain, which they extend westward to the Gulf of Carpentaria. However, west of the belt of basement rocks there are several erosion surfaces on the Mesozoic and Cainozoic sediments, and until these are better known they should be referred to collectively as the Western Plains, or as the northern continuation of the Carpentaria Plains of Twidale (1966). We have therefore changed the name Coleman Peneplain to Coleman Plateau, and restrict it to the plateau formed on the basement rocks of the axis of the peninsula.

The eastern edge of the plateau is defined by an abrupt scarp rising steeply from the plains of the Laura Basin. To the southwest the low undulating surface of the plateau merges into the Western Plains. De Keyser & Lucas state that the plateau merges in the south into the western part of the Deighton Tableland (The Desert), but in fact it is distinctly lower than The Desert. Elongate ridges of resistant metamorphic rocks rise a few hundred metres above the plateau in places, particularly along the eastern margin.

The *McIlwraith Plateau,* to the east and north of Coen, extends almost to the northern margin of the Coen Sheet area. It is underlain by granitic rocks and is generally over 300 m high. East of Coen it is stepped up to a surface between 450 and 550 m above sea level, from which hills rise gently to a height of 800 m. The McIlwraith Plateau is considerably higher than the Coleman Plateau and the junction between the two is abrupt and dissected. In the east, the McIlwraith Plateau is bounded by a steep escarpment that falls away to the northern continuation of the plains of the Laura Basin, and to the valleys of the Lockhart and Nesbit Rivers. To the west it is bounded by a scarp which falls to the headwaters of the Archer River. The isolated flat-topped mountains, such as Birthday Mountain and Bald Hill, are remnants separated from the main plateau by erosion. The McIlwraith Plateau is close to the coast and receives a high rainfall. The main streams are perennial and have cut deep gorges into both the western and eastern escarpments.

The *Archer River Piedmont Basin* has been formed by headward erosion of the Archer River into the McIlwraith Plateau. The floor of the basin is covered with thick deposits of poorly consolidated sandstone and conglomerate. In the north the basin merges into low undulating country that rises gradually to the level of the McIlwraith Plateau.

The eastern escarpment of the McIlwraith Plateau falls to the *Lockhart-Nesbit Valley,* a broad northerly trending corridor that has probably been formed along a fault zone. The headwaters of the Lockhart and Nesbit Rivers are separated by a low saddle. A thick sequence of poorly consolidated sandstone, derived from the plateau to the west, covers much of the valley; in the north the sandstone is overlain by alluvium. In the far north mangrove swamps extend several kilometres inland.

The Lockhart-Nesbit Valley separates the McIlwraith Plateau from the *Coastal Range,* which consists of a number of high ranges, averaging 380 m in height, linked by low saddles. A narrow coastal plain lies to the east.

The *Mount Carter Block,* on the northern margin of the McIlwraith Plateau, is a deeply incised plateau of resistant metamorphic rocks that rises to an elevation of over 600 m.

To the north the *Pascoe River Plateau* extends northwards to Mount Tozer at an average height of 230 m. The plateau is saucer-shaped, and consists of a sandy central depression surrounded by a rim and escarpment on most sides. The Pascoe River rises in the northeast and flows across the western escarpment.

The *Janet Ranges Mountain Block,* which extends from the Pascoe River Plateau to Temple Bay, consists of numerous steep peaks, up to 500 m high, separated by broad alluviated valleys. The broad valley of the Pascoe River to the west is floored by poorly consolidated Cainozoic sediments which form an elevated plain. Where the sediments are eroded small escarpments or breakaways have been developed along the streams.

In the east, the Pascoe River Plateau and Janet Ranges Mountain Block are separated from the *Iron Range Lowlands* by a steep escarpment. The lowlands extend northwards from the mouth of the Lockhart River, where they are underlain by alluvium, to Iron Range and Weymouth Bay, where they consist of strike ridges of low-grade metamorphic rocks up to 150 m high. Hills of granite, such as the Round Back Hills (400 m), and iron-bearing schist rise above the general surface.

North of Coen, the Mesozoic sediments of the Carpentaria Basin crop out along an escarpment, which includes the Geikie Range, the hills near Bald Hill, and part of the Sir William Thompson Range. Farther north this escarpment culminates in a dissected laterite-capped tableland, about 200 m high, called the *Glennie Tableland*. From this tableland, and the Sir William Thompson and Geikie Ranges, the surface of the Mesozoic sediments merges gradually into the Western Plains.

The ranges and plateaux along the axis of Cape York Peninsula are part of the Great Dividing Range. In the east the streams fall steeply to the coast, but to the west they fall gently, except in the southern part of the McIlwraith Plateau, where they are incised in gorges along the western escarpment. On the Coleman Plateau the westerly flowing streams follow the southerly strike of the metamorphic rocks before coalescing into large rivers which cut across the strike towards the Gulf of Carpentaria. The headwaters of some of the westerly flowing rivers have been captured by the more active easterly flowing streams; for example the Stewart River has captured the headwaters of the Holroyd River, and the headwaters of the Pascoe River may have originally continued westward to join the Wenlock River.

Plains of the Laura Basin

The plains on the flat-lying Mesozoic and Cainozoic sediments of the Laura Basin have been divided by de Keyser & Lucas (1968) into the Jack Peneplain and Normanby Sediplain. The *Normanby Sediplain* is a flood-plain which extends up to 80 km inland from the marine deposits bordering Princess Charlotte Bay, and for another 50 km as narrow strips along the stream valleys. To the north it merges into the southern part of the Lockhart-Nesbit Valley. The streams crossing the plain are generally braided, but change to a meandering form on reaching the marine deposits flanking the coast. Beach ridges extend up to 15 km inland in places, which suggests an emergence of about 3 m, and Galloway et al. (1970) concluded that the maximum rise in sea level during the Pleistocene was about 5 m above its present height.

The *Jack Peneplain* consists of sand-covered interfluves separated by shallow stream valleys that broaden outwards onto the Normanby Sediplain. The sand covering the interfluves was mainly derived from poorly consolidated Cainozoic sandstone and conglomerate. However, many of the low rises between the Morehead and Nesbit Rivers are covered by red soil, and are probably underlain at shallow depth by metamorphic rocks or Mesozoic sediments. The Jack Peneplain slopes up to the escarpment of the Deighton Tableland and the Coleman and McIlwraith Plateaux. The younger deposits of the Normanby Sediplain are probably encroaching on the Jack Peneplain. De Keyser & Lucas (1968) suggest that the peneplain may have been formed at the same time as the Coleman Plateau, but we believe it to be considerably younger.

Plains of the Carpentaria Basin

In the west the low plains on Mesozoic and Cainozoic sediments extend westward to the Gulf of Carpentaria. South of the Mitchell River they have been named the Carpentaria Plains by Twidale (1966), but as they are little known farther north we refer to them as the Western Plains (Galloway et al., 1970). In the east the plains are gently undulating, with occasional low mesas of sandstone. Between Coen and Temple Bay the plains are higher and slope up to the Geikie and Sir William Thompson Ranges and the Glennie Tableland.

The *Olive River Dune Field* north of Temple Bay has been developed on sands derived from underlying Mesozoic sandstone. The field consists of large longitudinal dunes trending northwest; they average 30 m in height, but range up to 100 m. Many of the dunes are still advancing to the northwest under the influence of the prevailing southeasterly winds. Others have been stabilized by low shrubs.

Torres Strait

The islands of Torres Strait can be divided into three groups: the western rocky islands, the central and eastern sand cays, and the eastern volcanic islands. The *western rocky islands* extend north from the coast of Cape York Peninsula to Dauan Island and Mabaduan Hill on the Papuan coast. They are generally over 100 m high, but some are much higher, such as Moa Island (400 m), Dauan Island (220 m), and Prince of Wales Island (250 m). In the interior of the larger islands broad ranges are separated by sand-covered plains and valleys. The depth of water between the islands is rarely greater than 10 m.

The *central and eastern sand cays* lie between the western rocky islands and the Great Barrier Reef and are composed of accumulations of coral sand and debris on coral reefs of the platform type. The central parts of Long and Dungeness Islands are low and swampy.

The *eastern volcanic islands* comprise five high islands near the northern end of the Great Barrier Reef. They consist of Pleistocene basalt and tuff, and three well preserved volcanic cones on the Murray Islands.

The northern end of Cape York Peninsula consists of *undulating uplands* on Mesozoic sediments. The uplands range from an elevation of about 100 m in the north to about 30 m in the south and southeast. In the far north and northwest the uplands have been dissected and give way to rounded hills of the acid volcanics. In the low-lying country south of Bamaga there are extensive freshwater swamps near the mouth of the Jardine River, and mangrove swamps in the estuaries on the south side of Newcastle Bay.

In southwest Papua the coastal plains, swamps, and stream valleys extend inland to the Oriomo Plateau, which rarely exceeds 50 m in height (Blake & Ollier, 1970). The swampy Boigu, Saibai, and Bristow Islands resemble the coastal plain.

Development of land surface

The three large plateaux of granitic rocks, which extend northwards for 350 km from the headwaters of the Morehead River to Iron Range, are considered to be part of a modified peneplain on which the Mesozoic sediments of the Carpentaria Basin were laid down. On the southern margin of the Coleman Plateau the peneplain is overlain by the Mesozoic sediments of The Desert, and at Bald Hill in the northern part of the Coen Sheet area the Mesozoic sediments at an elevation of about 350 m rest on a surface that is probably a dissected remnant of the McIlwraith Plateau. Farther north several small outliers of Mesozoic sediments are perched on the western margin of the Pascoe River Plateau at an elevation of about 220 m. The elevation of the base of the Mesozoic sediments in all three areas corresponds roughly with the elevation of the plateaux farther east. Twidale (1966) has found evidence that the early Mesozoic erosion surface, underlying the Mesozoic sediments, has been exhumed to form part of the present land surface.

The Mesozoic sediments probably did not originally cover the whole axis, although there was a wider connexion between the Laura Basin and the Carpentaria Basin than remains at present.

The present elevation of the plateaux is partly the result of Tertiary uplift of the east side of the peninsula along the northern continuation of the Palmerville Fault. In the south, de Keyser (1963) describes mid-Tertiary uplift on the east side of the Palmerville Fault between the Palmer and Mitchell Rivers. We believe that the movement was scissor-like, with the east block tilted down to the north and the west block to the south. The greatest uplift on the west side of the fault was near Coen; movement on subsidiary faults may be responsible for the difference in height between the McIlwraith and Coleman Plateaux, and faulting probably also took place along the Lockhart and Nesbit valleys. There is evidence of post-Cretaceous uplift of the eastern part of Cape York Peninsula in the north-central part of the Coen Sheet area, where the base of the Mesozoic sediments is over 350 m above sea level. The sediments are cut by a number of northerly trending faults upthrown to the east, and the western edge of the flat-topped Birthday Mountain is also defined by a fault.

After uplift, a prominent erosional scarp was formed along the eastern margin of the plateaux. On the plateaux the Mesozoic rocks have been stripped off by westerly flowing streams and the underlying peneplain on the basement rocks exposed. On the southwest side of the McIlwraith Plateau an escarpment was formed, possibly as a result of uplift along subsidiary faults. Poorly consolidated sediments derived from the escarpments were laid down in the Archer River Piedmont Basin, the Lockhart-Nesbit Valley, and the Laura Basin west and south of Princess Charlotte Bay. The Jack Peneplain was formed on these deposits and on some of the older rocks, but subsequently it was dissected by streams and encroached upon by the Normanby Sediplain.

North of Iron Range, the peninsula was tilted down to the north; as a result the ranges forming the axis disappeared beneath the sea, the base of the Mesozoic sediments was depressed below sea level, and the mouths of the Lockhart and Kangaroo Rivers and Jacky Jacky Creek were drowned. The tilting probably began in the Tertiary, and continued into the Quaternary when the present seaway (Torres Strait) was formed across the shallow basement ridge.

OUTLINE OF GEOLOGY

Cape York Peninsula consists of a stable shield of Precambrian metamorphic and middle Palaeozoic granitic rocks, overlain by gently dipping Mesozoic and Cainozoic sediments of the Carpentaria, Laura, and Papuan Basins. The Precambrian and middle Palaeozoic rocks crop out in the east as the Peninsula Ridge and Yambo Inlier (Fig. 5), and continue south beneath the Mesozoic sediments to the Chillagoe area on the northern margin of the Georgetown Inlier (de Keyser & Lucas, 1968; White, 1965). In the southeast the shield is separated from the folded Palaeozoic sediments of the Hodgkinson Basin by the Palmerville Fault, a fundamental structure several hundred kilometres long. The shield and Palaeozoic sediments in the Hodgkinson Basin have been intruded by upper Palaeozoic granitic rocks, associated with acid volcanics, and similar rocks formed a pre-Mesozoic ridge across Torres Strait.

The Precambrian metamorphic rocks of the Yambo Inlier and Peninsula Ridge crop out discontinuously for over 450 km, from the Mitchell River in the south to Temple Bay in the north. Originally, they probably formed a continuous sequence of regionally metamorphosed sediments, which were subsequently intruded and disrupted by granitic rocks of probable middle Palaeozoic age. They have been named the *Dargalong Metamorphics, Coen Metamorphics, Holroyd Metamorphics,* and *Sefton Metamorphics,* and have been differentiated on the basis of geographical location, and to a certain extent on lithology. The grade of metamorphism ranges from low in the greenschist facies in the north and west, to high in the amphibolite facies in the south and east; the metamorphism was of the low-pressure andalusite-sillimanite type. The rocks range from indurated sandstone and siltstone, slate and phyllite, to schist, amphibolite, gneiss, and marble. They

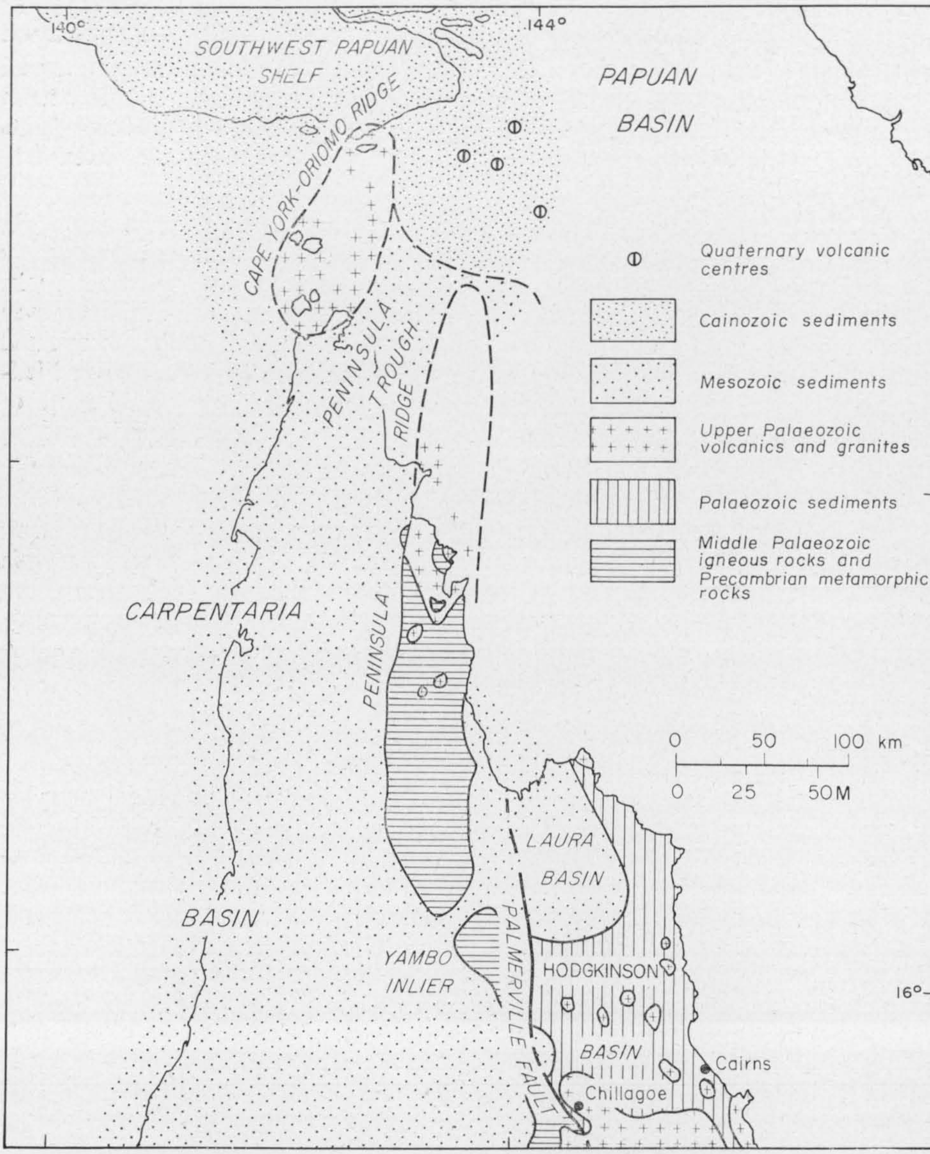

Fig. 5. Regional setting.

were derived from mudstone and sandstone, and some greywacke, basic lava, and limestone, which were possibly laid down in a relatively stable basin rather than in a deep eugeosynclinal trough. In the north there was one major period of folding, with compression from the east-northeast and folds trending mainly north-northwest. In the south, in the Yambo Inlier and Chillagoe area, the presence of northeasterly trending structures indicates more complicated folding. The Rb/Sr isotopic ages obtained on the metamorphic rocks are inconclusive, but suggest that there was at least one period of metamorphism in the late Precambrian. After being metamorphosed they were intruded by dykes and irregular bodies of *dolerite*.

The middle Palaeozoic granitic rocks form a large concordant body, the Cape York Peninsula Batholith, which intrudes the metamorphic sequence over a distance of 420 km, from the Yambo Inlier in the south to Weymouth Bay in the north. The batholith consists of biotite-muscovite adamellite, the *Kintore Adamellite,* and subordinate intrusions that have been named the *Aralba Adamellite, Lankelly Adamellite, Morris Adamellite, Wigan Adamellite, Blue Mountains Adamellite,* and *Flyspeck Granodiorite.* The Kintore Adamellite, and to a lesser extent the other units, are variable in composition and texture, and commonly contain leucocratic varieties such as garnet-muscovite granite, pegmatite, and aplite, particularly near the contacts. Foliation and banding are also common near the margins. The surrounding metamorphics have been thermally metamorphosed and in places metasomatized and migmatized. The batholith was emplaced at a deep level in the earth's crust. K/Ar isotopic analyses indicate an Upper Devonian age, but preliminary Rb/Sr total rock analyses suggest that the batholith is probably middle Palaeozoic. The K/Ar results may represent an Upper Devonian event which was possibly related to the metamorphism in the neighbouring Hodgkinson Basin.

The *Pascoe River Beds* were laid down in a small Lower Carboniferous freshwater basin. The sequence consists of sandstone, arkose, greywacke, siltstone, and shale, with a little coal, conglomerate, and chert, and was folded between the Lower Carboniferous and Lower Permian.

During the late Palaeozoic, acid volcanic rocks were erupted near Iron Range, Cape Grenville, and in Torres Strait. Near Iron Range and Cape Grenville the *Janet Ranges Volcanics, Kangaroo River Volcanics, Cape Grenville Volcanics,* and other unnamed volcanic rocks consist mainly of rhyolite welded tuff, rhyolite, and welded pumice-flow breccia, with some rhyodacite welded tuff, dacite welded tuff, and andesite. The Janet Ranges Volcanics rest unconformably on the Lower Carboniferous Pascoe River Beds. The *Torres Strait Volcanics* consist of rhyolite welded tuff and minor agglomerate, volcanic breccia, rhyolite, andesite, and interbedded sediments. In the south four separate members have been recognized, each of which is composed of several welded tuff sheets of similar composition. In the southern part of the Yambo Inlier the acid and basic lavas and tuff form part of the Nychum Volcanics in the Georgetown Inlier.

In Torres Strait the Upper Carboniferous *Badu Granite* has intruded and hornfelsed the Torres Strait Volcanics. It was followed by the intrusion of small bodies of porphyritic microgranite, and in the south by discontinuous hydrothermal activity. Near Iron Range the volcanics and older rocks were intruded and hornfelsed by a pluton and stocks of Lower Permian granite *(Weymouth Granite).* Small bodies of diorite occur around and within the granite, and granophyric and hybrid rocks crop out in a belt along its western margin. Farther south upper Palaeozoic granitic rocks crop out near Bald Hill *(Wolverton Adamellite)* and near Coen *(Twin Humps Adamellite)*. The Upper Permian Twin Humps Adamellite is the youngest of the upper Palaeozoic rocks.

During the late Permian and early Mesozoic, the Precambrian and Palaeozoic crystalline rocks were eroded to a peneplain. In the late Jurassic and Lower Cretaceous, sediments were laid down in the Carpentaria, Laura, and Papuan Basins in the west, southeast, and northeast respectively. The sediments have been described by Myers (1969), de Keyser & Lucas (1968), and the Australasian Petroleum Co. (APC, 1961) and are mentioned only briefly in this Bulletin.

In the Tertiary, the Mesozoic sediments were partly stripped off and the pre-Mesozoic peneplain was exhumed. Uplift in the east raised the basement rocks in the centre of the Peninsula Ridge to their present elevation, but farther north the basement may have been depressed. The Cainozoic sediments laid down after the uplift consist mainly of poorly consolidated sandstone and conglomerate, and younger residual sand, alluvium, and marine deposits.

Southeast of Coen a small body of *olivine nephelinite,* probably of Cainozoic age, forms a low hill near Princess Charlotte Bay. It is similar in composition to the Cainozoic ultra-alkaline lavas in the Cooktown district to the southeast (Morgan, 1968b).

In the far northeast of Torres Strait basaltic tuff and basalt of Pleistocene age (*Maer Volcanics*) form several small volcanic islands. They probably form part of the extensive Pleistocene volcanic province in the central Highlands of Papua New Guinea.

PRECAMBRIAN METAMORPHIC ROCKS

The Precambrian metamorphic rocks (Table 1) have been subdivided into four units (Fig. 6). Near Chillagoe they have been termed the *Dargalong Metamorphics* (de Keyser & Wolff, 1964; de Keyser & Lucas, 1968) and this name has also been used for the rocks in the Yambo Inlier (Amos & de Keyser, 1964; Whitaker & Willmott, 1968).

To the north, in the Peninsula Ridge, the metamorphic rocks are subdivided into the *Coen Metamorphics* in the eastern part of the Cape York Peninsula Batholith, the *Holroyd Metamorphics* to the west of the batholith, and the *Sefton Metamorphics* to the north. The Coen Metamorphics are defined in this Bulletin; they were previously included in the Dargalong Metamorphics by Whitaker & Willmott (1968). Detailed descriptions of each unit are given in the second part of the Bulletin.

Lithology

The metamorphics consist predominantly of mica-quartz schist, quartzite, and biotite-feldspar-quartz gneiss, but also include low-grade rocks such as indurated sandstone and siltstone, slate, phyllite, and fine-grained mica-quartz schist. Numerous bands of amphibolite and greenstone occur in the sequence, as well as lenses of schistose limestone, marble, and calc-silicate rocks. Some of the metamorphics near the granitic rocks have been recrystallized and metasomatized, and in places migmatite has been developed.

TABLE 1. PRECAMBRIAN METAMORPHIC AND IGNEOUS ROCKS

Formation (map symbol)	*Rock Type*	*Relationships*	*Remarks*
(Po)	Dolerite	Dykes and irregular bodies in Dargalong Metamorphics	Not metamorphosed, antedates batholith
Sefton Metamorphics (Ps)	Mica schist, quartzite, phyllite, minor amphibolite; hematite schist, magnetite quartzite, greenstone, marble, calc-silicate rocks, schistose limestone in north	Grade into Holroyd Metamorphics	
Holroyd Metamorphics (Ph)	Indurated sediments, phyllite, mica schist, quartzite, gneiss; some greenstone and amphibolite	Grade into Coen Metamorphics	
Coen Metamorphics (Pc)	Mica schist, quartzite, biotite gneiss; some garnet-amphibole gneiss, amphibolite, and calc-silicate rocks		
Dargalong Metamorphics (Pd)	Biotite gneiss, feldspar-mica schist, muscovite-quartz schist, quartzite, amphibolite; some migmatite in northeast	Part of same sedimentary sequence as Coen, Holroyd, and Sefton Metamorphics?	Confined to Yambo Inlier

Each of the four metamorphic units was subdivided by Whitaker & Willmott (1968, 1969a) into a number of lithological types, which were given formal names in the Sefton Metamorphics and informal names in the other units, but as these subdivisions are now considered to be unsatisfactory they have been abandoned.

The *Dargalong Metamorphics* in the Yambo Inlier consist mainly of biotite-plagioclase-quartz gneiss (Fig. 7), quartzite, and amphibolite in the east, and plagioclase-muscovite-biotite-quartz schist, muscovite-quartz schist, and quartzite in the west. A few small lenses of amphibole and diopside-bearing gneiss are interbanded with the gneiss.

The *Coen Metamorphics* consist of coarse-grained schist and gneiss similar to the eastern part of the Holroyd Metamorphics, with which they were continuous before the intrusion of the batholith. The main rock types are biotite-muscovite-quartz schist, quartzite, and biotite-quartz-feldspar gneiss. Schist and quartzite are about three times as abundant as gneiss. Other rock types include thin bands of garnet-amphibole-quartz-feldspar gneiss within the biotite gneiss, amphibolite, and a few lenses of calc-silicate rocks.

The *Holroyd Metamorphics* consist of indurated sandstone and siltstone, phyllite, fine and medium-grained schist and gneiss, quartzite, and some bands of greenstone and amphibolite. The indurated sandstone and siltstone (Fig. 8) crop out only in the west in a narrow north-northwesterly trending belt crossing the Lukin River near The Gorge. To the east and west (chlorite-)sericite-quartz phyllite, fine-grained (biotite-)muscovite-quartz schist and interbedded quartzite are exposed. Graphite is present in much of the phyllite and schist. Medium or coarse-grained mica-quartz schist occurs mainly in the east; in places it contains garnet, andalusite, staurolite, cordierite, and feldspar (Fig. 9). The feldspar-bearing rocks have a poorly developed gneissic texture. Sillimanite is a minor constituent of the schist along the eastern margin of the unit. The interbanded basic rocks

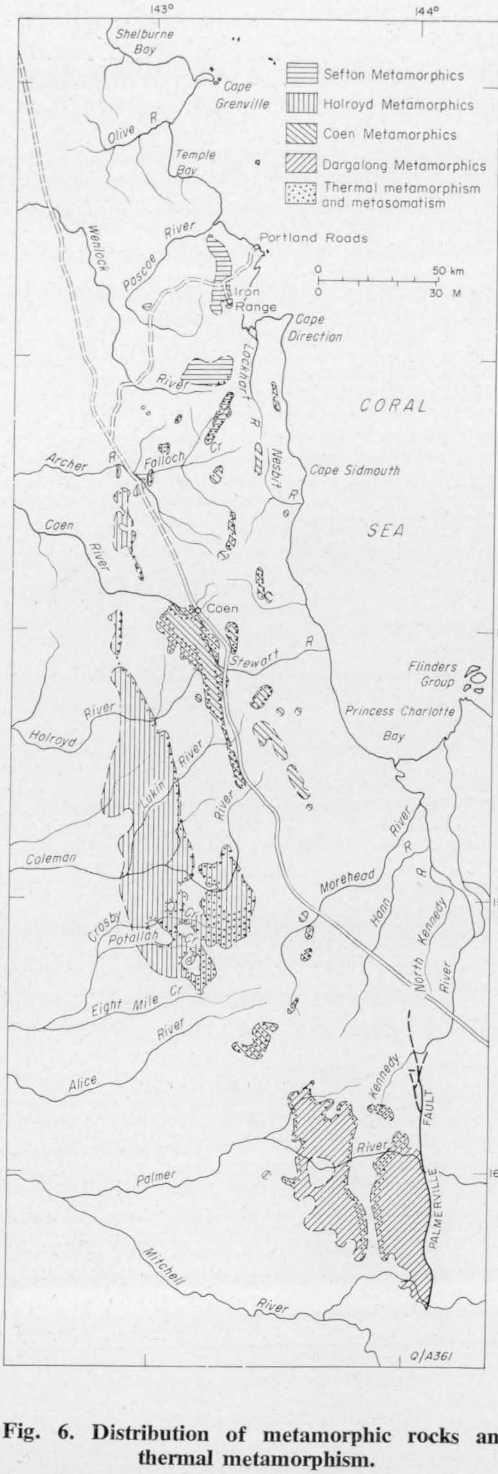

Fig. 6. Distribution of metamorphic rocks and thermal metamorphism.

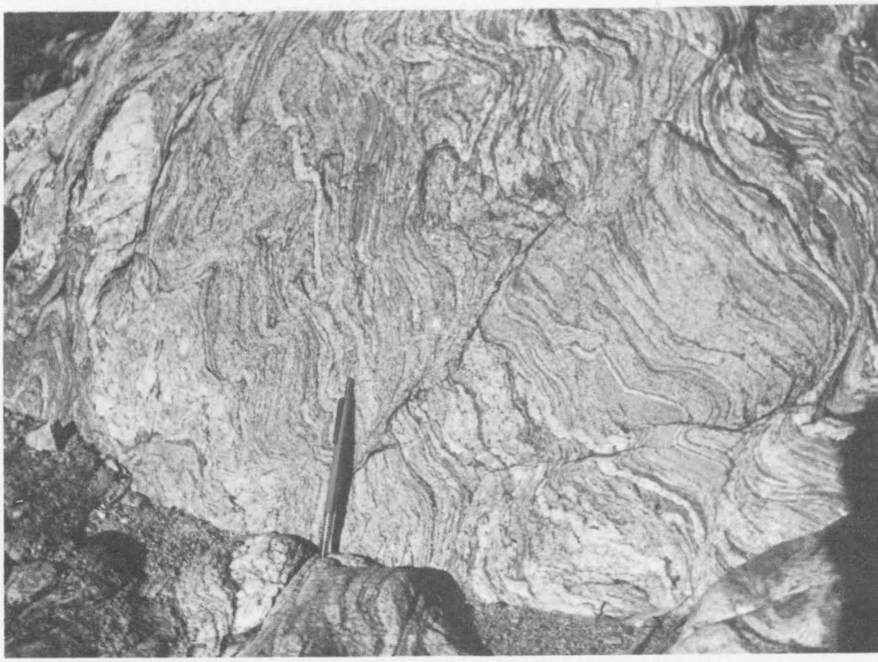

Fig. 7. Folding in gneiss, Dargalong Metamorphics.

Fig. 8. Cleaved siltstone, Holroyd Metamorphics.

Fig. 9. Andalusite porphyroblasts in schist, Holroyd Metamorphics.

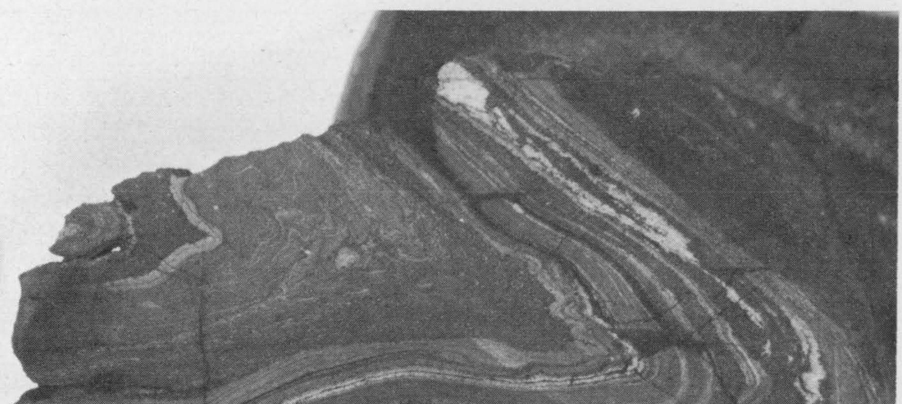

Fig. 10. Folded quartz-hematite schist, Sefton Metamorphics, near Iron Range.

grade from greenstone in the west to amphibolite in the east. Thin bands of lime-rich rocks and magnesia-rich rocks occur in association with greenstone in a few localities.

The *Sefton Metamorphics* are composed mainly of fine-grained muscovite-quartz schist, phyllite, and quartzite, and minor amphibolite similar to the Holroyd Metamorphics to the southwest. In the Iron Range area the schist and quartzite are interbanded with hematite-quartz schist, magnetite quartzite, greenstone, marble, and calc-silicate rocks (Fig. 10). In the Temple Bay area the muscovite-quartz schist grades into schistose limestone; calc-silicate rocks are also present.

Composition of original sediments

The predominance of mica-quartz schist and phyllite, quartzite, and biotite-feldspar-quartz gneiss suggests that the metamorphics were derived mainly from a sequence of siltstone and sandstone, with some greywacke and arkose. The thinly bedded siltstone, shale, and sandstone in the west have been only slightly metamorphosed, and small slump structures can still be seen in the pelitic rocks, and traces of cross-bedding in some of the quartzites.

The garnet-amphibole-bearing and diopsidic gneisses in the biotite gneiss of the Coen and Dargalong Metamorphics were probably derived from thin beds that were richer in lime than the surrounding greywackes. The marble and calc-silicate rocks in the Coen and Sefton Metamorphics represent lenses of limestone, dolomite, and dolomitic detrital sediments.

Greenstone and amphibolite are common only in the eastern part of the Yambo Inlier. They were derived from basic igneous rocks, and the sharp concordant contacts of the larger bands suggest that they are probably altered lavas. Near Iron Range and the Coleman River, amygdales have been recognized in the greenstone, but the relict ophitic texture of one of the greenstones near Iron Range suggests that it is an altered dolerite. Many of the smaller bands of greenstone and amphibolite, which have gradational contacts with the surrounding rocks, are probably altered lime-rich sediments. Some of the lenses with a talc-chlorite-tremolite assemblage may be metamorphosed ultramafic rocks.

Canavan (1965b) has shown that the iron-bearing schists and quartzites near Iron Range were derived from ferruginous siltstone and sandstone. Lee & Forsythe (1961) note that the magnetite quartzite passes along strike into an amphibole-quartz rock similar to the thin bands of diopside-actinolite-quartz rock in the Coen Metamorphics. These were probably derived from ferruginous and calcareous quartz-rich sediments, although Lee & Forsythe believe that the amphibole-rich rocks may be altered basic igneous rocks.

Environment of deposition

The predominance of siltstone and sandstone, with subordinate limestone, dolomite, and iron-rich sediments, suggests that the sequence was deposited in a relatively shallow miogeosynclinal environment, rather than in a deep eugeosynclinal trough. The presence of relict detrital potash feldspar, plagioclase, and biotite in some of the less altered rocks of the Holroyd Metamorphics, and the presence of pebbles of feldspathic quartzite and low-grade metamorphic rocks in a schistose conglomerate at Iron Range, suggest that the sediment was derived from an older sequence of metamorphic and plutonic rocks. The relict feldspar and biotite grains are relatively fresh and angular, and the sediment was probably transported only a short distance from its source.

Structure

The regional trend of the bedding in the metamorphics is clearly visible on air-photographs; it generally dips steeply and strikes north to north-northwest. There appears to have been only one major period of folding, in which the direction of maximum compression was from the east-northeast. The folding was isoclinal, and appears to have been tighter in the east than in the west. Between Potallah Creek and the Lukin River, three large northerly plunging folds, which repeat a band of quartzite and greenstone, are overturned from the east.

The schistosity and foliation are generally parallel to the trend of the bedding, but in the Holroyd Metamorphics the schistosity is locally obliquely inclined to the bedding. The schistosity is generally steeply inclined, and is probably parallel to the axial planes of the isoclinal folds. The small crenulations in the schistosity probably reflect minor folding during the main period of deformation, rather than a later period of deformation.

In the west the Holroyd Metamorphics have been cut by north-northwesterly trending faults. The largest, northwest of The Gorge, appears to separate the low-grade rocks to the west from high-grade rocks to the east. The large shear zones cutting the metamorphics between Coen and the Stewart River, and near the Archer River, were probably formed during the intrusion of the Cape York Peninsula Batholith.

In the south, near the headwaters of the Morehead River, the trend of the metamorphics swings from north-northwest to northwest, but farther south in the Yambo Inlier the swing is from north to northeast. The area in between is concealed by the Mesozoic sediments of The Desert, so the structural relationship between the two areas is uncertain. Still farther south in the Chillagoe area the structure of the metamorphic rocks is more complicated, with both northeasterly and northwesterly trends. In the north between Falloch Creek and Mount Carter, the strike of the metamorphics swings to the north-northeast. The trends at Mount Carter outline a broad synform plunging to the north. On the east limb bands of quartzite dip gently to the northwest and the schistosity is roughly parallel to the bedding, but on the west limb both schistosity and bedding are contorted. The synform appears to have been developed after the formation of the schistosity and may have resulted from the intrusion of the Permian Weymouth Granite.

Metamorphism

The metamorphics have undergone one major episode of regional metamorphism, which apparently accompanied the folding of the sequence. The metamorphic grade increases to the east and south from low in the greenschist facies to high in the amphibolite facies. The metamorphism was of the low-pressure andalusite-sillimanite type of Miyashiro (1961).

In the east the metamorphic rocks have been intruded by a deep-level granitic batholith, with accompanying thermal metamorphism, metasomatism, recrystallization, and migmatization in the contact zone.

The increase in metamorphic grade is revealed by the mineral assemblages of the psammopelitic rocks and the interbanded basic rocks (Fig. 11). The changes in the calcium-rich and magnesium-rich rocks are less marked.

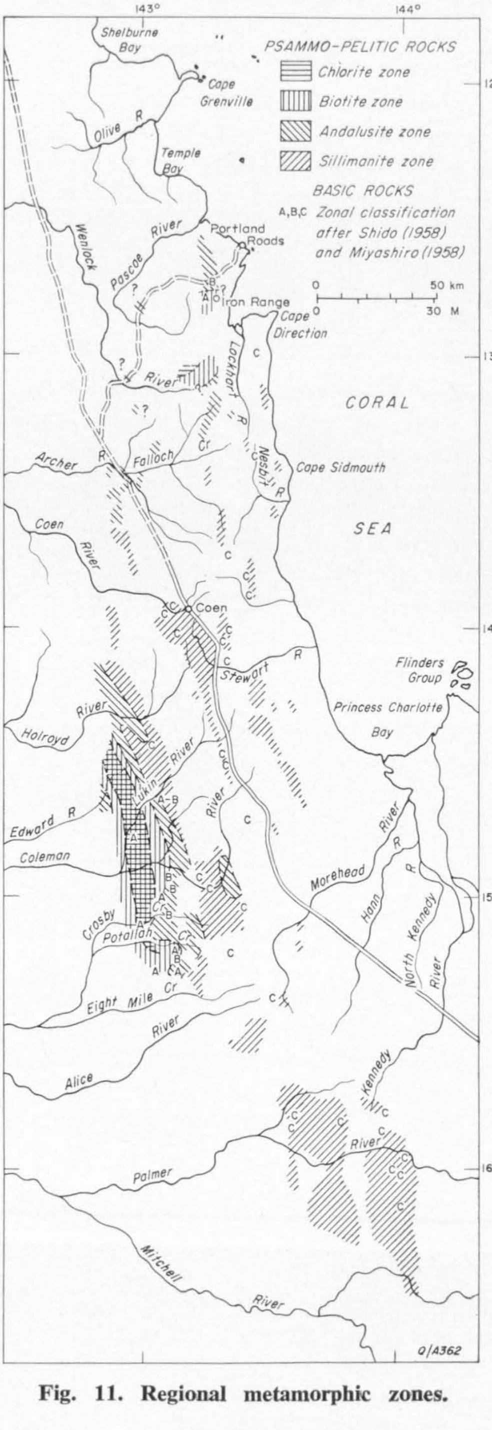

Fig. 11. Regional metamorphic zones.

In the psammopelitic rocks four metamorphic zones have been recognized: the chlorite and biotite zones of the greenschist facies, and the andalusite and sillimanite zones of the amphibolite facies. All four zones are represented in the Holroyd Metamorphics; the first three also occur in the Sefton Metamorphics, but only the sillimanite zone is represented in the Coen and Dargalong Metamorphics. The distribution of the zones is shown in Figure 11.

The *chlorite zone* includes the indurated sandstone and siltstone, phyllite, and slate in the central-western part of the Holroyd Metamorphics, and the phyllite and quartzite of the Sefton Metamorphics which form the northwest part of the Mount Carter Block. The common assemblage is (hematite-graphite-chlorite-) sericite-quartz; relict feldspar and rare biotite may also be present.

The *biotite zone* comprises fine-grained or medium-grained schists, spotted in places with garnet and biotite. The most common assemblage is (graphite-garnet-) biotite - muscovite - quartz, although (graphite-)garnet - muscovite - quartz and (graphite-)muscovite-quartz rocks also occur.

The medium-grained or coarse-grained schists of the *andalusite zone* are characterized by porphyroblasts of andalusite. In the lower-grade part of the zone schists spotted with garnet and biotite may also be present. Cordierite, staurolite, and potash feldspar occur in some of the rocks. The assemblages in this zone include: muscovite-quartz; biotite-muscovite-quartz; (andalusite-)garnet-biotite-muscovite-quartz; potash feldspar-muscovite-biotite-oligoclase-quartz; (tourmaline-graphite-)andalusite-muscovite-quartz; (hematite-graphite-)staurolite-muscovite-andalusite-biotite-quartz; cordierite-garnet-staurolite-biotite-muscovite-quartz; and cordierite-andalusite-muscovite-quartz.

The Sefton Metamorphics between the Kennedy Road and Temple Bay contain cordierite and probably belong to this zone, although neither andalusite nor staurolite has been identified. The composition of the basic rocks also indicates that the rocks belong to the andalusite zone.

In the *sillimanite zone* in the eastern part of the Holroyd Metamorphics sillimanite first appears as fibrolite in quartz and muscovite. In the coarse-grained mica schist and gneiss of the Coen and Dargalong Metamorphics it forms medium-sized or large prisms, most of which have been replaced by muscovite. The most common assemblages are: (sillimanite-garnet-)potash feldspar-biotite-plagioclase-quartz; (sillimanite-garnet-) biotite-plagioclase; (biotite-)garnet-hornblende-quartz-plagioclase; (sillimanite-garnet-)plagioclase-biotite-muscovite-quartz; and (sillimanite-)muscovite-quartz.

In the western part of the Holroyd Metamorphics andalusite may co-exist with sillimanite in the last two assemblages, and in the (sillimanite-)andalusite-biotite-muscovite-quartz assemblage. Cordierite occurs sporadically throughout the zone.

The mineral assemblages in the metamorphosed basic igneous rocks fall into three zones, A, B, and C, and conform essentially to those of Shido (1958), Shido & Miyashiro (1959), and Miyashiro (1958, 1968). The distribution of these zones is shown in Figure 11; the zones are delineated on the basis of the colour of the calcic amphibole.

Zone A is characterized by green actinolite and is largely equivalent to the chlorite and biotite zones described above. Common assemblages in Zone A are: quartz-tremolite-actinolite; sphene-albite or oligoclase-quartz-actinolite; clinozoisite-muscovite-andesine*-tremolite or actinolite; sphene-quartz-clinozoisite-actinolite-albite or oligoclase; biotite-quartz-andesine*-actinolite; and labradorite*-oligoclase-actinolite.

Zone B is characterized by bluish green hornblende and is equivalent to the andalusite zone of the psammopelitic rocks. The rocks contain andesine and hornblende, with various amounts of quartz, sphene, clinozoisite or epidote, and in places a little garnet or calcite. This assemblage has only been identified in the south central part of the Holroyd Metamorphics. The basic rocks north of the Kennedy Road in the Iron Range area probably contain hornblende and belong to Zone B, unlike the rocks to the south of the road, which contain actinolite.

Zone C is characterized by green or greenish brown hornblende and is equivalent to the sillimanite zone of the psammopelitic rocks. Zone C rocks are widely distributed and contain andesine or labradorite, or rarely bytownite, and hornblende, together with a little quartz, sphene, apatite, and clinopyroxene.

The mineral assemblages of both the psammopelitic and basic rocks indicate regional metamorphism of the low-pressure andalusite-sillimanite type. This, the Abakuma-type of metamorphism, is intermediate in pressure between contact or thermal metamorphism and the high-pressure kyanite-sillimanite or Dalradian type (Shido, 1958; Miyashiro, 1958, 1961, 1968; Hietanen, 1967; Winkler, 1967; Joplin, 1968a). In Cape York Peninsula, as in the type area, andalusite is stable in the lower part of the amphibolite facies, and in places co-exists with sillimanite. Cordierite is also present in the amphibolite facies. Kyanite, which is typical of high-pressure terrains, is absent. Garnet is absent in the basic igneous rocks, but occurs in some of the garnet-hornblende-bearing gneisses of the Coen Metamorphics.

Thermal metamorphism. In the east, the intrusion of the Cape York Peninsula Batholith resulted in extensive potash metasomatism, recrystallization, migmatization, and thermal metamorphism of the adjacent metamorphic rocks. The effects differ in intensity from place to place, but in general are most pronounced in the southern part of the Holroyd and Coen Metamorphics and in the Dargalong Metamorphics of the Yambo Inlier (Fig. 6).

The massive granoblastic microcline-bearing gneiss and augen gneiss in the northeast part of the Yambo Inlier have been formed by recrystallization and potash metasomatism. Recrystallized schists and gneisses, some of which contain microcline, are also found in the Holroyd Metamorphics southeast of the Dixie/Alice River road, as xenoliths in the batholith farther south, and in the small bodies of Coen Metamorphics along the western edge of The Desert. All gradations exist between the recrystallized gneiss and the surrounding granitic rocks. In the Ebagoola and Coen Sheet areas, similar rocks are found in relatively narrow zones around bodies of Coen Metamorphics.

The migmatites in the northeastern part of the Yambo Inlier and in the southeastern part of the Holroyd Metamorphics have been produced by intense recrystallization and metasomatism. They contain numerous thin concordant veins of quartz and microcline. The coarse cross-cutting crystals of muscovite in the adjacent schists, and the tourmaline in some of the metamorphics, are probably also of metasomatic origin.

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* Average composition; the crystals are zoned with sodic rims.

It is difficult to differentiate between the thermal metamorphic effects associated with the intrusion of the granitic rocks and the effects of regional metamorphism. Thermal metamorphic effects have been recognized in the chlorite and biotite zones in the southern part of the Holroyd Metamorphics, where chiastolite porphyroblasts and fibrolite have developed and muscovite has recrystallized along the margins of a number of small granite plutons.

Retrogressive metamorphism is widespread throughout the amphibolite facies rocks. Sillimanite and andalusite have been altered to sericite, cordierite to chlorite and sericite, plagioclase to sericite or clinozoisite, biotite to chlorite, garnet to chlorite, and hornblende to actinolite and chlorite. These changes may be related to an Upper Devonian event which corresponds with the K/Ar isotopic age of the batholith and metamorphics.

Age

The Dargalong Metamorphics in the Yambo Inlier and around Chillagoe are older than the Silurian to Devonian Chillagoe Formation, and are thought to be of Precambrian age (Amos & de Keyser, 1964; de Keyser & Lucas, 1968).

The K/Ar ages obtained on samples of the Coen and Holroyd Metamorphics indicate an Upper Devonian event, which was originally interpreted as the intrusion of the Cape York Peninsula Batholith. The Rb/Sr total rock ages of the Dargalong, Coen, and Holroyd Metamorphics suggest that there was at least one metamorphic event in the late Precambrian, although no specific date can be fixed. The K/Ar results could be interpreted as a re-setting of the micas for potassium and argon in the older granitic and metamorphic rocks during a major Upper Devonian event, at present of unknown origin.

The differences in the direction and complexity of the structural trends in the Dargalong Metamorphics in the Yambo Inlier, and the Coen, Holroyd, and Sefton Metamorphics in the Peninsula Ridge, suggest that there may be a difference in age between the metamorphics in the two areas. However, the Rb/Sr data show no significant variation, although the imprecise results obtained may conceal more than one age.

PRECAMBRIAN(?) IGNEOUS ROCKS

Dykes and irregular masses of dolerite intrude the metamorphics in the western part of the Yambo Inlier. The rock consists of labradorite, augite, orthopyroxene, hornblende, and minor magnetite. The dolerite was intruded after the period of regional metamorphism but before the intrusion of the Cape York Peninsula Batholith.

MIDDLE PALAEOZOIC: CAPE YORK PENINSULA BATHOLITH

The Precambrian metamorphic rocks have been extensively intruded by granitic rocks of probable middle Palaeozoic age, which have been named collectively the Cape York Peninsula Batholith (Whitaker & Willmott, 1969a). The intrusions are generally concordant, and form a northerly trending belt about 400 km long and from 60 to 2 km wide.

The batholith (Table 2) is exposed over an area of at least 5500 km^2 and probably underlies another 4000 km^2 covered by Cainozoic sediments. It contains many small remnants of older metamorphic rocks, and in the Coleman River area small granitic stocks or offshoots intrude the Holroyd Metamorphics several kilometres to the west of the main body. North of Mount Carter the batholith is overlain by upper Palaeozoic sediments and volcanics and is intruded by Lower Permian granite.

TABLE 2. MIDDLE PALAEOZOIC CAPE YORK PENINSULA BATHOLITH

Formation (map symbol)	*Rock Type*	*Relationships*	*Remarks*
Blue Mountains Adamellite (Pb)	Biotite adamellite, hornblende-biotite adamellite; some leucocratic biotite granite	Intrusive contact with Kintore Adamellite	
Morris Adamellite (Pm)	Porphyritic biotite adamellite; some biotite granite and leucocratic muscovite-biotite adamellite	Intrudes sheared Kintore Adamellite	
Wigan Adamellite (Pw)	Leucocratic biotite adamellite and granite; some biotite adamellite and granodiorite	Grades into Kintore Adamellite. Intrudes Flyspeck Granodiorite?	
Lankelly Adamellite (Pl)	Porphyritic biotite adamellite; some leucocratic muscovite granite and muscovite granite pegmatite and aplite	Grades into Kintore Adamellite	
Kintore Adamellite (Pk)	Biotite-muscovite adamellite and granite, muscovite-biotite adamellite and granodiorite; some muscovite granite and garnet-muscovite granite pegmatite and aplite	Grades into Lankelly, Aralba, and Wigan Adamellites; intrusive contacts with Blue Mountains and Morris Adamellites and Flyspeck Granodiorite	Dominant rock type in batholith
Aralba Adamellite (Pa)	Porphyritic biotite-muscovite adamellite	May grade into Kintore Adamellite	Confined to Yambo Inlier
Flyspeck Granodiorite (Pf)	Biotite granodiorite, hornblende-biotite tonalite, biotite-hornblende diorite	Intrusive contacts with Wigan and Kintore Adamellites	

The batholith is a complex body composed of a number of concordant intrusions, all of which are believed to belong to the same cycle of plutonic activity. Seven named units have been distinguished. The main component, the Kintore Adamellite, forms about 70 percent of the batholith and extends along the full length of the body. The Aralba Adamellite, which crops out in the northern part of the Yambo Inlier, appears to be a porphyritic variant of the Kintore Adamellite, into which it grades in places. Similarly, the Lankelly Adamellite, which is exposed to the east of Coen, grades into the Kintore Adamellite with an increase in the proportion of muscovite.

The intrusions of Blue Mountains Adamellite, Wigan Adamellite, and Morris Adamellite, which are exposed between Coen and Wenlock, are distinct mineralogically and texturally and generally have sharp boundaries with the Kintore Adamellite. The Flyspeck Granodiorite, which consists of a number of intrusions scattered over a distance of about 230 km between the Alice River and Wenlock, is younger than the Kintore Adamellite and is distinctly more basic than the other units (see Tables 3, 4).

There is considerable variation in composition and texture within most of the units, especially within the Kintore Adamellite. Leucocratic garnet-muscovite granite, pegmatite, and aplite are commonly found near the margins of the intrusions (Fig. 12) and as dykes in the country rock for several kilometres from the contact (Fig. 13); biotite-rich and plagioclase-rich varieties may also be present. Variations in the abundance of phenocrysts are common.

All the granitic rocks are generally massive and lack foliation or banding but, near the margin of the batholith, the Kintore Adamellite is foliated in places (Fig. 14). Rare compositional banding in the Kintore Adamellite probably represents partly digested xenoliths of metamorphic rocks into which the banded granite grades (Fig. 15). Banding has also been observed in the Lankelly Adamellite (Fig. 16). Xenoliths of country rocks are fairly common, especially near the contacts of the batholith. The feldspar phenocrysts in the Lankelly Adamellite are, in places, aligned parallel to the margin of the body (Fig. 17). Acid and intermediate dykes cut the Kintore Adamellite, and are particularly common in or near the Flyspeck Granodiorite. Near many of the contacts both the granitic and metamorphic rocks are cut by quartz reefs, some of which contain traces of gold.

TABLE 3. CHEMICAL ANALYSES, CAPE YORK PENINSULA BATHOLITH

	1	2	3	4	5	6	7	8	9	10	11
SiO_2	61.80	69.17	66.74	68.02	67.05	56.24	75.16	75.26	70.33	74.20	72.16
Al_2O_3	16.55	16.45	16.19	17.28	16.63	17.09	16.06	15.37	15.03	14.21	15.79
Fe_2O_3*	5.47	2.65	4.86	3.44	4.42	7.55	1.43	0.57	2.80	1.41	1.58
MgO	4.14	1.55	2.13	1.21	1.57	4.18	0.76	0.34	0.72	0.66	0.70
CaO	6.19	2.72	4.30	4.65	3.92	6.97	2.20	1.09	2.18	1.36	2.28
Na_2O	2.51	2.94	2.47	2.99	3.04	1.92	3.22	4.17	2.53	3.14	4.00
K_2O	1.89	5.28	3.12	2.72	2.31	2.80	3.37	4.30	5.16	5.50	3.42
TiO_2	0.51	0.33	0.64	0.41	0.84	0.87	0.17	0.02	0.45	0.20	0.20
P_2O_5	0.12	0.32	0.14	0.10	0.15	0.23	0.10	0.05	0.17	0.08	0.10
MnO	0.09	0.07	0.08	0.06	0.04	0.13	0.03	0.03	0.04	0.52	0.03
Loss on ignition	0.75	0.85	0.59	0.75	0.46	0.49	0.71	0.62	0.96	0.52	0.48
Total+	99.27	101.48	100.67	100.88	99.97	97.98	102.50	101.20	99.41	100.28	100.26

*Total iron as Fe_2O_3
+Does not include loss on ignition

Flyspeck Granodiorite
1. Biotite-hornblende tonalite, 47 km NW of Kimba homestead (BMR 68480229).
2. Biotite granodiorite, 13 km NE of Dixie homestead. (BMR 67570021).
3. Hornblende-biotite granodiorite, Spion Kop. (BMR 67570017).
4. Porphyritic biotite granodiorite, 20 km SSW of Yarraden homestead. (BMR 67570015).
5. Hornblende-biotite granodiorite, 16 km SE of Coen. (BMR 67570001).
6. Biotite-hornblende tonalite, 20 km WNW of Coen airstrip. (BMR 68480239).

Aralba Adamellite
7. Biotite-muscovite granite, junction of Oswald Cr. with the King R. (BMR 68480222).
8. Garnet-muscovite-biotite adamellite, 37 km NE of King Junction homestead. (BMR 68480225).

Lankelly Adamellite
9. Porphyritic biotite adamellite, 6 km E of Coen airstrip. (BMR 68480237).

Wigan Adamellite
10. Leucocratc biotite adamellite, 22 km ESE of Wenlock. (BMR 68480201).
11. Biotite adamellite, 20 km ESE of Wenlock. (BMR 68480200).

Analysed by G. H. Berryman (BMR) by X-ray fluorescence method.

The batholith is cut by a number of northwesterly or northerly trending shear zones up to 20 km long, and minor shearing is widespread.

The metamorphics have been thermally metamorphosed, metasomatized, and in places migmatized, by the batholith. The effects are most intense where the batholith cuts across the trend of the metamorphics, such as near the Morehead River, and in the northeast part of the Yambo Inlier, where extensive areas of migmatite and muscovite granite pegmatite and aplite occur near the contact.

Nature of the batholith

The general concordance of the batholith, the presence of foliation, and of pegmatite and aplite at the margins, and the occurrence of migmatite and partly granitized rocks in the surrounding metamorphics, suggest that it was emplaced at a considerable depth in the crust, probably in the lower mesozone of Buddington's classification (1959).

Although the batholith was emplaced at a deep level in a metamorphic terrain, it was not necessarily closely related to, or generated by, the metamorphic event,

TABLE 4. CHEMICAL ANALYSES, CAPE YORK PENINSULA BATHOLITH

	1	2	3	4	5	6	7	8	9	10	11
SiO_2	74.85	71.42	74.70	74.67	70.63	75.17	72.72	74.81	71.71	64.98	71.99
Al_2O_3	14.96	15.26	14.00	15.21	15.01	14.43	14.70	15.54	14.14	16.06	14.11
Fe_2O_3	0.70	2.51	0.13	1.07	2.29	1.34	2.13	1.17	3.87	5.29	2.35
FeO	—	—	1.20	—	—	—	—	—	—	—	—
MgO	0.22	0.80	0.22	0.40	0.77	0.51	0.65	0.37	0.98	1.76	0.73
CaO	0.36	1.60	1.84	0.74	1.99	0.93	1.80	1.48	2.24	3.88	2.01
Na_2O	4.45	2.58	3.85	3.71	2.72	3.14	3.00	3.85	2.78	2.59	2.63
K_2O	4.19	5.70	3.05	5.56	5.54	5.59	5.03	4.04	4.10	4.24	5.52
H_2O+	—	—	0.50	—	—	—	—	—	—	—	—
H_2O-	—	—	0.14	—	—	—	—	—	—	—	—
CO_2	—	—	0.08	—	—	—	—	—	—	—	—
TiO_2	0.02	0.38	0.11	0.01	0.52	0.13	0.33	0.10	0.57	0.82	0.32
P_2O_5	0.24	0.09	0.07	0.08	0.15	0.09	0.14	0.11	0.19	0.23	0.08
MnO	0.16	0.03	0.04	0.15	0.02	0.03	0.05	0.03	0.07	0.09	0.05
Loss on ignition	0.73	0.70	—	0.36	0.79	0.67	0.70	0.64	0.57	0.56	0.57
Total+	100.15	100.37	99.93	101.60	99.64	101.36	100.55	101.50	100.65	99.94	99.79

+Does not include loss on ignition.

Kintore Adamellite

1. Muscovite granite, 27 km SW of Dixie homestead. (BMR 67570026).
2. Porphyritic muscovite-biotite adamellite, 3 km SSW of Yarraden homestead. (BMR 67570013).
3. Biotite-muscovite granodiorite, on Kennedy Road 1.5 km NW of New Bamboo homestead. (BMR D54/12/1).
4. Aplite, at Coleman R. crossing of Musgrave-Glengarland road. (BMR 67570019).
5. Biotite-muscovite adamellite, Leo Cr. mine. (BMR 67570031).
6. Biotite-muscovite adamellite, 40 km N of Coen. (BMR 67570008).
7. Biotite adamellite, 20 km WSW of Buthen Buthen. (BMR 67570007).
8. Biotite-muscovite adamellite, on Kennedy Road near Luttrell hill. (BMR 68480195).

Morris Adamellite

9. Porphyritic biotite adamellite, Kennedy Road crossing of Archer R. (BMR 67570006).

Blue Mountains Adamellite

10. Coarse-grained biotite adamellite, 3 km E of Birthday Mountain trig. (BMR 67570032).
11. Fine-grained biotite adamellite, 5 km S of Birthday Mountain trig. (BMR 67570033).

Analysed by G. H. Berryman (BMR) by X-ray fluorescence method (except analysis 3).

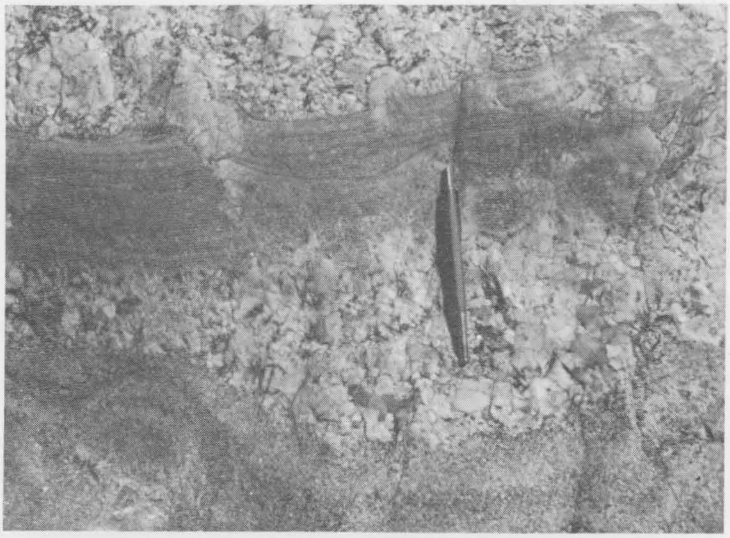

Fig. 12. Bands of aplite and pegmatite in Kintore Adamellite.

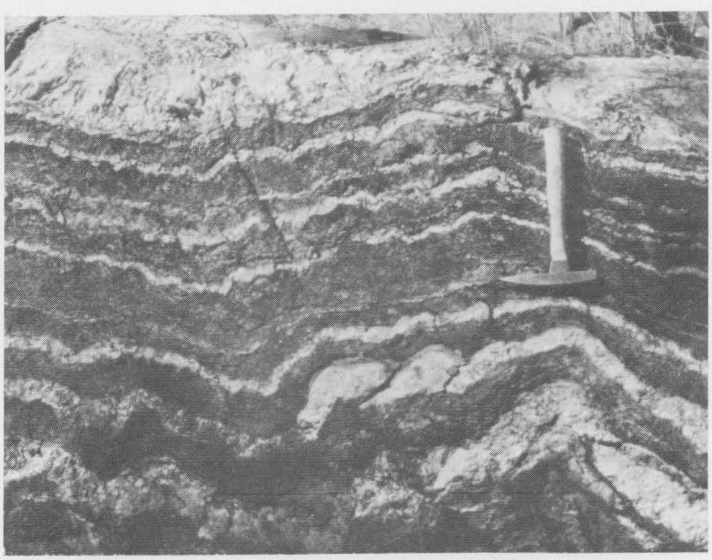

Fig. 13. Hornfelsed Holroyd Metamorphics with pegmatite bands, near contact with Kintore Adamellite.

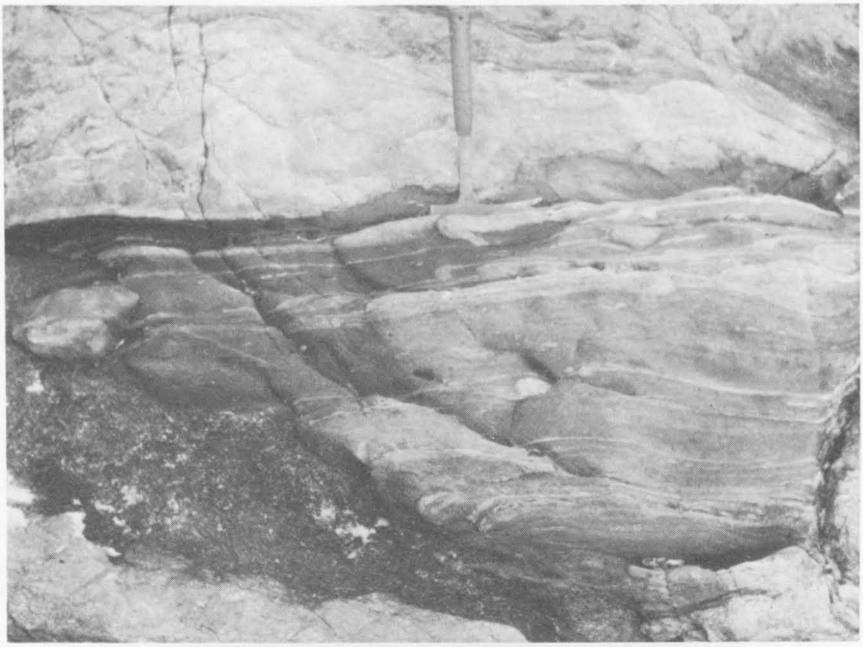

Fig. 14. Contact between foliated Kintore Adamellite and amphibolite of Coen Metamorphics.

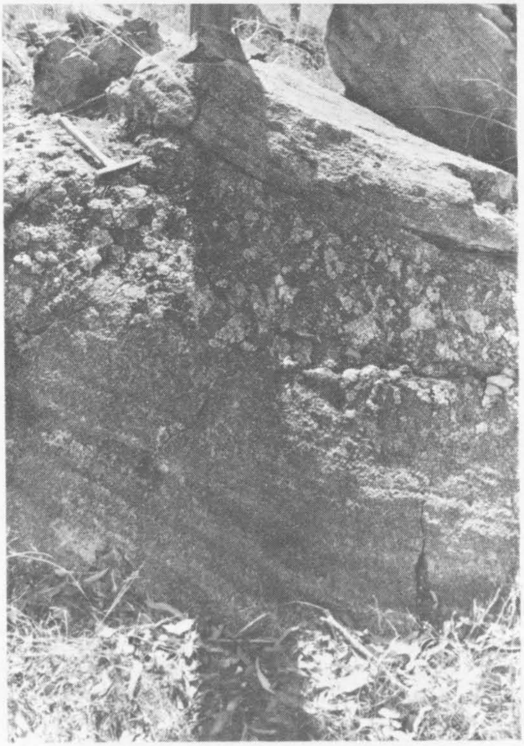

Fig. 15. Banding in Kintore Adamellite.

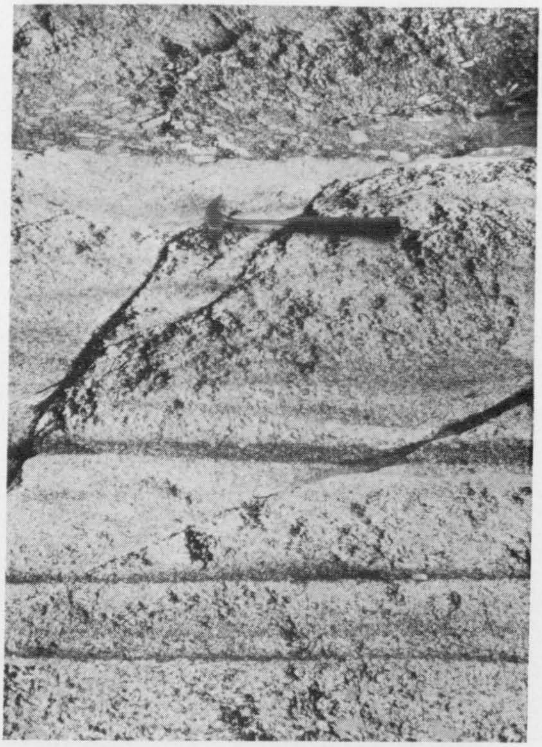

Fig. 16. Banding in Llankelly Adamellite.

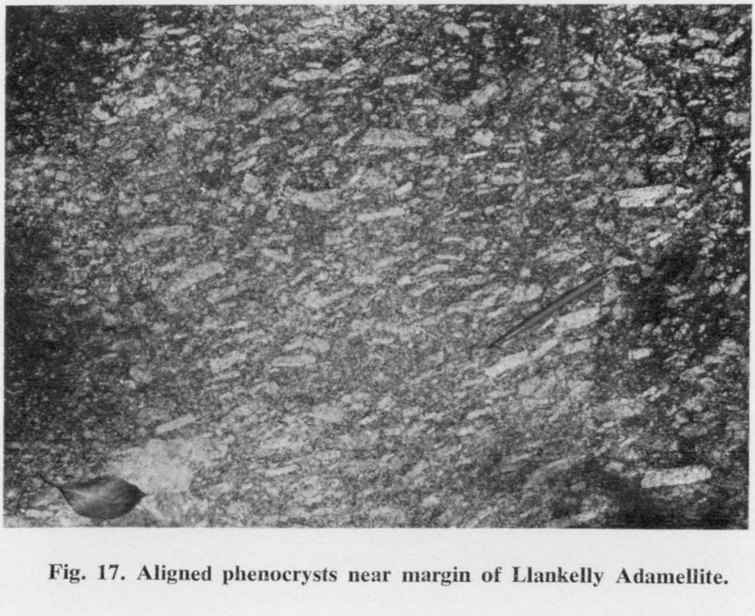

Fig. 17. Aligned phenocrysts near margin of Llankelly Adamellite.

as it indiscriminately intrudes both the low-grade and high-grade metamorphic rocks. This is supported by the results of preliminary isotopic analyses.

Age

The K/Ar ages of the micas from the batholith and surrounding metamorphics indicate an event during the Upper Devonian (Trail et al., 1969), but the preliminary Rb/Sr total rock data, based on regional sampling of the batholith, suggest that it was emplaced during the middle Palaeozoic rather than in the Upper Devonian.

Relationship with other granitic rocks

In an area west of Chillagoe, the Dargalong Metamorphics are associated with muscovite granite, muscovite granite pegmatite, and migmatite (Best, 1962; de Keyser & Wolff, 1964; de Keyser & Lucas, 1968). The smaller bodies of granitic material have gradational contacts and have been included in the surrounding metamorphics. The granites which have sharp contacts with the metamorphics have been equated with the Precambrian Forsayth Granite of the Georgetown Inlier (Best, 1962). The 1040-m.y. age obtained from one body of granite (Richards et al., 1966) is now considered to be doubtful and this granite could be much younger (J. R. Richards, pers. comm.).

These granitic rocks are petrographically and structurally very similar to the Kintore Adamellite of the Yambo Inlier, but as the two areas are separated by 50 km of Mesozoic sediments the relationship is considered to be uncertain.

LOWER CARBONIFEROUS SEDIMENTARY ROCKS

The Lower Carboniferous *Pascoe River Beds* (Whitaker & Willmott, 1969a) crop out in the valleys of the Pascoe River and its tributaries (Fig. 42). They consist of sandstone, arkose, greywacke, siltstone, and shale, with a little coal, conglomerate, and chert (Table 5; Figs 18, 19), which were probably deposited in a small freshwater basin on the metamorphic and granitic rocks. The sequence was folded and faulted before the overlying Janet Ranges Volcanics were extruded.

Provenance and depositional environment

The presence of abundant angular fragments and rare rounded cobbles of rhyolite and devitrified welded tuff in the lithic greywacke and tuffaceous sandstone suggests contemporaneous volcanism. The feldspathic greywacke and arkose contain grains of oligoclase and andesine, and less commonly of microcline, and were probably derived mainly from a granitic or metamorphic terrain. Flakes of muscovite, and more rarely biotite, are also present.

The presence of thin coal seams and carbonaceous siltstone and shale suggests that the Pascoe River beds are non-marine (AAP, 1965).

Structure

The Pascoe River Beds in the middle reaches of the Pascoe River have been folded into broad anticlines and tighter synclines trending north-northwest, and part of the sequence is probably repeated by folding. The beds in Hamilton Creek and Garraway Creek have also been folded, but the trend of the fold axes is

TABLE 5. CARBONIFEROUS AND PERMIAN SEDIMENTARY AND IGNEOUS ROCKS

Age	*Formation* (map symbol)	*Thickness* (m)	*Rock Type*	*Relationship*	*Remarks*
U. Permian	Twin Humps Adamellite (Put)		Hornblende-biotite adamellite, leucocratic biotite adamellite, and granite	Intrudes rocks of batholith	Broadly contemporaneous with Weymouth Granite
Permian?	Wolverton Adamellite (Pw)		Leucocratic biotite adamellite and granite; some microgranite and aplite	Intrudes rocks of batholith; covered by Mesozoic sediments	Contemporaneous with Weymouth Granite?
L. Permian	Weymouth Granite (Plw)		Porphyritic biotite granite and adamellite; some microgranite and leucocratic granite	Intrudes Palaeozoic volcanics, rocks of batholith, and metamorphics	
	(Pld)		Biotite-hornblende diorite, hornblende-biotite tonalite	Within Weymouth Granite	Comagmatic with Weymouth Granite?
L. Carboniferous to L. Permian	(CPn)		Granophyric and hybrid adamellite, granodiorite, and granite	Close association with both Weymouth Granite and Palaeozoic acid volcanics	Possibly comagmatic with Weymouth Granite
	(CPo)		Dolerite	Probably intrudes Palaeozoic volcanics	Possibly related to Weymouth Granite
	Cape Grenville Volcanics (CPc)	300	Bedded breccia and tuff, welded tuff, rhyolite	Overlain by Mesozoic sediments	Contemporaneous with Janet Ranges Volcanics?
	Kangaroo River Volcanics (CPk)	300	Rhyolite welded tuff and breccia, andesite, rhyodacite and dacite welded tuff	Intruded by Weymouth Granite	Contemporaneous with Janet Ranges Volcanics?
	Janet Ranges Volcanics (CPj)	+500	Rhyolite welded tuff, rhyolite, welded pumice-flow breccia	Unconformable on Pascoe R. Beds; intruded by Weymouth Granite	Extensively hornfelsed. Younger than L. Carboniferous, older than L. Permian
	(CPv)	100?	Acid welded tuff, agglomerate; some andesite and metabasalt	Doubtful	Similar to other Palaeozoic volcanics

TABLE 5 (continued)

Age	*Formation* (map symbol)	*Thickness* (m)	*Rock Type*	*Relationship*	*Remarks*
U. Carboniferous	(Cup)		Porphyritic microgranite	Intrudes Torres Strait Volcanics	Contemporaneous with Badu Granite?
	Badu Granite (Cub)		Leucocratic biotite granite, porphyritic biotite granite and adamellite, hornblende-biotite adamellite and granodiorite	Intrudes Torres Strait Volcanics	
	Nychum Volcanics* (Cun)	150	Rhyolite, tuff, welded tuff; subordinate andesite, basalt, and sediments	Unconformable on metamorphics; covered by Mesozoic sediments	
Carboniferous?	Torres Strait Volcanics (Ct)	+300	Acid welded tuff, hornfels	Intruded by Badu Granite	Older than U. Carboniferous
	Muralug Ignimbrite (Cm)	+150	Rhyolite welded tuff, rhyolite, breccia; some dacite welded tuff		
	Goods Island Ignimbrite (Cg)	+80	Dacite and dellenite welded tuff; some sediments		
	Endeavour Strait Ignimbrite (Cn)	+100	Rhyolite welded tuff; some agglomerate, breccia, rhyolite, and andesite		Hornfelsed locally
	Eborac Ignimbrite (Ce)	+100	Rhyolite welded tuff; some rhyolite and agglomerate		
L. Carboniferous	Pascoe River Beds (Clp)	1000	Sandstone, arkose, greywacke, siltstone, shale; some chert, tuff, coal, and conglomerate	Covered unconformably by Janet Ranges Volcanics	Folded and faulted; base unseen

*Now thought to be U. Permian

Fig. 18. Gently dipping carbonaceous siltstone, Pascoe River Beds.

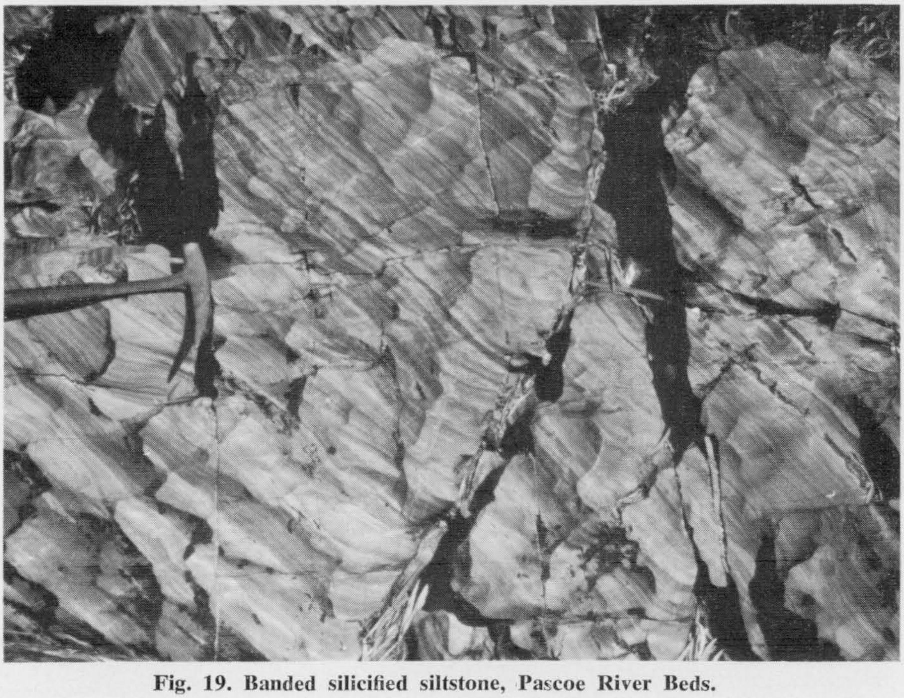

Fig. 19. Banded silicified siltstone, Pascoe River Beds.

irregular, possibly owing to faulting. The folding took place before the eruption of the overlying Janet Ranges Volcanics.

Age

Although the base is not exposed, the Pascoe River Beds, which contain occasional fragments of schist and phyllite, appear to overlie the Precambrian Sefton Metamorphics in the Garraway Creek area.

The fossil plants collected by Morton in Garraway Creek were identified by Dr A. B. Walkom as Carboniferous lepidodendroids and *Cordaites* (Morton, 1924). The plant remains collected by Australian Aquitaine Petroleum were examined by Playford (AAP, 1965). He identified *Lepidodendron* and *Rhacopteris* in two shale horizons overlying thin coal seams in the Pascoe River section and *Rhacopteris* in a thin band of siltstone in Hamilton Creek; the fossil plants in a thin band of siltstone immediately under the Janet Ranges Volcanics in Garraway Creek were found to consist mainly of *Lepidodendron.* These fossils suggest a Lower Carboniferous age. Evans (1966) concluded that the spores in a carbonaceous siltstone from the Pascoe River range from Devonian to Upper Carboniferous in age. The plant remains collected during this survey from Hamilton Creek have been identified by White (1969; also Appendix 2): they include *Stigmaria ficoides* Bgt; the root buttress of *Lepidodendron,* and a species of *Cardiopteris,* which indicate a Lower Carboniferous age.

Relationship with volcanic rocks

In Hamilton Creek and Garraway Creek the steeply dipping Pascoe River Beds are overlain by flat-lying Janet Ranges Volcanics, and the intervening period of folding presumably marks a considerable time-break.

UPPER PALAEOZOIC VOLCANIC ROCKS

During the late Palaeozoic acid volcanic rocks were erupted over an area of about 200 km^2 near Iron Range, at Cape Grenville, and in Torres Strait (Table 5). They are probably an extension of the middle Carboniferous to Lower Permian acid volcanic province in the Georgetown Inlier and Featherbed/Bulgonunna lineament of the Cairns hinterland (Branch, 1966, 1969; Paine, 1969). The province may have extended north of Torres Strait, as rhyodacite and dacite have been encountered in southwest Papua under Mesozoic and younger sediments in the Iamara 1 and Wuroi 1 petroleum exploration wells (Oil Search, 1963, 1965).

In both Cape York Peninsula and the Georgetown Inlier the volcanics were erupted through the Precambrian shield. Cauldron subsidence areas have not been identified in Cape York Peninsula, but they may have been destroyed by later granitic rocks or covered by the sea. The volcanics consist predominantly of acid welded tuff, with some flows of rhyolite and minor intermediate rocks.

In the Georgetown Inlier the volcanics are genetically related to the middle Carboniferous to Lower Permian high-level granitic rocks which intrude them (Branch, 1966). The volcanics near Iron Range and in Torres Strait are also intruded by high-level granites and adamellites: the Upper Carboniferous Badu Granite in Torres Strait is probably related to the volcanics; but the relationship of the Lower Permian Weymouth Granite to the volcanics near Iron Range is uncertain. Recrystallization of the volcanics by the granitic rocks is more wide spread and intense in the Iron Range area and in Torres Strait than in the Georgetown Inlier. In Torres Strait the volcanics have been altered and mineralized, probably as a result of late-stage hydrothermal activity related to the intrusive rocks.

The *Nychum Volcanics* near Mount Mulgrave homestead on the Mitchell River have been described by Morgan (1961), Branch (1966), and de Keyser & Lucas (1968).

The volcanics in the Iron Range region crop out in three separate areas, and were probably erupted from separate centres (Fig. 46). The three sequences have been named the *Janet Ranges Volcanics,* the *Kangaroo River Volcanics,* and the *Cape Grenville Volcanics* (Whitaker & Willmott, 1969a). The small outcrops of volcanic rocks east of Iron Range airstrip and at the 2nd Red Rocky Point have not been named.

In Torres Strait the *Torres Strait Volcanics* (Whitaker & Willmott, 1969b) crop out on numerous islands between Cape York Peninsula and Mabaduan on the coast of Papua. Much of the original area of outcrop is now covered by the sea, and by younger sedimentary rocks in Cape York Peninsula and in Papua. Their great extent suggests that they were erupted from a number of centres, although none has been recognized.

In the southern part of Torres Strait the following four members have been recognized: the Eborac Ignimbrite, Endeavour Strait Ignimbrite, Goods Island Ignimbrite, and Muralug Ignimbrite (Whitaker & Willmott, 1969b). Each member consists mainly of a number of sheets of welded ash-flow tuff of similar composition, but the composition differs from member to member (see Table 7). The term 'ignimbrite' has been adopted on the advice of the Queensland Sub-committee for Stratigraphic Nomenclature.

The upper Palaeozoic volcanic rocks consist of rhyolite welded tuff and rhyolite with subordinate welded pumice-flow breccia, dellenitic, rhyodacitic, and dacitic welded tuffs, andesite, and basalt.

Rhyolite welded tuff predominates in the Iron Range district (Fig. 20) and in the Eborac, Endeavour Strait, and Muralug Ignimbrites in Torres Strait. The Goods Island Ignimbrite and lower units of the Muralug Ignimbrite and Kangaroo River Volcanics consist of dellenitic, rhyodacitic, and dacitic welded tuffs. The welded tuffs in the Iron Range district contain fewer phenocrysts and more pumice and rock fragments than those in Torres Strait (Fig. 21). The tuff sheets are more densely welded than those in Torres Strait and glass shards are less well preserved. In the Iron Range area devitrification is more pronounced and incipient recrystallization is widespread.

Welded pumice-flow breccia and banded spherulitic rhyolitic flows are common in the Janet Ranges Volcanics. Rhyolite is also common in the Cape Grenville Volcanics (Figs 22, 23, 24) and some flows are present in Torres Strait. Andesite flows occur near the base of the Kangaroo River Volcanics.

Age

No isotopic ages have been obtained on the volcanics. The Torres Strait Volcanics are intruded by the Upper Carboniferous Badu Granite, but the granite is believed to be comagmatic with the volcanics.

Fig. 20. Eutaxitic texture in welded tuff, Lloyd Islands. Note numerous streaky lenses of devitrified pumice.

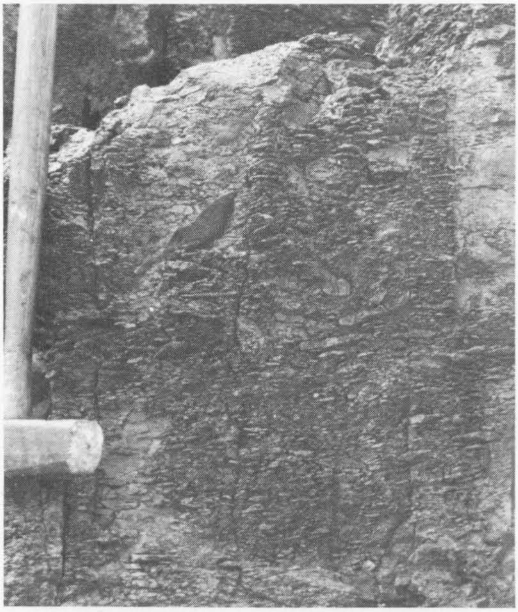

Fig. 21. Collapsed fragments of pumice in welded tuff, Cape Grenville Volcanics.

Fig. 22. Tongue of rhyolite in agglomerate, Cape Grenville Volcanics.

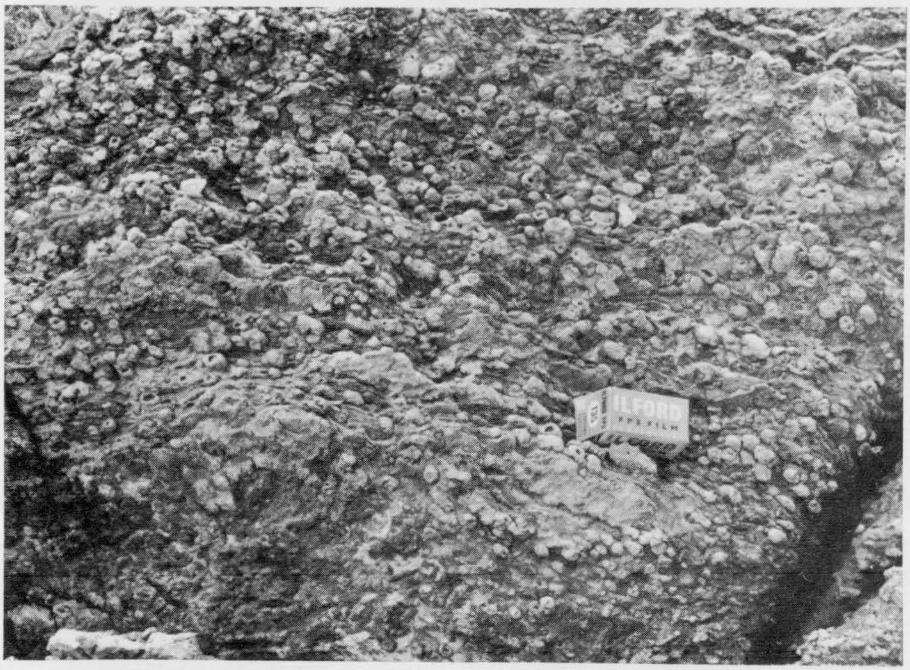

Fig. 23. Spherulitic rhyolite, Cape Grenville Volcanics.

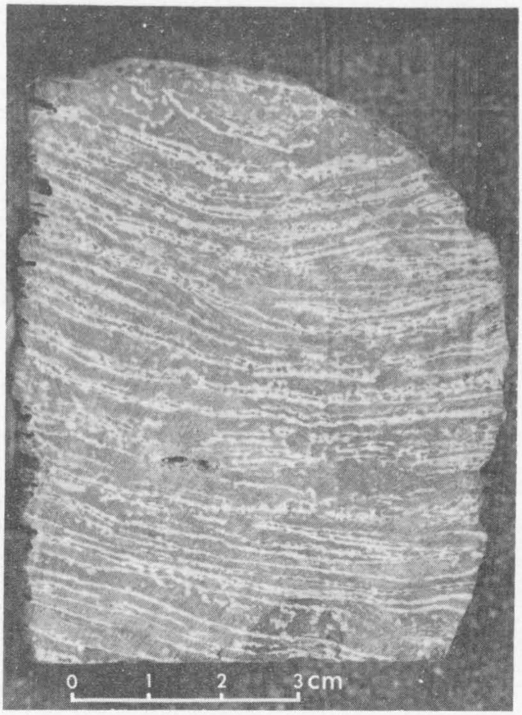

Fig. 24. Flow-banded rhyolite, Cape Grenville Volcanics.

The Janet Ranges Volcanics are younger than the Lower Carboniferous Pascoe River Beds and are intruded by the Lower Permian Weymouth Granite; the other volcanic rocks in the Iron Range district are probably of similar age. If the Weymouth Granite is comagmatic with the volcanics, with which it appears to be closely associated, then the volcanics are considerably younger than those in Torres Strait.

The presence of fragments of acid volcanic rocks in the Pascoe River Beds indicates that volcanism occurred in the Lower Carboniferous or earlier in the Iron Range district, and it is possible that some of the acid volcanics mapped as Lower Carboniferous to Lower Permian are older.

Petrography and chemistry

The rhyolite welded tuffs contain phenocrysts of quartz, alkali feldspar, and plagioclase. Ferromagnesian minerals are rare, but occasional crystals of altered hornblende and biotite may be present. The rocks from Torres Strait contain up to 60 percent phenocrysts compared with 20 percent in the rocks in the Iron Range district. The alkali feldspar in the volcanics from the Iron Range district is probably orthoclase but the feldspar in the Torres Strait Volcanics may be anorthoclase. Plagioclase phenocrysts (probably oligoclase) are common only in the Endeavour Strait Ignimbrite.

The pumice fragments range from large blocks to microscopic shards. The lenticular shape of the larger fragments of collapsed pumice gives some of the rocks a pronounced eutaxitic texture, and in some of the Janet Ranges Volcanics the pumice fragments were compressed into very thin lenses before the rock was welded. Most of the pumice has been devitrified, and now consists of subspherulitic intergrowths of quartz, feldspar, and green amphibole. Some of the welded tuffs have been extensively recrystallized by granitic rocks, but most of the fragments can still be recognized by their coarser texture.

The rock fragments generally consist of devitrified acid rocks with a fine granular texture, welded tuff similar to the host rock, and intermediate rocks. Small aggregates of coarsely intergrown plagioclase and amphibole or chlorite, resembling partly digested fragments of coarse andesite, are present in the Endeavour Strait Ignimbrite.

Although the groundmass is almost invariably devitrified, glass shards can still be recognized in many of the rocks, especially in those from Torres Strait. The degree of compaction of the shards indicates that most of the rocks are moderately or densely welded. The devitrified rocks consist of a microcrystalline intergrowth of quartz and feldspar, with rare green amphibole or chlorite.

In Torres Strait the dellenitic, rhyodacitic, and dacitic welded tuffs are similar in texture to the rhyolite welded tuff in the Endeavour Strait Ignimbrite, but they

TABLE 6. CHEMICAL ANALYSES OF VOLCANICS FROM IRON RANGE DISTRICT

	1	2	3	4	5	6	7	8	9	10	11
SiO_2	74.54	77.99	75.66	76.26	66.56	51.54	53.21	77.01	75.37	74.75	74.83
Al_2O_3	13.06	12.34	12.72	12.44	14.93	18.61	17.01	12.63	12.68	13.18	13.21
Fe_2O_3*	2.41	1.44	1.55	1.99	4.55	10.13	9.39	1.19	2.07	1.66	1.66
MgO	0.17	0.03	0.24	0.09	1.65	3.88	3.85	0.15	0.07	0.36	0.12
CaO	0.79	0.11	0.76	0.59	4.38	9.54	9.63	0.16	0.60	0.98	0.97
Na_2O	2.58	3.03	3.12	2.90	2.79	3.35	4.43	3.52	4.05	3.19	3,33
K_2O	5.55	5.20	5.24	4.99	3.21	0.94	0.76	4.97	4.40	5.32	5.35
TiO_2	0.20	0.10	0.10	0.13	0.89	1.56	1.49	0.16	0.17	0.16	0.15
P_2O_5	0.08	0.03	0.04	0.04	0.17	0.23	0.23	0.05	0.04	0.03	0.05
MnO	0.02	0.02	0.03	0.04	0.06	0.16	0.14	0.01	0.03	0.04	0.04
Loss on ignition	2.55	0.81	0.54	0.70	0.51	2.34	1.57	1.09	0.50	0.59	2.55
Total+	99.40	100.29	99.46	99.47	99.19	99.94	100.14	99.85	99.48	99.67	99.71

*Total iron as Fe_2O_3.
+Does not include loss on ignition.

Janet Ranges Volcanics

1. Recrystallized rhyolite welded tuff, Garraway Cr. 3 km upstream from junction with Brown Cr. (BMR 68480144).
2. Recrystallized rhyolite welded tuff, 5 km W of Garraway hill. (BMR 68480146).
3. Rhyolite welded tuff, 6 km WNW of Garraway hill. (BMR 68480145).
4. Rhyolite welded tuff, 5 km W of Garraway hill. (BMR 68480147).
5. Dacite welded tuff, 11 km W of mouth of Pascoe R. (BMR 67480330).

Kangaroo River Volcanics

6. Altered andesite or basalt, 2 km SW of Baldy Hills. (BMR 67480266).
7. Altered andesite, 5 km WSW of Baldy Hills. (BMR 67480377).

Cape Grenville Volcanics

8. Rhyolite welded tuff, Indian Bay, C. Grenville. (BMR 68480149).
9. Rhyolite welded tuff, northern island of Sir Charles Hardy Is. (BMR 67480315).

Undivided Volcanics

10. Rhyolite welded tuff, Lloyd I. (BMR 68480142).
11. Rhyolite welded tuff, Lloyd I. (BMR 68480143).

Analysed by G. H. Berryman (BMR) by X-ray fluorescence method.

contain about twice as many phenocrysts of plagioclase and ferromagnesian minerals (Table 18). They generally contain fewer fragments of pumice, but more rock fragments; the groundmass has been devitrified to quartz, feldspar, and green amphibole. The dacite and rhyodacite(?) welded tuffs of the Kangaroo River Vclcanics contain far fewer phenocrysts than those in Torres Strait, and are more extensively devitrified; they also contain numerous rock fragments.

The andesite and basalt in the Kangaroo River Volcanics (Table 6) are high-alumina varieties similar to those in the Nychum Volcanics (Morgan, 1961). The andesites are completely devitrified, and most of them are slightly altered. Both the andesites and basalts are composed mainly of a fine-grained mesh of plagioclase laths with a little interstitial greenish brown hornblende. Some of the coarser rocks contain plagioclase laths up to 5 mm long.

The chemical analyses (Table 7) have been used to identify the rock series to which the volcanics belong, and to compare them with the volcanics of the Georgetown Inlier (Branch, 1966). A plot of the solidification index (Kuno, 1959) against silica (Fig. 25) shows that there are insufficient analyses to define a definite trend, but that the volcanics from the Iron Range district and Torres Strait appear to belong to the calc-alkali series. On the FMA diagram (Fig. 26)

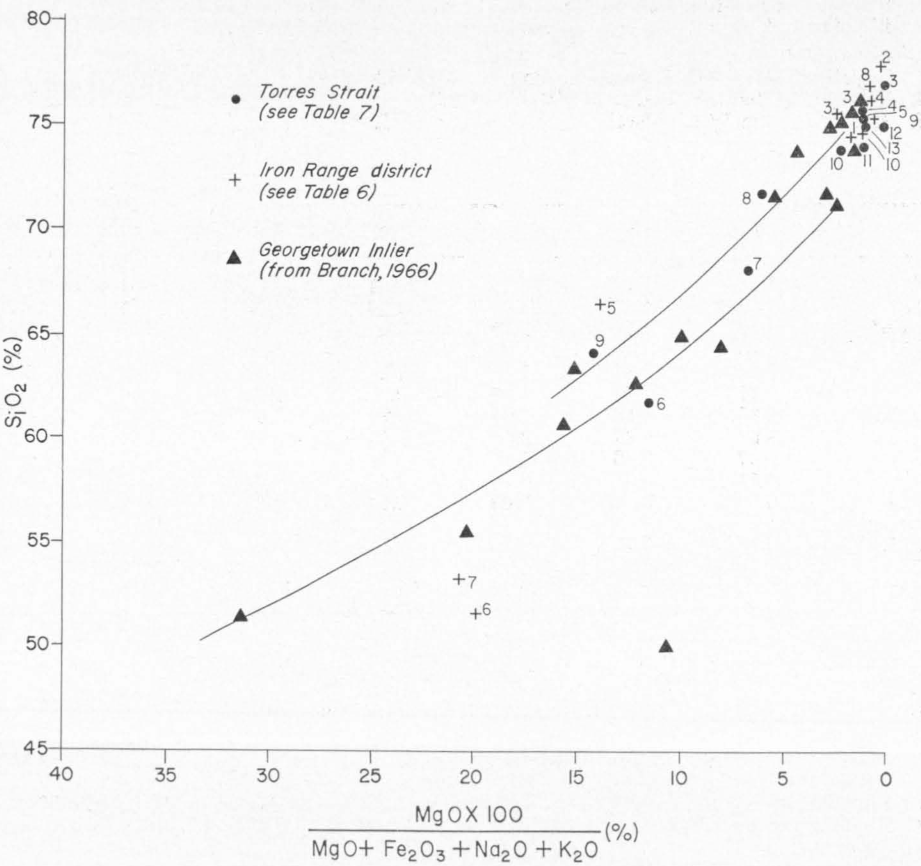

Fig. 25. Solidification index (Kuno, 1950), Palaeozoic acid volcanic rocks.

TABLE 7. CHEMICAL ANALYSES OF TORRES STRAIT VOLCANICS

	1	2	3	4	5	6
SiO_2	74.45	75.74	76.89	76.33	75.55	61.50
Al_2O_3	15.43	12.38	11.95	12.92	13.02	16.50
Fe_2O_3*	0.59	1.86	1.96	1.54	1.86	7.72
FeO	0.38	—	—	—	—	—
MgO	tr	0.46	0.04	0.50	0.12	1.82
CaO	0.44	0.45	0.93	1.16	1.15	4.30
Na_2O	0.97	3.18	2.94	2.83	3.34	3.56
K_2O	5.87	5.11	4.87	4.81	4.76	2.62
TiO_2	0.10	0.17	0.17	0.13	0.16	1.40
P_2O_5	—	0.06	0.05	0.05	0.05	0.29
MnO	—	0.02	0.02	0.05	0.03	0.07
Loss on ignition	2.47	0.71	0.99	0.44	1.39	1.98
Total+	98.23	99.43	99.82	100.32	100.04	99.78

*Total iron as Fe_2O_3 (excluding analysis 1).
+Does not include loss on ignition.

Eborac Ignimbrite

1. 'Quartz porphyry', Eborac I. Analyst, S.A. Tout (Richards & Hedley, 1925; Jones & Jones, 1956).
2. Rhyolite welded tuff, summit Eborac I. (BMR 68480140).
3. Rhyolite welded tuff, Forbes Hd, Mt Adolphus I. (BMR 68480073).

Endeavour Strait Ignimbrite

4. Rhyolite welded tuff, E end Thursday I. (BMR 68480109).
5. Rhyolite welded tuff, Red I. (BMR 68480135).
6. Andesite, 1 km W of Cowal Cr. Settlement. (BMR 68480075).

	7	8	9	10	11	12	13
SiO_2	68.56	71.75	64.13	73.81	73.75	75.03	74.96
Al_2O_3	15.12	14.57	17.02	13.20	11.78	11.71	13.77
Fe_2O_3*	3.32	2.63	5.15	2.63	1.83	1.70	0.99
FeO	—	—	—	—	—	—	—
MgO	0.74	0.57	1.79	0.24	0.11	0.03	0.13
CaO	3.11	2.79	5.09	0.87	0.49	0.60	0.39
Na_2O	3.39	2.68	3.14	2.90	3.05	3.38	4.39
K_2O	3.83	3.95	2.60	5.65	5.20	5.11	5.06
TiO_2	0.37	0.30	0.59	0.24	0.16	0.14	0.19
P_2O_5	0.11	0.09	0.17	0.05	0.04	0.03	0.04
MnO	0.05	0.05	0.08	0.04	0.02	0.02	0.07
Loss on ignition	0.75	0.70	0.78	1.52	0.85	0.48	0.65
Total+	98.60	99.38	99.76	99.63	96.43	97.75	99.99

Goods Island Ignimbrite

7. Rhyodacite welded tuff, 2.5 km W of Heath Pt, Prince of Wales I. (BMR 68480137).
8. Dellenite welded tuff, SW corner Hammond I. (BMR 68480047).
9. Dacite welded tuff, SW corner Hammond I. (BMR 68480046).

Muralug Ignimbrite

10. Rhyolite or dellenite welded tuff, S coast Prince of Wales I., opposite Packe I. (BMR 68480013).
11. Rhyolite or dellenite welded tuff, Northwest Islet, Prince of Wales I. (BMR 68480015).
12. Rhyolite welded tuff, Hochepied Hd, Prince of Wales I. (BMR 68480136).

Undivided Volcanics

13. Rhyolite welded tuff, SW corner Gabba I. (BMR 68480180).

Analysed by G. H. Berryman (BMR) by X-ray fluorescence method (except analysis 1).

the rocks fall between the typical tholeiite trend of Tilley (1950) and the calc-alkaline trend. Branch reports the same result for the Nychum Volcanics and for a volcanic sequence described by Oliver (1961).

UPPER PALAEOZOIC INTRUSIVE ROCKS

The upper Palaeozoic granitic rocks (Table 5) cover an area of over 1700 km^2 in the northern part of Cape York Peninsula; they crop out in Torres Strait, in the Iron Range district, and near Coen. They intrude the acid volcanics (Fig. 27), and have been dated isotopically as Upper Carboniferous to Upper Permian. In the Iron Range district the *Weymouth Granite* consists of a suboval batholith 65 km long, and a number of stocks and smaller offshoots. Small bodies of diorite occur on the margin of the granite and within the granite, and granophyric and hybrid rocks (Fig. 28) crop out as an elongate belt along its western margin. Small bodies of dolerite may also be associated with the granite. Farther south the upper Palaeozoic granitic rocks crop out near Bald Hill (*Wolverton Adamellite*) and near Coen (*Twin Humps Adamellite*). In Torres Strait the granites have been collectively named the *Badu Granite*. The small bodies of porphyritic microgranite and numerous acid and intermediate dykes are considered to be comagmatic with the Badu Granite.

The upper Palaeozoic intrusions are typical of the high-level granites found in association with acid and intermediate volcanics (Joplin, 1964). The suboval intrusions have sharp contacts, and are commonly porphyritic, and in places contain many xenoliths. They generally contain orthoclase rather than microcline. Micrographic intergrowths are common, especially in the hybrid and granophyric rocks marginal to the Weymouth Granite, and in the leucocratic biotite granite phase of the Badu Granite in which small miarolitic cavities are also present. Most of the intrusions are surrounded by extensive aureoles of recrystallized country rock. In the Iron Range district the intrusion of the granites was accompanied by tin, gold, and tungsten mineralization, and in Torres Strait by tin, tungsten, gold, copper, and lead mineralization.

Age

K/Ar dating on biotite indicates an Upper Carboniferous age of 295 ± 5 m.y. for the Badu Granite (Richards & Willmott, 1970), Lower Permian ages of 262 and 273 m.y. for the Weymouth Granite, and an early Upper Permian age of 253 m.y. for the Twin Humps Adamellite (Trail et al., 1969). Harding (1969) has reported an Upper Permian K/Ar age of 236 m.y. for the basement in the Aramia 1 well, in southwest Papua. The granitic rocks are similar in age to the high-level granites and comagmatic middle Carboniferous to Lower Permian volcanics in the Georgetown Inlier (Branch, 1966). The Upper Carboniferous Badu Granite may be comagmatic with the Torres Strait Volcanics, but the relationship between the Lower Permian Weymouth Granite and the volcanics in the Iron Range district is less certain.

The Wolverton Adamellite has many features in common with the Weymouth Granite, to which it is probably closely related, but the early Upper Permian Twin Humps Adamellite apparently represents a distinctly younger event.

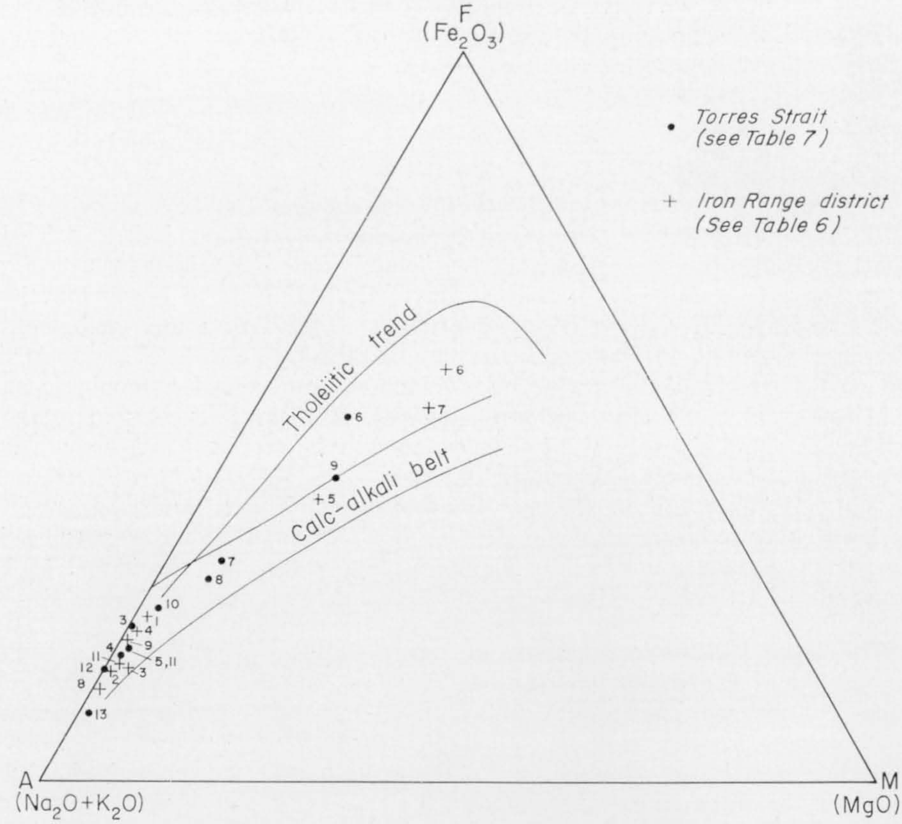

Fig. 26. FMA diagram, Palaeozoic acid volcanics.

MESOZOIC SEDIMENTARY ROCKS

The Precambrian and Palaeozoic basement rocks of Cape York Peninsula and Torres Strait are overlain and surrounded by gently dipping Mesozoic sedimentary rocks of the Laura, Carpentaria, and Papuan Basins. The rocks (Table 8) were not examined in detail, and are shown on the map as undivided Mesozoic rocks. The Laura Basin has been described by de Keyser & Lucas (1968), and the Papuan Basin by the Australasian Petroleum Co. (APC, 1961). Parts of the Carpentaria Basin have been examined by Morton (1924), Woods (1961), Australian Aquitaine Petroleum (AAP, 1965), and de Keyser & Lucas (1968); Meyers (1969) has summarized the available information. The Carpentaria Basin is now being mapped by a combined party from the Bureau of Mineral Resources and Geological Survey of Queensland.

CAINOZOIC SEDIMENTARY ROCKS

The basement rocks of the Peninsula Ridge are partly covered by thin deposits of poorly consolidated continental sandstone (*Lilyvale Beds* and *Yam Creek Beds*) and by residual sand, alluvium, dune sand, and coastal marine sediments (Table 8). The basement and surrounding Mesozoic rocks are capped by ferricrete in places. North and northeast of Torres Strait the basement and Mesozoic rocks

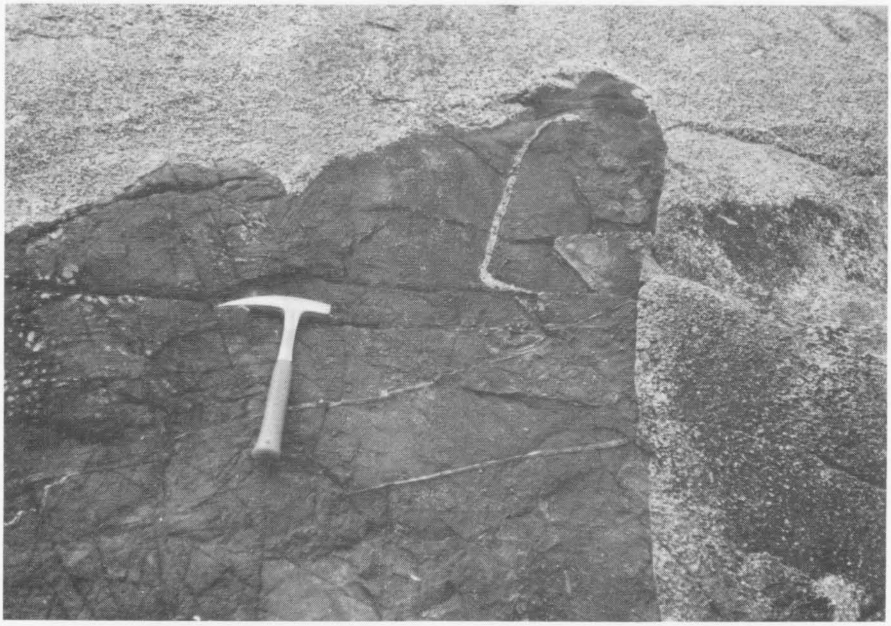

Fig. 27. Contact between Weymouth Granite and hornfelsed Janet Ranges Volcanics.

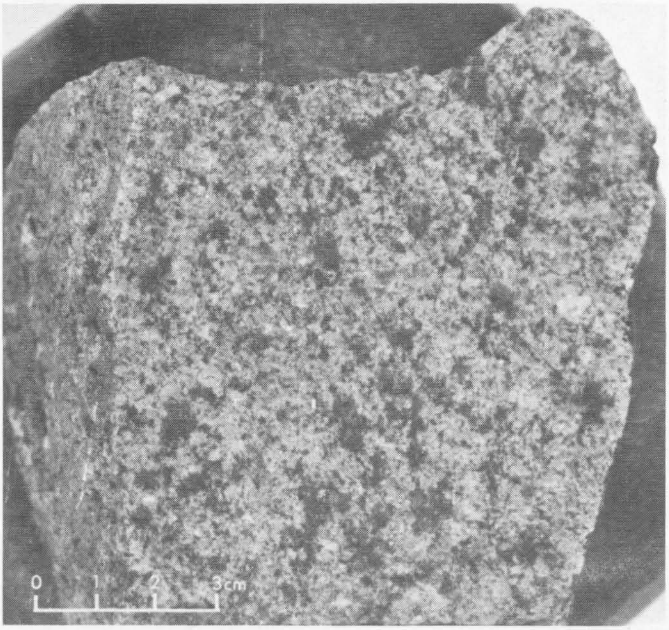

Fig. 28. Clots of ferromagnesian minerals in hybrid adamellite.

TABLE 8. MESOZOIC AND CAINOZOIC SEDIMENTARY AND IGNEOUS ROCKS

Age	*Formation* (map symbol)	*Thickness* (m)	*Rock Type*	*Relationships*	*Remarks*
Pleistocene	Maer Volcanics (Qpm)	+250	Olivine basalt, basaltic tuff	Contains fragments of Cainozoic limestone	Contemporaneous with basic volcanoes of Atherton Tableland and Highlands of New Guinea?
Tertiary to Quaternary	Yam Creek Beds (Cza)	1-60	Poorly consolidated sandstone; some conglomerate	Unconformable on Palaeozoic rocks	Possibly lake deposits along Pascoe R. and tributaries
	Lilyvale Beds (Czy)	1-45	Poorly consolidated sandstone and conglomerate	Unconformable on rocks of batholith	River deposits following Tertiary uplift
	(Czn)		Olivine nephelinite	Plug in metamorphics	Probably contemporaneous with nephelinite at Cooktown
	(T)		Limestone; some mudstone. sandstone, and conglomerate	Unconformable on Palaeozoic volcanics	
Mesozoic	(Mz)	Up to 1500	Sandstone, siltstone, conglomerate	Unconformable on granitic, volcanic, and metamorphic rocks	Lateritized pyritic shale drilled in NE part of Torres Strait

in the Papuan Basin are overlain by a considerable thickness of Tertiary and Quaternary sediments. The numerous coral reefs in Torres Strait are part of the Great Barrier Reef on the edge of the continental shelf.

The Cainozoic sediments were not examined in detail. The sediments of the Papuan Basin north and northeast of Torres Strait have been described by the Australasian Petroleum Co. Pty Ltd (APC, 1961), Stach (1964), Gulf International Overseas Ltd (Gulf, 1965), Tenneco Australia Inc. (Tenneco, 1967), Thompson (1967), Rickwood (1968), Phillips Australian Oil Co. (Phillips, 1968), and Oppel (1969).

CAINOZOIC IGNEOUS ROCKS

Olivine nephelinite

A small plug of olivine nephelinite crops out 17 km inland from the western shores of Princess Charlotte Bay. It is similar in composition to the Cainozoic ultra-alkaline lavas near Cooktown (Morgan, 1968b).

Maer Volcanics

The Pleistocene Maer Volcanics (Whitaker & Willmott, 1969b) comprise the basic lavas and tuffs forming the Murray, Darnley, and Stephens Islands, the Black Rocks, and a small exposure at Bramble Cay in the northeastern part of Torres Strait (Figs 29, 30, 31); the calcareous tuff and tuffaceous sediments forming Daru Island in Papua are also included (Table 8). The older volcanoes forming Darnley

Fig. 29. Bedded tuff overlain by basalt, Darnley Island.

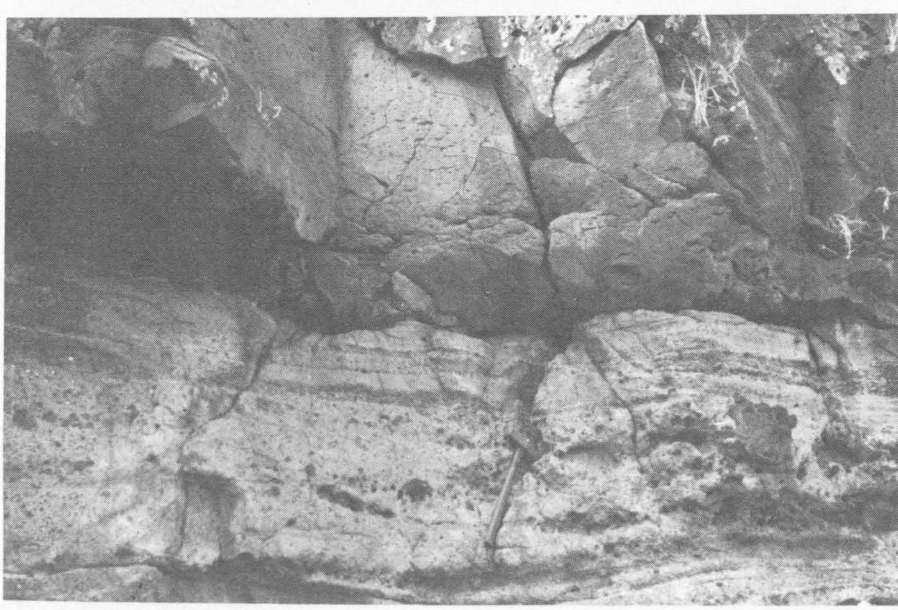

Fig. 30. Contact between basalt and tuff, Treacherous Bay, Darnley Island.

Fig. 31. Bedded tuff deformed by volcanic bomb, Treacherous Bay, Darnley Island.

Fig. 32. Fragments of white limestone in scour in bedded tuff, Treacherous Bay, Darnley Island.

and Stephens Islands, Bramble Cay, and the Black Rocks have been deeply eroded, and it is believed that the well preserved cones in the Murray Islands are considerably younger.

The eruptions at each centre appear to have started with the subaqueous emission of volcanic ash, followed by basalt flows when the vents were closed off from the sea. The presence of cross-beds and scours in the tuffs on Darnley Island (Fig. 32) suggests that they were deposited in the sea. If the tuffs represent the southern half of an ash cone, as suggested by Jardine (1928b), and the basalt was extruded on its flanks, the cone was about 8 km across and 200 m high. The three ash cones of the Murray Islands were built up high above sea level, and the scours and ill defined cross-beds in the tuff on Gelam hill on Maer Island were probably formed by the scouring action of rain water. The original form and size of the volcanoes on Stephens Island, Bramble Cay, and the Black Rocks is uncertain, but there was probably only a small cone at Bramble Cay.

The limestone fragments in the tuffs from the Murray Islands, Darnley Island (Fig. 32), and Daru are of Pleistocene or Holocene age (D. J. Belford, pers. comm.). The tuffaceous sediments on Daru overlie beds similar to the Pliocene or Pleistocene sequence described by the Australasian Petroleum Co. Pty Ltd (APC, 1961) at Oriomo on the Papuan mainland. The volcanoes have probably not been active in the Holocene, as even in the relatively young Murray Islands the cone of Maer has been dissected by three small creeks, and a thin layer of soil has been formed on the tuff and basalt flows; an extensive fringing coral reef has also grown since the formation of the island. The cones of Dauar and Waier Islands (Figs 33, 34) are less subdued than that of Maer Island and may represent the latest phase of activity, but they also are dissected, covered with vegetation, and surrounded by fringing coral reefs. The volcanoes are therefore considered to be Pleistocene.

The Maer Volcanics may be of the same age as many of the large basic and intermediate Quaternary volcanoes extending from the central Highlands of New Guinea to the Biwau Hills, 200 km north of Daru (APC, 1961).

STRUCTURE

The igneous and metamorphic rocks of Cape York Peninsula and Torres Strait form two northerly trending ridges, the Peninsula Ridge and its southern extension, the Yambo Inlier, which runs north from the Mitchell River to enter the sea at Temple Bay, and the Cape York/Oriomo Ridge, which extends across Torres Strait (Fig. 5). In the Peninsula Ridge and Yambo Inlier, the major faults, the foliation and fold axes in the metamorphic rocks, and the contacts of the batholith all have a northerly trend (Fig. 35). Both ridges are flanked to the east and west by sedimentary basins, which are also elongated in a northerly direction; one of them is partly the result of subsidence along the east side of the Palmerville Fault. The two ridges appear to be separated by a trough trending north-northeast across the northern part of Cape York Peninsula (the Peninsula Trough).

The main structure in the Precambrian metamorphic rocks is the steeply dipping northerly trending foliation, which is probably parallel to the axial planes of the tight isoclinal folds. The foliation is also parallel to the banding in the metamorphic rocks, which probably represents the original bedding. Large isoclinal folds with north-trending axial planes, which are clearly visible on the air-photographs, flank the Coleman River about 50 km west of Musgrave homestead. Three northerly

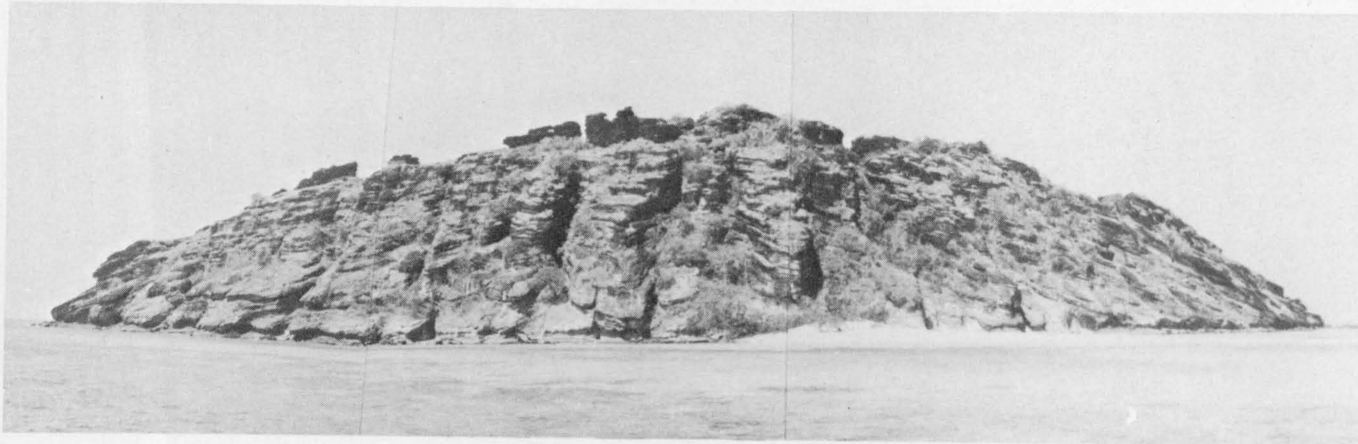

Fig. 33. Truncated ash cone, Waier Island, showing radial dip.

Fig. 34. Interior of truncated cone, Waier Island. Note slumping of ash beds into extinct crater.

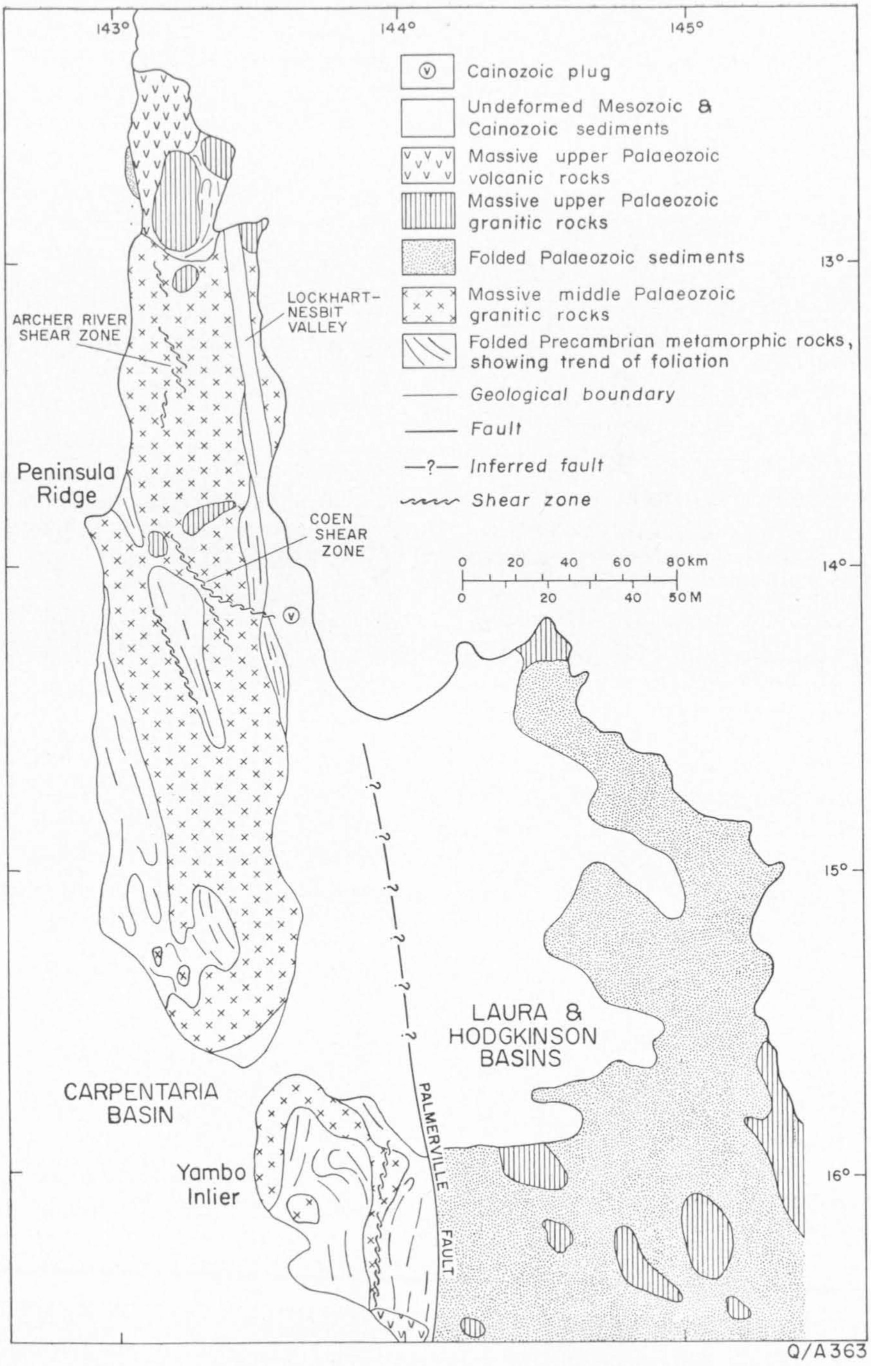

Fig. 35. Structural elements of Peninsula Ridge and Yambo Inlier.

plunging folds, which appear to be overturned to the west, are delineated by bands of quartzite and greenstone up to 1000 m across. The faults associated with the overturned folds may be east-dipping thrust faults. Folds of this type are also visible on the air-photographs of the area between the Lukin and Holroyd Rivers, about 40 km north of the Coleman River, but they are not so well defined. Small-scale isoclinal folds are common in the banded hematite-quartz schist in the Iron Range area, and traces of large-scale isoclinal folds can be seen on the air-photographs of the area near Black Hill, about 20 km north of Iron Range airstrip.

In a number of places the trend of the foliation is north to north-northwest, as in the Holroyd Metamorphics, or north-northeast, as in the eastern part of the Yambo Inlier. In the northern part of the Yambo Inlier, the foliation outlines a large synform on the limbs of which the foliation dips at less than 40° and strikes northeast. The Mount Carter Block also consists of a broad north-plunging synform in which the foliation swings from southeast to east and northeast. Both these structures are complemented by upwarps occupied by granite, which were probably formed during the emplacement of the middle Palaeozoic granites.

The broad folds in the Holroyd Metamorphics southeast of the Potallah Creek gold mine, 60 km southwest of Musgrave homestead, appear to have been generated by the forcible intrusion of stocks of adamellite, and the sharp diversion in the trend of the foliation in the northern part of the Yambo Inlier may also be the result of granitic intrusion.

The tight minor folds with the steeply plunging axes in the Dargalong Metamorphics adjacent to the Palmerville Fault are more clearly delineated in the Chillagoe Formation on the east side of the fault. W.B. Dallwitz (pers. comm.) has suggested that they indicate transcurrent movement on the fault.

The Carboniferous Pascoe River Beds in the Peninsula Ridge are deformed into broad anticlines and tighter synclines with axes trending north-northwest.

The foliation and shear zones in the middle Palaeozoic Cape York Peninsula Batholith, and its contacts, are generally parallel to the predominant northerly strike of the foliation in the Precambrian metamorphic rocks. Most of the shear zones are confined to the batholith, but as they are generally parallel to the foliation their presence in the less competent metamorphic rocks may be much less obvious.

The shear zones in the granitic rocks extend across the Yambo Inlier, and in both the granitic and gneissic rocks from Ebagoola to Coen; they are particularly numerous in the Lankelly Adamellite, where they may have resulted in the preferred alignment of feldspar phenocrysts. The Coen Shear Zone separating the Lankelly Adamellite from the Coen Metamorphics may continue northwards under alluvium to connect with the Archer River Shear Zone.

Right-lateral transcurrent movement along the Archer River Shear Zone can be inferred from the relative positions of the Kintore Adamellite and Holroyd Metamorphics near Geikie Creek, and a similar movement along the Coen Shear Zone is indicated by the disposition of two bodies of schist on either side of the zone southeast of Coen. The gold mineralization at Coen and to the southeast appears to be located along the Coen Shear Zone.

The parallelism of the phenocrysts in the Lankelly Adamellite and the presence of foliation parallel to the shearing in the Kintore Adamellite suggest that shearing began before the rocks had completely crystallized and continued after consolidation of the rocks.

Relatively few faults have been mapped on Cape York Peninsula, probably because they are difficult to detect when parallel to the foliation in the metamorphic rocks.

The Palmerville Fault is a fundamental structure (de Keyser, 1963) which separates the geosynclinal sediments of the Hodgkinson Basin from the metamorphic rocks of the Yambo Inlier. The presence of pebbles of metamorphic rocks in the sediments in the Hodgkinson Basin suggests that the fault formed the western limit of the basin in Silurian time. It was again active in the Permian, when coal was laid down in a small basin within the fault zone. Movement continued into the Lower Cretaceous, and probably into the Tertiary. The fault was one of the main structures controlling the development of the Mesozoic Laura Basin, which is strongly asymmetrical in cross-section and is deepest close to the fault (de Keyser & Lucas, 1968).

Cross-faults diverge from the Palmerville Fault at various angles, and parallel faults are associated with it; Amos (1968) has discussed the faulting in relation to the Palaeozoic sediments of the Hodgkinson Basin.

The northerly extension of the Palmerville Fault is believed to be roughly coincident with the east coast of the peninsula (de Keyser, 1963) and may be represented in the fault that formed the Lockhart-Nesbit Valley. There are two faults that are not related to the Palmerville Fault, one north of the Palmer River in the Yambo Inlier, and the other cutting the synform of schist forming Mount Carter.

The folds in the Carboniferous Pascoe River Beds do not appear to continue into the overlying Janet Ranges Volcanics. There is a broad north-northeasterly trending syncline in the Kangaroo River Volcanics south of Temple Bay, and another broad fold may be present in the volcanics at Cape Grenville.

The Weymouth Granite forms an oval intrusion with steeply dipping contacts surrounded by selvedges of hybrid rocks, volcanics, and older granitic rocks. The smaller bodies of diorite are subcircular and are presumably plug-like in form. No evidence of ring-fracturing or cauldron subsidence has been found in the overlying acid volcanics.

Few faults have been mapped in Torres Strait, although most of the steep dips in the volcanic rocks are probably the result of faulting rather than folding. The faults separating the Muralug Ignimbrite from the Endeavour Strait Ignimbrite may represent part of the boundary of a cauldron subsidence area that is mostly concealed by the sea.

The faults mapped in the Mesozoic and Cainozoic rocks generally trend north; geologists of Australian Aquitaine Petroleum Pty Ltd (AAP, 1965) consider that easterly trending faults are important in the Cape Weymouth Sheet area, but none were observed during this survey.

The difference of a few hundred metres in the level of the base of the Mesozoic sequence between Bald Hill and Temple Bay is probably due to irregularities in the floor of the basin. The irregularities in the pre-Mesozoic surface in the vicinity of the McIlwraith Range, however, are probably the result of faulting. The scarps along the western margin of the Laura Basin, north of the Morehead River, may also be due to relatively recent movement on northerly trending faults.

The alignment of the major centres of Cainozoic volcanism in Torres Strait, and the apparent increase in age to the northwest, suggest that the volcanism was related to a deep-seated lineament.

The presence of coarse Cainozoic sediments in parts of the Laura and Carpentaria Basins and in the Archer River Piedmont Basin suggests that the source areas were elevated after the consolidation of the Cretaceous marine sediments, and the presence of gravel resting unconformably on the marine Cretaceous in the Laura Basin (Lucas & de Keyser, 1965a) indicates rapid uplift. This movement has continued intermittently to the present day, and has given rise to the coarse unconsolidated sediments overlying the Lilyvale Beds.

ECONOMIC GEOLOGY

Gold, the most important mineral produced in Cape York Peninsula and Torres Strait, was discovered in the Palmer River in 1872, and later at Coen (1876), in Torres Strait (1894), near Wenlock (1892), at Ebagoola (1900), and finally in the Claudie River in 1933. Cassiterite and wolfram have also been mined, and traces of antimony, arsenic, lead, zinc, copper, and molybdenum have been recorded. The deposits of iron and manganese at Iron Range have been examined in some detail. Minor occurrences of mica, coal, limestone, and heavy-mineral beach sands have been noted, and silica sand occurs in coastal dunes. The search for petroleum in the sedimentary basins has so far been unsuccessful. The water resources of the region have not yet been systematically explored.

Much of the information on the mines and prospects has been obtained from the Queensland Government Mining Journal and the Annual Reports of the Queensland Department of Mines. The production figures were also obtained from the Annual Reports of the Department of Mines.

Controls of Mineralization

The iron and manganese deposits in the Iron Range area occur in regionally metamorphosed iron-rich sediments, which form relatively thin bands in the steeply dipping Sefton Metamorphics.

Most of the gold is associated with quartz lodes and acid dykes related to the granitic rocks of Cape York Peninsula Batholith (Fig. 36). Gold and traces of stibnite, arsenopyrite, pyrite, and galena are the only mineralization associated with these granites, A little tin, tungsten, gold, molybdenum, lead, and copper occur in association with the upper Palaeozoic plutonic rocks. The discontinuous mineralized zone of hydrothermally altered volcanic and intrusive rocks in the southern part of Torres Strait was probably formed immediately after the intrusion of the Upper Carboniferous Badu Granite and porphyritic microgranite. Cassiterite, pyrite, and chalcopyrite occur at Cape York; gold, galena, chalcopyrite, sphalerite, and pyrite on Horn and Possession Islands; and traces of copper minerals on other islands (Fig. 38).

Metals

Gold

Most of the gold was produced before World War I. Both alluvial and lode gold have been mined. Although some of the reefs were rich, most were small and few sustained mining operations for long. Most of the reefs occur in the granitic rocks or adjacent country rocks, but a few are associated with shear zones. Excluding the Palmer Gold and Mineral Field, the recorded production is about 6843 kg of gold. The gold and mineral fields are described in order from south to north; the fields and main mining centres in Cape York Peninsula are shown in Figure 36.

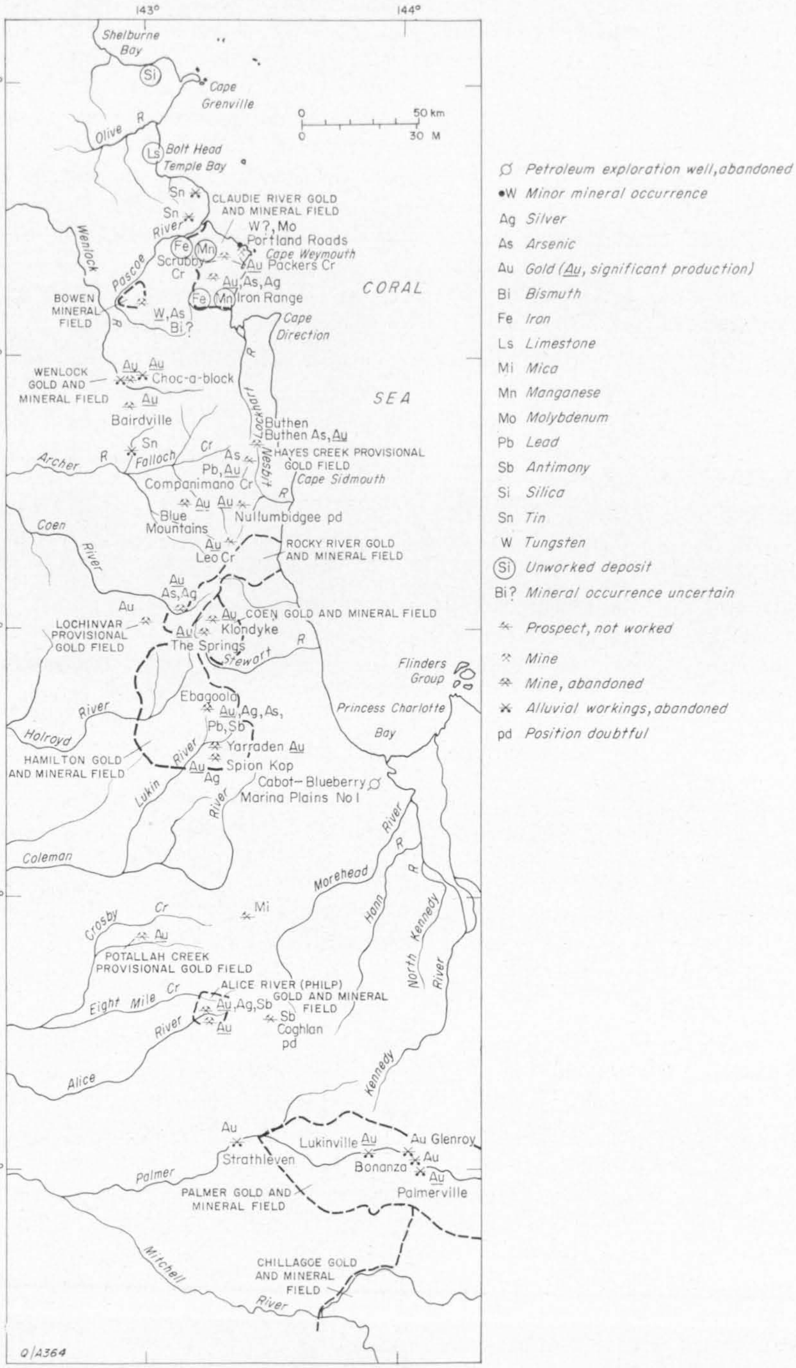

Fig. 36. Mines, mineral fields, and mineral occurrences in Cape York Peninsula.

In the *Palmer Gold and Mineral Field* alluvial gold was first reported from the Palmer River below Palmerville in 1872 (Hann, 1873a,b). The gold-bearing sands in the river and its tributaries were reported to be payable by Mulligan in 1873 and the rush to the field began soon afterwards (Jack, 1922; Holthouse, 1967). The alluvial gold was virtually exhausted by the end of the decade. A recorded production of 41 488.74 kg is given in Amos & de Keyser (1964), but the true figure was probably about twice as much. Some reef mining was carried out east of the Palmerville Fault (Amos & de Keyser, 1964; de Keyser & Lucas, 1968), but none is recorded to the west of the fault. Between 1926 and 1936 dredging at Strathleven, Glenroy, and Bonanza west of Palmerville (Jensen, 1940b; Amos & de Keyser, 1964) produced 105.75 kg of gold, but operations ceased when the recovery grade fell to 4.8 g per m^3. The gold in the Palmer River was probably derived from mineralized reefs in the Hodgkinson Formation.

Alice River (or Philp) Gold and Mineral Field. Gold was discovered in the upper reaches of the Alice River in 1903 by the prospector Dickie (1903, 1905). From 1904 to 1909 mining was virtually confined to the Alice Queen and Peninsula King reefs, and since 1917 the field has received little attention. The total recorded production from 1903 to 1917 is 93.3 kg of gold from about 2800 tonnes of ore, together with 14 kg of alluvial gold. Between 1904 and 1909 the Alice Queen reef produced about 37 kg of gold from 1570 tonnes of ore, and the Peninsula King reef about 31.1 kg of gold from 632 tonnes of ore.

The two reefs lie within 1.5 km of each other on a north-northwesterly line. The Alice Queen mine in the north is in a vertical quartz reef between 1 and 2 m wide and over 100 m long (Cameron, 1906). Of the two shafts, the southerly was 34 m deep in 1906. The quartz from the mullock dump contains small grains of pyrite and stibnite. Felsite dykes trending south-southeast cut the altered Kintore Adamellite to the west of the workings. The Peninsula King reef is 0.5 to 1 m wide. In 1906 several shallow shafts had been sunk along the line of the reef.

In the *Potallah Creek Provisional Gold Field* only one reef, the Perserverance, has been recorded. It is situated in fine-grained schist of the Holroyd Metamorphics about 1 km west of a stock of Kintore Adamellite. According to Cameron (1906) the reef trends north and is 75 cm wide at a depth of 12 m. The only recorded production is 18.26 kg of gold from 593 tonnes of ore in 1903-04. A shaft was sunk at Potallah Creek in 1946; the reef at a depth of 33 m is reported to have been 2 m wide with a grade of 15.6 g of gold per tonne.

Jensen (1964) records a small number of gold occurrences in the Potallah Creek area. Production of 0.16 kg of gold is recorded from Olain Creek in 1914 (probably O'Lane Creek, 13 km north-northwest of the Potallah Creek shaft).

Hamilton Gold and Mineral Field. A small rush followed the discovery of gold by Dickie at Ebagoola early in 1900 (Dickie, 1900; Ball, 1901). Gold was found farther south near the Lukin River in the following year. Peak production was reached in the first year when about 470 kg of gold, 342 kg from alluvials, was recorded. Mining virtually ceased during World War I and has been sporadic since. Total production from 1900 to 1951 was 2291.58 kg, made up of 1371.63 kg of reef gold from 34 196 tonnes of ore, 682.41 kg of alluvial gold, and 237.54 kg from the treatment of 19 256 tonnes of tailings.

Mining at Ebagoola was centred about the old townsite (Fig. 37). The Yarraden mining area, about 15 km south-southeast of Ebagoola, extends for 8 km from the Lukin River southwards to Spion Kop; it does not include Yarraden

Fig. 37. Abandoned battery at Ebagoola.

homestead. Gold occurs principally in numerous quartz reefs. Ball (1901) reported that the reefs in the Ebagoola area trend roughly north along the contact between the 'older' granite (Kintore Adamellite), which he considered to be metamorphosed, and the schist and gneiss to the east (Coen Metamorphics). He believed that the reefs were related to the 'newer' granite (Flyspeck Granodiorite); in the Yarraden area the reefs occur within the Flyspeck Granodiorite. In the Ebagoola area quartz occurs as leaders, veins, or compound reefs. The leaders are up to 15 cm wide and occur mainly in shrinkage cracks in the granite. Although they are of limited length or depth, and are seldom rich in gold, most of the alluvial deposits were probably derived from them. True fissure reefs, such as the Caledonia and All Nations reefs, occupy shears along the contact between the metamorphic and granitic rocks. The compound fissure veins are associated with acid dykes, or with beds of quartzite, such as the May Queen reef.

The water-table is generally at a depth of less than 20 m in the dry season, and consequently sulphides such as pyrite, arsenopyrite, galena, and stibnite are found almost at the surface. Mining was generally not profitable at grades below 47 g of gold per tonne.

The most productive workings in the Ebagoola area were the Caledonia, Hamilton King, May Queen, Hit or Miss, Violet, Hidden Treasure, All Nations, and Golden Treasure (Table 9).

In the Yarraden area the two most important reefs were the Golden King and Savannah. According to Cameron (1906) the Golden King reef trends roughly north, dips vertically, and ranges from 15 to 40 cm wide; it was worked over a length in excess of 300 m to a maximum depth of 65 m. Mining was almost continuous between 1901 and 1915, and was resumed in 1917 and 1921. Recorded production is 239.84 kg of gold from 7699 tonnes of ore. The Savannah reef lies

TABLE 9. GOLD PRODUCTION AT EBAGOOLA, 1902-12*
(From Ann. Rep., Dep. Mines, Queensland)

Reef	*Ore* (tonnes)	*Gold* (kg)
Caledonia	3438	102.40
*Hamilton King	2230	113.90
May Queen	2054	80.68
Hit or Miss	1089	67.09
Hidden Treasure	1538	47.71
All Nations	502	38.01
Golden Treasure	1000	35.61
Violet	782	49.64

*Minor production in 1930s included.

about 500 m east of the Golden King and dips steeply west. It is more than 30 m long with a steep southerly plunge. Mining was carried out to a depth of at least 38 m. Between 1901 and 1907 and in 1912 a total of 2761 tonnes of ore yielded 156.51 kg of gold. Attempts to reopen the mine in 1939-40 were unsuccessful.

Other reefs of importance in the Yarraden area were; the Lukin King with a total production between 1901 and 1926 of 63.73 kg of gold from 1631 tonnes of ore, the Gold Mount which yielded 2.99 kg of gold from 781 tonnes of ore between 1901 and 1921, and the Hiaki (or Haikai) which produced 39.22 kg of gold from 1622 tonnes of ore between 1909 and 1918.

Alluvial mining was mainly restricted to the Ebagoola area (Ball, 1901) and most of the production was before 1910. The gold was coarse, and was derived mainly from eluvial deposits shed from nearby reefs and leaders.

The *Coen Gold and Mineral Field* was proclaimed over an area of 95 km^2 in 1892 and enlarged to 480 km^2 in 1898 (Ball, 1901). Alluvial gold was discovered at Coen in 1876 (Jack, 1922), and in 1878 there was a small rush from the Palmer River, but few miners stayed more than two weeks and the workings were abandoned in the same year. In 1880 Chinese miners attempted to work the alluvium without success.

In 1885 land was taken up for mining silver, and machinery was erected in 1886, but productive reef mining did not start until 1892. Between 1893 and 1899, 16 689 tonnes of ore crushed at Coen yielded 888.1 kg of gold. Ball (1901) visited the field in 1900 and recorded mining activity at Coen town, at The Springs 15 km to the southeast, and at Klondyke 13 km northeast of The Springs. According to Ball the reefs are from several centimetres to 1.5 m thick, and generally trend northwest to north, with a steep dip. Most of them are fissure veins composed of quartz, but a few consist of siliceous slate; some of the poorer reefs contain pyrite or arsenopyrite.

The most successful mine was the Great Northern, about 1 km southeast of Coen township; it has produced about three-quarters of the gold won from the field. Other productive reefs near Coen, which were mined mainly before 1900, were the Daisy, Hanging Rock, Homeward Bound, Lankelly, Long Tunnel, Trafalgar, and Wilson reefs. Between 1894 and 1899 the Great Northern mine yielded 230.85 kg of gold with a high silver content from 4394 tonnes of ore (Ball, 1901). In 1900 activity at Coen came almost to a standstill when the Hamilton goldfield was opened, but gold continued to be won at Coen for many years, mainly from the Great Northern and from the treatment of tailings with cyanide.

The total recorded production of reef gold at Coen from 1892 to 1916 was about 2333 kg, of which 2172.86 kg came from the Great Northern mine, including 412.4 kg from the treatment of 20 000 tonnes of tailings and mullock. The total amount of ore recorded between 1892 and 1916 was 28 985 tonnes, of which 26 234 tonnes came from the Great Northern mine. After 1910 production fell off rapidly, and in 1914 only 7 tonnes of ore was mined.

The Great Northern mine was reported to have been worked to a depth of 150 m, but little work was done at that depth. The north end of the No. 4 level, somewhere below 54 m, was reported in 1909 to be 78 m from the shaft. The reefs in the lower levels ranged in width from 75 cm to 1.2 m. After 1909 production came from small rich leaders in the hangingwall and footwall above the No. 3 level, possibly at 54 m. Little is known of the mine after 1914, but attempts were made to reopen it as late as 1949 (Jones, 1949).

Mining was carried out at The Springs, 15 km southeast of Coen, from the early 1890s to about 1901. The main reefs were the Westralia, where 455 tonnes of ore were crushed for 19.56 kg of gold in 1901, the Goolha Goolha, the Rothwell, and the Sirdar, where 207 tonnes of ore produced 13.41 kg of gold between 1898 and 1901 (Ball, 1901). This part of the Coen field was abandoned during the rush to the Hamilton goldfield in 1900 and 1901.

At the Klondyke, 13 km northeast of The Springs, the Springfield reef yielded about 40 kg of gold from 366 tonnes of ore between 1898 and 1902. The Klondyke lodes trend roughly north and occur in schist and gneiss of the Coen Metamorphics near their contact with the Lankelly Adamellite.

The workings at Coen and The Springs lie within or adjacent to the Coen Shear Zone. The zone extends for about 27 km southeast of Coen and lies largely within the Lankelly Adamellite and along its southwest margin. The schistose sheared adamellite contains a little pyrite and arsenopyrite. Quartz reefs are common along the shear zones, and in the south they are up to 5 km long and 100 m wide. Most of the mullock dump at the Great Northern mine, which lies in the shear zone, consists of a breccia composed of fragments of silicified granite set in a matrix of white quartz; the country rock is sheared Lankelly Adamellite. The quartz and gold were probably deposited from hydrothermal fluids introduced after the rocks were sheared.

In the *Blue Mountains,* 40 km north of Coen, which are not included in the Coen Gold and Mineral Field, gold was mined from some time before 1934 until 1951. The gold occurs in narrow quartz veins in granite (Banks, 1947). The total recorded production in 1935, 1938-46, and 1948-51 is 33.53 kg of gold from 950 tonnes of ore; of this 17.5 kg from 593 tonnes came from mines operated by Blue Mountains Gold N.L., principally the Golden Ladder and the Convict. One of the other major producers was the Yarraman mine. Beck (1935) and Jolly (1946) have reported on the area. No mines were operating in 1967.

A small number of leases have been held in recent years in the *Leo Creek* area, 30 km northeast of Coen, but no production is recorded. In the Nullumbidgee area a few kilometres to the north 3.5 tonnes of ore yielded 0.40 kg of gold.

The small *Lochinvar Provisional Goldfield* on Tadpole Creek, about 18 km southwest of Coen, is situated in Kintore Adamellite. The only recorded production is 2.2 kg of gold from 50 tonnes of ore in 1904.

Rocky River Gold and Mineral Field. Alluvial gold was discovered in the Rocky River, 32 km northeast of Coen, in 1893 by Lakeland (Jack, 1922). Reef mining began on Neville Creek (location unknown) in 1896 and the field was proclaimed in 1897. Between 1896 and 1901, 951 tonnes of ore yielded 142.64 kg of gold. Interest waned in 1901 following the discovery of the Hamilton goldfield, but it revived for a short time in 1910 and 1911 when 57 tonnes of ore yielded 8.77 kg of gold. Jack (1922) notes that only four people lived on the field in 1914, and there were no returns that year. No mines were located in 1967.

Hayes Creek Provisional Gold Field. Jack recorded traces of gold in Hayes Creek, 60 km northeast of Coen, during his 1880 expedition, and the area was later visited by Dickie and Campbell during a prospecting journey to Lloyd Bay in 1907 (Jack, 1922). Shepherd (1938) records that the Hayes Creek field was discovered in 1909, but this probably refers to the start of reef mining on the Golden Gate claim.

Production has been small and spasmodic. In 1909 production from the Golden Gate claim was 37 tonnes of ore which yielded 6.81 kg of gold and a further 1.71 kg on cyanidation. In 1911 production from the field was 3.18 kg of gold from 21 tonnes of ore. Production in 1914 was 1.14 kg of reef gold and 0.37 kg of alluvial gold. The field was deserted in 1915. Some prospecting continued until 1938, and between 1938 and 1942 some 150 tonnes of ore were crushed for a yield of about 6 kg of gold. In the early 1950s small parcels of ore are reported to have yielded between 80 and 120 g of gold to the tonne (Jones, 1951b), and one 4-tonne crushing returned 0.2 kg of 850-fine gold.

Shepherd (1938) noted four sets of workings at the main centre at Buthen Buthen. At the Theodore lease a quartz reef between 30 and 35 cm wide was exposed for 65 m, with a strike of 140° and dip of 47° to the southwest; the reef contained a little pyrite and arsenopyrite. The 20-cm reef on the Diana Lease contained pyrite and a little free gold; on the Campbell and Buthen Buthen leases Shepherd saw only shallow trenches and small shafts. At Companimano Creek, 6 km south-southwest of Buthen Buthen, a quartz reef 90 cm to 1.2 m wide contained gold, galena, pyrite, and arsenopyrite. The reefs in the Hayes Creek field are situated in a northerly trending shear zone in Kintore Adamellite; the valleys of the Lockhart and Nesbit Rivers follow this zone.

In 1964 the valley of the Nesbit River between Buthen Buthen and Kampanjinbano (Companimano?) Creek was investigated as an alluvial gold prospect (Gibson, 1964), and an almost enclosed basin on Leo Creek, 8 km southwest of its junction with the Nesbit River, was also tested, but little gold was found.

Wenlock Gold and Mineral Field. Gold was discovered in 1892 at Retreat Creek, a tributary of the Batavia (Wenlock) River and later at the site of Bairdville (Morton, 1924, 1930). Further prospecting, mainly between 1905 and 1911, disclosed several small alluvial deposits at Downs Gully, Choc-a-block Creek, and other nearby sites. The amount of gold produced up to 1910 has been estimated at 93 kg.

In 1910 an aboriginal prospector named Pluto located a large lead at the base of the Mesozoic sediments overlying the Kintore Adamellite; the locality became known as Plutoville and was rushed by miners from Coen and Ebagoola (Jack, 1922; Morton, 1930). According to Fisher (1966) the early workings covered an area of about 350 m^2, and consisted of shallow alluvium and small reefs, which were worked to a maximum depth of 5 m. Morton (1930) mentions a shallow lead of cemented wash with rich gutters at the workings. Total recorded production from Plutoville is estimated at 190 kg of gold (Fisher, 1966).

The Main Leader about 5 km northeast of Plutoville was discovered in 1922. It consists of a narrow quartz reef with payable gold for over 300 m along strike. The discovery became known as Lower Camp and later as Wenlock. Fisher (1966) describes the Main Leader as a northwesterly trending fissure reef, with a few cymoid loops, which dips at 60° to the south in the north and 35° in the south. In the south it is cut by the Main Reef, a quartz reef over 6 m wide. The average width of the Main Leader is 20 cm, and its walls are slickensided. It contains free gold to a depth of at least 100 m, or about 30 m below the water-table. Connah (1951) states that the Main Leader is composed of quartz with a distinctive white and blue banding, and ranges in thickness from 2 to 45 cm. Short rich shoots with a northerly pitch are common, and coarse particles of gold are evenly distributed in the reef, with a few rich local concentrations. Fisher (1966) estimated the average grade at about 50 g of gold per tonne.

The Main Leader occurs in Kintore Adamellite and is overlain by Mesozoic sediments and alluvium. The deep leads at the base of the Mesozoic sediments on the west side of the Main Leader also contain gold. Connah (1951) found that the main deep lead was a narrow rich gutter which spread out into a wide drainage channel trending west-southwest. He has suggested that the extension of the channel beyond the workings is downthrown by a fault trending southeast. This may be the continuation of a post-Cretaceous southeasterly trending fault, downthrown to the west, which was mapped in 1967, 13 km southeast of Wenlock. Total production from Lower Camp is estimated at 1089 kg (Fisher, 1966). Morton (1924, 1930, 1932) and Shepherd (1941) have described the mining operations at Wenlock.

The Wenlock field was deserted during World War II. The claims along the Main Leader were amalgamated in 1946, but operations ceased again in 1952, partly as a result of flooding in 1950. Prospectors have continued to be active around the field, and in 1964-65 it is reported that 87.09 kg of gold were obtained from 2 tonnes of picked specimen stone.

According to Hadley (1934) and Beck (1935) gold was first produced from the *Claudie River Gold and Mineral Field* in 1933; the field was proclaimed in 1936. The gold was mined at Iron Range, Scrubby Creek, and Packers Creek (Fig. 39). Shepherd (1939) gives the total production from 1935 to June 1938 as 173.31 kg of gold from 6104 tonnes of ore and 1067 tonnes of tailings. Iron Range produced 134.21 kg from 3753 tonnes of ore, Scrubby Creek 33.65 kg from 1984 tonnes of ore and 1067 tonnes of tailings, and Packers Creek 5.44 kg from 376 tonnes. The largest reef, Gordons 'Iron Range', yielded 108.4 kg of gold from 2568 tonnes of ore. The average yield from the rest of the field was 16.2 g per tonne. The field closed in 1942 for the duration of the war. A little mining was carried out after 1945, and between 1950 and 1953 the Cape York Development Co. attempted without success to develop a few of the mines at Iron Range. Total recorded production from the field between 1934 and 1942 is 333.12 kg of gold from 17 100 tonnes of ore and 3221 tonnes of tailings. Production since the War has been small, but a little gold is still obtained from a mine at Packers Creek.

At Iron Range the gold occurs in quartz veins and lodes in schist of the Sefton Metamorphics, while at Scrubby Creek and Packers Creek the gold-bearing lodes and veins are in the Weymouth Granite. The deposits have been described by Broadhurst & Rayner (1937) and Shepherd (1939). At Iron Range, the deposits are large but low grade in the iron-bearing schist, but small and rich in the adjacent iron-free schist (e.g. the Iron Range reef); the reefs occur along fault lines in the schists. Southeast of Iron Range some of the reefs are parallel to the schistosity and others have components both along and across the schistosity; short ore shoots occur where the reefs intersect. North of Iron Range the lodes, such as the Peninsula Hope and Northern Queen, are composed of crushed sericite schist with quartz stringers. Broadhurst & Rayner (1937) suggest that in the primary zone the ore shoots will prove to be lenses of silicified schist impregnated with sulphides, chiefly arsenopyrite.

Rayner (1937) noted the discovery of a wide body of sulphide ore on the Peninsula Hope lease at Iron Range, and a CSIRO (1953) report on the treatment of arsenical gold ore from the Peninsula Hope mine gives the head assay of the ore as 18.2 g of gold, 1.8 g of silver, 4.4 percent arsenic, 20.7 percent iron, 9.79 percent sulphur, and less than 0.05 percent copper. The sulphides are arsenopyrite and pyrite, with some altered pyrrhotite and traces of chalcopyrite, sphalerite, and gold.

The gold and sulphide minerals at Iron Range may have been introduced by the Kintore Adamellite, as elsewhere in Cape York Peninsula, or by the Weymouth Granite.

Gold was discovered in the *Possession Island Gold and Mineral Field* in Torres Strait (Fig. 38) in 1896, and production began in 1897; Jackson (1902) described the mines he visited in 1901. All the workings are near the northwest coast, east and northeast of the monument to Captain Cook. Mining was carried on until 1906 when the leases were abandoned. Attempts were made to reopen the workings in 1919, and again in 1934-35, but without success.

Recorded production between 1897 and 1905 is 155.42 kg of gold from 7245 tonnes of ore, including some returns for the Horn Island Gold and Mineral Field. Four tonnes of ore yielded 0.09 kg of gold in 1919.

Jackson (1902) noted that the main workings were located on two almost vertical reefs about 230 m apart, which trend south-southeast. The reefs consist of quartz veins, up to several centimetres thick, in a matrix of fractured and altered welded tuff; the veins contain a small quantity of sulphide minerals. Jackson also noted several shafts and small cuts, and records that a sample of ore, composed of vein quartz with galena and pyrite, assayed 57.95 g of gold and 33.9 g of silver to the tonne.

Copper-staining associated with limonite has been noted in the chloritized and silicified welded tuff northeast and southwest of the abandoned workings. Northeast of the workings some galena and pyrite have been observed in joints.

Alluvial gold was discovered in the eastern part of Horn Island in 1894 and the *Horn Island Gold and Mineral Field* was proclaimed the same year. Reef mining began in 1895 or 1896 in an area of about 0.5 km^2, 1 km inland from the east coast.

The mines are situated in altered and silicified porphyritic microgranite to the south of a stretch of sandy alluvium. The history of the mines has been described by Rands (1896) and Jackson (1902). Recorded production is 31.07 kg of alluvial gold between 1894 and 1896, and 176.67 kg of gold from 16 904 tonnes of ore between 1896 and 1900. The recovery of gold declined sharply in 1900, and by 1901 the field was almost deserted.

Most of the reefs are steeply dipping and trend east-southeast or southeast. They consist of closely spaced quartz veins in altered microgranite. Sulphide minerals were found in many of the reefs only 3 m below the surface. Pyrite and galena are the most common sulphides, but some of the reefs also contain sphalerite, and two contain chalcopyrite (Rands, 1896). The average yield decreased from 30

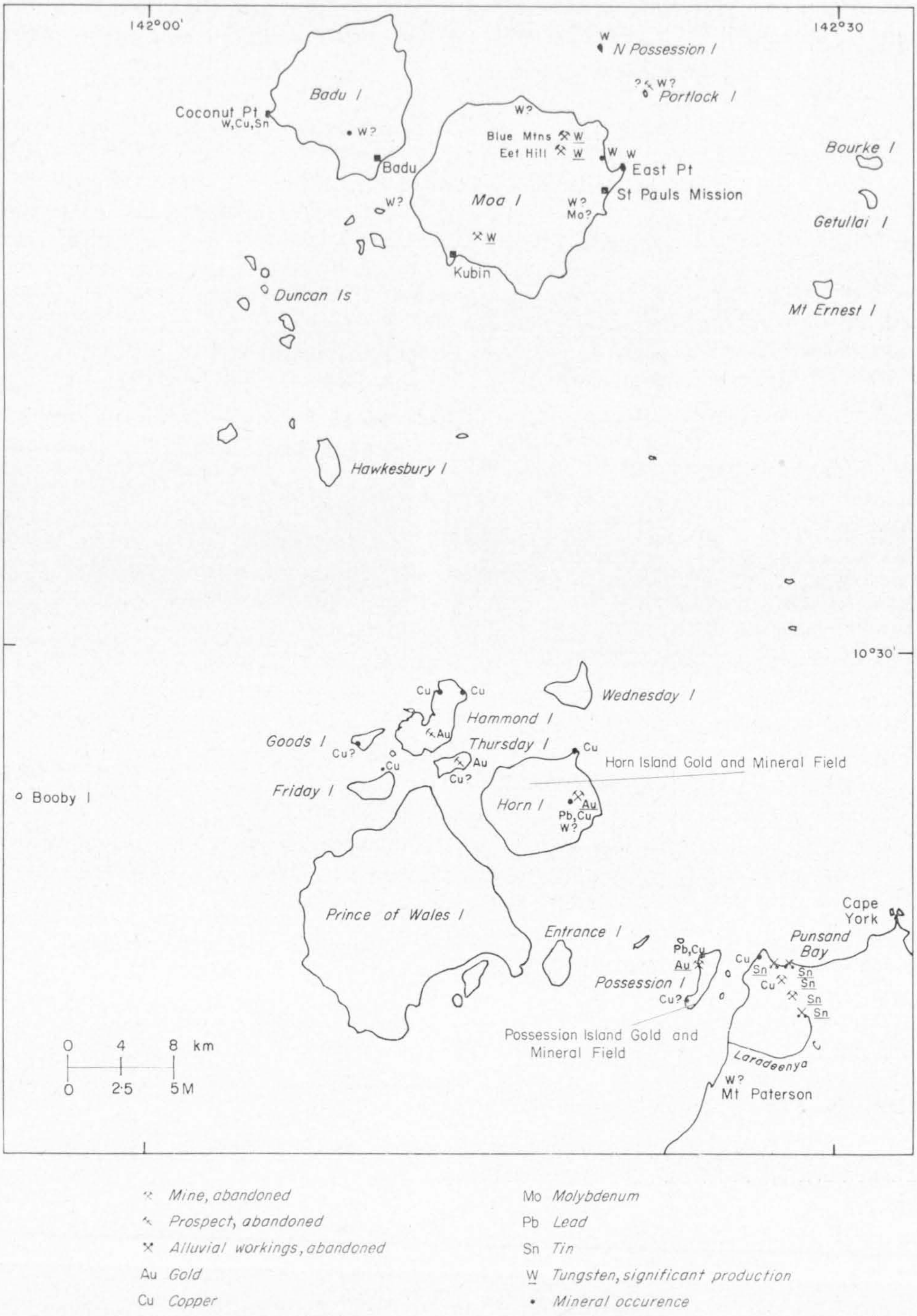

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Fig. 38. Mines, mineral fields, and mineral occurrences in Torres Strait.

g per tonne in 1896 to 20 g per tonne in 1900. Sporadic production continued on a small scale until 1919, and prospecting went on at intervals until 1966.

Australian Selection Pty Ltd drilled three holes to depths of about 75 m in 1963, but did not consider the prospect payable; an ore concentrate assayed in 1961 yielded 750 g of gold and 440 g of silver per tonne. In 1965 overburden was removed and 120 m^3 of alluvium were taken for sampling, but the results are not known. A visit to the mines in 1968 revealed a large open cut, probably on the Welcome reef, about 100 m long by 50 m across, and a smaller open cut, in the vicinity of the Dead Cat claim, with a timbered shaft 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 pit the microgranite is less altered and contains fewer quartz veins; the sulphide minerals occur in small veins. Pyrite and galena are common, and chalcopyrite and a little wolfram(?) were also observed.

Elsewhere, minor amounts of gold are reported to have been won on Hammond Island between 1907 and 1909, and possibly until 1919, and on Thursday Island in the 1930s.

Tin

Most of the cassiterite has come from alluvial deposits in four localities, but total production is less than 200 tonnes of concentrate. All the deposits were probably derived from the upper Palaeozoic granitic rocks.

Alluvial cassiterite has been mined in three localities between Coen and Temple Bay: Granite or Tin Creek near the Archer River, and Tin Creek and Stony Point to the north of the lower reaches of the Pascoe River. Alluvial cassiterite and cassiterite-bearing lodes occur about 8 km southwest of Cape York.

About 118 tonnes of tin concentrate were produced around Granite Creek (Cherry, 1907b) between 1907 and 1931, with a further 1.5 tonnes in 1938-40. The extent of the area mined is not known, but according to the local people at least some of the cassiterite was won from the area indicated in Figure 36, where small amounts can still be obtained after the wet season.

The small alluvial deposits at Tin Creek and Stony Point were found to be uneconomic by the Broken Hill Pty Co. Ltd (BHP, 1962). About 12 tonnes of concentrate were produced between 1900 and 1928 with a further 2 tonnes in 1938-40. The cassiterite was probably derived from Permian alkali granite and associated tourmaline-bearing pegmatite veins. The Broken Hill Pty Co. Ltd sampled the soil and shallow alluvium around the granite to the north of the Pascoe River, but tin was found only near the known occurrences.

Tin veins and alluvial cassiterite were found near Cape York in 1948. The tin mineralization occurs at the southeastern end of a zone of altered and mineralized Torres Strait Volcanics. It appears to be confined to an area of about 10 km^2, between the site of the old Cape York Post Office and Peak Point, and for about 3 km to the south into the hills behind the coast.

Cassiterite has been won from the alluvial sands and beach sands between these hills and Punsand Bay, and to the south in the upper reaches of Laradeenya Creek and its tributaries. Most of the 12 to 14 tonnes of tin concentrate produced between 1952 and 1962 came from small rich pockets in the sands at the head of the beach in Punsand Bay, and 10 to 12 tonnes of concentrate were obtained from a number of lodes, principally in 1952-56 from Hollands Reef 3 km south of the beach.

According to Robertson (1959) Hollands Reef consists of 5 to 12 cm of silicified porphyry or welded tuff with visible tin, and 2 to 50 cm of mineralized quartz, most of which contains no tin. The reef strikes about 10° and dips west at 10° to 45°. Fleischman (1953) states that the tin occurs in shoots. In 1968 it was found that the silicified welded tuff at the workings 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 3 cm by 1 cm. Some chalcopyrite(?) is also present in the lenses. Carpco Australia Pty Ltd (Carpco, 1958) investigated the ore from Hollands reef and concluded that it was not difficult to treat. Other lode deposits—the Booty, Northern mine or Mulhollands, and Bluff Quarry—are described by Robertson (1959), Fleischman (1953), Willmott et al. (1969), and Taylor (1969).

Both the alluvial and lode deposits have been tested by various companies and individuals since 1949, and almost all have made discouraging reports. Surveys have been made of the Laradeenya Creek area by Mount Isa Mines Ltd (Carter & Porter, 1952), and by Mineral Deposits Pty Ltd (McKeague, 1957), and of the alluvial deposits bordering Punsand Bay by Mineral Deposits Pty Ltd, Cape York Tin Pty Ltd (Wilson, 1961), the Broken Hill Pty Co. Ltd (Rowell, 1962), Tennent (1964), Webb & Fitzpatrick (1965), and New Consolidated Goldfields (A/asia) Pty Ltd (Hughes, 1962). However, in 1969, Consolidated Mining Industries Ltd were testing the alluvial deposits with promising results.

No tin has previously been reported from any of the islands of Torres Strait, but a sample collected in 1968 from a mineralized porphyritic microgranite dyke at Coconut Point on Badu Island was found to contain over 1 percent metallic tin.

Tungsten

Wolfram occurs in the Bowden Mineral Field 30 km west of Iron Range, and on Moa Island in Torres Strait. About 70 tonnes of concentrate was produced in the Bowden field and 84 tonnes on Moa Island, principally during World War II and the Korean War. Minor occurrences of wolfram are also known in the Coen/Iron Range region, and in Torres Strait.

Wolfram was discovered in the Bowden Mineral Field in 1892 (Cherry, 1907b; Morton, 1924), but claims were not taken up until 1904. The field was proclaimed in 1907, when there was an influx of miners following a rise in the price of wolfram. Production of wolfram concentrate is recorded as 71 tonnes in the period 1905 to 1916. Very little work has been done since World War I, though 178 kg were produced in 1952.

Morton (1924) noted that the wolfram occurs in quartz lodes in a strip 2.5 km long by 1.5 km wide in disturbed mica schist (Sefton Metamorphics), close to the contact of the (Weymouth) granite. The lodes are up to about 2 m wide and are generally concordant with the strike and dip of the schists, although a few of them occupy almost vertical fissures in the schists. The wolfram is commonly concentrated in bunches in the quartz, and in places is accompanied by tourmaline, arsenopyrite, pyrite, and according to Cherry (1907b), bismuth. In one claim the wolfram is disseminated in the lode.

A small deposit of wolfram and molybdenite occurs about 10 km east of Coen. The wolfram occurs in a vein 22 cm thick, as bunches in quartz, and as layers with molybdenite on the sides (Ball, 1901). Recorded production is 2.5 tonnes in 1904, 2.6 tonnes in 1916-18, and 0.7 tonnes in 1952.

A small reef is reported to have been worked for wolfram on Rocky Island near Portland Roads (Cherry, 1907b), but in 1967 the quartz debris near the shaft was found to contain only small specks of molybdenite. Wolfram has also been reported north of the mouth of the Pascoe River (Cherry, 1907b; Dickie, 1909).

Except for the locality near Coen, the wolfram mineralization occurs within or close to the Weymouth Granite. Although the occurrence near Coen apparently lies within the Lankelly Adamellite, it may be genetically related to the Twin Humps Adamellite to the west and north.

In Torres Strait wolfram has been mined since 1938 at three localities on Moa Island: Blue Mountains, Eet Hill, and near Kubin village (Shepherd, 1944). The wolfram occurs in quartz lodes in the Badu Granite or hornfelsed Torres Strait Volcanics.

At Eet Hill, about 8 km northwest of St Pauls Mission, the lode consists of white quartz, from 2 to 3 m wide (Shepherd, 1944). The lode trends east-southeast, and is exposed horizontally for 300 m along strike and vertically for 30 m in the side of the hill. Fleischman (1953) considers that the reef consists of two or more quartz reefs within a dyke, 6 to 8 m wide, which cuts the granite, and that shoots of wolfram also occur in the dyke. Anderson (1944) observed that most of the lode was barren, with patches containing 6 to 20 percent wolfram. He estimates that the concentrates produced to the end of 1943 were 'of approximately 66 percent WO_3 grade', and Jones (1951a) estimated that the content of picked ore mined from Eet Hill was about 1 percent wolfram concentrate, containing 70 percent tungstic oxide. According to Anderson there is a second lode, the Gerheim, parallel to the Eet Hill lode and some distance to the south.

The workings at Blue Mountains, north of Eet Hill, are about 2 km from the north coast of Moa Island. The lode consists of ironstained white quartz which cuts granite and is chloritized at its margins (Shepherd, 1944). It is vertical, 2m thick, and trends at 70°. Shepherd reported small isolated crystals of wolfram in the quartz, but was told that 400 kg of wolfram had been taken from a small cut 60 cm deep.

The workings about 2 km northeast of Kubin village are about 1 km from the coast. They are located on four or five parallel quartz lodes trending north and dipping at 20° to 30° east; they are generally 25 to 50 cm wide, but one is 1.5 m across (Shepherd, 1944). The lodes occur in welded tuff near the contact with fine grey granite. Hematite is abundant in the northeastern part of the workings, and during Shepherd's visit rich bunches of wolfram were exposed in four pits. In 1968 about 10 shallow pits were observed along a northerly line about 50 m long. There are one or more quartz veins, which are generally several centimetres thick, but range up to 1 m in places, cutting sheared and recrystallized welded tuff. Wolfram was seen in a few pits, in lenses up to 5 cm by 1 cm.

Wolfram has been found at several other places on Moa Island and on adjacent islands: near St Pauls Mission (Shepherd, 1944; Jones, 1951a; Fleischman, 1953), near the north point of Moa Island (Jones, 1951a), in the southeastern part of Badu Island (Shepherd, 1944), on a small island 3 km south of Badu Island (Anderson, 1944), at Coconut Point on Badu Island, where it occurs in quartz in a microgranite dyke together with tin (Willmott et al., 1969), and on North Possession Island, 12 km north of St Pauls Mission (Willmott et al., 1969). Twenty-seven kilograms of wolfram are reported to have been mined on Portlock Island, 8 km north-northeast of St Pauls Mission, in 1951. Wolfram has also been reported by Jones (1951a) at Mount Paterson, 20 km southwest of Cape York.

The wolfram mineralization in Torres Strait is related to the Badu Granite. At Eet Hill on Moa Island, Coconut Point on Badu Island, and North Possession Island, the wolfram-bearing quartz lodes were probably formed about the same time as the dykes of porphyritic microgranite and other acid dykes. As the lodes have been worked by handpicking and gouging very little wolfram is to be seen, but all who have inspected the deposits agree that Eet Hill is worthy of further investigation.

Iron and manganese

The iron deposits at Iron Range were investigated in 1957-62 by the Broken Hill Pty Co. Ltd (Canavan, 1965b). The deposits consist of large steeply dipping lenses of schist and quartzite (Sefton Metamorphics, Fig. 39), rich in magnetite and hematite, and their ferruginous weathering products. The iron-bearing rocks also contain substantial amounts of manganese.

Canavan (1965a) gives the indicated reserves at Iron Range as 1 million tonnes of ore containing between 54 and 62 percent iron (including manganese), and inferred reserves of 300 000 tonnes containing 45 to 55 percent iron (including manganese). Some of the richest ore is only 8 km from the sea, and the remainder is from 15 to 30 km from Portland Roads, a protected deep-water anchorage.

Canavan (1965b) has divided the iron-bearing rocks into the Black Hill (or northern) type composed of magnetite quartzite containing subordinate hematite, manganese oxides, rhodocrosite, calcite, pyrite, and pyrrhotite, and the Lamond Hill (or southern) type composed of hematite-quartz schist.

In the northern type, much of the ore consists of a highly oxidized residual capping, which is usually rich in manganese. The combined iron and manganese content is about 60 percent, with iron and manganese each ranging from 15 to 45 percent. This ore generally contains less than 2 percent silica, but in the less oxidized zone below, which ranges from 15 to 30 m thick, silica ranges up to 30 percent. The manganiferous ore is composed mainly of pitted magnetite grains with interstitial fine-grained hematite; psilomelane and pyrolusite are confined to veinlets and microjoints (Canavan, 1965b). The southern or hematite-quartz type commonly lacks the residual capping found in the north, and contains only a little manganiferous ore near the contacts of the ore lenses with the surrounding weathered schist.

Broadhurst & Rayner (1937) have noted that the iron-bearing schist at Iron Range, or the associated quartz stringers, may contain a few grams of gold per tonne.

Antimony

Stibnite occurs in association with pyrite, arsenopyrite, and galena in the gold-bearing quartz reefs of the Alice River and Hamilton Gold and Mineral Fields (Ball, 1901; Cameron, 1906). An antimony deposit is reported to have been discovered by Dickie in 1907, 30 km east of the Alice River Gold and Mineral Field, and Cherry (1907a) has described three outcrops with 12 antimony occurrences within 3 km of the main Coghlan deposit. The Coghlan deposit produced ore assay-

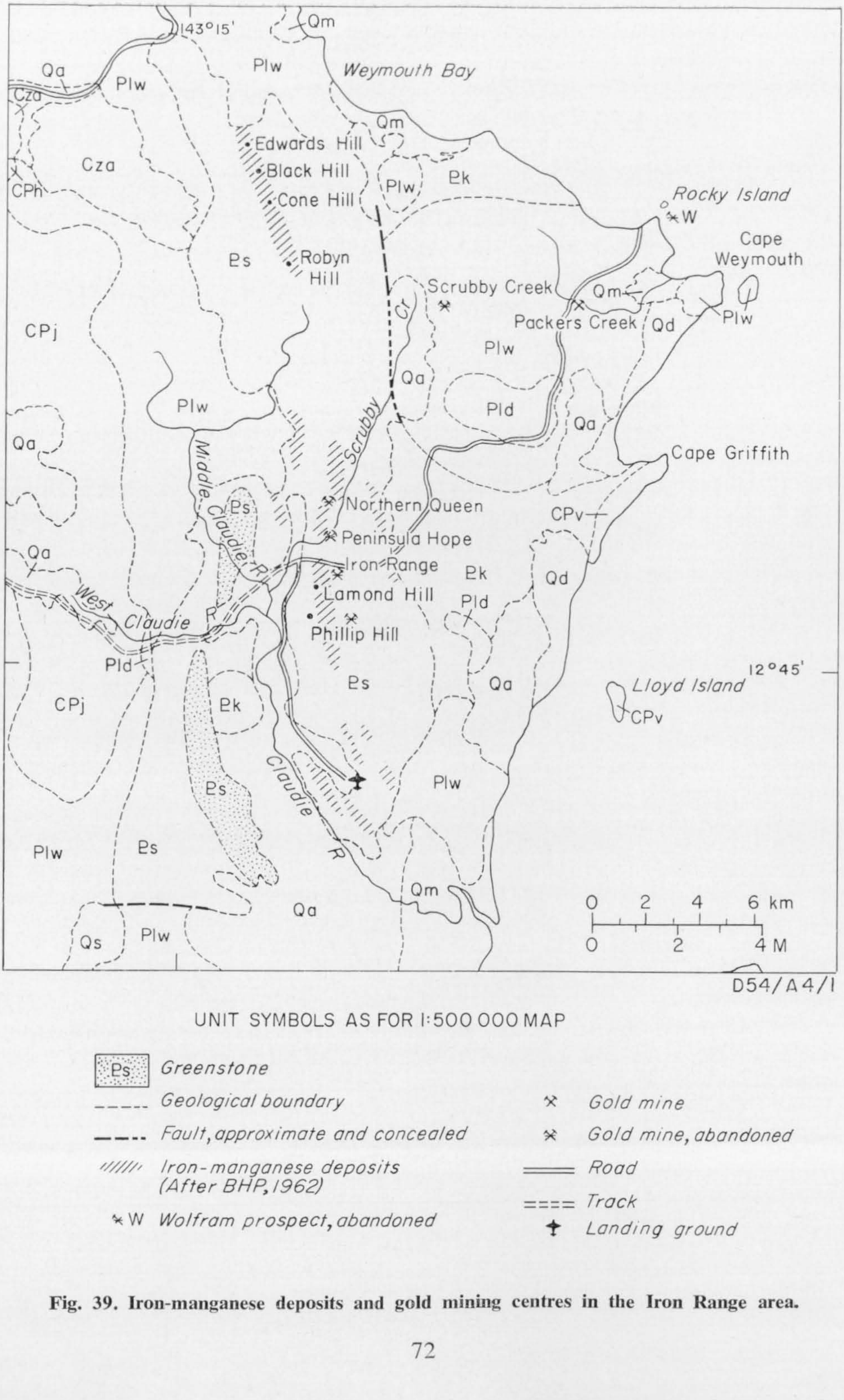


Fig. 39. Iron-manganese deposits and gold mining centres in the Iron Range area.

ing 58 percent antimony, but no production is recorded. In 1969-70 Consolidated Mining Industries Ltd were investigating the deposits.

Arsenic

Arsenopyrite is commonly associated with the gold mineralization. It generally occurs with pyrite and galena, and is most common between Coen and Iron Range. Its concentration is rarely recorded, but Shepherd (1938) has noted up to 1 percent arsenic in gold-bearing samples from the Hayes Creek Provisional Gold Field, and 4.4 percent arsenic has been recorded in ore from the Peninsula Hope mine at Iron Range (CSIRO, 1953).

Lead

Galena, pyrite, and arsenopyrite are commonly associated with the gold mineralization. Galena is probably most abundant on Horn Island.

Copper

Surface evidence of copper mineralization is rare in Cape York Peninsula south of Temple Bay; a little malachite staining has been noted in a few of the greenstones in the Iron Range area, but minor copper mineralization is common in places in the southern part of Torres Strait (Fig. 38). It occurs mainly as chalcopyrite, partly altered to malachite and azurite, in quartz-veined and hydrothermally altered welded tuff or porphyritic microgranite. A regional geochemical survey (Whitcher, 1966) found only an average of 5 to 15 ppm of copper in Torres Strait; the highest values obtained were 40 ppm on Moa Island and 28 ppm in the central part of Hammond Island. Copper mineralization has also been noted by Spratt (1957), and Jackson (1902) has reported chalcopyrite with the gold mineralization on Horn Island. On the northeast coast of Hammond Island Willmott et al. (1969) note a zone of disseminated chalcopyrite, about 50 m across, in a body of tonalite near its contact with welded tuff.

Molybdenum

A minor occurrence of molybdenite associated with wolfram was reported by Ball (1901) about 10 km east of Coen; 130 kg of molybdenite were produced in 1915 and 1917. Traces of molybdenite have also been recorded in the Bowden Mineral Field (Cherry, 1907b), on Rocky Island near Portland Roads, and southeast of St Pauls Mission on Moa Island (Jones, 1951a).

Aluminium

Bauxite is exposed beneath a cover of sand in the coastal cliffs in the Turtle Head Island and Escape River area, 30 km south of Cape York. Connah & Hubble (*in* Hill & Denmead, 1960) have noted that bauxitization is prevalent to the east of the Great Divide; the bauxite is from 30 cm to 5 m thick, and crops out at elevations between sea level and 50 m. They concluded that the bauxite is generally siliceous and of rather low average grade.

Heavy-mineral sands

The heavy-mineral beach sands between Princess Charlotte Bay and Cape Grenville appear to be of little importance. A number of thin discontinuous seams occur in the narrow beaches between Cape Sidmouth and Cape Direction, and near the mouths of the Nesbit and Pascoe Rivers (Zimmerman, 1969). The heavy mineral concentrates generally consist of over 90 percent ilmenite, with a little zircon, rutile, magnetite, and monazite; up to 40 percent monazite is present in one of the concentrates from a sample collected between Cape Sidmouth and Cape Direction.

A sample from a small deposit in Shelburne Bay, northwest of Cape Grenville, was found to contain 65 percent heavy minerals, of which 30 percent was zircon, 53.5 percent rutile, and 2.06 percent ilmenite (Paterson, 1957). Traces of cassiterite have been recorded in the sands near the mouth of the Pascoe River (Zimmerman, 1969), and concentrations of garnet, monazite, ilmenite, and tantalite(?) have been reported in the sands from the Palmer River. Ilmenite, monazite, zircon, and minor rutile occur in the sands in the Lockhart River and Geikie Creek.

Non-metals

Agate

Hann's expedition (Jack, 1922) reported the presence of agate in the basalts along the Mitchell River upstream from the site of Mount Mulgrave homestead. Agate is common in the rubble on a hill of Nychum Volcanics a few kilometres south of Mount Mulgrave homestead.

Coal

The Lower Carboniferous Pascoe River Beds in the Iron Range district contain thin seams of coal. Morton (1924) investigated the deposits along the Pascoe River and Hamilton Creek, 30 km northwest of Iron Range, and found that they consist mainly of carbonaceous shale, with bands of coal up to several centimetres thick. One seam, previously reported to be 3 m thick, was found to be composed of highly metamorphosed carbonaceous strata, 50 percent of which consist of graphitic stony bands.

Spratt (1958) located two weathered coal seams, 3.5 and 2.5 m thick, but concluded that they were not suitable for exploitation because of the intense folding and faulting in the nearby sediments. Miller (1957) found that the coal pebbles in the Pascoe River had a high calorific value and a low or moderate ash content. Morton (1924) gives the following analyses of two coal pebbles from the Pascoe River: ash 9.5 and 22.7 percent; fixed carbon, 51.3 and 42.6 percent; volatiles, 37.9 and 34.1 percent; and moisture, 1.3 and 0.6 percent. Australian Aquitaine Petroleum Pty Ltd (AAP, 1965) have described three thin seams of coal exposed in coaly shale along the Pascoe River and its tributaries.

Coal also occurs in a thin bed of shale near the base of the Mesozoic sandstone overlying the Pascoe River Beds near the confluence of Canoe Creek and the Pascoe River (Morton, 1924). The second analysis quoted by Morton refers to this locality.

Limestone and marble

Small pods of marble and calc-silicate rocks, rarely more than 30 m across, occur in the Kintore Adamellite on the east flank of the coastal range north of the Nesbit River, to the northwest of the McIlwraith Range about 30 km northeast of Coen, and to the southeast of Coen. Some of the marble is almost pure white and coarsely crystalline, but most of it contains scattered veins and clumps of silicate minerals.

The schistose limestone in the Sefton Metamorphics at Bolt Head, in Temple Bay, was examined by the Broken Hill Pty Co. Ltd (BHP, 1962); they estimate that the deposit contains less than 1 million tonnes of limestone, of which about 25 000 tonnes is easily available, but consider that the quartz veins in the deposit would probably lower the grade to an undesirable level. Miller (1957) found the carbonate content of the limestone to be between 83.7 and 96.84 percent.

Mica

A small muscovite mine operated between 1941 and 1943 about 42 km south-southeast of Musgrave homestead (Ball, 1943). The books of mica average 200 cm^2 in area in places. They occur in concordant bodies of quartz, pegmatite, and greisen in mica schist and quartz-feldspar gneiss of the Holroyd Metamorphics. The workings consist mainly of shallow shafts, small open cuts, and costeans. In 1942 a parcel of a few hundred kilograms was made up from 3.5 tonnes of split mica and sent to Melbourne, but the mine was closed by 1944.

Olivine

The sand on the small beaches on the south side of Maer Island contain a high proportion of olivine crystals derived from the nearby basaltic tuffs; pyroxene and iron-titanium oxides are also present. The beach sand deposits are too small to be of value, and the presence of a broad fringing coral reef makes it unlikely that sizeable deposits exist offshore.

Petroleum

Petroleum exploration has been confined mainly to the sediments in the Laura, Carpentaria, and Papuan Basins. The geophysical surveys are shown in Figure 3.

Exploration in the Laura Basin has been summarized by Lucas & de Keyser (1965b). One dry hole, the Cabot-Blueberry Marina Plains 1 well, was drilled. The Mesozoic sediments on the eastern edge of the Carpentaria Basin have been mapped by Australian Aquitaine Petroleum Pty Ltd (AAP, 1965, 1967); they also examined the Carboniferous Pascoe River Beds for source rocks.

The northeastern part of Torres Strait is underlain by as much as 3500 m of Mesozoic and Tertiary sediments similar to those in the Gulf of Papua, where large flows of gas have been obtained in a number of wells. Seismic and magnetic surveys indicate a number of positive structures developed by faulting in the Mesozoic sediments, which were later draped by Miocene limestone. The Anchor Cay 1 well was drilled on one of these structures, but did not encounter hydrocarbons.

Phosphate

Very small deposits of guano are present on some of the smaller islands in Torres Strait; the largest is at Bramble Cay, 75 km east of Daru. They are of technical interest only. Ladd (1968) notes that several hundred tonnes were shipped from Bramble Cay in 1878 and it is possible that guano was removed from Booby Island, 35 km west of Thursday Island, at about the same time (Richards & Hedley, 1925).

Silica

Sand dunes cover an area of 400 km^2 between the Olive River and Shelburne Bay, to the west of Cape Grenville. Most of the dunes are covered with vegetation.

They form hills up to 100 m above sea level, and extend up to 15 km inland. The dunes on the coast are composed almost entirely of clear quartz with a few grains of limonite. White sand dunes cover large areas on the coast between Shelburne Bay and Newcastle Bay; they are not shown on the accompanying geological map. There are two smaller dune fields south of Bolt Head and Cape Griffith, but many of the quartz grains are yellow and some contain clay in cracks. White sand dunes also occur along the coast between Cape Direction and the 2nd Red Rocky Point, and on the northern shore of Newcastle Bay.

Analyses of samples from the beach dune in Margaret Bay and from near Bolt Head are given below:

Percentage Composition of Silica Sands

	Shelburne Bay		*Bolt Head*
	BMR Sample No. 67480534	*BMR Sample No. 67480535*	*BMR Sample No. 67480536*
SiO_2	99.8	99.6	99.6
Fe_2O_3	0.015	0.015	0.030
Al_2O_3	0.10	0.08	0.11
CaO	0.01	0.04	0.01
Loss on ignition	0.11	0.10	0.12

In 1968 Metals Exploration N.L. proved over 6 million tonnes of sand at Shelburne Bay. The silica content was in excess of 99 percent to a depth of 12 m.

Stone

The patchy pisolitic ironstones have been used to surface roads south of Coen and at Higginsfield near Bamaga. The granite hill at Mabaduan in Papua may be a useful future source of aggregate and road metal as it is the only large exposure of hard rock in this part of Papua. Larger quantities of stone are available on Dauan Island, 25 km southwest of Mabaduan in Queensland territory.

The upper Palaeozoic granitic and volcanic rocks, and some of the white and green marbles northeast of Coen, may be useful as building and ornamental stone. Dried coral blocks have been used for some buildings in Torres Strait.

Water

The average rainfall ranges from over 2000 mm in the coastal region near Iron Range to between 1800 and 2000 mm in Torres Strait, and less than 1000 mm in the southern part of Cape York Peninsula. Most of the rain falls between December and March, but in the coastal ranges there are occasional light falls throughout the remainder of the year. Supplies of surface water decrease throughout the dry season, and by September it is scarce in the south and west, and in the Torres Strait Islands. The main rivers, such as the Coen, Archer, Pascoe, and Claudie Rivers, are fed from the McIlwraith Range and ranges to the north, and generally flow throughout the year. In the south the perennial easterly flowing Hann River is fed from springs in the sandstone of The Desert. Permanent waterholes occur in or adjacent to many sizeable streams throughout the region. In the far south the Mitchell River generally flows throughout the year.

Little is known of the groundwater resources. Some bores have been sunk for homesteads and cattle-watering points. They are sited in alluvium along rivers and creeks, and are generally less than 10 m deep. The Cainozoic sands of the Lilyvale Beds in the Archer River Piedmont Basin and elsewhere may contain substantial supplies of groundwater. Water is obtainable in the thick residual sands filling depressions in the granitic rocks on the Coleman Plateau. Both surface and underground water supplies are likely to be greatest in the Mesozoic sediments flanking the igneous and metamorphic rocks; perennial lagoons are common on these sediments.

A hot spring, at a temperature of about 65°C, occurs about 30 km north of New Bamboo homestead, and another, at about 40°C, at Musgrave homestead (Trail et al., 1968; Ball, 1901).

Ogilvie & Weller (1949) have reported on water supply in Torres Strait. On Thursday Island the only reservoir is inadequate. A little used reservoir exists on nearby Horn Island, but an undersea pipeline would be difficult to construct and maintain owing to the swift tidal currents. Sites for reservoirs are also available on the nearby Prince of Wales Island.

Daru Island, in Papua, is often short of water, although emergency supplies of poor quality are available in shallow bores. McGregor (1967) has suggested that increased tank storage of rain water may solve the problem, and this may also be the best solution for Thursday Island.

An irrigation scheme using water piped from the perennial Jardine River is planned for the Bamaga community, 30 km southwest of Cape York.

DESCRIPTION OF ROCK UNITS

PRECAMBRIAN METAMORPHIC ROCKS

Dargalong Metamorphics
(de Keyser, Bayly, & Wolff, 1960, *amended)*

Derivation of name

The Dargalong Beds were named by Skertchly (1899) after an abandoned mining camp near Chillagoe in the Atherton Sheet area. The name was changed to Dargalong Metamorphics by de Keyser et al. (1960). Similar metamorphics in the Yambo Inlier, 50 km north of Chillagoe, were called the Frome Series by Jensen (1940b), but were included in the Dargalong Metamorphics by Amos & de Keyser (1964). This nomenclature was followed by Whitaker & Willmott (1968) and is continued in this Bulletin, except that the gneiss and coarse schist north of the Yambo Inlier, which Whitaker & Willmott included in the Dargalong Metamorphics, are described as a separate unit (Coen Metamorphics).

Distribution

The Dargalong Metamorphics crop out over about 1100 km^2 in the Chillagoe area, and over about 1500 km^2 between the Mitchell and King Rivers in the Yambo Inlier. They are bounded in the east by the Palmerville Fault, which separates them from folded Palaeozoic sediments of the Hodgkinson Basin. Only the rocks in the Yambo Inlier are described here.

The metamorphics crop out in low undulating country with ridges of resistant quartzite or amphibolite up to 60 m high. The less resistant rocks are generally covered by sand and are well exposed only in the larger creeks and in the bed of the Palmer River.

Lithology

The Dargalong Metamorphics consist of biotite-plagioclase-quartz gneiss, plagioclase-muscovite-biotite-quartz schist, muscovite-quartz schist, quartzite, amphibolite, and rare bands of amphibole and diopside-bearing gneiss. Some migmatite is present near the contact with the Cape York Peninsula Batholith.

The *biotite-plagioclase-quartz gneiss* in the eastern part of the Yambo Inlier is greenish grey, medium-grained, and well foliated. It consists of granular bands of quartz and feldspar, up to 5 mm thick, alternating with thinner bands rich in biotite. It is also banded on a large scale, with all gradations between dark mica-rich gneiss and leucocratic gneiss. Garnet is generally present, particularly in the biotite-rich gneiss, which contains up to 20 percent garnet porphyroblasts up to 2.5 cm across. Muscovite is also generally present, particularly in the leucocratic gneiss, and sillimanite has been recorded in places.

The *plagioclase-muscovite-biotite-quartz schist,* which predominates in the west, is brownish grey, medium or fine-grained, and more finely foliated than the gneiss. It ranges from muscovite-quartz schist to plagioclase-biotite-quartz schist. Garnet is found in the biotite-rich schist and accessory sillimanite in the muscovite-rich rocks. With an increase in the amount of plagioclase the schist grades into the gneiss in the eastern part of the inlier.

The plagioclase in the schist and gneiss ranges from calcic oligoclase to calcic andesine, and is commonly partly altered to sericite and clay. The biotite is pleochroic from pale yellowish brown to dark reddish brown, and contains inclusions of apatite and zircon, or monazite; some of the biotite has been altered to chlorite. Muscovite is generally associated with the biotite, but is also found as fine-grained aggregates formed by the alteration of sillimanite. In places the gneiss contains large crystals of sillimanite, which are partly replaced by muscovite, or sillimanite inclusions in mica or quartz. The accessories are zircon, apatite, monazite, sphene, and opaque minerals.

Muscovite-quartz schist and quartzite occur as scattered bands and large bodies within the other rocks. Bands of schist and quartzite, from 1 m to a few hundred metres thick, commonly alternate. The schist is light grey and weathers purple or red; it is fine or medium-grained and has a moderately well developed schistosity which is contorted in places. Muscovite commonly occurs as fine aggregates up to 8 mm long, formed by the alteration of needles of sillimanite; some larger flakes up to 4 cm across are also present. Small crystals of sillimanite are preserved in the centre of some of the pseudomorphs.

Sillimanite also occurs as fine needles in muscovite and quartz, and in patches of chlorite which were probably formed by the alteration of cordierite. The schists are heavily stained by hematite, particularly along the planes of schistosity. Some of the hematite may have been formed by the breakdown of biotite or garnet, but the abundant small needles parallel to the schistosity may be a primary constituent. Pale pink porphyroblasts of garnet are common in some of the quartz-rich schists.

The quartzite is medium-grained and has a sugary texture; in some of the rocks the grains have a preferred orientation parallel to the schistosity. A little muscovite (pseudomorphs after sillimanite), garnet, and hematite are generally present; one specimen contains 60 percent garnet. Most of the garnet is altered to a boxwork of limonite. In the eastern part of the Yambo Inlier thick bands of quartzite and amphibolite are present in the biotite-plagioclase-quartz gneiss.

The *amphibolites* interbanded with the biotite-plagioclase-quartz gneiss in the eastern part of the Yambo Inlier are fine-grained, black or greenish black rocks composed of hornblende, plagioclase, and quartz. The long subhedral crystals of hornblende are parallel to the foliation in the surrounding rocks; they are generally pleochroic from pale yellow to pale brown, although a darker variety is present in some specimens. The interstitial laths of plagioclase commonly range from andesine to labradorite (An_{40}-An_{54}). Quartz is also interstitial.

The amphibolite bands are usually from 1 to 500 m wide, and the larger bands are up to 5 km long. The contacts between the larger bands and the gneiss are generally sharp.

In the eastern part of the Yambo Inlier small lenses of amphibole and diopside-bearing gneiss grade into the biotite-plagioclase-quartz gneiss. These lenses probably represent metamorphosed carbonate-bearing sediments. The main assemblages are: (garnet-)quartz-diopside-hornblende-plagioclase; quartz-garnet-plagioclase-hornblende; (plagioclase-)quartz-biotite-hornblende; and quartz-diopside-plagioclase. The irregular poikiloblastic laths of hornblende are pale brown in the diopside-free rocks, but green or greenish brown in the diopsidic rocks. The diopside forms small rounded grains and rare porphyroblasts up to 6 mm long.

The *migmatite* at the contact with granitic rocks near the headwaters of the Kennedy River, in the northeastern part of the Yambo Inlier has been recrystallized and contains granoblasts and porphyroblasts of microcline, which were probably formed during the intrusion of the granitic rocks into which the recrystallized gneiss grades.

The gneiss adjoining the eastern boundary of the granitic rocks in the southern part of the Yambo Inlier has been recrystallized and appears to grade into the granitic rocks, but no migmatite has developed. Both the granite and gneiss near the contact have been affected by shearing and are difficult to distinguish from each other.

Coen Metamorphics
(new name)

Derivation of name

The name Coen Metamorphics is taken from the township of Coen (lat. 13°57′S, long. 143°11′E) in the Coen Sheet area. The formation consists of numerous bodies of coarse schist and gneiss to the east of the Holroyd Metamorphics, most of which form inliers within the Cape York Peninsula Batholith. They were previously included in the Dargalong Metamorphics (Whitaker & Willmott, 1968, 1969a; Trail et al., 1968, 1969), which are now restricted to the Yambo Inlier and Chillagoe area. The type area is a broad belt which extends for about 20 km to the south of Coen.

Distribution

The isolated bodies of Coen Metamorphics cover a total area of over 1100 km^2. The largest belt, which extends southwards from Coen into the Ebagoola Sheet area, tapers in width from 15 km near Coen to 3 km between Ebagoola and the abandoned Bamboo homestead. To the east there is a parallel belt running southeastwards from Kintore hill. North of Coen, the metamorphics crop out as numerous small bodies in the McIlwraith Range and coastal ranges, only the larger of which are shown on the map. In the Hann River Sheet area several small bodies of metamorphics crop out within the granitic rocks along the western edge of The Desert between Dixie and Kimba homesteads.

The metamorphics crop out in rough country with strike ridges of quartzite up to 150 m high. In spite of the relief, the less resistant rocks are poorly exposed and deeply weathered.

Lithology

The Coen Metamorphics consist of biotite-muscovite-quartz schist, quartzite, and biotite-quartz-feldspar gneiss, with scattered thin bands of garnet-amphibole-quartz-feldspar gneiss, amphibolite, and calc-silicate rocks. The schist, quartzite, and biotite gneiss grade into one another and are generally intimately interbanded, although large bodies of gneiss with little schist have been delineated near Coen and Ebagoola. Schist and quartzite are about three times as abundant as gneiss. Conformable bands of amphibolite are generally present, but the lenses of calc-silicate rock are less common.

Between Ebagoola and Coen the metamorphics have been intimately intruded by adamellite, leucocratic granite, pegmatite, and aplite of the Cape York Peninsula Batholith. The small bodies of metamorphics within the batholith in the Coen Sheet area have also been invaded by similar rocks.

The *biotite-muscovite-quartz schist* is fine or medium-grained, and has a moderately well developed schistosity which is crenulated in places. The fresh rocks are silvery grey, and the weathered rocks are stained purple. Muscovite generally predominates over biotite, and with an increase in the quartz content the schist grades into quartzite. Many of the rocks contain porphyroblasts of sillimanite, up to 8 cm long, which have been pseudomorphed by aggregates of muscovite, as well as subordinate garnet, plagioclase, potash feldspar, and opaque minerals.

Most of the muscovite forms aggregates of fine flakes formed by the alteration of sillimanite; the larger flakes may be primary. Occasional cores of sillimanite are preserved in the muscovite pseudomorphs. The biotite associated with the coarse muscovite is partly or completely chloritized. One specimen from the centre of the Coen Sheet area contains fine needles of sillimanite formed by the recrystallization of cordierite(?), the remainder of which has been replaced by muscovite.

Colourless or pale pink porphyroblasts of almandine(?) garnet are generally present in small amounts only, but in places they form up to 20 percent of the rock. The poikilitic crystals are altered to chlorite along fractures. Some plagioclase and potash feldspar is present in rocks transitional between schist and gneiss. Up to 10 percent iron oxide and graphite occur as flakes parallel to the schistosity. The accessories include zircon, monazite, rutile, apatite, and tourmaline, and one specimen contains spinel and corundum in what were probably alumina-rich bands.

The *quartzite* is grey or white, medium or coarse-grained, and generally has a sugary texture; in places the quartz grains are weakly aligned parallel to the foliation in the schist. One specimen from northeast of Musgrave homestead contains garnet and sillimanite. Some of the rocks contain small amounts of sillimanite either as interstitial euhedral needles or as inclusions in quartz.

The *biotite-quartz-feldspar gneiss* is grey or white, medium or coarse-grained, banded, and poorly to moderately schistose. The banding is commonly irregular, especially where large feldspar porphyroblasts are present, and the leucocratic rocks have a granoblastic texture. Some of the gneiss interlayered with the schist and quartzite contains a little feldspar and has a more pronounced schistosity. The gneiss generally contains from 20 to 40 percent plagioclase (calcic oligoclase to sodic andesine); some of the rocks contain small subhedral grains of poorly twinned microcline, but except in the leucocratic gneiss, it forms less than 20 percent of the rock. The rock contains up to 25 percent biotite, which in places is replaced by chlorite. The fine aggregates of muscovite are similar to those in the biotite-muscovite-quartz schist, and appear to be pseudomorphs after sillimanite. The colourless or pale pink garnet is probably almandine. The accessory minerals are zircon, monazite, apatite, sphene, and opaque minerals. One specimen from the Rocky River contains long streaks and thin folia of cordierite and sillimanite. The sillimanite forms myriads of fine needles within the cordierite, which is partly altered to muscovite.

Along the western margin of The Desert small inliers of muscovite-biotite-quartz-feldspar gneiss crop out in the granitic rocks. The gneiss is medium or coarse-grained and leucocratic, and has a weak foliation. The contacts with the granitic rocks are vague, and near the contact the gneiss is more leucocratic and massive, and the granitic rocks contain streaky remnants of biotite-rich bands, which in places impart a weak foliation to the rock. The leucocratic gneiss is composed of a granoblastic mosaic of (muscovite), quartz, plagioclase, and microcline; most of the rocks appear to have been recrystallized and probably metasomatized.

The rare thin bands of *garnet-amphibole-quartz-feldspar gneiss* interbanded with biotite gneiss have a similar texture to the host rock, although they are generally more mafic. They probably grade into each other through intermediate varieties such as amphibole-biotite-quartz-feldspar gneiss. The plagioclase (calcic andesine to calcic labradorite), is more basic than in the biotite gneiss, and the amphibole, which forms up to 40 percent of the rock, is generally yellow or pale greenish brown hornblende, but in places consists of colourless or pale green tremolite-actinolite. Large poikilitic porphyroblasts of pale pink almandine(?) garnet form up to 25 percent of some specimens. The accessories are sphene, apatite, zircon, and opaque minerals.

The *amphibolite* is a fine-grained greenish black rock composed of hornblende, plagioclase, and quartz. The amphibolite forms bands, up to 10 m thick, which are concordant with the foliation in the surrounding metamorphic rocks; the amphibole crystals are also parallel to the foliation. The bands of amphibolite within the Cape York Peninsula Batholith are probably large xenoliths that have resisted digestion.

The large subhedral crystals of hornblende are generally pale yellow or greenish brown, but near lenses of calc-silicate rock they have a bluish green tinge. The plagioclase ranges from andesine to sodic labradorite. Most of the amphibolites contain only a little interstitial quartz, but some contain up to 15 percent. Opaque minerals, sphene, and apatite are common.

The *calc-silicate rocks* are light to dark green, fine-grained, banded and schistose, and are rich in calcic ferromagnesian minerals; they also include coarse white marble. They crop out as small concordant lenses in schist and gneiss, and as xenoliths within the granitic rocks (Fig. 40). The largest outcrops are found east of Coen airport in the headwaters of Peach Creek; lenses of calc-silicate rocks are common in the coastal ranges, east of the Lockhart River. Each outcrop consists of irregular light and dark-coloured bands which can generally be divided into three mineral assemblages (see Table 10).

1. Light and dark green bands with lime-magnesia-silica assemblages are common. They are composed of various proportions of tremolite and clinopyroxene, with subordinate chlorite, altered plagioclase(?), and a little quartz, sphene, and calcite. X-ray diffraction suggests that the clinopyroxene ranges from diopside to hedenbergite. The large subhedral laths of tremolite commonly contain poikilitic inclusions of quartz and altered feldspar; X-ray diffraction indicates about 10 percent of the actinolite molecule.

One calc-silicate band in gneiss near the mouth of the Nesbit River consists of diopside, altered albite, and large crystals of vesuvianite. At Whale Hill, 10 km southwest of Cape Sidmouth, a calc-silicate xenolith within granitic rocks is composed of epidote (60%), quartz (25%), and dark green hornblende (15%). Another rock, from the west side of the McIlwraith Range between Wilson and Beetle Creeks, is composed of calcite (15%), chondrodite (15%), spinel (20%), fine flakes of talc(?) (40%), and chlorite (5%). Some of the colourless or pale yellow euhedral chondrodite crystals are twinned and partly altered to

TABLE 10. MINERAL ASSEMBLAGES IN CALC-SILICATE ROCKS, COEN METAMORPHICS

I. *Lime-magnesia-silica assemblages*
tremolite
chlorite-tremolite
quartz-plagioclase-tremolite
plagioclase-diopside-tremolite
tremolite-diopside
plagioclase-tremolite-diopside
quartz-plagioclase-diopside
vesuvianite-albite-diopside
calcite?-diopside
quartz-plagioclase-diopside-hornblende
quartz-clinozoisite-hornblende-diopside
hornblende-quartz-epidote
chlorite-chondrodite-calcite-spinel-talc?*
II. *Carbonate-rich assemblages*
olivine-calcite-dolomite*
olivine-diopside-calcite-dolomite*
diopside-calcite-dolomite
III. *Silica-rich assemblages*
diopside-actinolite-quartz
sphene-actinolite-diopside-quartz

*Silica deficient.

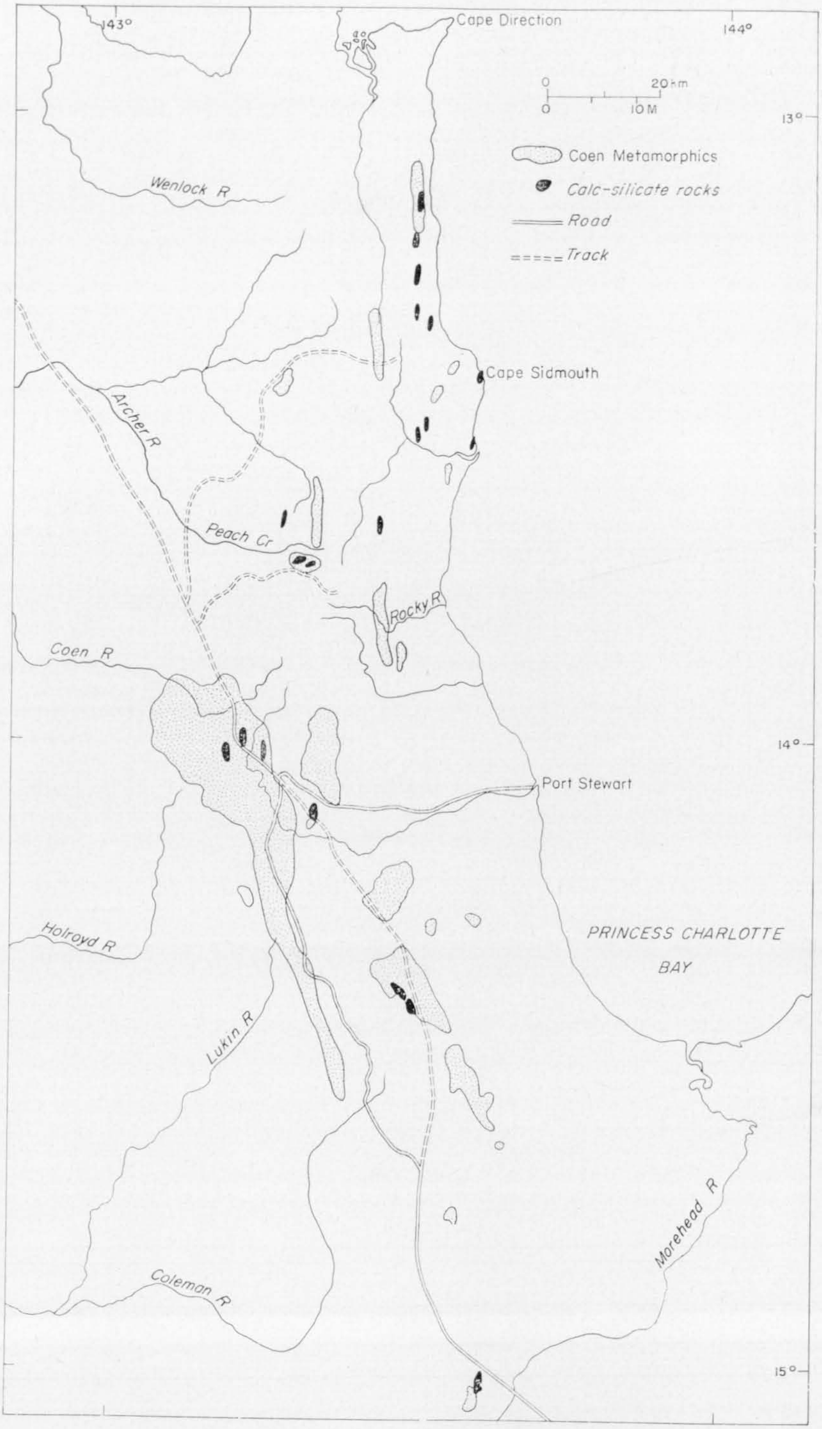


Fig. 40. Distribution of calc-silicate rocks in Coen Metamorphics.

serpentine. The large body of very dark calc-silicate rock south of the Coen/Leo Creek track is composed of bluish green hornblende (40%), plagioclase (30%), pale green clinopyroxene (25%), and quartz (5%). This rock may represent a transitional type between the more common calc-silicate rocks and the amphibolites.

2. Light-coloured bands with carbonate-rich assemblages are abundant in places. The impure white marble south of the Coen/Leo Creek track is composed of a mosaic of large grains of dolomite and calcite. Small grains of forsterite(?), partly replaced by serpentine, and bands of diopside(?) are also present.

3. Silica-rich assemblages were observed in a few places only. They contain up to 70 percent quartz, up to 35 percent interstitial grains and poikilitic laths of clinopyroxene and tremolite-actinolite, and a little altered feldspar and sphene.

Holroyd Metamorphics
(Whitaker & Willmott, 1968, 1969a)

Derivation of name

The Holroyd Metamorphics were named after the Holroyd River in the northern part of the Ebagoola Sheet area (Whitaker & Willmott, 1968). Later, Whitaker & Willmott (1969a) included all the metamorphic rocks along the western margin of the Cape York Peninsula Batholith as far north as Bald Hill, and it is here proposed to include the small exposures as far north as Wenlock that were previously referred to the Sefton Metamorphics. The gneiss in the southeast, which was included in the Dargalong Metamorphics by Whitaker & Willmott (1968), has been transferred to the Holroyd Metamorphics.

Distribution

The Holroyd Metamorphics cover an area of about 3800 km^2 in a belt 250 km long along the western margin of the batholith. They extend northwards from Eight Mile Creek in the central part of the Hann River Sheet area to Wenlock in the Coen Sheet area. In the south, the belt is 55 km wide in the vicinity of the Coleman River. The metamorphics are well exposed between the Coleman and Coen Rivers, but in the west they are overlain by Mesozoic sediments.

The Holroyd Metamorphics form flat or undulating country with steep strike ridges of quartzite. Between the Lukin and Holroyd Rivers, in the Ebagoola Sheet area, the ridges are up to 250 m high. Outcrops are generally restricted to the banks of creeks, but the quartzite and interbedded schist are well exposed in the strike ridges. The metamorphics crop out in some of the dissected areas near the base of the Mesozoic sediments.

Lithology

The Holroyd Metamorphics comprise indurated sandstone and siltstone, phyllite, fine to coarse mica-quartz schist, spotted and porphyroblastic schist, feldspathic schist, quartzite, gneiss, greenstone, and amphibolite. In general, the grainsize and metamorphic grade increase towards the east. The main lithological subdivisions in the south are shown in Figure 41.

A belt of *indurated mudstone, fissile shale, and sandstone,* up to 7 km wide, extends about 20 km north-northwest and 12 km south from The Gorge on the Lukin River. Small outcrops are also found to the south near the Coleman River. The indurated sediments grade east and west into phyllite and schist. The fine slaty cleavage in the shale is generally steeply dipping. The cleavage planes commonly have a silky sheen, and a lineation has developed along the intersection of the bedding and cleavage planes.

The mudstone and sandstone of this belt are well exposed in a gorge in the Edward River, 7 km northwest of The Gorge. The mudstone consists of irregular dark grey laminae and interbedded lighter bands; the irregularity of the bedding suggests slumping or distortion by compaction. The rocks are composed of sericite, quartz, and a little chlorite; the presence of relict plagioclase and microcline, and rare biotite, suggests that the sediment was derived, at least in part, from acid plutonic rocks. The interbedded sandstone is finely bedded and crude cross-bedding is present near the Lukin River.

Slate is found as small outcrops, mainly south of Potallah Creek. The rock is composed of sericite, quartz, and minor graphite. Interbands of graphitic phyllite and indurated mudstone are also present.

Phyllite and fine-grained schist are widespread throughout the western two-thirds of the Holroyd Metamorphics in the Hann River and Ebagoola Sheet areas, and in places in the Coen Sheet area.

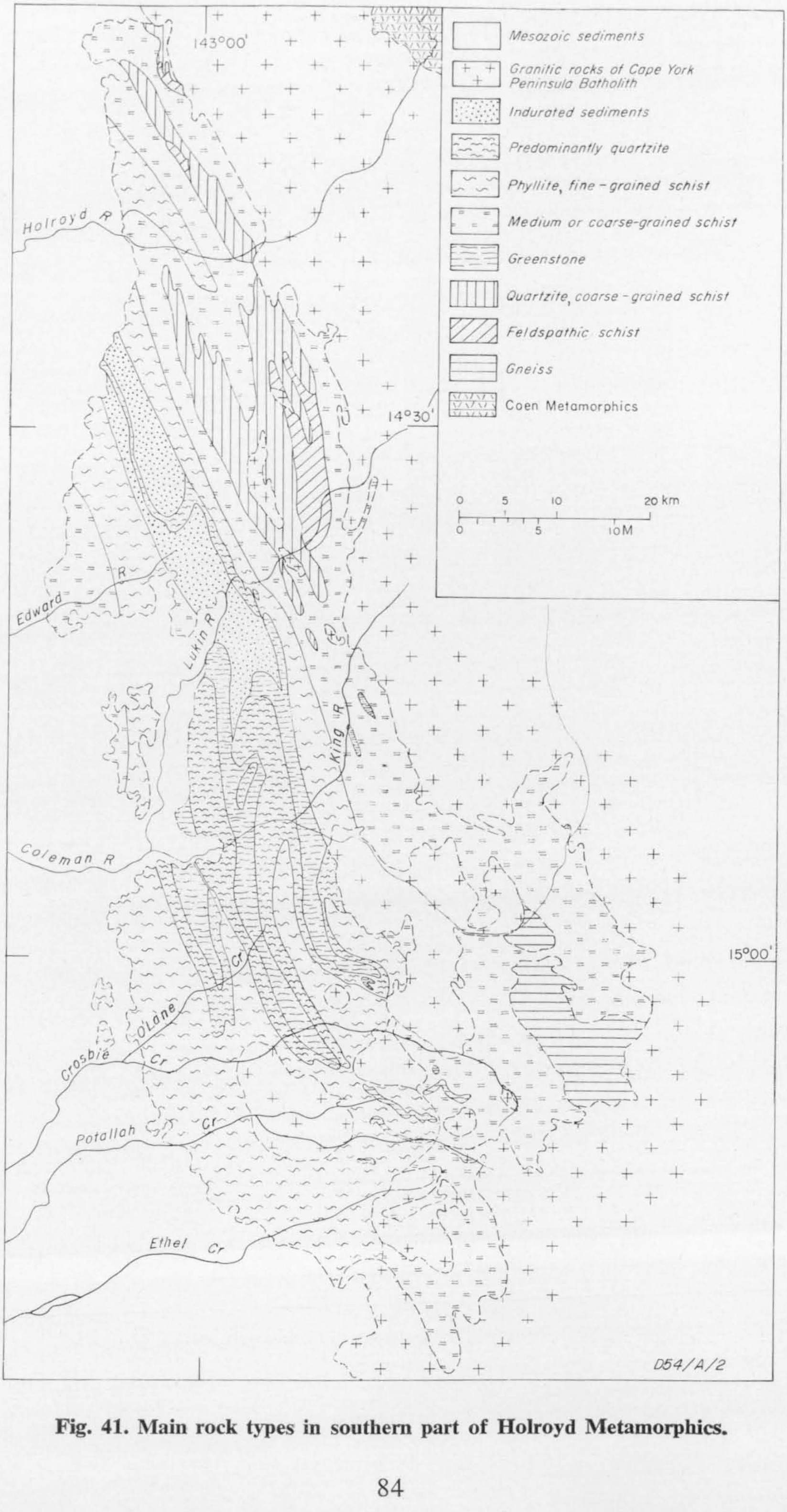


Fig. 41. Main rock types in southern part of Holroyd Metamorphics.

They are composed mainly of sericite and quartz, and range from grey to purplish red or reddish brown. The sericite grades into muscovite in the coarser rocks. Other minerals include graphite, chlorite, garnet, hematite, relict feldspar, and detrital tourmaline and zircon.

Dark grey graphitic schist and phyllite are common in the south between O'Lane and Ethel Creeks, and graphitic schist also crops out between The Gorge and the King River, and west of the King River in a zone up to 9 km wide. The rocks contain up to 20 percent flaky graphite, oriented roughly parallel to the schistosity. The flakes are scattered or localized in bands and lenses; some disseminated particles may also be present.

In the south hematite forms up to 5 percent of some of the ironstained rocks near the Potallah Creek mine, where it occurs as scattered stringers and rectangular pseudomorphs of sulphide minerals. Large grains of iron oxide are present in small quartz lenses in the graphite-sericite-quartz schist 6 km west of the mine.

In places *spotted fine-grained schist* is associated with the phyllite and schist. In the west spotted schist forms a belt up to several kilometres wide near the Edward River, and scattered outcrops are found as far south as Crosbie Creek. A similar rock forms a narrow zone extending 20 km to the north of the Holroyd River; coarser schist occurs farther east. Spotted phyllite and schist are also associated with the granitic rocks in the Potallah Creek area.

The spotted rocks are composed mainly of sericite or muscovite, and quartz. They are generally homogeneous, but quartz-rich bands with gradational boundaries are not uncommon. The schist is light grey and, in places, ferruginous, but is generally not graphitic. The spots consist of aggregates of biotite and garnet which have commonly been altered to hydrous iron oxides. They form from 2 to 15 percent of the rock, are usually less than 1 mm in diameter, and have a random but fairly uniform distribution. Small porphyroblasts of andalusite form narrow bands in places.

Medium and coarse-grained schist predominates in the eastern part of the Holroyd Metamorphics in the Hann River and Ebagoola Sheet areas. The schist includes muscovite-quartz and (graphite-)biotite-muscovite-quartz schist; in places muscovite predominates over quartz. The schist is commonly crenulated and exhibits a prominent lineation. It is grey to buff and commonly ironstained.

Some of the schist contains porphyroblasts of andalusite or chiastolite, which are generally partly altered to sericite. The porphyroblasts are 2 to 3 cm long and are aligned parallel to the schistosity, which is warped around them. The even-grained schist contains lenses or bands of andalusite-bearing schist from 10 to 100 m wide and up to 5 km long.

Xenoblastic laths of staurolite and idioblastic garnet occur in some of the schist in the southeast, but andalusite and staurolite or garnet are rarely present in the same rock. Small grains of tourmaline are present in places.

Sillimanite is widespread near the eastern boundary of the metamorphics. Fibrolite is found in quartz and muscovite, and occasionally in biotite. Some of the rocks contain aggregates of fibrolite parallel to the schistosity. The muscovite and fibrolite are generally replaced by sericite and many of the small lenses of sericite may have been formed by the alteration of the fibrolite aggregates. Prisms of sillimanite, similar to those in the Coen Metamorphics to the east, are rare; some of the sillimanite may have been formed by the recrystallization of andalusite.

Some of the schist contains scattered porphyroblasts of cordierite that are largely altered to chlorite and sericite. In places, the schist near the margin of the batholith contains coarse flakes of muscovite inclined to the foliation. The muscovite was probably formed by contact metamorphism.

Feldspathic schist crops out in the east. The most common assemblage is (sillimanite-) oligoclase-biotite-muscovite-quartz. The schist is speckled light grey to dark grey, or green, and weakly schistose or granofelsic, with incipient gneissic texture in places. The biotite contains inclusions of zircon and occasional crystals of monazite. Brookite or anatase, and more rarely sphene and cordierite, may be associated with the biotite. Graphite or hematite may also be present.

Feldspathic schist is most common between the Holroyd and Lukin Rivers, and between the Coen River and Pretender Creek to the north. South of the Lukin River oligoclase-bearing schist is rare, and where present contains minor microcline.

Gneisses are rare in the Holroyd Metamorphics; they occur only south of the Coleman River and in scattered outcrops north of the Archer River in the Coen Sheet area.

In the south gneiss forms a belt, up to 8 km wide, within the coarse mica-quartz schist, into which it probably grades. The gneiss is a fairly massive rock composed of biotite, muscovite, feldspar, and quartz. The feldspar is usually andesine, but microcline is present in places. In the south the gneiss has been recrystallized and metasomatized by the Cape York Peninsula Batholith.

Bands of *quartzite*, from 1 m to several hundred metres in width, are widely distributed in the Holroyd Metamorphics, particularly in the folded belt extending for 15 km north and 20 km south of the Coleman River, and in a belt to the north and south of the Holroyd River near Pollappa. Scattered bands of quartzite are found elsewhere. Bedding and rare crude cross-bedding can be recognized in places.

In the west the quartzite bands range from several centimetres to several metres in width, and in many places they grade into phyllite or schist.

Near the Coleman River the quartzite bands are up to 2 km wide and 30 km long; they form prominent low hills up to 75 m high, covered by blocky rubble. The quartzites are commonly white or grey, fine or medium-grained, and massive; they consist almost entirely of interlocking grains of strained quartz, and in places have a crude schistosity owing to the alignment of sericite. A little hematite, rare feldspar, chlorite, and graphite and detrital tourmaline and zircon may also be present.

The quartzite bands in the coarse schist near the Holroyd River are up to 60 m wide and 25 km long. The interbanded belt of schist is up to 1 km wide. The quartzite is white or grey, medium or coarse-grained, and has a massive granulose texture. A little sericite and iron oxide may be present. The minor bands of quartzite in the Holroyd Metamorphics in the Coen Sheet area are similar to those farther south.

Greenstone and amphibolite are not widespread in the Holroyd Metamorphics, and only the larger bodies have been mapped. In the southwest the greenstone belts are up to 30 km long and 3 km wide. In the southeast, and north of the Lukin River, there are only scattered narrow bands or small isolated bodies of greenstone and amphibolite.

Greenstone bands near the Coleman River are interbanded with pelitic and psammitic rocks. They are fine to coarse-grained massive green rocks, some of which have a relict igneous or epidioritic texture. One exposure consists of partly recrystallized amygdaloidal basalt.

The greenstones are composed of colourless or pale green tremolite-actinolite or pale bluish green partly altered hornblende, with subordinate plagioclase, quartz, clinozoisite, sphene, biotite, chlorite, sericite, and carbonate. The plagioclase ranges from partly recrystallized zoned grains with cores of andesine or labradorite rimmed by albite or oligoclase to unzoned grains of albite and oligoclase. Tremolite and primary chlorite and talc are characteristic of the magnesium-rich assemblages found as small lenses within the greenstone; the lenses may represent metamorphosed ultramafic rocks. Lenses of tremolite-chlorite or tremolite-talc rock are also present farther east.

The amphibolites, which are found mainly in the southeast, are greenish black, and schistose to massive or granoblastic. They are composed of bluish green, green, or rarely brown hornblende, andesine or labradorite, a little quartz, sphene, clinozoisite, calcite, and clinopyroxene.

Recrystallized and metasomatized rocks and migmatite were formed during the intrusion of the Cape York Peninsula Batholith. In the east, where the contact with the batholith is poorly exposed, there is a narrow zone along most of the contact in which the schist is penetrated by bands and dykes of leucocratic granite. The partial recrystallization of the schist was accompanied by minor potash metasomatism.

In the southeast, where there was extensive recrystallization and potash metasomatism, the biotite-muscovite-quartz schist grades into a coarser granoblastic rock towards the batholith. With increasing metamorphism spots of muscovite and microcline coalesce to form mica or feldspar-rich bands. Banded migmatite has been formed in places by the injection of quartzofeldspathic material. The gneiss west of Dixie homestead has been recrystallized and metasomatized, and is interbanded with granitic material in places.

In the contact metamorphic aureoles surrounding the granite plutons in the Potallah Creek area spots of biotite and garnet have developed in the phyllite and schist, and porphyroblasts, composed of chiastolite and a little fibrolite(?), have been formed in places. Occasional porphyroblasts of cordierite(?) have been developed in the phyllite near the Kennedy Road south of the Archer River, and some of the muscovite in the schist near the granite contact has been recrystallized.

Sefton Metamorphics
(Whitaker & Willmott, 1969a)

Derivation of name

The Sefton Metamorphics were named after Sefton Creek in the Coen Sheet area. The formation includes all the metamorphic rocks referred to informally by the Broken Hill Pty Co. Ltd (BHP, 1962) as the Sefton Group, Iron Range Group, Bowden Group, and Bolt Head Limestone.

Distribution

The metamorphics are exposed over about 450 km^2 in the Cape Weymouth Sheet area and northern part of the Coen Sheet area. They crop out in four main regions: the Mount Carter Block and a belt extending 30 km to the south; a north-trending belt between the Iron Range airstrip and the Pascoe River; three small outcrops on headlands in Temple Bay; and several small bodies in the Bowden area. The rocks in the first three regions were called the Mount Carter Schist, Iron Range Schist, and Bolt Head Schist by Whitaker & Willmott (1969a), but as similar rock types are present in all three areas, this terminology has been abandoned.

The metamorphics are well exposed in gorges in the Mount Carter Block and on wave-cut platforms in Temple Bay. Elsewhere they are generally poorly exposed except along quartzite ridges south of Mount Carter, near Bowden, and in the Iron Range area.

Lithology

The Sefton Metamorphics are composed of fine-grained muscovite-quartz schist and quartzite interbanded with subordinate phyllite, muscovite-biotite-quartz-feldspar schist, hematite-quartz schist, magnetite quartzite, greenstone, amphibolite, schistose limestone, and calc-silicate rocks. The only rock type shown separately on the map is a belt of greenstone near Iron Range. The iron-bearing rocks near Iron Range were examined in detail by the Broken Hill Pty Co. Ltd between 1957 and 1962 (BHP, 1962; Canavan, 1965b).

The interbanded *muscovite-quartz schist* and *muscovite quartzite* grade from schist containing about 50 percent quartz to quartzite composed of quartz and a little muscovite. In the western part of the Mount Carter Block fine-grained schist grades into phyllite. The grainsize increases to the east and south in the Mount Carter Block, and along the belt to the south; some of the rocks at the southern end of the belt are gneissic. The schist at Mount Carter contains up to 15 percent biotite in places. A little tourmaline occurs in the biotite-bearing schist in the eastern and central parts of the block, and some of the fine-grained rocks probably contain a little graphite and hematite. The schist on the southern and eastern margins contains scattered grains and porphyroblasts of andalusite.

Near Iron Range the schist is well exposed only where it is interbanded with resistant quartzite. In Scrubby Creek, 7 km west of Iron Range airstrip, bands of graphite-muscovite-quartz schist and muscovite-oligoclase-quartz schist are associated with muscovite quartzite and schistose conglomerate. The pebbles in the conglomerate consist of feldspathic quartzite and some fine-grained graphitic rocks. Graphitic phyllite crops out intermittently in this creek, and also 5 km farther south.

Reid (1959) notes that the mica schist in the diamond drill cores at Lamond Hill, 7 km north of Iron Range airstrip, are composed of calcite (20%), quartz (20%), and muscovite with some biotite and chlorite (60%). The schist about 8 km north of Lamond Hill contains porphyroblasts of altered cordierite (?), abundant biotite and muscovite, and quartz.

Muscovite quartzite is common in the hills northeast of Iron Range airstrip and along the western margin of the metamorphics to the south of the Kennedy Road. It contains a little chlorite, and graphite or iron oxide. A few porphyroblasts of altered cordierite (?) occur in the quartzite in the West Claudie River near the Kennedy Road.

At Bolt Head in the Temple Bay area muscovite-quartz schist and quartzite are interbanded with schistose limestone. The schist is a dark grey fine-grained rock composed of quartz, muscovite, and chlorite (?). In places the schistosity is crenulated and strain-slip cleavage is developed.

In the Bowden region there are several small outcrops of muscovite-quartz schist and muscovite quartzite to the west of the Kennedy Road, between the crossing on the Pascoe

River and Garraway Creek. The rocks range from phyllite to coarse schist. The large outcrop of metamorphics on Canoe Creek is composed of quartzite and muscovite-quartz phyllite; in the south the phyllite contains knots of altered andalusite (?). The large outcrop, 8 km to the south, is composed of coarse muscovite-quartz schist, with books of mica up to 4 cm across, cut by irregular veins of quartz, quartz-tourmaline rock, and sheared granite.

The small bodies of muscovite-quartz schist in the Kintore Adamellite along the southwest margin of the Weymouth Granite, between the Pascoe River and Sefton Creek, contain graphite and small crystals of tourmaline in places. In some exposures the schistosity is crenulated.

Muscovite-biotite-quartz-feldspar schist is interbanded with muscovite-quartz schist and muscovite quartzite in a belt to the north of Falloch Creek in the Coen Sheet area. The schist is generally medium or coarse-grained, and in places it becomes gneissic and contains thin segregations of biotite-quartz rock. The proportion of microcline and cloudy sodic andesine present is variable.

The *hematite-quartz schist,* forming the high ridge of Lamond Hill and nearby ridges, is composed of tightly folded bands of quartz, from 1 mm to 10 cm thick, alternating with slightly thicker bands of red platy hematite and scattered crystals of magnetite. The hematite-quartz schist contains bands, several metres thick, of muscovite quartzite, muscovite-quartz schist, and calcite-quartz-mica schist.

The *magnetite quartzite* at Black Hill, 23 km north of Iron Range airstrip, and other prominent hills nearby, has been leached of silica to form a massive laterite rich in iron and manganese (BHP, 1962). Drilling by the Broken Hill Pty Co. Ltd (Sheppard & Jobling, 1960; Lee & Forsythe, 1961) has shown that the laterite has been derived mainly from amphibole-bearing magnetite quartzite, which grades along strike into amphibole-quartz rock. The amphiboles in the magnetite quartzite have been shown by BHP geologists to consist of hornblende with subordinate tremolite, actinolite, cummingtonite, grunerite, and riebeckite; other minerals in the quartzite are hypersthene, epidote, garnet, fayalite, calcite, rhodocrosite, and iron sulphides. The amphibole quartzite is thus similar to the silica-rich calc-silicate rocks found in the Coen Metamorphics to the south.

A subdued ridge of *greenstone* extends north and south of the Kennedy Road to the west of Iron Range. At Yarraman Creek south of the Kennedy Road the rock is a dark bluish grey medium-grained metadolerite with a relict ophitic texture. It is composed of sericitized plagioclase, augite, chlorite, and a little quartz. The greenstone near the Kennedy Road, which is probably an altered lava, is composed of quartz, actinolite, epidote, and cloudy plagioclase. The rock contains up to 20 percent quartz, which is commonly concentrated in small aggregates, set in a fine-grained groundmass composed of epidote or plagioclase and subordinate actinolite. Amygdales filled with epidote, calcite, or quartz, occur in places. The greenstone north of the Kennedy Road is poorly exposed, but Reid (1959) has recorded the presence of magnetite-albite-quartz-epidote-hornblende schist.

Lee & Forsythe (1961) consider that the magnetite-glaucophane-amphibole rock and banded magnetite-quartz-hornblende rock in the drill cores at Black Hill are altered basic igneous rocks.

Several poorly exposed concordant bands of *amphibolite* crop out in the southern part of the belt of metamorphics to the south of Mount Carter. One band is composed of green hornblende, altered plagioclase, quartz, opaque minerals, and a little biotite.

Schistose limestone crops out at Bolt Head and Limestone Point, 2 km to the south, on the coast of Temple Bay. The fine-grained limestone is light to dark grey and is cut by thin veins of calcite. It consists of a mosaic of interlocking calcite crystals which, in places, have a strong preferred orientation. In places the rock contains numerous thin bands of quartz or quartz and muscovite and grades into quartzite or muscovite-quartz schist. The dark grey variety contains small scattered grains of carbonaceous (?) material.

Calc-silicate rocks and marble are recorded by Lee & Forsythe (1961) in the drill cores at Black Hill. The rocks include impure marble, fine tremolite marble, tremolite-quartz schist with some diopside, and quartz-chlorite and quartz-biotite rocks with minor tremolite, diopside, and ilmenite. There are a few small exposures of banded granular quartz-diopside-plagioclase rock northeast of Black Hill, one of which contains a few porphyroblasts of garnet.

Another calc-silicate rock is exposed at Intruder Head, 5 km to the north of Bolt Head. It is composed of quartz (40%), green hornblende (30%), granules of diopside (30%), and a little plagioclase. The quartz and plagioclase are concentrated in bands and the hornblende has a marked preferred orientation. A few small ill defined lenses of calcite are also present.

PRECAMBRIAN(?) DOLERITE

In the western part of the Yambo Inlier dykes and irregular masses of dolerite intrude the metamorphic rocks. The dykes are up to 5 km long and occur in small swarms, mainly to the south of the Palmer River. They trend northwest or north. The irregular bodies of dolerite are up to 5 km long and 2 km wide; some of them are concordant with the foliation in the metamorphic rocks, but others are disconcordant. Occasional dolerite dykes are also present in the Holroyd Metamorphics north of the Coleman River, and in the Coen Metamorphics east of Yarraden homestead and north of Silver Plains homestead. The dolerite is generally more resistant than the metamorphic rocks, and forms small ridges covered with a bouldery dark reddish brown soil.

The dolerite consists of labradorite, or rarely bytownite, augite, poikilitic phenocrysts of colourless orthopyroxene (probably enstatite), hornblende, and scattered grains of magnetite. The hornblende forms small brown subhedral crystals, small lath-like phenocrysts, and a reddish brown type rimming and partly replacing the augite. Other minerals include a little sphene, apatite, biotite, spinel, and olivine(?), and secondary actinolite, chlorite, and calcite.

The dykes were intruded after the regional metamorphism, but before the emplacement of the Cape York Peninsula Batholith, as altered dolerite is found as inclusions in the Kintore Adamellite in the Yambo Inlier. Farther north, near Glengarland homestead, a dolerite dyke has been thermally metamorphosed by the Kintore Adamellite.

MIDDLE PALAEOZOIC: CAPE YORK PENINSULA BATHOLITH

Flyspeck Granodiorite
(Whitaker & Willmott, 1968)

Derivation of name

The Flyspeck Granodiorite was named after Flyspeck Creek, a tributary of the Coleman River, about 25 km northwest of Musgrave homestead in the Ebagoola Sheet area.

Distribution

The granodiorite comprises several large elongate intrusions, trending north-northwest, in the central part of the Cape York Peninsula Batholith, between Dixie homestead in the Hann River Sheet area and Falloch Creek 190 km to the north. There are two other intrusions near the western margin of the batholith, one northwest of the Alice River goldfield and the other north-northwest of Coen airport. Small bodies of granodiorite crop out north and northwest of Bald Hill in the Coen Sheet area, and also within the Kintore Adamellite along the eastern edge of the McIlwraith Range and in the centre of the range west of the Leo Creek mine. There are a few small patches of granodiorite within the Lankelly Adamellite east of Coen. The small bodies of diorite and granodiorite east of the Geikie Range and south of the Archer River, which are included in the Flyspeck Granodiorite, are intruded by the Morris Adamellite.

The granodiorite is moderately well exposed in creeks and as boulders. The soil on the granodiorite can be distinguished on the air-photographs by its dark tone.

Lithology and relationships

The Flyspeck Granodiorite consists of biotite granodiorite, which grades into adamellite, hornblende-biotite tonalite, and some biotite-hornblende diorite in the Coen Sheet area.

The hornblende-bearing rocks are sparsely but widely distributed, although they predominate in an area to the northwest of the Alice River goldfield. The transitional zone between the biotite granodiorite and hornblende-biotite tonalite ranges in width from 1 m to 1.5 km. The granodiorite is generally massive, but in places ill defined biotite-rich bands alternate with bands rich in quartz and feldspar.

To the northwest of the Alice River goldfield the rock has a weak vertical foliation parallel to the contact owing to the rough alignment of the hornblende and biotite crystals. The northern and southern margins of the intrusion west of Coen airport are gneissic and migmatitic, but towards the centre it becomes massive. In the south the granodiorite contains large phenocrysts of microcline, and is foliated parallel to the schistosity in the surrounding metamorphic rocks. To the north, banded or migmatitic granodiorite alternates irregularly with the porphyritic type. Fine-grained biotite-rich xenoliths occur in several places. A small body of gneissic granodiorite crops out at the base of the Mesozoic sandstone at the southern end of the Geikie Range.

Northeast of Ebagoola, southeast of Coen, and at Coen, the Flyspeck Granodiorite is cut by a number of shear zones. In the sheared rock the quartz grains are strained and in places broken, the plagioclase laths are bent or broken, and the biotite flakes recrystallized.

The Flyspeck Granodiorite is cut by numerous small acid or intermediate dykes, and occasional larger dykes up to 10 m thick and several kilometres long. The dykes have no overall preferred orientation, but tend to occur in groups consisting of several subparallel dykes. They range from rhyodacite to andesite, and consist mainly of a fine mosaic of anhedral quartz and untwinned feldspar, with chlorite in places; some contain small euhedral phenocrysts of quartz, plagioclase, or untwinned feldspar. The granodiorite is also cut by a few pegmatite dykes.

The contact between the Flyspeck Granodiorite and Kintore Adamellite is sharp. There is very little change in the granodiorite towards the contact, but muscovite granite is usually concentrated towards the margin of the Kintore Adamellite. Near the contact the Flyspeck Granodiorite is cut by dykes and veins of muscovite granite pegmatite associated with the Kintore Adamellite, but northwest of the Alice River goldfield the Flyspeck Granodiorite intrudes the migmatite along the contact of the Kintore Adamellite. West of the Leo Creek mine the Kintore Adamellite appears to be intruded by small bodies of biotite granodiorite.

East of the southern end of the Geikie Range, granodiorite and diorite are intruded by coarse porphyritic biotite adamellite of the Morris Adamellite, and the Wigan Adamellite intrudes fine-grained biotite-hornblende granodiorite east of Bald Hill.

Petrography

Modal analysis (Table 11) shows that there is more variation within the Flyspeck Granodiorite than in any other unit in the batholith. In contrast to most other units the quartz content varies considerably as does the total content of mafic minerals. Coupled with these are variations in the ratio of potash feldspar to plagioclase and biotite to hornblende.

TABLE 11. MODES OF THE FLYSPECK GRANODIORITE

	1	2	3
Quartz	38	20	8
Plagioclase	35	53	47
Potash feldspar	17	tr	4
Biotite	9	16	13
Hornblende	—	10	27
Accessories	1	1	1

1. Biotite granodiorite. 38 km SW of Yarraden homestead. (BMR 66480284).
2. Hornblende-biotite tonalite, 13 km S of old Bamboo homestead. (BMR 66480279).
3. Biotite-hornblende diorite, 13 km W of Howard Range. (BMR 67480082).

The Flyspeck Granodiorite consists of quartz, microcline, laths of well twinned andesine (An_{32-42}), pinkish brown biotite, greenish brown hornblende, and a little allanite, zircon, and sphene. Microcline occurs as small anhedral grains, with occasional subhedral phenocrysts up to 1 cm long, containing inclusions of quartz, plagioclase, and biotite. The biotite, hornblende, and accessory minerals are commonly associated. Some of the quartz and andesine is strained, and the latter is commonly altered.

Aralba Adamellite
(Whitaker & Willmott, 1968)

Derivation of name

The name is taken from Aralba Creek, a south-bank tributary which joins the Palmer River 52 km west of Palmerville.

Distribution

The Aralba Adamellite consists of several large irregular bodies with a total area of about 380 km^2 in the northwest-central part of the Yambo Inlier. The adamellite is generally weathered, but is well exposed in the Palmer River and some of its larger tributaries. Two of the intrusions are largely concealed by residual sand and alluvium, and two others are exposed only as corestones in gently undulating country.

Lithology and relationships

The porphyritic biotite-muscovite adamellite is a light grey medium or coarse-grained rock containing large flakes of muscovite and numerous phenocrysts of microcline. It is similar to the Kintore Adamellite, but contains more muscovite. In places the porphyritic adamellite passes into an even-grained rock resembling the Kintore Adamellite, and in one locality it contains xenoliths of even-grained adamellite up to 2.5 m across.

In the northern part of the Yambo Inlier the contact between the Aralba and Kintore Adamellites is obscured by the presence of numerous dykes of garnet-muscovite granite pegmatite and aplite; the texture of the Aralba Adamellite does not appear to change near the contact and it may grade into the Kintore Adamellite.

The contact between the Aralba Adamellite and the Dargalong Metamorphics commonly consists of a zone about 500 m wide in which bands of adamellite become increasingly common in the metamorphic rocks. In places the gneiss grades into adamellite through a granular zone enriched in quartz and feldspar.

Petrography

The Aralba Adamellite (Table 12) consists of anhedral quartz, microcline, oligoclase (An_{24-28}), muscovite, biotite, and accessory zircon, apatite, and garnet. Most of the laths of microcline are about 1.5 cm long, but a few are up to 7 cm. The microcline phenocrysts contain inclusions of quartz and plagioclase. Biotite generally occurs as inclusions in the muscovite. The quartz is strained, and the elongate grains are aligned parallel to the weakly developed foliation.

TABLE 12. MODE OF THE ARALBA ADAMELLITE

	1
Quartz	37
Plagioclase	23
Potash feldspar	27
Muscovite	9
Biotite	4

1. Biotite muscovite adamellite, 32 km NE of King Junction homestead. (BMR 66480010).

Kintore Adamellite
(Whitaker & Willmott, 1968)

Derivation of name

The Kintore Adamellite was named after Kintore, a prominent hill 42 km southeast of Coen.

Distribution

The Kintore Adamellite forms about 65 percent of the Cape York Peninsula Batholith. It is exposed over an area of about 4500 km^2, between the Mitchell River in the south and Weymouth Bay to the north, and forms the bulk of the Coleman and McIlwraith Plateaux. It is generally covered by soil or thick sand, and in lowland areas by Tertiary sandstone. Where well exposed it crops out as tors and low whalebacks. The adamellite underlying the Cainozoic sediments is generally deeply weathered.

Lithology and relationships

The Kintore Adamellite consists mainly of biotite-muscovite adamellite grading into granite, and muscovite-biotite adamellite grading into granodiorite. Some muscovite granite and garnet-muscovite granite pegmatite and aplite occur near the margins of the batholith.

The adamellite is a grey fine or medium-grained rock composed of quartz, microcline, plagioclase, muscovite, and biotite with accessory garnet in places. It is generally even-grained, though small bodies with microcline phenocrysts up to several centimetres long are widely distributed.

In the Coen Sheet area biotite generally predominates over muscovite, and with an increase in the proportion of plagioclase and decrease in muscovite the adamellite grades in places into leucocratic biotite granodiorite. In the Yambo Inlier there are a few small discrete bodies of leucocratic adamellite containing less than 5 percent mica.

Some of the numerous small bodies of muscovite granite in the Kintore Adamellite contain microcline phenocrysts up to 30 cm long. Diffuse bodies of fine-grained garnet-muscovite granite are commonly associated with the porphyritic muscovite granite near the margin of the batholith.

Irregular bodies, veins, and dykes of garnet-muscovite granite pegmatite and banded aplite are associated with the garnet-muscovite granite. In places they form well defined cross-cutting bodies, but elsewhere they merge into the surrounding garnet-muscovite granite or biotite-muscovite adamellite. Along the margin of the batholith the adamellite and surrounding metamorphics are cut by reefs of massive white quartz ranging from 50 cm to 20 m wide and from a few metres to 1 km long; one quartz dyke extends for 8 km. Rhyodacite, dacite, and andesite dykes cut the Kintore Adamellite in a number of places.

The stocks of muscovite-biotite adamellite or muscovite granite on the west flank of the batholith in the Hann River and Ebagoola Sheet areas are subcircular or irregular in plan and range from 5 to about 120 km^2 in area. Porphyritic muscovite granite, garnet-muscovite granite, garnet-muscovite granite pegmatite, and aplite are common near the margins of the stocks. Some of the stocks are surrounded by discontinuous zones, up to 1 km wide, containing numerous reefs of massive white quartz.

Faint compositional banding occurs in a number of places, especially near the margin of the batholith where the rocks grade into migmatite. The partial alignment of the mica and microcline phenocrysts commonly imparts a poorly defined foliation to the adamellite.

Bodies of schist, gneiss, amphibolite, and calc-silicate rock, from 1 m to several kilometres long, occur within the Kintore Adamellite. They are intimately penetrated by the adamellite and particularly by the garnet-muscovite granite.

Shearing is common in the Kintore Adamellite from the Yambo Inlier to the northern fall of the Archer River. Some of the shear zones are over 30 km long and up to 100 m wide. In them, quartz is elongate and strained, mica preferentially aligned, feldspar crystals fractured and granulated, and both altered to chlorite. The strong foliation in the adamellite adjacent to some of the shear zones suggests that movement may have begun before the rock was completely consolidated, but in other places the sheared rocks are mylonitized and recrystallized. In one exposure the shearing appears to have preceded the emplacement of the pegmatite and aplite.

The direction of shearing is generally between north and northwest, parallel to the regional trend of the foliation and schistosity in the metamorphic rocks. A few of the shear zones trend north-northeast.

Acid dykes up to 30 m wide and a few kilometres long cut the Kintore Adamellite, particularly in the coastal ranges, the McIlwraith Range, and the northern part of the Ebagoola Sheet area. Most of them consist of pink rhyolite or rhyodacite, but some are coloured light green by chlorite. A few small dykes of andesite are present in the same area, and a dyke of dacite (?), 400 m wide, cuts the contact between the adamellite and metamorphic rocks about 10 km north of Yarraden.

Petrography

Modal analyses of the Kintore Adamellite are given in Table 13.

TABLE 13. MODES OF THE KINTORE ADAMELLITE

	1	2	3	4	5	6
Quartz	36	39	33	38	35	36
Plagioclase	13	18	30	25	26	39
Potash feldspar	37	31	28	24	27	10
Muscovite	13	8	8	3	—	3
Biotite	<1	4	1	10	12	12

1. Muscovite granite, 18 km ENE of Birthday Mountain. (BMR 67480050).
2. Biotite-muscovite granite, 22 km NW of Coen. (BMR 67480096).
3. Biotite-muscovite adamellite, 26 km SSW of Bowden. (BMR 67480304).
4. Muscovite-biotite adamellite, 18 km E of Birthday Mountain. (BMR 67480048).
5. Biotite adamellite, 18 km NE of Birthday Mountain. (BMR 67480053).
6. Muscovite-biotite granodiorite, 20 km ENE of Birthday Mountain. (BMR 67480051).

The Kintore Adamellite contains anhedral quartz, microcline, well twinned oligoclase or andesine (An_{20-37}), muscovite, pinkish brown or reddish brown biotite, and accessory garnet, zircon, and apatite. The rare phenocrysts of microcline contain inclusions of mica, plagioclase, and quartz. The plagioclase laths are commonly twinned and partly altered. Some of the quartz is strained, and the biotite is commonly altered.

The considerable variation in the modal composition of the Kintore Adamellite (Table 13) is due almost entirely to variations in the proportion of potash feldspar to plagioclase and of muscovite to biotite. The total quartz, feldspar, and mica contents are constant to within a few percent.

Lankelly Adamellite
(Whitaker & Willmott, 1968)

Derivation of name

The Lankelly Adamellite was named after Lankelly Creek, a tributary of the Coen River northeast of Coen.

Distribution

The adamellite extends northwards for 30 km from Little Stewart Creek to Mount Croll, 10 km east of Coen airport, and forms the high plateau of the McIlwraith Range, east of Coen. The total area is about 500 km^2.

Lithology and relationships

The Lankelly Adamellite is a grey porphyritic biotite adamellite with numerous phenocrysts of pale pink microcline up to 4 cm long. It generally contains only a little muscovite, but in places the rock grades into biotite-muscovite adamellite similar to the Kintore Adamellite. The zones of leucocratic muscovite granite up to 500 m across along the southern margin of the Lankelly Adamellite are associated with veins and dykes of muscovite granite pegmatite and aplite.

In places the microcline phenocrysts have a preferred orientation and are concentrated in bands; elsewhere bands and dykes of muscovite granite pegmatite and aplite alternate with bands of even-grained leucocratic adamellite. Near the summit of the McIlwraith Range and at the mouth of Massey Creek gorge to the east, bands of even-grained biotite adamellite alternate with bands of porphyritic adamellite, and near the second locality the porphyritic adamellite is cut by dykes of fine even-grained pink leucocratic biotite adamellite up to 200 m wide. Biotite-rich xenoliths from 50 cm to 3 m across are also common in this area. The zones of fine even-grained biotite granodiorite within the Lankelly Adamellite closely resemble the Flyspeck Granodiorite.

South of Coen, where there is an increase in the proportion of muscovite and a decrease in the number of microcline phenocrysts, the Lankelly Adamellite grades into the Kintore Adamellite. The presence of local zones of even-grained muscovite-biotite adamellite, leucocratic muscovite granite, and muscovite granite pegmatite and aplite within the Lankelly Adamellite suggests that it is closely related to the Kintore Adamellite.

Small bodies of metamorphic rock, ranging from a few metres to a kilometre across, are particularly common near the southeast boundary, where the Lankelly Adamellite is separated from the Dargalong Metamorphics to the west by a shear zone. As the shear zone is approached the microcline phenocrysts become aligned and then ruptured, quartz is recrystallized to a mosaic of small grains, and biotite and plagioclase are altered to chlorite and sericite respectively; thin bands of quartz-feldspar rock impart a foliation to the adamellite.

Petrography

The Lankelly Adamellite (Table 14) is composed of strained anhedral quartz, twinned phenocrysts of microcline, well twinned andesine (An_{30-39}), yellow to reddish brown biotite,

TABLE 14. MODE OF THE LANKELLY ADAMELLITE

	1
Quartz	28
Plagioclase	31
Potash feldspar	26
Muscovite	3
Biotite	12

1. Porphyritic muscovite-biotite adamellite, 19 km SE of Coen. (BMR 66480226).

muscovite, and a little apatite and zircon. The microcline laths contain included plagioclase, quartz, and mica. The andesine is commonly zoned and partly altered. Muscovite and zircon are associated with the biotite.

With an increase in the abundance of microcline and muscovite and a decrease in biotite the rock probably grades into granite in places.

Wigan Adamellite
(Whitaker & Willmott, 1969a)

Derivation of name

The name is taken from the Parish of Wigan, between Bald Hill and the Wenlock River.

Distribution

The Wigan Adamellite is an annular body with an area of about 120 km^2 between Bald Hill and the south flank of the Sir William Thompson Range in the northern part of the Coen Sheet area. The adamellite is well exposed as boulders on the flanks of low hills rising from the alluvial and sand-covered plains.

Lithology and relationships

The Wigan Adamellite ranges from leucocratic biotite adamellite and granite, containing small phenocrysts of feldspar and small clots or streaks of biotite, to even-grained biotite adamellite and granodiorite in which the biotite is finely disseminated.

Andalusite and cordierite are present south of Sefton Creek and north of Bald Hill. These minerals were probably formed as a result of the recrystallization of aluminous metamorphic rocks, but some of the discrete hexagonal crystals of cordierite may have crystallized from a granite melt locally enriched in alumina (Joplin, 1964). No cordierite has been recorded in the neighbouring Sefton Metamorphics.

A few dykes and irregular patches of granite pegmatite and aplite occur in the Wigan Adamellite, mainly near the contacts. The patches of pegmatite and aplite generally grade into the adamellite.

South of the Wenlock River the Wigan Adamellite is cut by two shear zones trending north and north-northwest. In the more intensely sheared zone the quartz grains are crushed or strained, the feldspar crystals are deformed and altered, and the streaky biotite is partly or wholly replaced by chlorite. In the less intensely sheared zone the adamellite is foliated parallel to the sheer zones.

In Sefton Creek the contact between the Wigan Adamellite and the upper Palaeozoic Weymouth Granite is sharp, and nearby the Wigan Adamellite is cut by a dyke of pink aplite, which is probably related to the Weymouth Granite; the pink aplite along the eastern margin of the Wigan Adamellite has also been mapped as Weymouth Granite. The contact with the upper Palaeozoic hybrid and dioritic rocks is also sharp, but the contact with the Kintore Adamellite 7 km northeast of Bald Hill appears to be gradational, though part of it may be faulted. The Wigan Adamellite is faulted against the Wolverton Adamellite 8 km north of Bald Hill, but 3 km to the south it intrudes and metamorphoses a biotite-hornblende microgranodiorite, which has been tentatively mapped as Flyspeck Granodiorite. The micro-granodiorite consists of intergrowths of hornblende and actinolite, and a little plagioclase and quartz, set in a hornfelsed groundmass.

Petrography

Modal analyses of the Wigan Adamellite are given in Table 15.

The Wigan Adamellite is composed of quartz, microcline perthite, oligoclase or andesine (An_{28-34}), yellow to brown biotite, muscovite, and accessory zircon, apatite, allanite, and sphene. Pale pink enhedral andalusite, and partly altered cordierite occur in several specimens. The microcline phenocrysts usually contain inclusions of quartz and plagioclase. The plagioclase laths are commonly twinned and partly or wholly altered. The muscovite and the accessory minerals are usually associated with biotite.

The considerable variation in modal composition of the Wigan Adamellite (Table 15) is due to variation in the ratio of potash feldspar to plagioclase and the content of muscovite and biotite. The proportion of quartz is constant, and the total feldspar content varies by less than 13 percent.

TABLE 15. MODES OF THE WIGAN ADAMELLITE

	1	2	3	4
Quartz	36	36	36	38
Plagioclase	19	13	27	43
Potash feldspar	44	43	33	7
Muscovite	—	2	3	—
Biotite	—	6	1	12
Accessories	1	—	—	—

1. Leucocratic microgranite, 26 km SE of Wenlock. (BMR 67480275).
2. Muscovite-biotite granite, 22 km SE of Wenlock. (BMR 67480272).
3. Biotite-muscovite adamellite, 24 km SE of Wenlock. (BMR 67480333).
4. Biotite granodiorite, 19 km ENE of Wenlock. (BMR 67480037).

Morris Adamellite
(Whitaker & Willmott, 1969a)

Derivation of name

The Morris Adamellite was named after the Parish of Morris, south of the Archer River, in the Coen Sheet area.

Distribution

The adamellite is an elongate body, about 30 km long and up to 8 km wide, which covers an area of about 150 km^2 to the north and south of the Archer River. It is best exposed at the base of the Mesozoic escarpment, and in the Archer River.

Lithology and relationships

The main biotite adamellite is a light grey medium or coarse-grained rock with subhedral phenocrysts of microcline microperthite up to 4 cm long.

Small bodies of well jointed leucocratic fine or medium-grained muscovite-biotite adamellite, up to 100 m across, crop out to the north of Geikie Creek. They grade laterally into biotite adamellite, which is cut by a few veins of aplite and pegmatite. A very small body of biotite granite is also exposed near Geikie Creek.

Round or elliptical xenoliths are common in the Morris Adamellite. They average about 30 cm in diameter, but range up to 2 m across, and consist of dark grey fine-grained biotite adamellite, with small phenocrysts of quartz and plagioclase in places. They contain less quartz than the host rock and are richer in sphene, zircon, apatite, and allanite.

In the east the contact between the Morris Adamellite and the sheared Kintore Adamellite appears to be partly faulted and partly intrusive; in the south and west the Morris Adamellite includes schist and quartzite of the Holroyd Metamorphics. In the southwest, the adjacent metamorphics are intruded and recrystallized by pegmatite dykes, which are probably related to the Morris Adamellite. The dykes are composed of albite, quartz, tourmaline, and minor muscovite; perthite occurs only in the dykes near the adamellite. The tourmaline crystals are up to 15 cm across and 30 cm long; they are embedded in the quartz, generally with their long axes at right angles to the walls of the dyke.

Petrography

Modal analyses of the Morris Adamellite are given in Table 16.

TABLE 16. MODES OF THE MORRIS ADAMELLITE

	1	2
Quartz	38	35
Plagioclase	32	26
Potash feldspar	29	24
Muscovite	tr	—
Biotite	1	15

1. Leucocratic adamellite, 32 km S of Wenlock. (BMR 67480141).
2. Porphyritic biotite adamellite. 30 km S of Wenlock. (BMR 67480132).

The adamellite consists of quartz, microperthitic microcline, oligoclase or andesine, light to dark brown biotite, and accessory apatite, allanite, and sphene. The numerous phenocrysts of microcline usually contain inclusions of quartz and plagioclase. The plagioclase laths are commonly zoned and rimmed by albite; they are usually partly altered.

The leucocratic phase (Table 16) is distinguished by the paucity of biotite. The rocks containing a high proportion of phenocrysts probably have a granitic composition.

Blue Mountains Adamellite
(Whitaker & Willmott, 1969a)

Derivation of name

The name is taken from the Blue Mountains, an isolated northwestern spur of the McIlwraith Range.

Distribution

The adamellite crops out over about 80 km^2 to the west and northwest of the McIlwraith Range, in the centre of the Coen Sheet area. The largest exposures include Birthday Mountain and the western part of the Blue Mountains. Of the smaller bodies on the west flank of the McIlwraith Range, one lies between Beetle Creek and Wilson Creek, and the other on the east side of the Blue Mountains. The adamellite is also exposed at Ben Lomond, to the north, and in the headwaters of Falloch and Hull Creeks. The adamellite is generally well exposed and commonly weathers into large boulders.

Lithology

The Blue Mountains Adamellite consists of massive pinkish grey fine even-grained biotite adamellite, subordinate coarse hornblende-biotite adamellite, and a little leucocratic granite.

The coarse hornblende-biotite adamellite crops out in the headwaters of Hull and Falloch Creeks, at the west end of the Blue Mountains, and as small patches elsewhere. In places the rock contains phenocrysts of bright pink potash feldspar. Along the west side of the Blue Mountains the adamellite grades into fine-grained leucocratic granite, and at Ben Lomond a coarse leucocratic granite with very little biotite crops out.

In contrast to the Kintore Adamellite, the Blue Mountains Adamellite is massive, non-foliated, and unbanded. It contains no inclusions of metamorphic rock; pegmatites and aplites are also absent.

At the east end of the Blue Mountains, there is a sharp contact between the coarse hornblende-biotite adamellite and the Kintore Adamellite, and the Blue Mountains Adamellite is cut by small veins of muscovite aplite.

Petrography

Modes of the Blue Mountains Adamellite are given in Table 17.

TABLE 17. MODES OF THE BLUE MOUNTAINS ADAMELLITE

	1	2	3	4
Quartz	27	32	42	28
Plagioclase	20	17	26	29
Potash feldspar	51	43	27	32
Biotite	1	4	5	9
Hornblende	—	3	—	1
Allanite	} 1	1	tr	} 1
Sphene		tr	1	

1. Leucocratic granite, N end of Birthday Mountain. (BMR 67480032).
2. Hornblende-biotite granite, 10 kgm W of Howard Range. (BMR 67480076).
3. Biotite adamellite, 21 km NE of Coen airport. (BMR 67480068).
4. Hornblende-biotite adamellite. 10 km W of Howard Range. (BMR 67480075).

The adamellite consists of quartz, orthoclase or microcline perthite, oligoclase or andesine (An_{28-36}), yellow to brown biotite, hornblende, and accessory sphene, allanite, zircon, and apatite. The potash feldspar commonly forms anhedral phenocrysts enclosing quartz and plagioclase. The hornblende and accessory minerals are associated with the biotite. Evidence of straining includes the undulose extinction of the quartz and the presence of kinked flakes of biotite.

The variations in rock type (Table 17) are governed by the relative abundance of potash feldspar, biotite, and hornblende. The more mafic rocks contain a higher proportion of accessory minerals.

LOWER CARBONIFEROUS SEDIMENTARY ROCKS

Pascoe River Beds

(Whitaker & Willmott, 1969a, amended)

Derivation of name

The Pascoe River Beds of Morton (1924) were referred to as the Hamilton Group by the Broken Hill Pty Co. Ltd (BHP, 1962) and as the Pascoe River Group by Australian Aquitaine Petroleum Ltd (AAP, 1965). The sediments were renamed the Pascoe River Beds by Whitaker & Willmott (1969a) because they are not well enough exposed to be subdivided into formations, and because the base of the sequence was not located.

Distribution

The Pascoe River Beds crop out in the valley of the Pascoe River and in several of its small west-bank tributaries, in the valleys of Garraway, Brown, and Hamilton Creeks, and in an unnamed stream between Hamilton Creek and the Pascoe River (Fig. 42). The sediments forming Haggerstone Island, 13 km southeast of Cape Grenville, on the northern edge of the Cape Weymouth Sheet area, are correlated with the Pascoe River Beds. The most extensive and continuous exposures are found in the middle reaches of the Pascoe River from 3 km north of the confluence with Garraway Creek to 3 km east of the junction with Hamilton Creek. The sediments only crop out where the overlying Janet Ranges Volcanics, Mesozoic sediments, and Yam Creek Beds have been stripped off. Most of the exposures are in the beds of streams and are under water during the wet season. The beds are generally deeply weathered.

Lithology

The Pascoe River Beds were informally divided into seven formations by Australian Aquitaine Petroleum Ltd (AAP, 1965), but these units have not been defined because the beds are so poorly exposed and because they may be repeated by faulting and folding. However, the sequence in the Pascoe River and its west-bank tributaries has been divided into three associations (Fig. 42), which broadly correspond with three of the formations proposed by Australian Aquitaine Petroleum: a carbonaceous shale/coal association, an arkose/greywacke association, and a siliceous siltstone/chert/greywacke association. These lithological associations have not been recognized elsewhere.

In the carbonaceous shale/coal association carbonaceous shale and siltstone, grading into fine carbonaceous sandstone, predominate. Some poorly sorted lithic greywacke and thin bands of coal or carbonaceous shale are present in places. The arkose/greywacke association is characterized by the abundance of medium or coarse-grained arkose or feldspathic sandstone, interbedded with subordinate feldspathic greywacke, tuffaceous sandstone, and tuff. All the sediments are massive and thickly bedded. The siltstone/chert/greywacke association comprises siliceous carbonaceous siltstone and shale, chert, lithic greywacke, and subordinate subgreywacke, tuffaceous sandstone, and volcanic(?) breccia.

About 1000 m of the Pascoe River Beds are exposed in the Pascoe River (AAP, 1965). The sequence in Garraway Creek consists of sandstone, lithic greywacke, tuffaceous sandstone, tuff, conglomerate, siltstone, and shale. The coarser sediments are more abundant, and in places they contain a considerable proportion of rock fragments. The siltstone and shale near the junction of Brown and Garraway Creeks are well bedded, massive, and in part carbonaceous. In places they have been partly silicified and slightly recrystallized. The sandstone, conglomerate, siltstone, and shale in Brown Creek contain a little interbedded chert.

Isolated outcrops of fine lithic greywacke, feldspathic greywacke, siltstone, and shale are exposed in a small east-bank tributary of the Pascoe River. The lithic greywacke is massive and well bedded and grades into feldspathic greywacke. The thinly bedded fissile siltstone and shale range from green or purple to dark grey. Siltstone, fine-grained sandstone, and lithic greywacke crop out in Hamilton Creek from 3 to 7 km upstream from the Pascoe River. About 13 km from the confluence there is a small exposure of argillaceous siltstone below

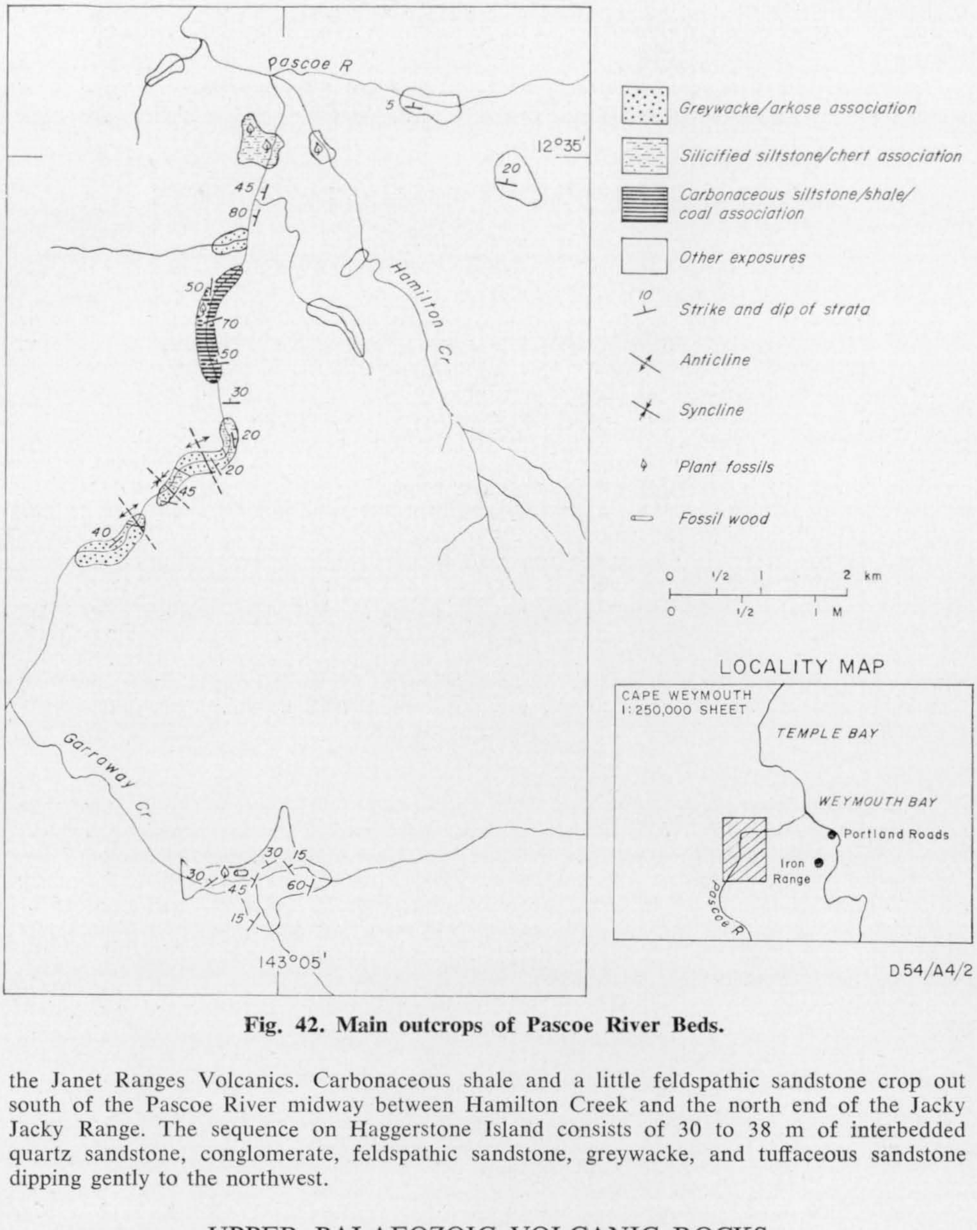


Fig. 42. Main outcrops of Pascoe River Beds.

the Janet Ranges Volcanics. Carbonaceous shale and a little feldspathic sandstone crop out south of the Pascoe River midway between Hamilton Creek and the north end of the Jacky Jacky Range. The sequence on Haggerstone Island consists of 30 to 38 m of interbedded quartz sandstone, conglomerate, feldspathic sandstone, greywacke, and tuffaceous sandstone dipping gently to the northwest.

UPPER PALAEOZOIC VOLCANIC ROCKS

Torres Strait Volcanics
(Whitaker & Willmott, 1969b, amended)

Derivation of name

The name Torres Strait Ignimbrite was introduced by Jones & Jones (1956) and was amended to Torres Strait Volcanics by Whitaker & Willmott (1969b).

Distribution

The most extensive area of outcrop covers 400 km^2 in the southern part of Torres Strait; it includes the west and north coast of Cape York Peninsula from Mutee Head to Albany Island, Mount Adolphus Island and adjacent islands, the islands of Endeavour Strait, and

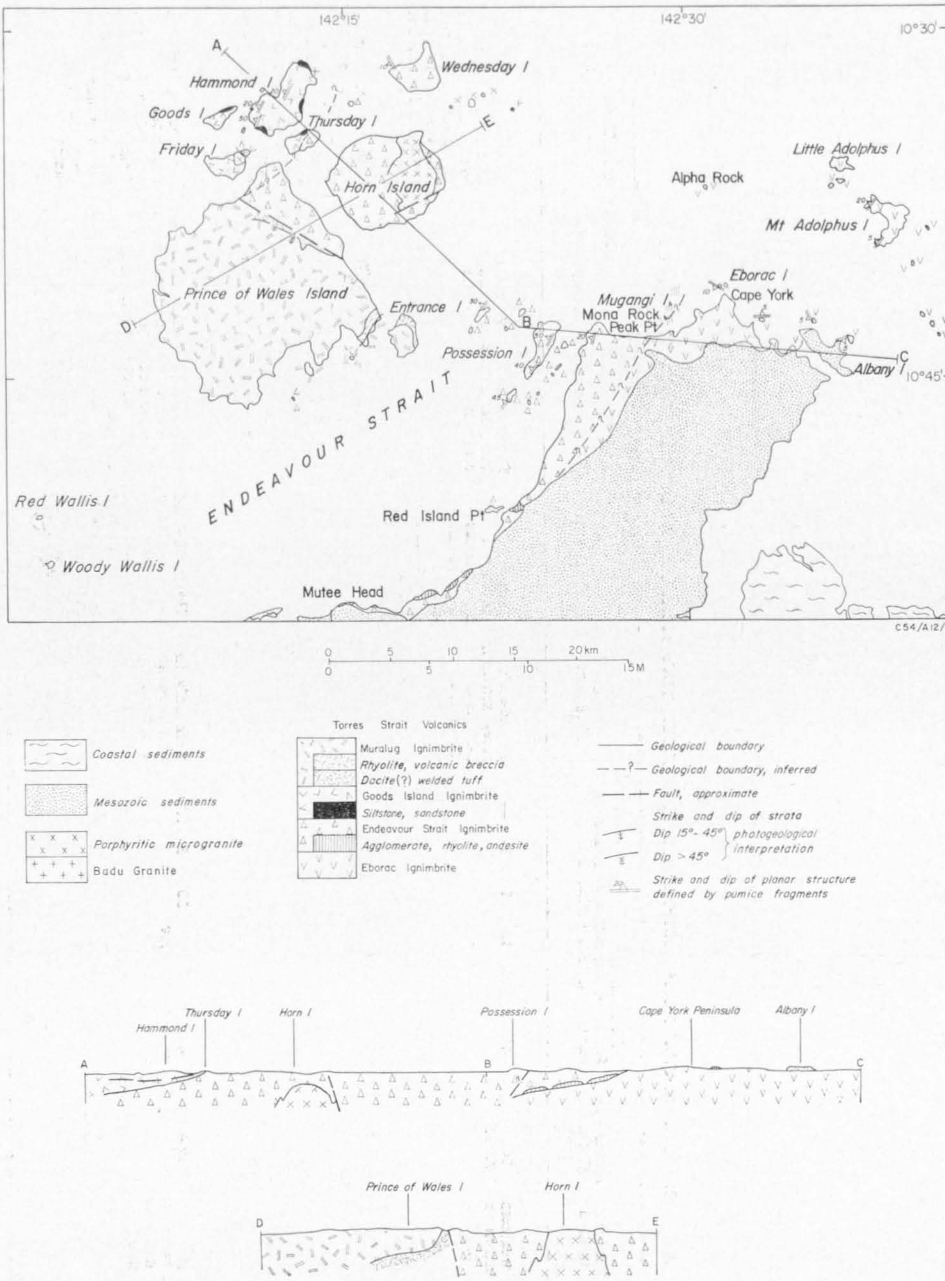


Fig. 43. Subdivision of Torres Strait Volcanics in southern part of Torres Strait.

Prince of Wales, Horn, Wednesday, Thursday, Friday, Hammond, and Goods Islands (Fig. 43). About 100 km^2 of volcanics are also exposed on islands to the north as far as the Papuan coast.

The volcanics form relatively infertile islands, up to 250 m high, consisting of broad rugged hills separated by sand-covered plains and valleys. The rocks are well exposed in headlands around many of the islands.

TABLE 18. DISTINGUISHING CHARACTERISTICS OF WELDED TUFF MEMBERS OF TORRES STRAIT VOLCANICS

Member	Thickness (m)	Colour and Composition	Phenocrysts							Pumice Fragments	Rock Fragments	Groundmass	Minor Rock Types	
			Abundance (% total rock)	Size (mm)	Composition (% total rock)								Composition	Location and Description
					Qtz	Al/F	Plag	Fm	Acc					
Muralug Ignimbrite	+150	Grey, weathers light brown to fawn; rhyolitic	10-20 Av 15	4	10	10	1	1	—	Abundant to rare; generally 5-30 cm; devitrified	Rare; devitrified structureless acid rocks; some intermediate rocks	Devitrified, but glass shards common	Volcanic breccia, rhyolite	Interbedded with tuff in SE part Prince of Wales and Entrance Is. Boulders of tuff and rhyolite breccia, averaging 50 cm, but ranging up to 2 m
													Dacite(?) welded tuff	Thin sheet under main mass at NE margin. Dark grey; 70% fragmented crystals of plagioclase, K-feldspar and ferromagnesian minerals. Also on Woody Wallis Is
Goods Island Ignimbrite	+80	Dark grey to black, weathers grey; dellenitic to dacitic	Av 45	4	10	10 Av	20	5	All	Seen only in thin section; devitrified	Up to 70% of rock in places; up to several cm long; black tuff similar to host. Some andesite and microscopic aggregates of plagioclase and amphibole	Devitrified to quartz, feldspar, and amphibole or chlorite	Carbonaceous and tuffaceous siltstone and sandstone	Interbedded tuff on Hammond, Goods, and Friday Is. Grey; fragments of quartz and feldspar crystals up to 3 mm. Poorly preserved plant remains

TABLE 18—(continued)

Member	Thickness (m)	Colour and Composition	Abundance (% total rock)	Phenocrysts Size (mm)	Composition (% total rock) Qtz	Al/F	Plag	Fm	Acc	Pumice Fragments	Rock Fragments	Groundmass	Minor Rock Types Composition	Location and Description
Endeavour Strait Ignimbrite	+100	Greenish grey or pinkish grey, weathers brown; rhyolitic	Av 45	6	15	20 Av	10	2	All	Seen only in thin section; devitrified	Abundant and small; larger pebbles and blocks in places. Structureless acid rocks, acid tuff, and intermediate rocks. Also microscopic aggregates of plagioclase and amphibole	Devitrified to quartz, feldspar, and chlorite; structureless	Agglomerate, volcanic breccia	Mutee Hd to Red Is Pt and Dayman I. Angular fragments of welded tuff, rhyolite, and andesite
													Andesite	S of Cowal Cr, Dumaralug I. Labradorite and hornblende laths in groundmass of chlorite and opaque minerals
													Rhyolite	Interbedded with above agglomerate, also on Mona Rock and Murangi I, where strongly spherulitic
													Recrystallized welded tuff, hornfels	On S and E coasts of Horn I, NE part Prince of Wales I
													Rhyolite	On Little Adolphus I and S end of Mt Adolphus I
Eborac Ignimbrite	+100	Light grey, weathers purple; rhyolitic	25-60 Av 30	5	15	15	3	—	Mz?	Generally rare; abundant and p to 1 m long on Albany, Adolphus, and Lacey Is.; devitrified	Rare, small; devitrified structureless acid rocks; tuff band with rhyolite fragments on Mt Adolphus I	Devitrified to quartz and feldspar; glass shards in places	Agglomerate	At Osnaburg Pt contains boulders of welded tuff

Abbreviations: Qtz, quartz; Fm, ferromagnesian minerals, mainly hornblende and biotite; All, allanite; Al/F, alkali feldspar, probably anorthoclase; Acc, accessories; Av. average; An, anorthoclase; Pl, plagioclase; Mz, monzonite.

Lithology

The Torres Strait Volcanics consist of crystal-rich rhyolite welded tuff and subordinate dacite or dellenite welded tuff, agglomerate, volcanic breccia, rhyolite, andesite, and interbedded sediments. In many places the volcanics have been recrystallized and hornfelsed by granitic rocks, and in the south they have been hydrothermally altered and mineralized. Four members have been recognized. The Eborac Ignimbrite is probably overlain by the Endeavour Strait Ignimbrite, which passes up gradually into the overlying Goods Island Ignimbrite. The Muralug Ignimbrite is faulted against the Endeavour Strait Ignimbrite, and its relationship to the other members is unknown. The lithology and petrography of each member are summarized in Table 18. The small outcrops of volcanics on the islands in the northern part of Torres Strait have been mapped as undivided Torres Strait Volcanics.

Eborac Ignimbrite

The Eborac Ignimbrite crops out over an area of about 28 km^2 along the north coast of Cape York Peninsula, from the west of Cape York to Albany Island, and on Mount Adolphus and adjacent islands (Fig. 43). The name is taken from Eborac Island a few hundred metres north of Cape York. It is composed of light grey rhyolite welded tuff, which contains abundant small phenocrysts of quartz and white or pale pink feldspar, but few fragments of rock or pumice. In places the tuff is crudely banded, and consists of alternating layers of crystal-rich and crystal-poor tuff about 15 cm thick. Some rhyolite and agglomerate crop out on Mount Adolphus and Little Adolphus Islands, and at Osnaburg Point on Albany Island. Near Cape York the member is at least 100 m thick, but the base is not exposed.

Endeavour Strait Ignimbrite

The Endeavour Strait Ignimbrite crops out over about 45 km^2 along the west coast of Cape York Peninsula from Mutee Head to Peak Point, on islands in Endeavour Strait, and on Horn, Prince of Wales, Thursday, and Wednesday Islands. The name is taken from Endeavour Strait, between the mainland and Prince of Wales Island. It consists of over 100 m of light greenish grey or pinkish grey rhyolite welded tuff, containing phenocrysts of quartz and pale pink feldspar, up to 1 cm long, and numerous small fragments of fine-grained acid and intermediate volcanic rocks and acid welded tuff; larger blocks are present in places. The pumice fragments can generally only be seen in thin section.

The agglomerate, volcanic breccia, rhyolite, and andesite, which crop out along the west coast of the peninsula between Red Island Point and Mutee Head, and the rhyolites on Mona Rock and Murangi Island, probably represent the basal part of the sequence overlying the Eborac Ignimbrite. The rhyolite on Murangi Island has a conspicuous spherulitic texture.

On the south and east coasts of Horn Island the welded tuff has been hornfelsed by an intrusion of porphyritic microgranite. The recrystallization decreases from east to west, where the hornfels appears to pass into unmetamorphosed welded tuff. The welded tuff in the northeastern part of Prince of Wales Island is also mildly recrystallized.

Goods Island Ignimbrite

The Goods Island Ignimbrite is exposed over about 27 km^2 on Goods, Prince of Wales, Friday, Hammond, and Thursday Islands. The name is taken from Goods Island. It consists of dark grey or black dacite and dellenite welded tuff, containing small phenocrysts of white feldspar and a few crystals of quartz and hornblende. Fragments of andesite and welded tuff, similar to the host rock, are common, but fragments of pumice can only be seen in thin section. The Goods Island Ignimbrite is similar in texture to the Endeavour Strait Ignimbrite, and on Thursday Island the boundary between the two units appears to be gradational in places.

Carbonaceous and tuffaceous siltstone and sandstone are interbedded with welded tuff on Hammond, Goods, and Thursday Islands. The grey carbonaceous siltstone contains interbeds from 5 mm to 15 cm thick of poorly sorted black tuffaceous sandstone. Poorly preserved plant remains have been found in the finer beds (Jones & Jones, 1956). A bed of limestone has been reported at the west end of Goods Island (P. O'Rourke, pers. comm.).

In the northeastern part of Hammond Island the welded tuff and interbedded siltstone have been recrystallized. The welded tuff has been only slightly affected, but the matrix of the siltstone is recrystallized and speckled with small aggregates of muscovite. The Goods Island Ignimbrite is at least 80 m thick, and the interbedded sediments on Thursday Island are up to 10 m thick.

Muralug Ignimbrite

The Muralug Ignimbrite crops out over an area of about 130 km^2 on Prince of Wales Island, Entrance Island, and the Wallis Islands. The name is taken from Muralug, the indigenous name for Prince of Wales Island. The member consists mainly of light grey rhyolite welded tuff containing small phenocrysts of quartz and pink feldspar. Compressed fragments of pumice up to 5 cm long are abundant in some outcrops, but absent in others; rock fragments are rare, except in the Wallis Islands.

Over much of Prince of Wales Island the Muralug Ignimbrite probably consists of a single massive horizontal sheet at least 150 m thick, but in the southeast and on Entrance Island the sequence consists of two similar sheets of welded tuff separated by up to 50 m of flow-banded rhyolite and volcanic breccia. Along the northeast margin of the unit the massive welded tuff unit is underlain by a number of thin welded tuff sheets of similar composition; one sheet is dark grey and is probably dacitic in composition. A thin bed of agglomerate or autobrecciated rhyolite and a thin band of dacite welded tuff are present on Woody Wallis Island.

Undivided Torres Strait Volcanics

The volcanics cropping out on islands in the northwestern part of Torres Strait have not been subdivided. *West Island* is composed of several sheets of dark grey or black welded tuff similar to the Goods Island Ignimbrite. Fragments of devitrified pumice and massive acid rocks are present in places, and in the northwest volcanic breccia. composed of angular fragments of welded tuff set in a tuffaceous matrix, is interbanded with the welded tuff. At the south end of the island, the volcanics are intruded by granite, but are not visibly recrystallized.

Two small outcrops of light grey recrystallized volcanic rocks surrounded by granite are exposed in the *Duncan Islands*. Quartz and feldspar phenocrysts can still be recognized in the altered volcanics. Hornfelsed volcanics also crop out 7 km south of Badu, on *Barney, Brown,* and *Clarke Islands* (Fig. 44). The hornfels is weakly foliated, and consists of thin bands of muscovite and biotite between folia of quartz and feldspar. On Clarke Island the rock has a gneissic texture, and small crystals of garnet are present in the biotite-rich bands. In the northern part of Barney Island recrystallized fragments of pumice up to 15 cm long are aligned parallel to the streaky texture. The fragments are undistorted and clearly indicate the pyroclastic origin of the rocks. Rounded aggregates of tourmaline up to 2 mm across are found in the hornfels on Brown Island.

A small body of brown welded tuff and black welded volcanic breccia or acid lava is exposed within the granite on the northeast side of *Badu Island.* The breccia or lava contains numerous angular fragments of welded tuff up to 8 cm long; the glass shards in the fragments are moderately to densely welded, but the matrix is faintly flow-banded; the welded tuff contains numerous fragments of pumice. The volcanics have been recrystallized for a short distance from the contact with the surrounding granite.

The southwestern half of *Moa Island* consists of recrystallized and hornfelsed volcanic rocks. Most of the rocks are composed of corroded phenocrysts of quartz and feldspar set in a recrystallized groundmass, but the more intensely recrystallized rocks near the granite contact contain porphyroblasts of andalusite, muscovite, biotite, and garnet set in a groundmass of cordierite, quartz, and feldspar. The ovoid andalusite porphyroblasts are up to 5 cm long, and are concentrated in bands up to 1 m thick. The aggregates of mica impart a weak foliation to the rock.

The southern end of *Mabuiag Island* is composed of massive pinkish grey welded tuff containing numerous phenocrysts of quartz and feldspar, but virtually no pumice or rock fragments. The leucocratic bands, up to 2 m long and 5 cm thick, noted in one outcrop may represent large compacted blocks of pumice. The welded tuff has been intruded by granite and porphyritic microgranite, but there is little evidence of recrystallization even at the contacts.

The southwest part of *Gabba Island* is composed of dark grey rhyolite welded tuff which contains small phenocrysts of feldspar and occasional crystals of quartz, fragments of pumice, and abundant rock fragments. The rock fragments include devitrified welded tuff, rhyolite, and some intermediate rocks. The fragments average 1.5 cm across and form up to 30 percent of the tuff. The groundmass is only slightly devitrified, and incipiently welded or moderately welded glass shards are clearly visible in thin section. In the north the welded tuff is intruded by granite and is recrystallized for about 5 m from the contact.

Dauan Island is composed of granite with a small outcrop of recrystallized welded tuff on the west coast. The groundmass of the tuff has been recrystallized, but the original porphyritic texture is generally preserved and rock fragments can be recognized in places; small aggregates of biotite are common. Near the granite contact the rock is finer and more even-grained, and passes into dark green hornfels composed of quartz (60%) and cordierite (40%) with a little biotite and muscovite.

Small patches of hornfelsed volcanics crop out near *Mabaduan* on the south coast of Papua. The volcanics are grey, medium-grained, granoblastic or weakly foliated, and are composed of quartz, feldspar, biotite, and numerous porphyroblasts of garnet up to 5 mm across. The foliation is defined by elongate aggregates of fine biotite.

Saddle Island is composed of two types of welded tuff. The non-porphyritic light grey fine-grained incipiently welded tuff forming the western hill is composed of small angular fragments of quartz and feldspar (up to 40%) set in a devitrified groundmass of very fine quartz and feldspar. The groundmass was probably mainly composed of glass shards, some of which can still be recognized in thin section. The tuff contains small fragments of other pyroclastic rocks in places, and a few blocks, up to 50 cm across, of bedded black mudstone were noted in some outcrops. In the east greenish grey welded tuff, similar to the Endeavour Strait Ignimbrite, is exposed. It overlies the welded tuff in the west, and dips gently southeast. The tuff contains blocks of bedded siltstone, and in places numerous fragments of pumice.

The *Harvey Rocks* 15 km south of Saddle Island are composed of welded tuff similar to the Endeavour Strait Ignimbrite.

Booby Island, Black Rock, and *Ninepin Rock* are composed of hydrothermally altered pyroclastic rocks.

Thickness and structure

The thickness of the Torres Strait Volcanics is unknown because the base is not exposed and much of the area of outcrop is covered by the sea. In the south the four members do not form a simple succession, but in many places they are probably over 300 m thick.

Bedding is seldom visible in the massive welded tuffs, and the attitude of the sheets has been deduced from the orientation of the compressed pumice fragments, which is assumed to be parallel to the surface on which the sheets were laid down. The Eborac Ignimbrite is flat or dips gently southwest. The Endeavour Strait Ignimbrite dips gently northwest and presumably overlies the Eborac Ignimbrite. The steep northwesterly dips measured on some of the islands of Endeavour Strait may be due to faulting. The Goods Island Ignimbrite, which also dips gently northwest except where disturbed by faulting, probably overlies the Endeavour Strait Ignimbrite.

On the air-photographs the main massive welded tuff sheet of the Muralug Ignimbrite appears to be horizontal, but along the northeast margin of the sheet the underlying thin vertical sheets of welded tuff form a prominent linear feature separating the Muralug Ignimbrite from the Endeavour Strait Ignimbrite. The steeply dipping tuff sheets may have been extruded along the boundary fault of a cauldron subsidence area formed after the eruption of the Endeavour Strait Ignimbrite (cf. Branch, 1966, p. 19).

On the northwest coast of Prince of Wales Island the pumice fragments dip steeply and their orientation is irregular over short distances. The steep dips may be due to folding, but it is more likely that they represent irregularities in the flow or compaction of the welded tuff. The dip and strike of the interbedded sediments in the Goods Island Ignimbrite vary considerably, and the tight small-scale folds in the sediments were probably developed as a result of slight flexuring of the massive welded tuff sheets.

Thermal metamorphism

The distribution of thermally metamorphosed Torres Strait Volcanics in the southern part of Torres Strait is shown in Figure 44; recrystallized volcanics are also found on the west coast of Dauan Island, and at Augaramuba Point and Marakara Island 5 km east of Mabaduan in Papua.

Metamorphism is most pronounced near the Badu Granite. Near the porphyritic microgranite metamorphism is generally restricted to slight recrystallization within 1 m of the contact. However, on Horn Island a wide zone of hornfels has been developed around the margin of a body of porphyritic microgranite, and a similar rock may be present at depth beneath recrystallized welded tuffs on Prince of Wales Island.

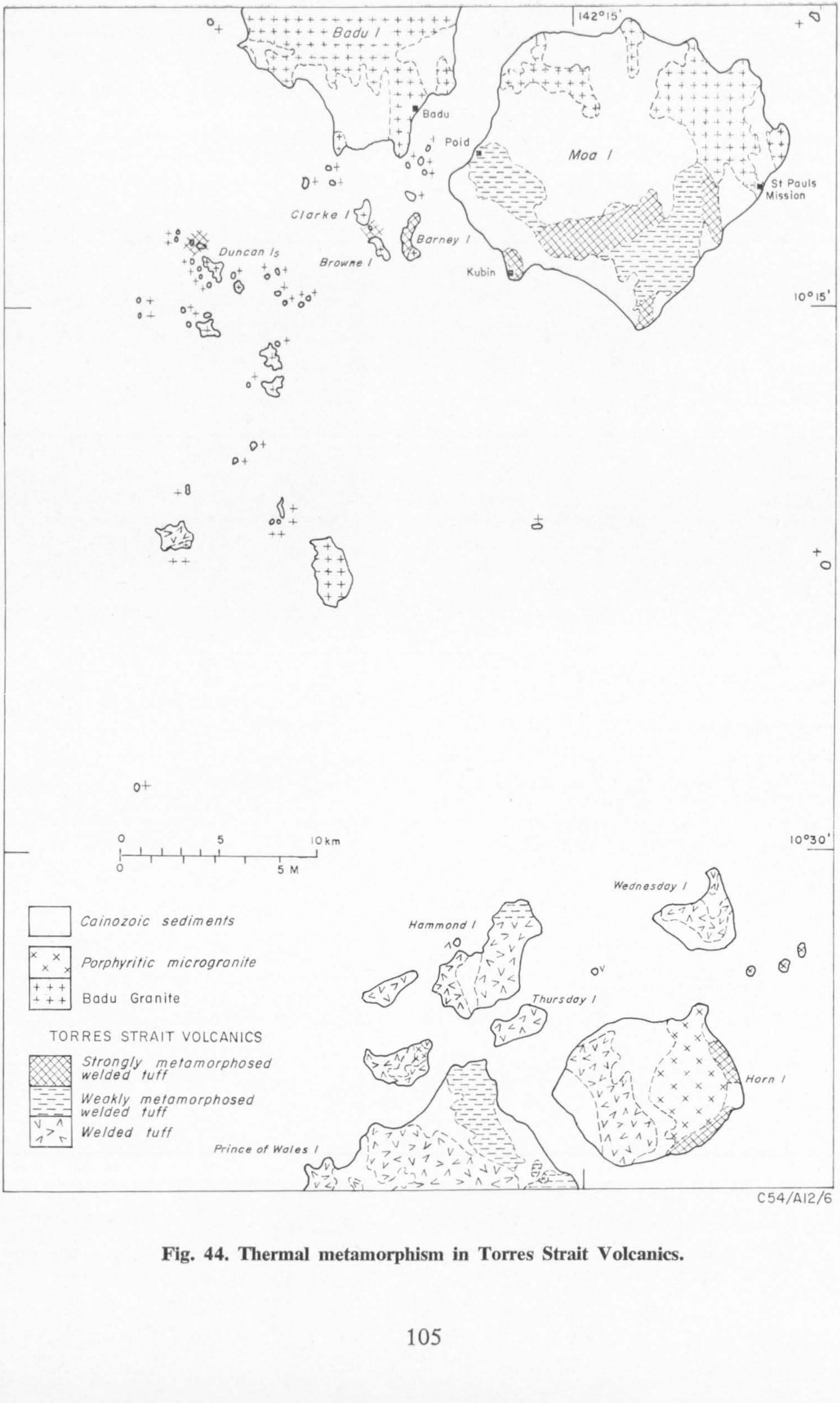


Fig. 44. Thermal metamorphism in Torres Strait Volcanics.

In the weakly metamorphosed volcanics the pyroclastic textures have been preserved, and the only visible changes are a general coarsening of the groundmass and some corrosion of the phenocrysts. The more intensely recrystallized rocks have a fine or medium-grained hornfelsic texture, although corroded quartz phenocrysts can still be recognized. The hornfels commonly has a weak foliation defined by thin layers of biotite. On Barney Island this foliation has been emphasized by the recrystallization of the pumice fragments. The most common mineral assemblage is biotite-muscovite-feldspar-quartz of the albite-epidote hornfels facies or lower hornblende hornfels facies of Turner & Verhoogen (1960). The highest-grade rocks are found near granite contacts on Horn, Moa, and Dauan Islands. They contain andalusite, cordierite, or garnet, which indicate the hornblende hornfels facies of Turner & Verhoogen.

Alteration

In many places in the south the volcanics have been altered to pale green, purple, or white rocks in which most of the original textures have been destroyed. The altered rocks are scattered along a zone extending from Goods and Hammond Islands through Horn Island and Endeavour Strait to near Peak Point on the mainland (Fig. 45); altered rocks are also found on Booby Island, West Island, Black Rock (north of Moa Island), Mabuiag Island, and Ninepin Rock. In places there is a gradation between the unaltered and altered rocks, but elsewhere the contact is sharp. Where the alteration is slight, quartz and feldspar phenocrysts and fragments of rock and pumice are still visible, but in the intensely altered rocks only the quartz phenocrysts are preserved.

The alteration consists mainly of the replacement of feldspar by a clay mineral. More intense alteration is accompanied by fracturing, silicification, and the introduction of closely spaced intersecting quartz veins, up to 5 cm wide, which form irregular boxworks. Some of the large lodes of quartz consist of zones of closely spaced small quartz veins, but others, such as that forming the hill behind Horned Point on Horn Island, consist of single veins.

The alteration has affected the acid dyke rocks, the porphyritic microgranite, and the surrounding volcanics on Horn Island, and was probably the result of late-stage hydrothermal activity associated with the Badu Granite and porphyritic microgranite.

Nychum Volcanics
(Morgan, 1961)

Derivation of name

The Nychum Volcanics were named after Nychum homestead, 48 km north-northwest of Chillagoe, in the Atherton Sheet area.

Distribution

The volcanics crop out over an area of 600 km^2 from the Walsh River to the Mitchell River between Chillagoe and Mount Mulgrave homestead; they may extend westwards beneath the Mesozoic sediments. Only the northernmost outcrops, on the Mitchell River, are shown on the accompanying map.

Lithology

The volcanics consist of rhyolite, tuff, and welded tuff, with subordinate andesite, basalt, and interbedded sediments. Lateral variations are common, but basalt, andesite, and sediments are generally present near the base of the sequence. About a dozen andesite vents and two or three rhyolite vents have been recognized by Morgan (1961). In the type area around Nychum homestead the total thickness is about 150 m.

On the Mitchell River the sequence consists of coarse current-bedded arkose or tuffaceous sandstone, grey siltstone, and a coal seam 1.5 m thick overlain by amygdaloidal and porphyritic acid lavas, hypersthene basalt, dacite, welded tuff, and andesite. Near Mount Mulgrave homestead agate concretions fill the vesicles in the acid lavas. In the bed of the Mitchell River 11 km west of Mount Mulgrave homestead a porphyritic acid dyke or fissure vent, 100 m wide, cuts sheared Kintore Adamellite. Similar acid dykes, up to 15 m wide, crop out in gneiss 1 km to the east. The dykes are probably related to the volcanics, although they are similar to the acid dykes intruded shortly after the granitic rocks of the Cape York Peninsula Batholith.

Age

On the basis of the fossil plants, spores, and pollen grains found along the Mitchell River, the Nychum Volcanics were assigned to the Upper Permian or Lower Triassic by Amos

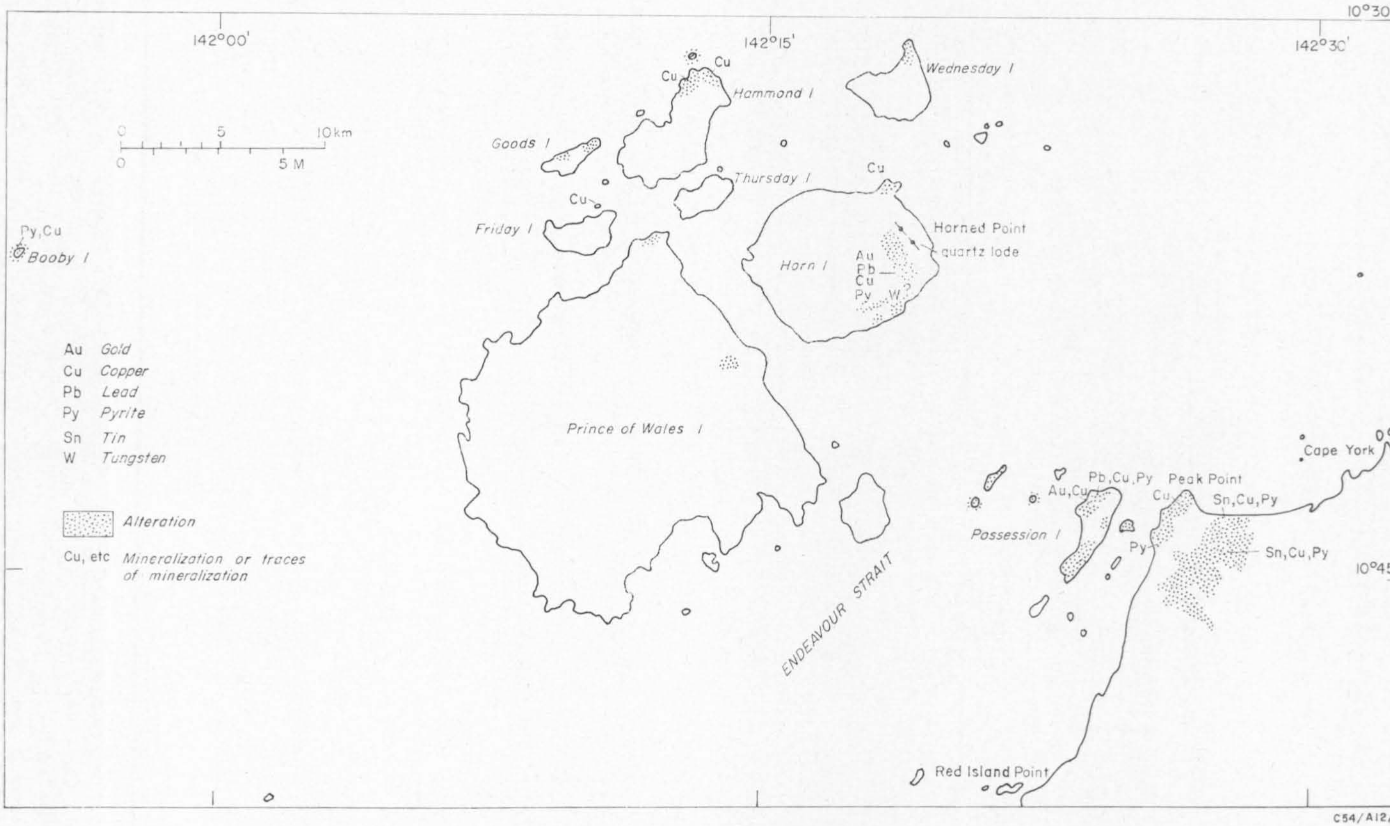


Fig. 45. Alteration and mineralization in southern part of Torres Strait.

& de Keyser (1964), and in 1965 W. R. Morgan (pers. comm.) found similar fossils near Nychum homestead. In 1968, however, the volcanics near Nychum homestead were dated as Upper Carboniferous by the Rb/Sr method, and re-examination of the plant specimens from near Nychum homestead indicated that they could be as old as uppermost Carboniferous (Black, 1969). Recent unpublished data on the volcanics on the Mitchell River, on the other hand, suggest that they are not equivalent to those near Nychum homestead and are Upper Permian, as originally thought (L. P. Black, pers. comm.).

Unnamed Volcanic Rocks

Distribution

The small bodies of unnamed volcanic rocks at Cape Griffith, Lloyd Island, and Sunter Islet in the Iron Range area, and at the 2nd Red Rocky Point, south of Cape Direction (Fig. 52), are probably of Lower Carboniferous to Lower Permian age, as are the nearby Janet Ranges Volcanics.

Lithology

The grey acid welded tuffs at *Cape Griffith* are composed of phenocrysts of quartz and feldspar and numerous rock fragments set in a devitrified matrix. They contain a few ill defined interbeds of massive brownish grey agglomerate containing pebble-size fragments of intermediate volcanic rocks. The beds strike between northeast and southeast and generally dip steeply eastwards. The fine-grained massive andesite forming *Sunter Islet* contains phenocrysts of greenish feldspar. The acid pyroclastics of *Lloyd Island* include fine-grained welded tuff, with numerous small fragments of pumice, and agglomerate.

The basalt at *2nd Red Rocky Point* has been hornfelsed by the Weymouth Granite and is cut by dykes of leucocratic microgranite. The rock is dark grey or black, fine-grained, and partly foliated or banded. It contains a few phenocrysts of feldspar, and veins of quartz and epidote between 5 mm and 1 cm thick. The altered rock has a fine-grained hornfelsic texture, and is composed of biotite, actinolite, and plagioclase.

The fine-grained altered acid rocks cropping out on a number of headlands in *Temple Bay* have intrusive contacts and are either related to the acid volcanics or the nearby Weymouth Granite.

Janet Ranges Volcanics
(Whitaker & Willmott, 1969a)

Derivation of name

The Janet Ranges Volcanics were named after the Janet Ranges, about 20 km northwest of Iron Range airstrip.

Distribution

The main outcrops (Fig. 46) cover an area of 350 km^2 inland from Portland Roads and Iron Range; they extend from the Goddard Hills 30 km southwards to Bowden and Mount Tozer. They also crop out over an area of 25 km^2 in a narrow north-trending belt farther south near Luttrel. In the main area of outcrop the volcanics are moderately well exposed, and form rounded rubble-covered mountains supporting low heath-type vegetation.

Lithology

The Janet Ranges Volcanics have been subdivided informally into three members composed respectively of rhyolite welded tuff, rhyolite, and welded pumice-flow breccia (Fig. 47). The sequence has been established in a broad arc from the middle reaches of Garraway Creek to Hamilton Creek and Mount Nelson.

The lower member consists of a number of rhyolite welded tuff sheets, up to about 50 m thick, each of which represents a compound cooling unit. The lower part of the member is composed of light brown massive welded tuff containing euhedral crystals of quartz, potash feldspar, and plagioclase; the upper part consists of massive black welded tuff, which in places contains numerous compressed fragments of pink pumice. The welded tuff sheets are well exposed in the middle reaches of Garraway Creek, where they rest unconformably on the Pascoe River Beds.

The middle member, which consists mainly of rhyolite flows, is probably over 150 m thick in the Janet Ranges near Mount Nelson. The rhyolites are strongly flow-banded and spherulitic. The spherulites range from 5 mm to 8 cm across, and appear to be about the same size within each flow. Between Garraway Creek and Hamilton Hill the sequence is much thinner and consists of autobrecciated flow-banded lavas similar to those in the lower reaches of Hamilton Creek and the western half of the Goddard Hills. Towards the top of the sequence there are a few thin interbeds of pumice-flow breccia.

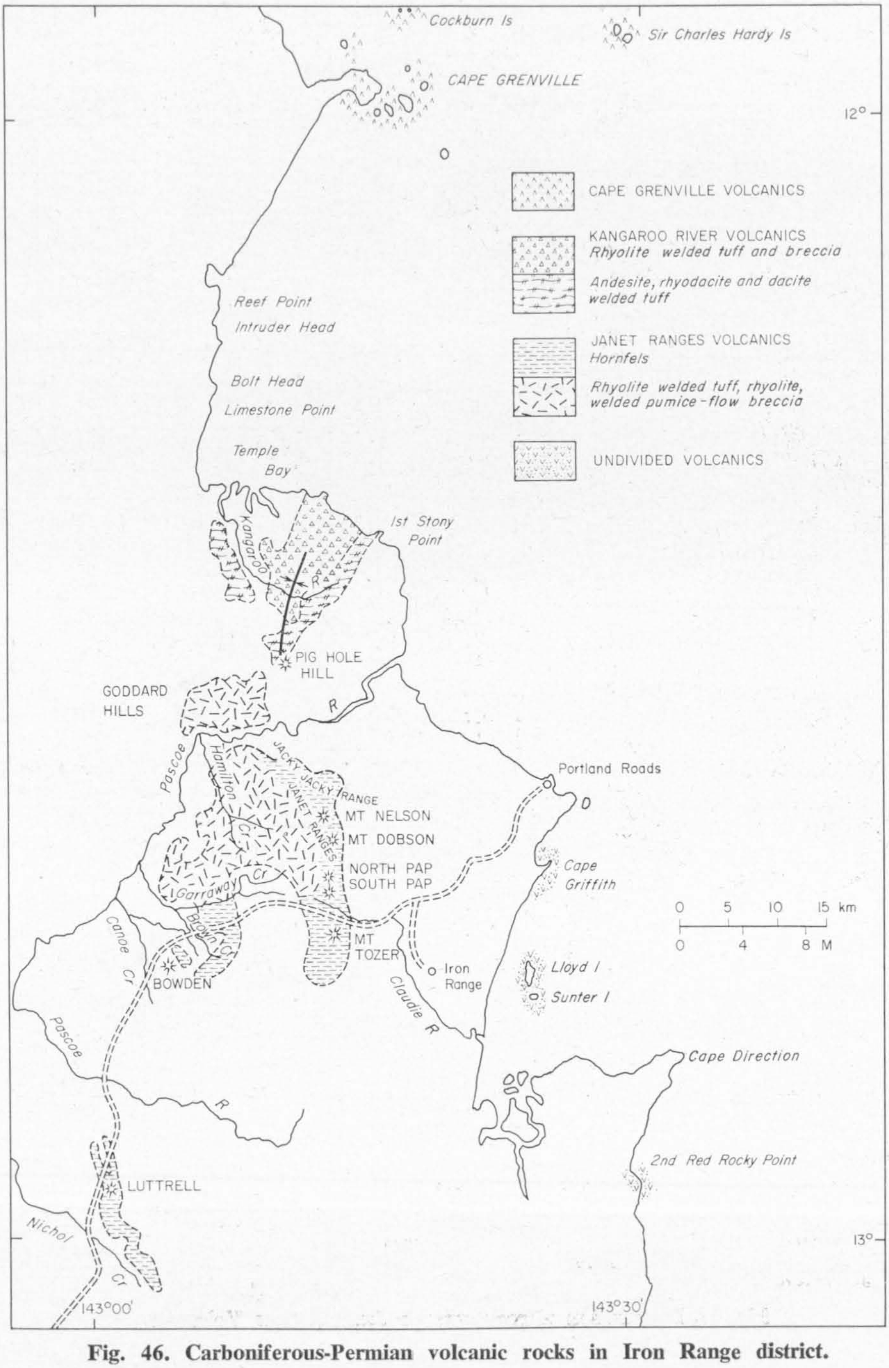


Fig. 46. Carboniferous-Permian volcanic rocks in Iron Range district.

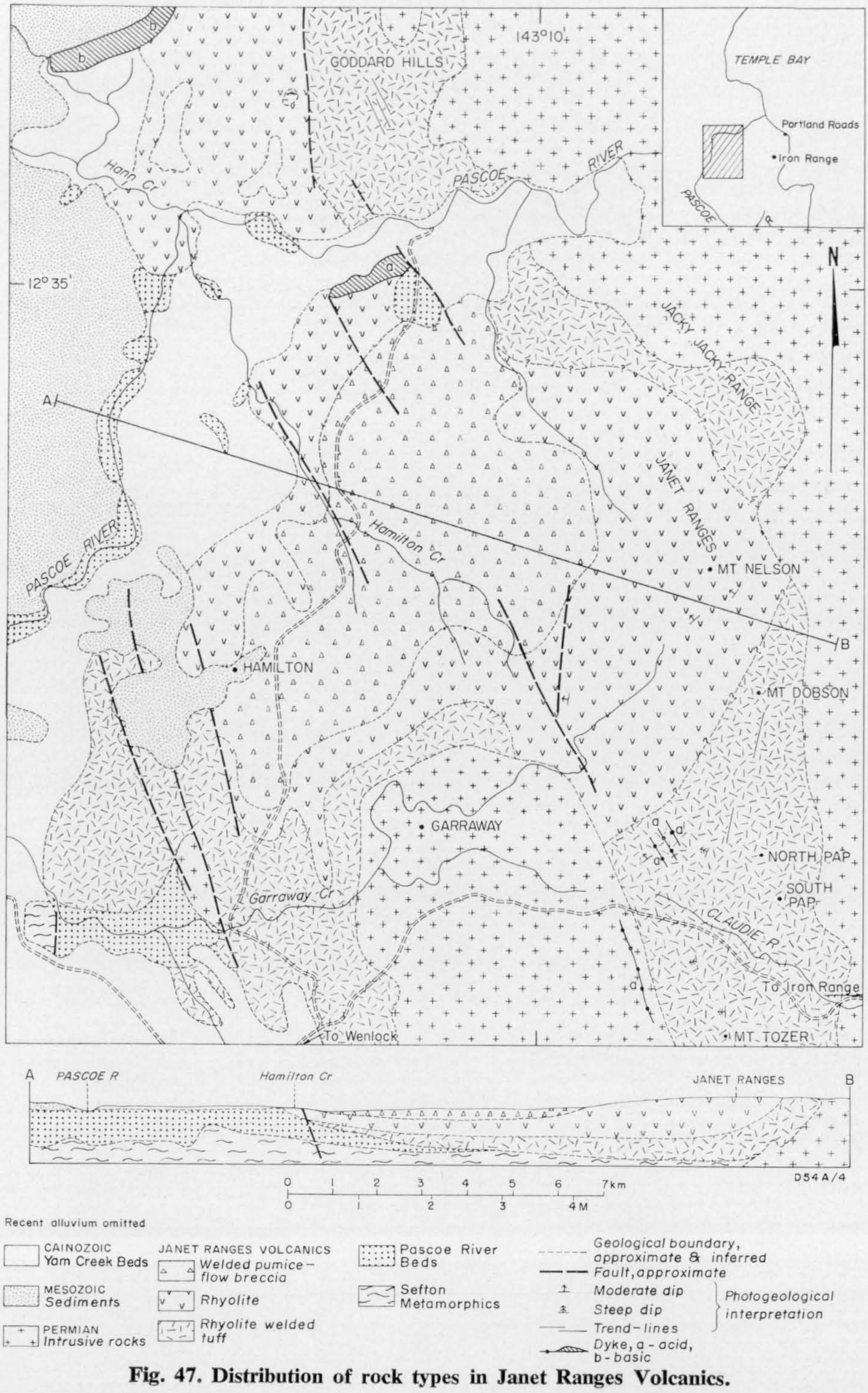


Fig. 47. Distribution of rock types in Janet Ranges Volcanics.

The upper member consists of at least 60 m of welded pumice-flow breccia, which is exposed mainly in the headwaters of Hamilton Creek. The breccias contain numerous large uncompressed fragments of pumice and acid lava set in a fine tuffaceous matrix. In the lower reaches of Hamilton Creek the boundary with the underlying autobrecciated acid lavas is indistinct.

Away from the Garraway Creek/Hamilton Creek/Mount Nelson region the three members are not easily distinguished on the air-photographs, and the succession has been disrupted by faulting and Permian granitic rocks. Near Mount Tozer, North and South Pap, and Mount Dobson, the lower member may be represented by the hornfelsed rocks underlying the acid lavas southwest of Mount Nelson. Similar rocks crop out in the Jacky Jacky Range, and the welded tuff exposed in the Goddard Hills may also belong to the same sequence, though some of it is dacitic. In the lower reaches of Hamilton Creek the lower member is represented by a few sheets of welded tuff interlayered with acid lavas.

The volcanics northeast of Luttrel (Fig. 46) consist of a narrow band of recrystallized acid lavas overlain to the west by recrystallized volcanic breccia, agglomerate, and welded tuff. Still farther west the rocks are so intensely recrystallized that their original nature is uncertain.

Thickness and structure

In the east the volcanic rocks are at least 500 m thick, but to the west they thin considerably against a ridge of Pascoe River Beds and Sefton Metamorphics; to the northwest they may extend under the Mesozoic sediments.

The volcanics are generally flat or gently dipping, except where intruded by granitic rocks. In the east they have been tilted to the west by the Weymouth Granite, and near Mount Tozer the dip is 50° to 60°. In the west the volcanics are cut by a number of short northwesterly trending faults. The thin sequence of steeply dipping volcanics near Luttrel lies between the Weymouth Granite in the east and an elongate intrusion of hybrid adamellite in the west.

The thickness of the acid lavas in the east suggests that the main centres of eruption were in this area.

Thermal recrystallization

The volcanics have been recrystallized for some distance from the contact of the Permian granitic intrusions, particularly in the east and near Bowden and Luttrel (Fig. 46). Near the contact the recrystallized groundmass has a hornfelsic texture and the phenocrysts are deeply embayed, but farther away the only effect is the coarsening of the groundmass. Near Luttrel the degree of recrystallization is greater near the contact with the hybrid adamellite than near the Weymouth Granite.

Kangaroo River Volcanics
(Whitaker & Willmott, 1969a)

Derivation of name

The Kangaroo River Volcanics were named after the Kangaroo River, which flows across them into Temple Bay.

Distribution

The volcanics are exposed in a triangular area of 130 km^2 to the north of the mouth of the Pascoe River and south of Temple Bay. The upper part of the sequence crops out in the rough mountainous country to the north of the Kangaroo River, and the lower part in the lower more fertile country.

Lithology

The formation has been divided informally into a lower member consisting of andesite, rhyodacite welded tuff, and dacite welded tuff, and an upper member composed of rhyolite welded tuff and breccia (Fig. 46).

The lower member, which is about 75 m thick, consists of andesite, rhyodacite and dacite welded tuffs, and subordinate rhyolite welded tuff and rhyolite. The intermediate lavas are fine or medium-grained, and range from light grey through creamy brown to dark greyish black. Some of the lavas near the top of the sequence contain vesicles filled with calcite. The dark grey rhyodacite and dacite welded tuffs contain phenocrysts of plagioclase, pink alkali feldspar, hornblende, and numerous dark grey rock fragments.

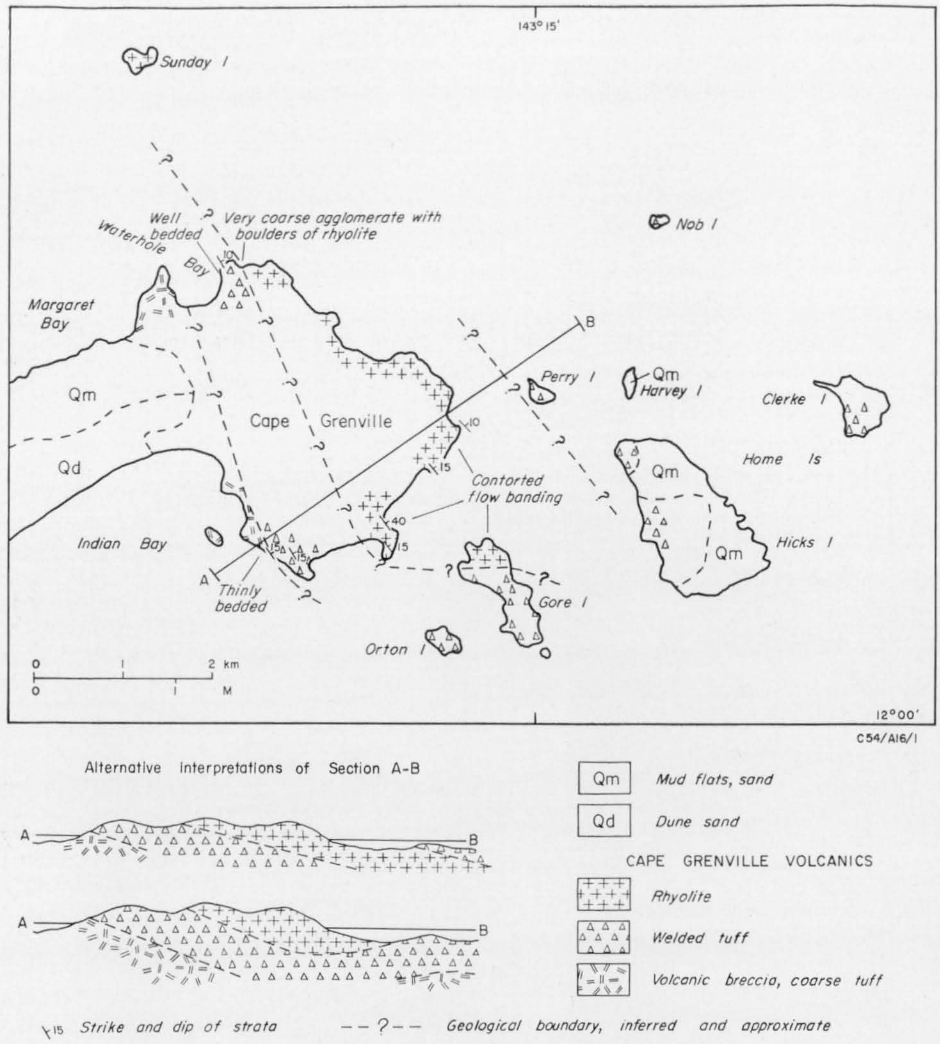


Fig. 48. Volcanic rocks in Cape Grenville area.

The sequence in the upper member is not known in detail, but includes about 150 m of acid welded tuff, volcanic breccia, and some flow-banded rhyolite. The welded tuff ranges from buff to cream, and contains small uncompressed fragments of pumice. The volcanic breccia is composed of numerous fragments of flow-banded acid lava and crystals of quartz and feldspar set in a light-coloured matrix.

Thickness and structure

The Kangaroo River Volcanics are at least 220 m thick, and may range up to 300 m. The upper member probably consists of several massive sheets of welded tuff separated by thin flows of rhyolite. The sharp contact with the lower member shows up well on the air-photographs.

The volcanics form a broad syncline with the axis plunging gently north-northeast. The dip on the flanks ranges from 5° to 10°, but near Pig Hole Hill at the nose of the syncline, steep dips are common. The age of the folding is uncertain, but it may be related to the intrusion of the Permian granitic rocks.

Cape Grenville Volcanics
(Whitaker & Willmott, 1969a)

Derivation of name

The Cape Grenville Volcanics were named after Cape Grenville, a prominent headland on the southern edge of the Orford Bay Sheet area. The welded tuff on Clerke Island near Cape Grenville, which is now included in the Cape Grenville Volcanics, was called the Clerke Island Ignimbrite by Jones & Jones (1956).

Distribution

The volcanics are exposed over about 15 km^2 on Cape Grenville, and the adjacent Home Islands, Cockburn Islands, and Sir Charles Hardy Islands. They form rounded hills covered with thin vegetation, and are well exposed in many rocky headlands.

Lithology

At Cape Grenville the volcanics can be divided into three or possibly four members consisting of well bedded volcanic breccia and tuff, welded tuff, and rhyolite (Fig. 48).

In Indian and Margaret Bays the lower member is composed of thinly bedded volcanic breccia and coarse tuff. The pyroclastic rocks contain fragments of acid welded tuff and intermediate or basic volcanic rocks, up to 45 cm across, set in a coarse pink matrix; in places the blocks form thin layers that extend for many metres.

The second member consists of 15 to 20 m of welded tuff composed of numerous lenticules of pink pumice up to 8 cm long, set in a greyish purple aphanitic groundmass. The lenticules have a planar structure roughly parallel to the top and bottom of the unit. In the cliffs around Indian Bay the member rests disconformably on the basal volcanic breccia. On the east side of Waterhole Bay the top of the sequence consists of a number of thin sheets of pumice-rich welded tuff which form a compound cooling unit. Welded tuff is also exposed on Orton and Gore Islands (Fig. 48).

The third member consists mainly of flow-banded and spherulitic acid lavas, which crop out in the eastern and northeastern part of Cape Grenville, on Sunday Island, and on part of Gore Island. On the east side of Waterhole Bay the base of the sequence consists of a layer of agglomerate, 10 m thick, composed of blocks of flow-banded acid lava averaging 60 cm across. The agglomerate contains tongues of lava up to 10 m long.

The welded tuff on *Hicks, Clerke, Perry,* and *Nob Islands* (Fig. 48), which contains numerous fragments of pumice, is similar to the member underlying the acid lavas. It may be part of that welded tuff member, or may constitute a fourth member overlying the acid lavas.

Buchan Rock, at the southern extremity of the Cockburn Islands, is composed of welded tuff with numerous elongate fragments of pumice; it is similar to the second member at Cape Grenville. *Pig, Manley,* and *Bootie Islands* are composed of dark welded tuff containing rare pumice fragments set in a groundmass of strongly welded devitrified glass shards.

The welded tuff forming the *Sir Charles Hardy Islands* is similar to the second member at Cape Grenville. The rock generally contains fragments of pink and green pumice up to 8 cm long, but where the fragments are less common the rock becomes massive.

Thickness and structure

The total thickness of the Cape Grenville Volcanics is unknown as the base is not exposed, and their full lateral extent is obscured by Mesozoic sediments, and by the sea. At Cape Grenville they are from 200 to 300 m thick, and strike roughly northwest and dip at 10° to 15° to the northeast. If the welded tuff on Nob, Clerke, and Hicks Islands is the same as the welded tuff member in Indian and Waterhole Bays, the member is folded into a gentle syncline with the axis plunging to the northwest.

UPPER PALAEOZOIC INTRUSIVE ROCKS

Badu Granite
(Whitaker & Willmott, 1969b)

Derivation of name

The Badu Granite was named after Badu Island, the third largest island in Torres Strait, about 80 km northwest of Cape York.

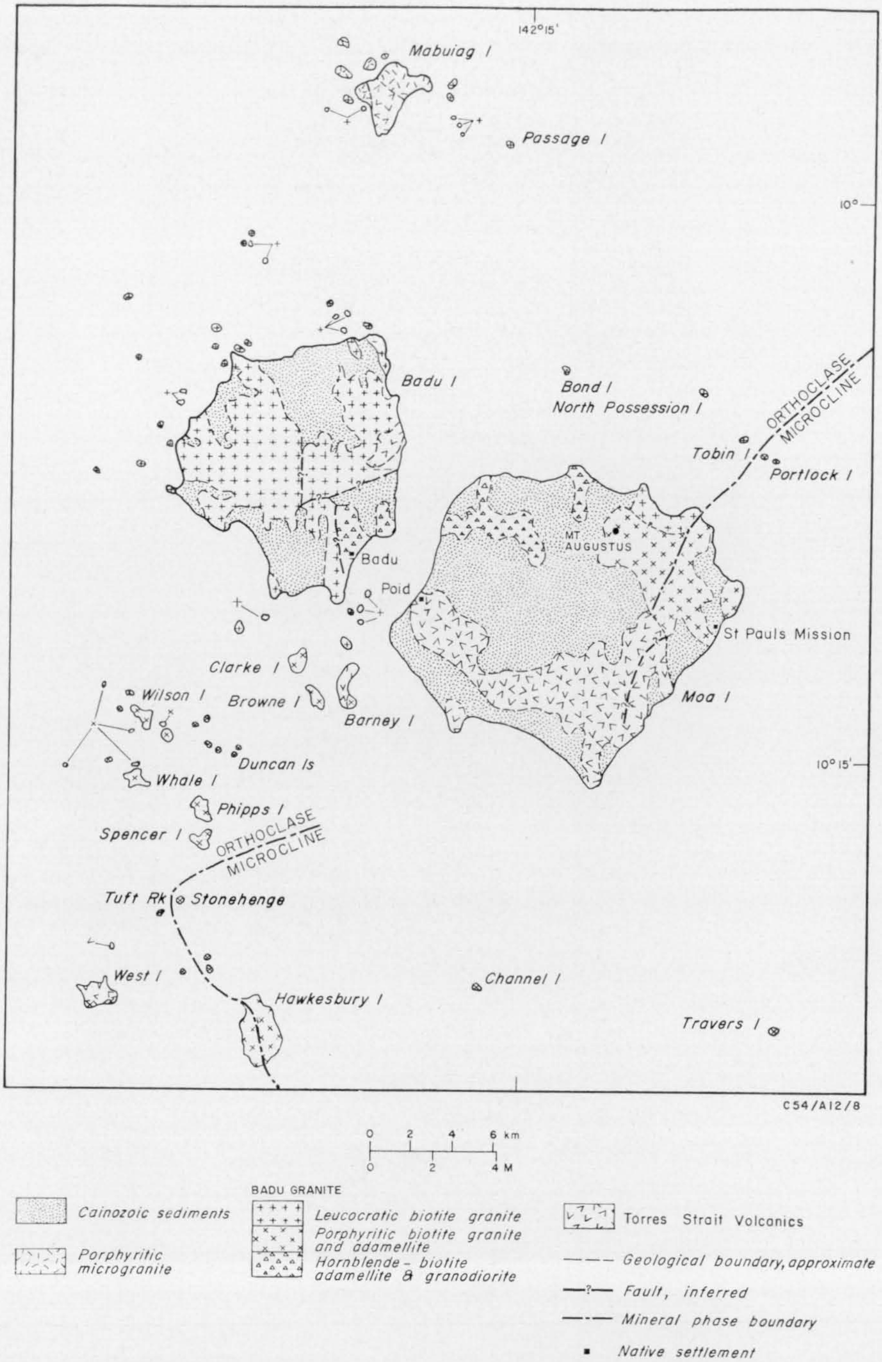


Fig. 49. Main rock types in Badu Granite.

Distribution

The granite forms the majority of the rocky islands in Torres Strait north of latitude 10°30'S and crops out at Mabaduan on the Papuan coast (Fig. 49). It intrudes the Torres Strait Volcanics, remnants of which are found on a number of islands. In western Papua the Badu Granite is overlain by Mesozoic and Cainozoic sediments.

The granite is generally well exposed, especially along the coasts of Badu and Moa Islands. On Moa and Dauan Islands the granitic peaks rise to an elevation of 400 m and 220 m respectively; Dauan Island is mantled by large boulders. Rock exposed on the wave-cut platforms and in boulders on the coast is generally fresh, although the leucocratic granites, as for example on Badu Island, are weathered.

Lithology

The Badu Granite comprises leucocratic biotite granite, porphyritic biotite granite and adamellite, and hornblende-biotite-adamellite and granodiorite (Fig. 49). Chemical analyses of the granite are given in Table 19.

TABLE 19. CHEMICAL ANALYSES, UPPER PALAEOZOIC INTRUSIVE ROCKS FROM TORRES STRAIT

	1	2	3	4	5	6
SiO_2	70.67	72.75	74.45	71.12	77.53	66.71
Al_2O_3	14.86	13.97	14.23	14.50	11.67	16.63
Fe_2O_3*	1.91	2.10	0.75	2.46	2.44	3.24
MgO	0.74	0.00	0.20	0.46	0.46	0.44
CaO	2.23	1.48	1.46	2.22	0.14	1.95
Na_2O	3.63	3.46	3.85	3.00	2.48	3.90
K_2O	3.84	5.19	4.54	4.89	5.21	6.11
TiO_2	0.23	0.21	0.10	0.27	0.18	0.40
P_2O_5	0.09	0.08	0.05	0.09	0.03	0.13
MnO	0.05	0.04	0.02	0.05	0.17	0.07
Loss on ignition	0.43	0.39	0.39	0.80	0.87	0.64
Total+	98.25	99.28	99.65	99.06	100.31	99.58

*Total iron as Fe_2O_3.
+Does not include loss on ignition.

Badu Granite

1. Porphyritic biotite granite, N end Hawkesbury I. (BMR 68480132).
2. Porphyritic biotite granite, Clarke I. (BMR 68480134).
3. Porphyritic biotite adamellite, Mabaduan village, Papua. (BMR 68480177).

Porphyritic Microgranite

4. Coarsely porphyritic microgranite, NE coast of Horn I. (BMR 68480138).
5. Porphyritic microgranite dyke, S coast Badu I. (BMR 68480062).
6. Porphyritic microgranite dyke, West I. (BMR 68480050).

Analysed by G. H. Berryman (BMR) by X-ray fluorescence method.

The greater part of Badu Island and the small islands to the southwest, west, and north, and the small islands near Mabuiag Island, are composed of *leucocratic biotite granite.* The granite is cream, pink, or red, and fine to coarse-grained; it generally contains phenocrysts of quartz and potash feldspar, and a little hornblende and pyrite in places. The fine-grained granite commonly contains miarolitic cavities partly filled with quartz and potash feldspar, and patches of aplite. Quartz veins up to a few centimetres wide are common, and narrow zones of mylonite can be seen in places. The leucocratic biotite granite is composed of phenocrysts of quartz and orthoclase microperthite, zoned oligoclase with narrow sodic rims, biotite (1-5%), and hornblende (up to 2%). The quartz commonly forms micropegmatitic intergrowths with potash feldspar, and the biotite and hornblende are partly altered to chlorite, leucoxene, and epidote.

A similar leucocratic biotite granite crops out on the north coast of Moa Island, and on Tobin, North Possession, Gabba, Cap, and Yama Islands. Pink leucocratic microgranite dykes are also present, and in places, especially on Yama Island, rounded xenoliths of fine-grained biotite-hornblende granodiorite or tonalite are common.

The *porphyritic biotite granite* between Clarke and Hawkesbury Islands (Fig. 49) is a grey medium or coarse-grained rock with phenocrysts of pink feldspar up to 1.5 cm long. The granite is coarser and less susceptible to weathering than the leucocratic biotite granite. In the porphyritic granite on Stonehenge, Tuft Rock, and Hawkesbury Islands the feldspar is microcline. The granite contains roof pendants of recrystallized Torres Strait Volcanics on Clarke and Barney Islands, on two of the Duncan Islands, and on West Island. In places the granite is intruded by small bodies and dykes of aplite, which contain miarolitic cavities, up to 4 cm across, partly filled with quartz.

On the west coast of Hawkesbury Island the porphyritic granite is intruded by even-grained biotite granite and by sheets of biotite granite pegmatite up to 1 m thick.

On Moa Island two types of porphyritic biotite granite are present. The rock near Mount Augustus is similar to the granite between Clarke and Hawkesbury Islands, but the granite around St Pauls Mission and on Portlock Island contains phenocrysts of microcline averaging 1.5 cm long, but lacks intergrowths of quartz and potash feldspar. In places the rock grades into *porphyritic biotite adamellite* and shows faint compositional banding. A belt of pink leucocratic microgranite or adamellite is exposed several kilometres to the northwest of St Pauls Mission and on the west slopes of Mount Augustus small bodies of fine-grained biotite granite or hornblende-biotite granite intrude the porphyritic granite. Porphyritic biotite granite, similar to that near St Pauls Mission, also crops out at Mabaduan on the Papuan coast and on Dauan Island. It is variable in grainsize, and on Dauan Island contains hornblende.

Hornblende-biotite adamellite and granodiorite are exposed in the northern and western parts of Moa Island and in a small area opposite on Badu Island. The rocks are grey or pinkish grey, medium-grained, and contain a few phenocrysts of pink orthoclase. The mafic minerals consist of biotite and irregular laths of hornblende up to 5 mm long. Intergrowths of quartz and orthoclase microperthite are present in the more acid varieties. The granodiorite contains dark grey xenoliths up to 30 cm across, and in places it has a speckled appearance owing to the presence of small clots of hornblende and plagioclase. The hornblende-bearing rocks appear to have been faulted against the leucocratic biotite granite west of Badu village.

Other varieties of granite. Burke, Getullai, and Mount Ernest Islands, to the east of Moa Island, are composed of fine to coarse pink leucocratic biotite granite which contains patches and dykes of aplite and rare pegmatite. The biotite generally forms small aggregates and on Burke Island streaks and patches of biotite-rich material are present. The microcline is strongly poikilitic and slightly microperthitic.

The massive dark grey fine equigranular muscovite-biotite granodiorite at the west end of Travers Island is intruded by light grey medium-grained porphyritic muscovite-biotite adamellite or granodiorite. Microcline phenocrysts, up to 3 cm long, are common in places, but are virtually absent at the east end of the island. Near the vertical contact with the fine-grained granodiorite the porphyritic rock is banded and slightly foliated and is cut by irregular dykes and patches of aplite and muscovite granite pegmatite.

The medium-grained leucocratic pink biotite-muscovite granite on Channel Island is aplitic or pegmatitic in places. Muscovite forms large crystals and biotite small clots; the quartz is strained and recrystallized. Twin Island, 10 km northeast of Wednesday Island, is composed of medium-grained massive grey biotite granite, with pink potash feldspar phenocrysts up to 2 cm long, grading into muscovite-biotite or muscovite granite. The muscovite-bearing phases are cut by or intimately banded with pegmatite composed of large aggregates or bands of pink potash feldspar and coarse crystals of muscovite set in a granitic groundmass. In places the granite is sheared and altered, and intruded by quartz veins up to 50 cm thick.

The medium or coarse-grained leucocratic pink or red biotite granite on East Strait Island, near Twin Island, is composed of quartz, microcline microperthite, and scattered clumps of biotite up to 5 mm across. The granite is cut by an extensive horizontal sheet of pegmatite, 30 cm thick, composed of intergrown crystals of quartz and potash feldspar up to 10 cm long. Similar rocks are exposed on Strait Rock near the Tuesday Islets.

On Hammond Island, a small body of grey medium-grained muscovite-biotite granodiorite or tonalite intrudes the altered and recrystallized welded tuff of the Goods Island Ignimbrite. The rock contains a few patches of muscovite-rich pegmatite. Near the sharp and almost vertical contact with the volcanics, small grains of chalcopyrite are present in a mineralized zone up to 6 m wide.

Contact metamorphism

The intrusion of the granites into the Torres Strait Volcanics was accompanied by extensive thermal metamorphism (Fig. 44). Recrystallization of the volcanics is most intense near bodies of porphyritic biotite adamellite. The leucocratic biotite granite on Badu Island appears to have been intruded at a lower temperature, as the volcanics have been only slightly recrystallized for about 1 m from the contact.

Dyke rocks

In addition to the aplite, pegmatite, and microgranite dykes associated with the Badu Granite, the granite and volcanics are cut by dykes of intermediate composition, felsite, and porphyritic microgranite.

The *intermediate dykes* in the southwestern part of Badu Island and eastern part of Moa Island are up to 15 m wide, but are generally much narrower. They are greenish black and generally contain a few small phenocrysts of plagioclase up to 3 mm long. The dykes range from dacite(?), through hornblende andesite and hornblende-augite andesite, to augite andesite. The andesine or sodic labradorite is partly altered to sericite, and the hornblende to actinolite, chlorite, or tremolite. The augite is titaniferous. The dykes contain a little iron oxide, apatite, sphene, and calcite.

Numerous flow-banded *felsite dykes* up to 10 m wide, but generally much narrower, intrude the Torres Strait Volcanics on the small islands in Endeavour Strait. They are generally vertical and trend between 20° and 60°, roughly parallel to the strike of the volcanics. The rocks consist of small embayed quartz phenocrysts up to 1.5 mm across, and subordinate sericitized potash feldspar phenocrysts set in a microcrystalline quartzofeldspathic groundmass. The flow banding is commonly contorted, especially near the margins of the dykes. The larger dykes become massive towards their centres. Narrow quartz veins are common in and near many of the dykes.

The felsite dykes intruding the Badu Granite to the north generally have narrow banded margins, but some are massive and have a coarser groundmass. Phenocrysts of plagioclase, quartz, and potash feldspar, up to 2 mm long, are common. Many of the quartz phenocrysts are slightly corroded. The dykes contain a few small chloritized flakes of biotite.

The *porphyritic microgranite* dykes are similar to the large bodies of porphyritic microgranite.

In the southwest part of Badu Island the order of intrusion is as follows: intermediate dykes, porphyritic microgranite dykes, and finally at least two groups of felsite dykes. A few narrow younger intermediate dykes intrude the microgranite dykes. Near St Pauls Mission, on Moa Island, there are no porphyritic microgranite dykes, but the sequence is otherwise the same as on Badu Island. The dykes generally have no preferred direction, but in places groups of dykes are roughly parallel, as for example in the southwest part of Badu Island. In the southern part of Torres Strait, far from the main bodies of granitic rocks, the volcanics are only intruded by felsite dykes.

Alteration and mineralization

In the southern part of Torres Strait the volcanics, acid dykes, and porphyritic microgranite have in places been hydrothermally altered, fractured, and penetrated by quartz veins. The alteration, which was accompanied by the introduction of a little gold, cassiterite, galena, chalcopyrite, and pyrite, probably took place during the final stage of intrusion and crystallization of the Badu Granite and the associated dykes and porphyritic microgranite.

The wolfram-bearing quartz veins on and near Badu and Moa Islands are also related to the Badu Granite and the associated felsic and porphyritic microgranite. Finely disseminated chalcopyrite occurs in the small body of tonalite at the northeast end of Hammond Island.

Porphyritic Microgranite

Distribution

On Mabuiag Island a small body of porphyritic microgranite intrudes the Torres Strait Volcanics, and between Mabuiag Island and Hawkesbury Island the Badu Granite is cut by numerous dykes of porphyritic microgranite. Elsewhere, porphyritic microgranite intrudes the volcanics on Horn Island and the Tuesday Islets, Friday Island, and Mount Adolphus Island.

Lithology

On *Mabuiag Island* the porphyritic microgranite is a massive poorly jointed reddish brown rock containing phenocrysts of altered orthoclase, up to 1 cm long, smaller phenocrysts of embayed quartz, and some plagioclase set in a fine-grained groundmass containing small clots of a dark green mafic mineral.

The largest dykes of microgranite between Mabuiag and Hawkesbury Islands are several hundred metres wide and 3 km long. Most of the larger dykes have a finely crystalline brown groundmass similar to the microgranite on Mabuiag Island, but the narrower dykes are dark grey and aphanitic. Chemical analyses of the dyke rocks are given in Table 19.

Some of the altered orthoclase crystals in the dyke rocks are poikilitic; others have recrystallized margins. The subhedral phenocrysts of oligoclase or albite have sodic rims or overgrowths of potash feldspar. The groundmass consists of microcrystalline or micro-granophyric intergrowths of quartz and feldspar. The mafic minerals include small grains and clots of chlorite, biotite, hornblende, and rarely, clinopyroxene.

Coarse porphyritic microgranite has intruded and thermally metamorphosed the Endeavour Strait Ignimbrite in the eastern part of *Horn Island,* and is also exposed in the *Tuesday Islets* to the northeast. A small body of similar microgranite intrudes the volcanics near the north-east coast of *Prince of Wales Island.* A specimen of similar porphyritic microgranite was obtained from the *Herald Patches,* 4 km north of the Tuesday Islets, by Captain MacRobert of the Department of Shipping and Transport in 1970.

The rock is grey and composed of phenocrysts of partly altered plagioclase, microcline, anorthoclase or albite, quartz, and clots of partly altered hornblende set in a fine-grained groundmass of quartz, microcline, and oligoclase. Small amounts of zircon, apatite, allanite, and opaque minerals are also present. A chemical analysis is given in Table 19.

In the east-central part of Horn Island the microgranite is hydrothermally altered and veined by quartz; the altered rocks contain lead and copper minerals and iron sulphides.

The small intrusions of massive grey quartz-alkali feldspar microgranite on *Mount Adolphus Island* probably intrude the surrounding Eborac Ignimbrite. They crop out on a small headland in Blackwood Bay and near the summit of Mount Adolphus.

They contain phenocrysts of sanidine or anorthoclase(?) and quartz, set in a groundmass of finely crystalline quartz, feldspar, and dusty opaque minerals, with a little calcite, chlorite, and sphene.

A small body of massive pale pink porphyritic biotite microgranite intrudes the Goods Island Ignimbrite in the eastern part of *Friday Island.* The rock consists of phenocrysts of quartz, microcline, orthoclase, and altered biotite set in a microcrystalline groundmass of quartz, feldspar, and a little sphene.

There are several breccia zones or minor fault zones in the microgranite near the contact with the volcanics, and several large xenoliths of recrystallized welded tuff up to 6 m across were noted. Small dykes and veins of pink aplite penetrate the volcanics near the contact.

Dolerite

An oval body of dolerite, about 2 km^2 in area, intrudes the Kangaroo River Volcanics 12 km south of Temple Bay. The dolerite 8 km to the southwest also apparently intrudes the volcanics.

The dolerite is a massive dark grey fine to medium-grained rock cut by occasional thin veins of dark green fibrous chlorite. In places the joints are coated with pyrite(?). The rock is composed of labradorite, subophitic hypersthene, clinopyroxene, pale greenish brown hornblende, formed mainly by the alteration of pyroxene, and interstitial opaque minerals and quartz. The dolerite may be related to the Weymouth Granite.

An altered dolerite crops out on Pigeon Island and on a headland near the mouth of the Pascoe River, and two dolerite dykes intrude the Cape York Peninsula Batholith between the Weymouth Granite and Geikie Creek in the Coen Sheet area.

Granophyric and Hybrid Intrusive Rocks

Distribution

Granophyric and hybrid intrusive rocks are exposed in two belts along the western margin of the main body of Weymouth Granite. They have a total area of about 125 km^2. The southern belt extends from near Sefton Creek to Bowden and is from 2 to 5 km wide (Fig. 50); the northern belt extends for 22 km from the Goddard Hills to Fair Cape. Small intrusions of hybrid rocks are found northeast of Bowden near Garraway Creek and another body crops out near the northern end of the Jacky Jacky Range.

Lithology

Between Sefton Creek and the Pascoe River hybrid rocks consisting of grey biotite-hornblende microadamellite or microgranodiorite predominate. North of the headwaters of One Mile Creek the rocks consist of pink and grey granophyric hornblende-biotite microadamellite.

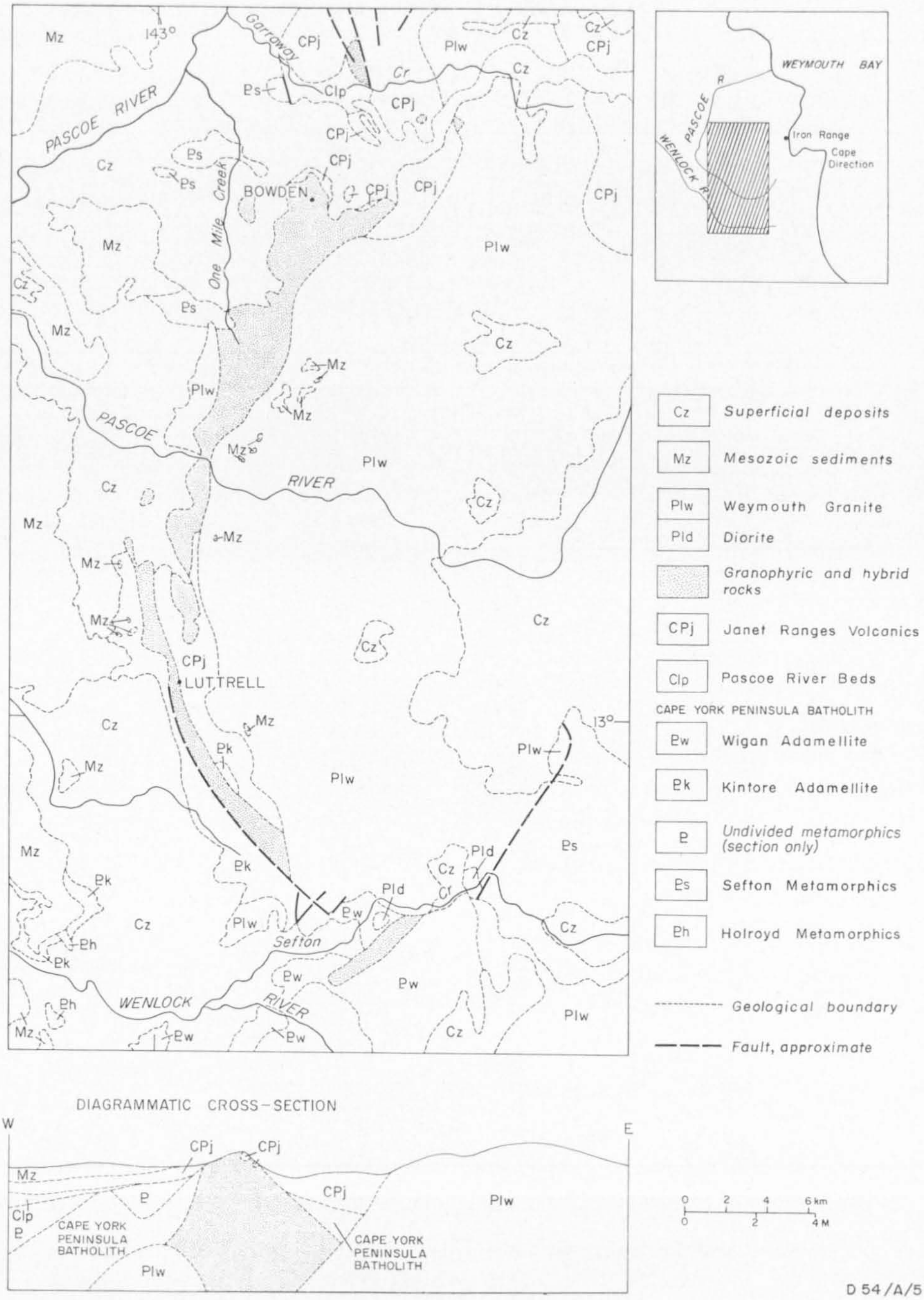


Fig. 50. Distribution of granophyric and hybrid rocks west of Iron Range.

The biotite-hornblende microadamellite is massive and fine or medium-grained; it contains rare phenocrysts of plagioclase, and has a characteristic clotted texture. The hornblende-biotite microadamellite generally contains small phenocrysts of white feldspar, and is mottled with greenish black clots of mafic minerals. Small partly assimilated xenoliths of recrystallized volcanics are found throughout the belt.

The texture of the hybrid rocks ranges from granitic or microgranitic to granophyric or microgranophyric. Some of the small zoned phenocrysts of oligoclase have cores of andesine, and many of the crystals have irregular overgrowths of alkali feldspar. One specimen contains a few phenocrysts of anhedral albite. The partly altered green hornblende and dark brown biotite form diffuse aggregates or small clots up to 5 mm across, which are associated in places with a little quartz and potash feldspar. Apatite is common in the clots and clinopyroxene was noted in one specimen from near Garraway Creek. The groundmass is generally composed of quartz, potash feldspar (probably orthoclase), and a little plagioclase, and commonly has a micropegmatitic, granophyric, or micrographic texture. Where the groundmass is coarser intergrowths are not as common, and the quartz tends to be subhedral and bipyramidal. The accessory minerals are zircon, monazite, opaque minerals, and rare allanite.

The composition of the hybrid rocks changes from south to north: the groundmass becomes more finely intergrown, the ratio of hornblende to biotite decreases from about 5:1 to 1:5, the mafic clots become smaller and more diffuse, and the degree of alteration of the mafic minerals and feldspar increases.

The northern belt consists of massive medium or coarse-grained greenish grey granophyric alkali granite which weathers pink or red. The rock is well jointed and commonly contains numerous quartz veins from 1 to 5 cm wide. North of Tin Creek the granite intrudes the Kangaroo River Volcanics, which near the contact are cut by veins of pink microgranite and tourmaline-quartz-feldspar pegmatite.

The granite consists of a micrographic intergrowth of quartz and altered potash feldspar, scattered crystals of oligoclase, a little biotite and muscovite, and accessory zircon, apatite, and opaque minerals. Chemical analyses are given in Table 20.

Genesis

The presence of numerous small mafic clots in the southern belt suggests that the rocks were probably formed by assimilation of dioritic or more basic material. The juxtaposition of the hybrid rocks and the Weymouth Granite, and the intrusive relationship of the granite to the diorite in the east, suggest that the acid magma was derived from the same source as the Weymouth Granite. The granophyric rocks in the northern belt are also closely associated with the Weymouth Granite.

Diorite

Distribution

Several bodies of diorite occur within or near the margin of the Weymouth Granite. The largest, at Ogilvie Hill 9 km southwest of Portland Roads, is 8 km^2 in area. Similar intrusives crop out near Ham Hill, 9 km northeast of Iron Range airstrip, on the Kennedy Road 3 km east of Mount Tozer, and near Sefton Creek, 18 km and 22 km east of Wenlock. The diorite crops out as small boulders and weathers to a darker soil than the adjacent granite.

Lithology and relationships

The medium-grained biotite-hornblende diorite is dark grey or bluish black, and grades into hornblende-biotite tonalite.

The diorite is composed of zoned sodic andesine, pale brownish green hornblende, reddish brown to dark brown biotite, interstitial quartz, and a little potash feldspar and opaque minerals. In the tonalite biotite predominates over hornblende and interstitial quartz is more abundant. Chemical analyses are given in Table 20.

The relationship of the diorite to the Weymouth Granite has not been established, but the presence of many large xenoliths of diorite in the granite near Portland Roads and Cape Weymouth suggests that the diorite is older than the granite, though probably a product of the same intrusive episode.

Weymouth Granite
(Whitaker & Willmott, 1969a)

Derivation of name

The Weymouth granite is named after the County of Weymouth.

Distribution

The granite is exposed over 1100 km^2 in the Cape Weymouth and Coen Sheet areas. The main body is a suboval batholith 65 km long between Garraway Creek in the north and the headwaters of Hull Creek in the south. Smaller stocks crop out near Cape Direction, and between Iron Range airstrip, the Goddard Hills, and the north coast of Weymouth Bay. The granite also forms the Forbes Islands, Quion Island, and small exposures along the coast of Temple Bay, and near the mouth of the Olive River.

The granite is particularly well exposed around the edge of the Pascoe River Plateau, and in the bed of the Pascoe River and in several of its larger tributaries. Some of the granite hills are mantled by large boulders blackened by lichen similar to the black granite hills near Cooktown (de Keyser & Lucas, 1968).

Lithology

The Weymouth Granite is a medium or coarse-grained hornblende biotite granite or adamellite containing phenocrysts of pale pink or salmon-pink potash feldspar up to 2.5 cm long. Small rounded xenoliths of fine-grained granodiorite are common. Subordinate coarse leucocratic granite or alaskite and irregular patches and dykes of microgranite and aplite are present.

TABLE 20. CHEMICAL ANALYSES, UPPER PALAEOZOIC INTRUSIVE ROCKS FROM COEN/IRON RANGE DISTRICT

	1	2	3	4	5	6	7	8	9
SiO_2	73.83	71.87	74.40	59.79	47.54	70.57	76.21	76.83	70.90
Al_2O_3	14.00	14.76	13.45	16.67	17.81	14.15	12.63	12.78	13.87
Fe_2O_3*	2.13	2.41	2.18	7.75	10.93	4.09	1.19	1.28	3.18
MgO	0.51	0.76	0.31	4.73	7.69	0.75	0.20	0.34	1.19
CaO	1.81	2.00	0.86	7.36	11.43	2.26	0.44	0.83	2.49
Na_2O	3.89	3.23	4.03	2.21	1.48	3.69	4.21	3.60	3.15
K_2O	3.86	4.88	4.67	2.06	0.46	3.92	5.01	4.61	3.62
TiO_2	0.21	0.33	0.16	1.15	0.94	0.46	0.11	0.12	0.50
P_2O_5	0.07	0.12	0.02	0.16	0.10	0.13	0.02	0.05	0.13
MnO	0.05	0.05	0.06	0.13	0.16	0.07	0.02	0.05	0.05
Loss on ignition	0.41	0.59	0.56	1.13	0.45	0.21	0.28	0.38	0.53
Total+	100.36	100.41	100.14	102.01	98.54	100.09	100.04	100.49	99.08

*Total iron as Fe_2O_3.
+Does not include loss on ignition.

Weymouth Granite
1. Biotite granite, Restoration I. (BMR 67570042).
2. Biotite granite, 3 km SW of Portland Roads. (BMR 67570035).
3. Hornblende-biotite granite, Heming Ra. (BMR 67570036).

Diorite
4. Biotite-hornblende tonalite, on Kennedy Rd 5 km ENE of Mt Tozer. (BMR 68480199).
5. Hornblende diorite, 5 km SE of Ogilvie Hill. (BMR 68480198).

Granophyric and Hybrid Rocks
6. Hornblende-biotite granodiorite, on Kennedy Rd near crossing of Pascoe R. (BMR 68480196).
7. Leucocratic biotite granite, Stony Pt. (BMR 67570040).

Wolverton Adamellite
8. Biotite granite, 8 km WSW of Bald Hill. (BMR 68480194).

Twin Humps Adamellite
9. Hornblende-biotite granite or adamellite, 11 km NNW of Coen. (BMR 68480238).

Analysed by G. H. Berryman (BMR) by X-ray fluorescence method.

Pink or grey microgranite crops out near Sefton Creek on the western margin of the Mount Carter Block, and dykes of microgranite and felsite cut the country rock near the granite contact. The small altered fine-grained porphyritic acid intrusives in the Sefton Metamorphics in Temple Bay may be related to the earlier acid volcanics or to the Weymouth Granite.

The granite contains anhedral quartz, subhedral phenocrysts of microcline or orthoclase, which are weakly microperthitic in places, and laths of oligoclase or sodic andesine, which are commonly rimmed with albite and partly altered to sericite and clay. Microcline is mainly confined to the eastern part of the granite. The ratio of potash feldspar to plagioclase ranges from 2:1 to 1:1. The biotite is yellowish brown to dark brown, and in places is altered to chlorite. Some of the rocks contain up to 3 percent of granular green hornblende, which in places forms aggregates with biotite. The accessories are zircon, apatite, allanite, sphene, and monazite. The monazite appears to be restricted to the granite in the Cape Direction area. Chemical analyses are given in Table 20.

Contact effects

The upper Palaeozoic volcanics have been thermally metamorphosed by the granite for several kilometres from the contact. In the least altered rocks the only change is a slight increase in the grainsize of the groundmass, but closer to the contact the volcanics have been converted into massive biotite-quartz-feldspar hornfels.

Between the Pascoe River and Bowden the granite intrudes a belt of hybrid and granophyric rocks. The contact is obscured by numerous apophyses of granite in the older rocks, and by the presence of many large xenoliths of recrystallized volcanic and hybrid rocks within the granite. At the contact with the Kintore Adamellite in the Round Back Hills, 10 km west of Portland Roads, large lenses of biotite gneiss or foliated Kintore Adamellite are found within the Weymouth Granite. Similar lenses are present in the Weymouth Granite near Portland Roads.

Wolverton Adamellite
(Whitaker & Willmott, 1969a)

Derivation of name

The Wolverton Adamellite was named after the Parish of Wolverton.

Distribution

The adamellite crops out over an area of about 80 km^2 to the north and west of Bald Hill in the Coen Sheet area, and extends to the northwest under the Mesozoic sandstone. It is fairly well exposed as small boulders and blocks, especially at the base of the Mesozoic rocks.

Lithology

The Wolverton Adamellite consists of massive fine or medium-grained grey or pink leucocratic biotite adamellite and granite, with some aplite or microgranite towards its eastern margin. The medium-grained adamellite contains a few phenocrysts of potash feldspar up to 7 mm long.

The leucocratic adamellite and granite are composed of quartz, untwinned orthoclase(?) microperthite, plagioclase, and a little dark brown biotite, largely altered to chlorite. The leucocratic granophyric microgranite in the southeast consists of orthoclase(?) microperthite, quartz, and oligoclase. A chemical analysis is given in Table 20.

The adamellite is cut by two or three systems of quartz reefs trending between 140° and 150°. In the south the reefs swing round to between 170° and 180° and cut across the eastern margin of the adamellite where it is faulted against older rocks. The adamellite also contains numerous small veins of translucent quartz, which probably occupy tension cracks. The main vertical joints trend 140° to 150° and the minor joints from 80° to 100°.

Twin Humps Adamellite
(Whitaker & Willmott, 1969a)

Derivation of name

The Twin Humps Adamellite was named after The Twin Humps, an isolated range 6 km northwest of Coen.

Distribution

The adamellite is exposed over about 130 km^2 in The Twin Humps range north of Coen, and in an east-trending body in the McIlwraith Range east of Coen airport. It intrudes the

Kintore and Lankelly Adamellites and the Coen Metamorphics. In the McIlwraith Range, where the adamellite is covered by rain forest, the boundary has been photo-interpreted. The rock is well jointed and has a distinctive pattern on the air-photographs, especially east of Coen airport.

Lithology

The typical medium or coarse-grained grey hornblende-biotite adamellite in The Twin Humps range is generally even-grained, but in places the rock contains phenocrysts of potash feldspar, up to 1.5 cm long, set in a fine-grained groundmass rich in biotite. A chemical analysis is given in Table 20.

The subordinate pink leucocratic variety is more variable in grainsize and composition and contains many patches and cross-cutting bodies of quartz-feldspar pegmatite and aplite. The contact between the two types is gradational except on the west side of the range.

The coarse-grained pink leucocratic biotite adamellite and granite east of Coen airport contain numerous small patches of quartz-feldspar pegmatite and aplite, especially in the north. The rock becomes progressively finer towards the contact with the Lankelly Adamellite in the southwest, where it is cut by numerous veins of biotite-quartz-feldspar pegmatite.

In The Twin Humps range the grey adamellite is composed of anhedral phenocrysts of microcline microperthite, quartz, laths of oligoclase, up to 5 percent biotite and hornblende, and a little allanite and zircon. Although the ratio of potash feldspar to plagioclase varies the total feldspar content remains constant at about 60 percent. The marginal pink leucocratic granite in The Twin Humps range contains a little biotite, but no hornblende or allanite.

The Twin Humps Adamellite east of Coen airport has a composition close to the adamellite-granite boundary. The rock contains quartz, orthoclase, oligoclase, and biotite, but no hornblende or allanite.

The Lankelly Adamellite between the two intrusions of Twin Humps Adamellite is cut by a number of acid dykes, the largest of which forms the summit of Mount Croll to the east of Coen airport. The dykes consist of cream aphanitic rhyodacite(?) containing numerous small phenocrysts of quartz and potash feldspar and a few crystals of plagioclase. They are probably related to the Twin Humps Adamellite.

MESOZOIC SEDIMENTARY ROCKS

Laura Basin

The sediments on the west flank of the Laura Basin overlie basement rocks on the eastern margin of the Yambo Inlier and southeastern margin of the Peninsula Ridge, between the Palmer and Morehead Rivers. The sequence is part of the Lower Cretaceous Battle Camp Formation of de Keyser & Lucas (1968), and consists of current-bedded pebbly sandstone, with a basal conglomerate containing pebbles and cobbles of quartzite from the underlying metamorphic rocks. The sandstone is predominantly medium-grained and is very poorly sorted; it consists mainly of quartz with a little kaolinized feldspar and muscovite. Cross-beds are common, and graded beds up to 5 cm thick were noted in places. The sandstone-conglomerate sequence appears to be thickest in depressions in the basement surface, which has a relief of up to 100 m.

The Mesozoic sediments in the southern part of the plateau (known as The Desert) form a connecting link between the Laura and Carpentaria Basins. The sequence comprises fine-grained sandstone, siltstone, and claystone overlying sandstone and conglomerate, which probably represent the upper part of the Battle Camp Formation; in The Desert area the Battle Camp Formation grades laterally in part into the Wrotham Park Sandstone (Amos & de Keyser, 1964) of the Carpentaria Basin.

On the coast at Princess Charlotte Bay cross-bedded quartz sandstone and conglomerate, with pebbles of quartzite, schist, and ferricrete, crop out in a low ridge which ends in a headland near the mouth of Gorge Creek, 25 km south of the Stewart River. The sequence resembles that on the nearby Cliff Islands, which was considered by Lucas (1963) to be Cretaceous or lower Tertiary. The poorly consolidated cross-bedded sandstone exposed in a low sand-covered ridge rising from the coastal plain north of Silver Plains homestead may be of the same age.

Carpentaria Basin

The sequence in the Carpentaria Basin overlies basement rocks along the western margin of the Peninsula Ridge and Yambo Inlier, and along the southern margin of Torres Strait. The basal part of the sequence generally consists of pebbly sandstone with some conglomerate, overlain by fine siltstone, mudstone, and shale, but in places the siltstone sequence rests directly on basement.

Sandstone sequence. There is generally a conglomerate containing pebbles, cobbles, and boulders of quartzite, schist, granite, and volcanic rocks at the base of the sandstone sequence. It is commonly about 3 m thick, but north of Bald Hill it thickens to 30 m. Between the Wenlock and the Pascoe Rivers the conglomerate contains thin interbeds of shale and coal (Morton, 1924; AAP, 1965). The sandstone is medium-grained or coarse-grained and poorly sorted; well developed current-bedding is usually present. The rock is generally leached, and most exposures are paved with ferricrete.

In the south, between the Mitchell and Coleman Rivers, the sandstone sequence is generally less than 30 m thick, except in The Desert region; in places the sandstone is absent and the siltstone sequence rests directly on basement. North of the Coleman River the sandstone is up to 60 m thick and contains many beds of conglomerate, especially where it fills depressions in the basement. West of Coen the sequence thins to less than 30 m, but farther north in the Geikie and Sir William Thompson Ranges Australian Aquitaine Petroleum Ltd recorded 600 m of sandstone and conglomerate (AAP, 1965). AAP estimated the sequence between Temple Bay and Cape York to be over 250 m thick.

In the south near the Mitchell River the sandstone sequence has been referred to as the Wrotham Park Sandstone by de Keyser & Lucas (1968). Woods (1961) considers it to be of Neocomian age because it underlies the Aptian Blackdown Formation. Across The Desert the Wrotham Park Sandstone grades into the Battle Camp Formation of the Laura Basin.

In the north, between the Archer River and Cape York, Australian Aquitaine Petroleum Ltd (AAP, 1965) have informally named and subdivided the sandstone into a number of formations and members. The fossil plants collected by Morton near the base of the sequence at Wenlock were determined as Lower Cretaceous by Walkom (1928). Whitehouse (1954) notes that Aptian fossils have been found in the sandstone sequence a few kilometres south of Cape York.

The *siltstone sequence* cropping out to the west of the sandstone sequence consists of siltstone, mudstone, shale, and fine-grained silty sandstone. In the south near the Mitchell River the sequence has been referred to as the Blackdown Formation (de Keyser & Lucas, 1968), which Woods (1961) considers to be Aptian. North of the Archer River it has been called the Mein Formation (Morton, 1924), which Australian Aquitaine Petroleum Ltd (AAP, 1965) estimated to be over 60 m thick. The abundant macrofossils and microfossils indicate a Neocomian to Albian age (Morton, 1924; Crespin, 1956; Cookson & Eisenack, 1958, 1960; Eisenack & Cookson, 1960; Fleming, 1965; Evans, 1966).

Papuan Basin

The Mesozoic sequence in the Papuan Basin north of Torres Strait is not exposed and is known only in petroleum exploration wells. The sequence consists of continental Jurassic arkosic sandstone with seams of coal and lignite overlain by marine Lower Cretaceous glauconitic quartz sandstone and silty mudstone (APC, 1961). The sequence was laid down on a shelf formed by the slowly subsiding northern extension of the Australian continental platform. The sequence has an average thickness of about 1000 m, but thins to about 100 m over a basement ridge in the Oriomo area.

Seismic and magnetic surveys by Gulf International Overseas Ltd (Gulf, 1962, 1965), Tenneco Australia Inc. (Tenneco, 1967, 1968), and Phillips Australian Oil Co. (Phillips, 1965, 1968) suggest that the Mesozoic sequence extends to the south into the northeastern part of Torres Strait, where it drapes irregularities in the basement and is complexly faulted. The Anchor Cay 1 well passed through about 1500 m of Lower Cretaceous sandstone and siltstone and Jurassic deep-water pyritic shale before approaching basement (Oppel, 1969); the pyritic shales are in marked contrast to the continental Jurassic sediments farther north. To the west and south the sediments apparently onlap the basement rocks, but there may be a narrow northerly trending connexion between the Papuan and Carpentaria Basins between the southern end of the Warrior Reefs and Shelburne Bay.

CAINOZOIC SEDIMENTARY ROCKS

Lilyvale Beds
(Whitaker & Willmott, 1968)

Derivation of name. The Lilyvale Beds were named after Lilyvale homestead in the eastern part of the Ebagoola Sheet area. The beds crop out below the eastern escarpments of the Coleman and McIlwraith Plateaux, and below the western escarpment of the McIlwraith Plateau in the Archer River Piedmont Basin. They are generally covered by residual sand or alluvium, but are well exposed in the smaller streams, especially near the base of the escarpments. Scattered outcrops of sandstone and conglomerate are common on the Holroyd Metamorphics and in the Yambo Inlier, and small exposures are also found in the interior of Moa and Wednesday Islands.

Lithology. The Lilyvale Beds are composed of poorly bedded clayey sandstone and conglomerate. The rocks are massive, friable, and poorly sorted. The presence of angular pebbles of quartz, derived from quartz veins in the underlying granites, indicates that the sediment was not transported far from its source. The weathered rocks have a characteristic honeycomb pattern.

The Lilyvale Beds are up to 10 m thick and are generally horizontal. Lucas & de Keyser (1965b) noted 45 m of clayey sandstone and grit that may belong to the Lilyvale Beds in the Marina Plains 1 well about 10 km south of Marina Plains homestead. The thickness in the Archer River Piedmont Basin may also exceed 30 m.

Yam Creek Beds
(Whitaker & Willmott, 1969a)

Derivation of name. The Yam Creek Beds were named after Yam Creek, a tributary of the Pascoe River. They were referred to informally as the Brown Creek Grit by the Broken Hill Pty Co. Ltd (BHP, 1962) and the Yam Creek Formation by Australian Aquitaine Petroleum Ltd (AAP, 1965).

Distribution. The Yam Creek Beds form elevated dissected plains around the Pascoe River and its tributaries. The beds are generally about 15 m thick, but range up to 60 m in places; they are capped by up to 3 m of ferricrete.

Lithology. The Yam Creek Beds consist of poorly consolidated clayey sandstone and conglomerate. They contain less conglomerate and are generally finer-grained than the Lilyvale Beds. The beds may have been laid down in a lake formed by the damming of the ancestral Pascoe River, or on an alluviated plain which has since been uplifted and dissected.

Ferricrete

The term ferricrete is used for the massive cappings of concretionary ironstone on the Mesozoic sandstones. Ferricrete also occurs on the metamorphic rocks in the western part of the Holroyd Metamorphics, and on the ridges of magnetite quartzite at Black Hill in the Iron Range region, where it is rich in manganese as well as iron. The Yam Creek Beds are also capped with ferricrete, but it is rare on the Lilyvale Beds. Cappings of ferricrete are also found on some of the ridges of acid volcanics on Moa and Mount Adolphus Islands in Torres Strait. On Turtle Head Island and on the nearby mainland the ferricrete is underlain by bauxite or aluminous laterite (Connah & Hubble, *in* Hill & Denmead, 1960).

Ferricrete is exposed in many of the stream valleys at a lower elevation than the main capping, as for example in the valley of Laradeenya Creek, 12 km southwest of Cape York. Connah & Hubble have suggested that the ferricrete on the lower surfaces may be related to the present-day level of groundwater. They consider that the older ferricrete was formed in late Tertiary time.

Residual Quartz Sand

Beds of white residual quartz sand up to a few metres thick are widely distributed on the granitic batholith in the Ebagoola and Hann River Sheet areas, and thinner sheets extend over a large part of the remainder of the area mapped; quartz sand is also abundant on the Mesozoic sandstone. On the low plains of the Laura Basin the residual quartz sand forming the interfluvial areas was called the Jack Peneplain by de Keyser & Lucas (1968). The sand was probably derived from the underlying Lilyvale Beds. In the Ebagoola Sheet area east of

Kintore hill, the residual deposits on the interfluvial areas overlie metamorphic rocks, and the quartz sand rests on dark red micaceous soil.

Dune Sand

The dune sands between Temple Bay and Shelburne Bay, in the Cape Weymouth and Orford Bay Sheet areas, extend over an area of more than 380 km². The longitudinal dunes are up to 100 m above sea level, and are aligned in a northwesterly direction; some are still advancing towards Shelburne Bay. The dunes were probably formed by reworking of thick residual quartz sand, derived from the underlying Mesozoic sandstone, by the prevailing south-easterly winds. The dunes west of Newcastle Bay, south of Turtle Head Island, and along the coast of the mainland in the Orford Bay Sheet area, are all developed on Mesozoic sandstone. Patches of small dunes also occur near Cape Griffith and south of Cape Direction.

Alluvium

Most of the alluvium ranges from silty clay to silty sand. It has been deposited in the lower reaches of some of the larger streams, such as the Lockhart, Claudie, and Jardine Rivers, and on the low plains of the Laura Basin and the low country east of the granitic escarpment farther north. In the Laura Basin the alluvium forms the Normanby Sediplain of de Keyser & Lucas (1968). The sediplain has a slightly lower elevation than the interfluvial areas of residual sand forming the Jack Peneplain.

The silty sand in some of the rivers is difficult to distinguish from the residual sands.

Marine Sediments

Much of the coast of Cape York Peninsula and many of the islands in Torres Strait are fringed with marine sediments, and many sand cays have been formed on the coral reefs.

There is a narrow ridge of quartz sand and shell debris at the head of most of the beaches; the sand generally slopes gently beneath the sea, and around Princess Charlotte Bay is is underlain by mud which extends seawards below low-tide level. Where a fringing reef is present, particularly in Torres Strait, the beach sand is mainly composed of shell and coral fragments, with a thin layer of mud on the dead inshore part of the reef. In places the sand of the beach ridge has been cemented to form beach rock. The series of raised beaches, which extend up to 15 km inland, around the southern shores of Princess Charlotte Bay indicates an emergence of 3 to 5 m.

In many places along the coast the beach ridges are backed by saline mud flats and mangrove swamps. The most extensive swamps are found at the mouths of northerly flowing streams, such as the Lockhart and Kangaroo Rivers. On many of the islands in Torres Strait there is no beach, and the reef flat extends seaward from a fringe of mangroves. The southern coast of Papua is also largely fringed by mangrove swamps.

Coral sand cays have been formed at the leeward ends of reefs of the platform type. They are composed of foraminiferal, shelly, and coral sand and shingle, and are covered by coarse grass or stunted thorn scrub. Some cays, such as Sassie and Dungeness Islands, are low and swampy.

Papuan Basin

The Cainozoic sediments in southwest Papua extend southeastwards into Torres Strait to about latitude 10°15′S. The oldest Cainozoic beds in the Anchor Cay 1 well in the north-eastern part of Torres Strait consist of over 300 m of Eocene limestone resting unconformably on the Mesozoic sequence (Oppel, 1969). Eocene sediments are also present in the Gulf of Papua. There is an unconformity at the top of the Eocene, and no Oligocene strata are known.

During the Miocene about 1000 m of limestone was laid down on an extensive shallow shelf covering much of southwest Papua and the northeastern part of Torres Strait. The limestone is well exposed northwest of Daru; the sequence is over 1000 m thick in the Anchor Cay I well. Thompson (1967) and Phillips Australian Oil Co. (Phillips, 1968) consider that the eastern edge of the Miocene shelf is marked by a buried barrier reef, which extends north from the end of the present Great Barrier Reef to the head of the Gulf of Papua. In the deeper waters east of the shelf basinal limestone was deposited, except in areas of local uplift where platform reefs developed.

A thin sequence of Pliocene and Pleistocene terrigenous sediments was then laid down over most of the shelf in southwest Papua (APC, 1961; MacGregor, 1967; Blake & Ollier, 1970), but in the Anchor Cay area on the southeastern edge of the shelf, where carbonate sedimentation has continued from the Pliocene to the present day, over 800 m of limestone was laid down; thus a barrier reef complex has probably existed in this region since the Miocene. To the north, the barrier reef was buried under a considerable thickness of Pliocene, Pleistocene, and Holocene argillaceous sediments, probably after uplift of the central Highlands in Papua.

The presence of two levels of Holocene(?) alluvium on the coastal plain in southwest Papua probably indicates slight uplift. Farther west in the Morehead area Blake & Ollier (1970) have shown that the Pleistocene sediments are warped.

Coral Reefs

The Great Barrier Reef extends along the edge of the continental shelf from Princess Charlotte Bay as far north as the Anchor and East Cays to the north of the Murray Islands. In the shallow water behind the barrier reefs many platform or patch reefs have grown. The Warrior Reefs in the north are situated on the eastern edge of a shallow shelf, and are so extensive they could be regarded as a subsidiary barrier reef. The platform reefs between the western islands in Torres Strait are oriented east-west, parallel to the currents that flow through the channels between the islands. Most of the islands in Torres Strait are surrounded by fringing coral reefs. They are less common along the coast of Cape York Peninsula, and are poorly developed along the Papuan coast, probably because of the suspended sediment brought down by the Fly River and other Papuan streams.

CAINOZOIC IGNEOUS ROCKS

Olivine Nephelinite

A plug of olivine nephelinite about 2.5 km in diameter crops out near Balclutha Creek, 50 km southeast of Coen. The plug forms a hill about 15 m high surrounded by white residual sand. The nephelinite crops out as boulders up to 1.5 m across, but the contacts are not exposed. Dr D. O. Zimmerman (pers. comm.) has recorded an olivine nephelinite about 7 km west of Silver Plains homestead, and the BMR gravity map shows a prominent gravity high of +45 mgal, between the Stewart River and Massey Creek, which may be due to the presence of another plug.

The nephelinite is a massive dark fine-grained rock composed of scattered subidiomorphic phenocrysts of olivine, from 0.1 to 5 mm across, set in a fine-grained groundmass of light green clinopyroxene, anhedral grains of nepheline, and opaque minerals. Some of the olivine has been altered to serpentine. A chemical analysis and CIPW norm are given in Table 21.

TABLE 21. CHEMICAL ANALYSIS OF OLIVINE NEPHELINITE

		CIPW Norm		
SiO_2	39.30	an		1.25
Al_2O_3	12.00	ne		27.00
Fe_2O_3	6.25	lc		1.60
FeO	7.50	kp		8.70
MgO	11.30		wo	18.90
CaO	11.30	di	en	16.30
Na_2O	5.10		fs	2.60
K_2O	2.80		fo	10.40
H_2O^+	0.92	ol		
H_2O^-	0.39		fa	1.65
CO_2	0.20	mt		6.30
TiO_2	2.20	il		3.00
P_2O_5	0.83	ap		1.60
MnO	0.15	cc		0.60
		H_2O		1.31
Total	100.24			

Analyst: A. Jorgenson, Australian Mineral Development Laboratories, Adelaide.

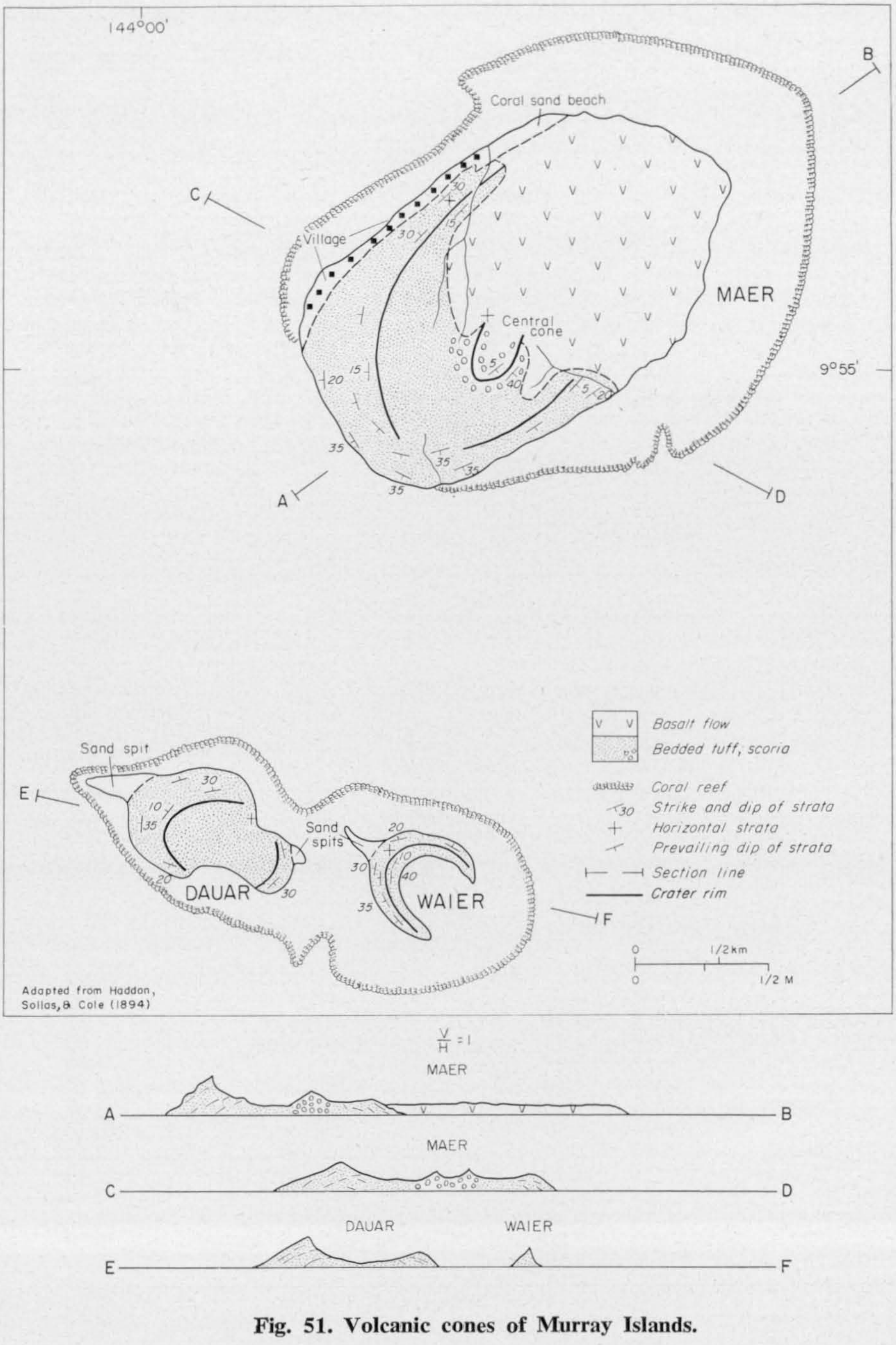


Fig. 51. Volcanic cones of Murray Islands.

The nephelinite is possibly related to the Cainozoic ultra-alkaline lavas of the Cooktown district (Morgan, 1968b).

Maer Volcanics
(Whitaker & Willmott, 1969b)

Derivation of name

The name Maer Volcanics is taken from Maer Island, the largest of the Murray Islands 200 km northeast of Cape York. The volcanics were described but not named by Haddon et al. (1894) and Jardine (1928a, b).

Distribution

The volcanics form the Murray Islands (Maer, Dauan, and Waier), Darnley Island, Stephens Island, the Black Rocks, and a small exposure at Bramble Cay, all in the northeastern part of Torres Strait. The calcareous tuff and tuffaceous sediments on Daru Island are probably of the same age and have therefore been included in the Maer Volcanics.

Physiography and structure

The three Murray Islands (Fig. 51) consist of volcanic cones composed of tuff. *Maer Island* is an ash cone with an elliptical crater about 2.5 km long and 1 km wide. At the west end of the island the rim of the crater rises to a peak about 200 m high, known locally as Gelam. In the east, the rim of the crater is less than 60 m high and has been breached by basalt flows with an aggregate thickness of over 30 m. The basalt supports dense tropical vegetation, and the tuff in the crater is covered with long grass. The dip of the tuffs increases outwards from 10° on the crest of the rim of the crater to about 30° around the coast. Local dips up to 60° due to slumping have been recorded. About 1 km east of Gelam, a small central cone rises over 30 m from the floor of the crater. It is covered by friable red soil containing blocks of vesicular basalt, but horizontal beds of coarse tuff and agglomerate crop out in the south. The cone lies near the apex of the triangular outcrop of basalt forming the east end of the island, and is possibly the vent from which the basalt was erupted.

Dauar Island is an ash cone about 1 km long and 180 m high. In the north and south the crater has been breached by the sea, and the island consists of a high western hill and a much lower eastern hill, separated by the thickly vegetated floor of the crater. The radial dips on the island range from 10° on the crest of the western hill to over 30° on the dip-slopes near the western shore.

Waier Island represents the semicircular western half of an ash cone with a diameter of about 1 km. The eastern half of the cone was probably much lower because of the strong prevailing southeasterly winds, and has since been destroyed by the sea. The radial dips range from horizontal around the summit of the crater rim, to 30° or 40° on the outer flanks. On the steep inner slopes slumped blocks of tuff up to 50 m across dip inwards at up to 50°. On all three islands the highest parts of the crater rims are in the west, probably because of the prevailing southeasterly winds.

Darnley Island consists of a broad dome of basalt about 5 km across and 180 m high. The island has been largely cleared of scrub and is now covered by grass. In the south and southwest the basalt flows dip gently to the south. The two steps on the ridge running south from the summit of the island probably represent the tops of lava flows. The steeper northern side of the island has been dissected by two streams running into Treacherous Bay. In the small cliffs around the bay the basalt is underlain by bedded tuff dipping outwards at 10° to 20° from a point in the sea to the north of Treacherous Bay. Jardine (1928b) concluded that the tuff represents the southern part of an ash cone.

Stephens Island is a small plateau of basalt about 2.5 km long and 30 m high covered by stunted tropical forest. The source of the basalt is unknown.

The *Black Rocks,* protruding above a small reef flat about 8 km southwest of Bramble Cay, are composed of coarse bedded tuff (Jardine, 1928a). The rocks have an area of about 250 m^2, and rise about 3 m above low tide level; they were not visited during this survey because of the high seas.

Bramble Cay is a sand cay with two small exposures of basalt at the east end of the coral reef flat. The largest is crescentic and about 400 m^2 in area. The rocks are only about 3 m high and are almost submerged at high tide.

Most of *Daru Island* is low and swampy, but the town of Daru is sited on a low central rise from 15 to 30 m high, formed of tuffaceous sediments. Best (1954) has suggested that the tuff was ejected from a vent on the highest part of the rise near the north end of the island, but no evidence of this could be found.

Lithology

All three cones of the *Murray Islands* consist of weathered yellowish brown bedded tuff, composed of lapilli and small bombs of basalt, crystals of olivine and pyroxene, and round fragments of white limestone set in a fine-grained matrix of altered brown basaltic glass. The sequence consists mainly of beds of fine-grained tuff up to 2 m thick alternating with beds of coarse tuff up to 60 cm thick. The fine-grained tuffs contain lenses of coarser material; cross-beds and scours were noted in places.

The bombs are composed of fragments of vesicular basalt averaging a few centimetres in diameter, with occasional blocks up to 1 m across. They are most abundant in the coarse-grained beds and some of them have distorted the beds for a few centimetres beneath them. The rounded fragments of limestone, which range up to several centimetres across, are more abundant in the coarser beds, but on Maer Island they are concentrated in particular beds containing relatively few basalt fragments. The limestone is light grey, with patches of white recrystallized material, and contains fragments of coral and molluscs.

On Maer Island there are a few thin beds of lapilli tuff composed almost entirely of well rounded brown weathered fragments. At Dauar Island the subhorizontal tuff within the crater is rich in olivine and pyroxene crystals, and on Waier Island some of the tuff beds contain up to 30 percent basaltic bombs. Limestone fragments are also more common on Waier Island.

The basalt that breaches the cone of Maer Island is a dark aphanitic vesicular rock with numerous phenocrysts of olivine and pyroxene. The wide variation in the number of the phenocrysts in the coastal exposures suggests that several flows are exposed.

On *Darnley Island* at least 30 m of bedded tuff is exposed beneath the basalt in Treacherous Bay; the base of the sequence is not exposed. The tuff is similar to that on the Murray Islands, but limestone fragments, cross-beds, and scours are more common. Some of the larger bombs have slightly deformed the bedding in the underlying tuff. The strike of the bedding is roughly parallel to the curved shore of Treacherous Bay.

The contact between the basalt and tuff is well exposed around the shore of Treacherous Bay; in places the basalt rests directly on tuff, but in others it is separated by a thin layer of rounded cobbles and small boulders of basalt set in a sparse matrix of red clay. In one place a thin tongue of basalt has penetrated the tuff along a bedding plane.

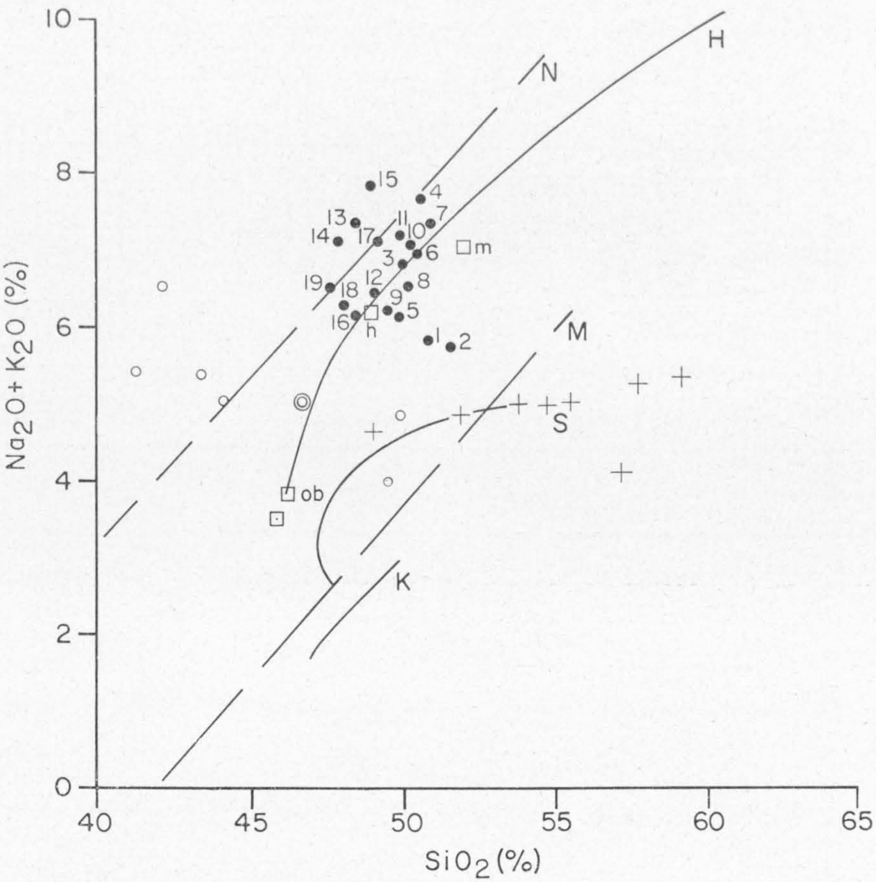
The basalt contains numerous phenocrysts of olivine and pyroxene and some laths of plagioclase; nodules of olivine are present in places. It is not as vesicular as the basalt on Maer Island. The sequence of lavas is about 150 m thick. It is generally difficult to distinguish individual flows, although the glassy basalt containing large blocks of vesicular basalt and the red earth on the northern slopes of the island may represent the tops of flows, and the ridge of clay in the northeast, which trends southeast across the island, may represent the weathered outcrop of a less resistant flow.

In the highly vesicular basalt on *Stephens Island* the vesicles are up to 8 cm long, and many of them are partly filled with zeolites. The basalt contains more phenocrysts of plagioclase, in addition to olivine and augite, than the basalts on Darnley and Maer Islands.

The *Black Rocks* consist of coarse ash and tuff with a well developed banded structure (Jardine, 1928a). They are composed of fragments of decomposed olivine basalt set in a fine-grained matrix of olivine and augite crystals and calcareous material. The beds strike at 110° and dip southwest at 15°.

The larger of the two exposures at *Bramble Cay* consists of vesicular basalt resting on non-vesicular pillow lava. A few of the pillows have a concentric structure. The breccia described by Jardine (1928a) consists of ferruginized and cemented blocks of basalt. The smaller exposure consists of a compact aggregate of rounded fragments of vesicular basalt.

The fine-grained tuffaceous sediments on *Daru Island* consist of small rounded fragments of basalt and limestone set in a matrix of lapilli, fragments of altered glass, scattered grains of olivine, pyroxene, and iron oxide, and abundant calcite cement. According to MacGregor (1967) the tuffaceous sandstone is almost horizontal and from 3 to 15 m thick; the base of the sandstone is up to 4 m below sea level and is underlain by a thick layer of yellow or blue clay. The sediments encountered in bores beneath the tuff are similar to Plio-Pleistocene sediments in the Oriomo area in Papua (APC, 1961).



EXPLANATION OF SYMBOLS USED ON FIGURES 58-60

● Basaltic rocks of Maer Volcanics (numbers refer to analyses in Tables 22 and 23), o Basaltic rocks from Cooktown district (Morgan, 1968b), ◎ Average of olivine basalts from Cairns hinterland (Morgan, 1968a), + Shoshonitic rocks from central Highlands of Papua New Guinea (Jakes & White, 1970), ⊡ Average olivine basalt (Nockolds, 1954). H Hawaiian alkali basalt trend: ob, olivine basalt; h, hawaiite; m, mugearite (Macdonald, 1949; Muir & Tilley, 1961), G Gough Island alkali basalt trend (Le Maitre, 1962), SH Shoshonite trend (from absarokite-shoshonite-banakite-quartz banakite series of Yellowstone Park, U.S.A., Joplin, 1968b), S Skaergaard tholeiitic liquid series (Wager, 1960), K Kilauea tholeiitic rocks (Muir & Tilley, 1963), T Tasmanian tholeiitic trend (Joplin, 1968b), CA Calc alkaline association (Joplin, 1968b), M Boundary between alkali and tholeiitic fields (Macdonald & Katsura, 1964), N Boundary between mildly and strongly alkaline rocks (Saggerson & Williams, 1964).

M(Pt) 88

Fig. 52. Ratio of SiO_2 to $Na_2O + K_2O$ in Maer Volcanics and other basalts.

TABLE 22. CHEMICAL ANALYSES OF MAER VOLCANICS

	1	2	3	4	5	6	7	8	9
SiO_2	50.70	51.50	50.00	50.50	49.80	50.40	50.70	50.10	49.40
Al_2O_3	15.50	15.60	14.30	14.60	14.10	14.80	14.70	14.50	14.80
Fe_2O_3	4.75	2.50	1.82	3.75	2.65	4.20	3.40	4.85	3.75
FeO	4.60	6.75	6.90	5.50	6.40	4.95	5.75	4.20	5.70
MgO	6.05	6.45	7.45	7.45	7.50	7.00	7.65	6.95	7.65
CaO	7.45	7.75	7.20	6.75	7.40	6.75	6.95	7.10	6.70
Na_2O	4.05	4.15	3.95	4.30	3.55	4.25	4.50	3.50	3.65
K_2O	1.67	1.64	2.85	3.35	2.55	2.70	2.80	3.00	2.60
$H_2O^{(+)}$	1.08	0.38	0.83	0.39	1.13	0.93	0.31	1.40	1.58
$H_2O^{(-)}$	0.82	0.28	1.07	0.35	1.52	0.75	0.35	1.27	0.98
CO_2	0.05	<0.05	0.35	<0.05	0.36	<0.05	<0.05	0.21	0.15
SO_3	0.54	—	0.10	—	—	—	—	—	—
TiO_2	2.10	2.15	2.25	2.30	2.20	2.25	2.20	2.20	2.15
P_2O_5	0.43	0.46	0.63	0.66	0.58	0.67	0.66	0.65	0.70
MnO	0.13	0.15	0.13	0.14	0.14	0.14	0.14	0.12	0.13
Total	99.92	99.82	99.83	100.09	99.87	99.84	100.16	100.05	99.94

CIPW Norms

		1	3	5	8	9
	or	9.87	16.84	15.07	17.72	15.36
	ab	34.25	29.00	30.02	29.60	30.87
	an	19.19	12.88	15.01	15.50	16.33
	ne	—	2.39	—	—	—
di	wo	6.11	6.89	6.53	6.12	4.76
	en	5.02	4.56	4.54	5.27	3.57
	fs	0.35	1.83	1.44	0.02	0.71
hy	en	9.50	—	2.49	6.20	2.69
	fs	0.67	—	0.79	0.03	0.54
ol	fo	0.39	9.80	8.16	4.09	8.96
	fa	0.03	4.34	2.85	0.02	1.98
	mt	6.89	2.64	3.84	7.03	5.44
	il	3.99	4.27	4.18	4.18	4.08
	ap	1.02	1.49	1.38	1.54	1.66
	cc	0.11	0.80	0.82	0.48	0.34
	H_2O	1.90	1.90	2.64	2.67	2.56
Total		99.29	99.63	99.76	100.47	99.85

1. Stephens I. (BMR 68480169).
2. Stephens I. (BMR 68480176).
3. Darnley I., SW coast. (BMR 68480263).
4. Darnley I., SW corner. (BMR 68480175).
5. Darnley I., S coast. (BMR 68480173).
6. Darnley I., W coast. (BMR 68480260).
7. Darnley I., W coast. (BMR 68480261).
8. Darnley I., ridge E of summit. (BMR 68480259).
9. Darnley I., ridge E of summit. (BMR 68480299).

Analysts: C. Holland, A. Jorgenson, AMDL, Adelaide.

TABLE 23. CHEMICAL ANALYSES OF MAER VOLCANICS

	10	11	12	13	14	15	16	17	18	19
SiO_2	50.20	49.80	49.00	48.40	47.70	48.90	48.50	49.20	48.00	47.60
Al_2O_3	15.30	15.40	15.30	16.80	15.70	16.50	14.50	16.80	15.10	14.80
Fe_2O_3	220	2.30	2.25	3.05	2.20	1.84	1.80	2.20	2.00	2.35
FeO	6.90	6.65	7.05	5.60	6.35	6.60	7.95	6.35	8.00	7.55
MgO	7.40	7.10	8.35	6.70	8.20	6.80	9.65	6.70	8.55	8.80
CaO	7.20	7.20	7.35	6.35	6.95	6.35	7.65	6.40	7.85	8.15
Na_2O	4.65	4.70	4.05	4.15	3.95	4.45	3.95	5.10	4.05	4.30
K_2O	2.45	2.50	2.45	3.25	3.10	3.40	2.15	1.93	2.25	2.20
$H_2O^{(+)}$	0.39	0.56	0.56	2.00	1.95	1.59	0.72	1.52	0.39	0.61
$H_2O^{(-)}$	0.30	0.42	0.62	0.72	0.81	0.49	0.30	0.78	0.65	0.56
CO_2	0.06	0.05	0.10	0.01	<0.05	0.16	<0.05	0.09	0.13	0.03
SO_3	—	—	—	—	—	—	—	—	—	—
TiO_2	2.30	2.35	1.95	2.00	1.93	1.96	1.90	2.00	2.05	1.97
P_2O_5	0.64	0.71	0.71	0.77	0.74	0.75	0.67	0.79	0.74	0.68
MnO	0.13	0.13	0.15	0.14	0.15	0.14	0.16	0.14	0.16	0.16
Total	100.12	99.87	99.89	99.94	99.78	99.93	99.95	100.00	99.92	99.76

CIPW Norms

		10	11	12	13	15	17	18	19
	or	14.48	14.77	14.48	19.20	20.09	11.40	13.29	13.00
	ab	28.66	28.26	25.98	25.02	23.17	33.09	22.76	19.98
	an	13.65	13.55	16.34	17.62	15.01	17.26	16.38	14.59
	ne	5.78	6.23	4.48	5.46	7.84	5.44	6.23	8.88
di	wo	7.31	7.19	6.20	3.67	4.42	3.66	7.06	8.85
	en	4.89	4.87	4.16	2.63	2.87	2.44	4.53	5.88
	fs	1.87	1.77	1.57	0.70	1.25	0.95	2.06	2.33
hy	en	—	—	—	—	—	—	—	—
	fs	—	—	—	—	—	—	—	—
ol	fo	9.48	8.98	11.65	9.84	9.85	9.98	11.74	11.23
	fa	4.00	3.60	4.86	2.90	4.72	4.31	5.87	4.90
	mt	3.19	3.33	3.26	4.42	2.67	3.19	2.90	3.41
	il	4.37	4.46	3.70	3.80	3.72	3.80	3.89	3.74
	ap	1.52	1.68	1.68	1.83	1.78	1.87	1.75	1.61
	cc	0.14	0.11	0.23	0.02	0.36	0.20	0.30	0.07
	H_2O	0.69	0.98	1.18	2.72	2.08	2.30	1.04	1.17
Total		100.03	99.78	99.77	99.83	99.83	99.89	99.80	99.64

10. Bramble Cay. (BMR 68480168).
11. Bramble Cay. (BMR 68480293).
12. Maer I., SE coast. (BMR 68480286).
13. Maer I., NE coast. (BMR 68480253).
14. Maer I., NE coast. (BMR 68480329).
15. Maer I., NE coast. (BMR 68480254).
16. Maer I., N coast. (BMR 68480264).
17. Maer I., N coast. (BMR 68480255).
18. N. side of Waier I. Lava bombs in tuff. (BMR 68480247).
19. N. side of Waier I. Lava bombs in tuff. (BMR 68480291).

Analysts: C. Holland, A. Jorgenson, AMDL, Adelaide.

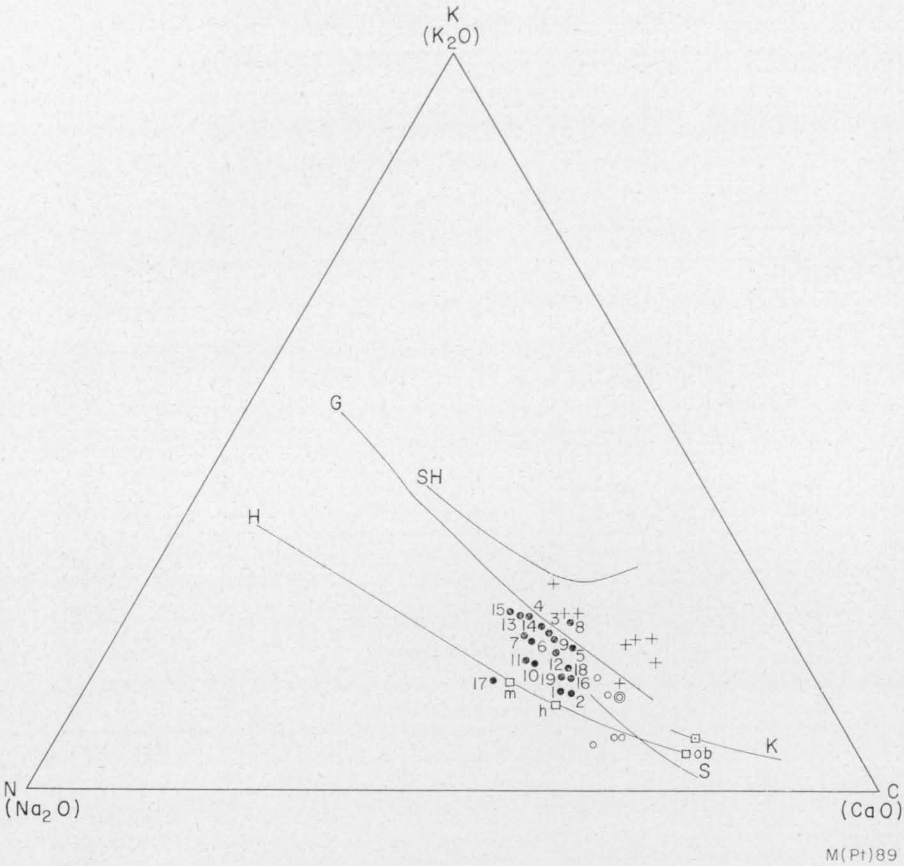


Fig. 53. KCN diagram, Maer Volcanics and other basalts.

Petrography

All the *basalts* contain numerous phenocrysts of olivine and augite. Most of them are holocrystalline, but some from the Murray Islands contain appreciable amounts of glass.

The basalt on Darnley Island is composed of phenocrysts of olivine, averaging about 2 mm across, crystals or clusters of pale brown augite up to 4 mm across, and subordinate plagioclase set in a groundmass of small subparallel laths of sodic labradorite, granular augite, olivine, opaque minerals, alkali(?) feldspar, and a little interstitial analcite. Most of the olivine is altered to deep red iddingsite. Spherical vesicles are common; some of them are filled with calcite and some are lined with a narrow shell of green zeolite.

The basalt on Stephens Island contains numerous phenocrysts of labradorite up to 3 mm long, but both the olivine and augite phenocrysts are smaller and slightly less abundant than in the basalts on Darnley Island. The groundmass is similar, but analcite is absent.

The basalt on Bramble Cay is similar to that on Darnley Island, but broken fragments of olivine and augite crystals are present in addition to the phenocrysts, and granular opaque minerals are much more abundant in the groundmass.

The basalt on Maer Island contains fewer and smaller phenocrysts than those on Darnley Island. Augite is not as common, but olivine is more abundant. The olivine is rarely altered to iddingsite and the augite is much paler in colour. The groundmass contains a little interstitial analcite. Spherical vesicles are very common, and in the more vesicular rocks the groundmass contains considerable amounts of reddish brown glass.

The basalt bombs in the tuff on Waier Island are similar in composition to the holocrystalline basalt on Maer Island.

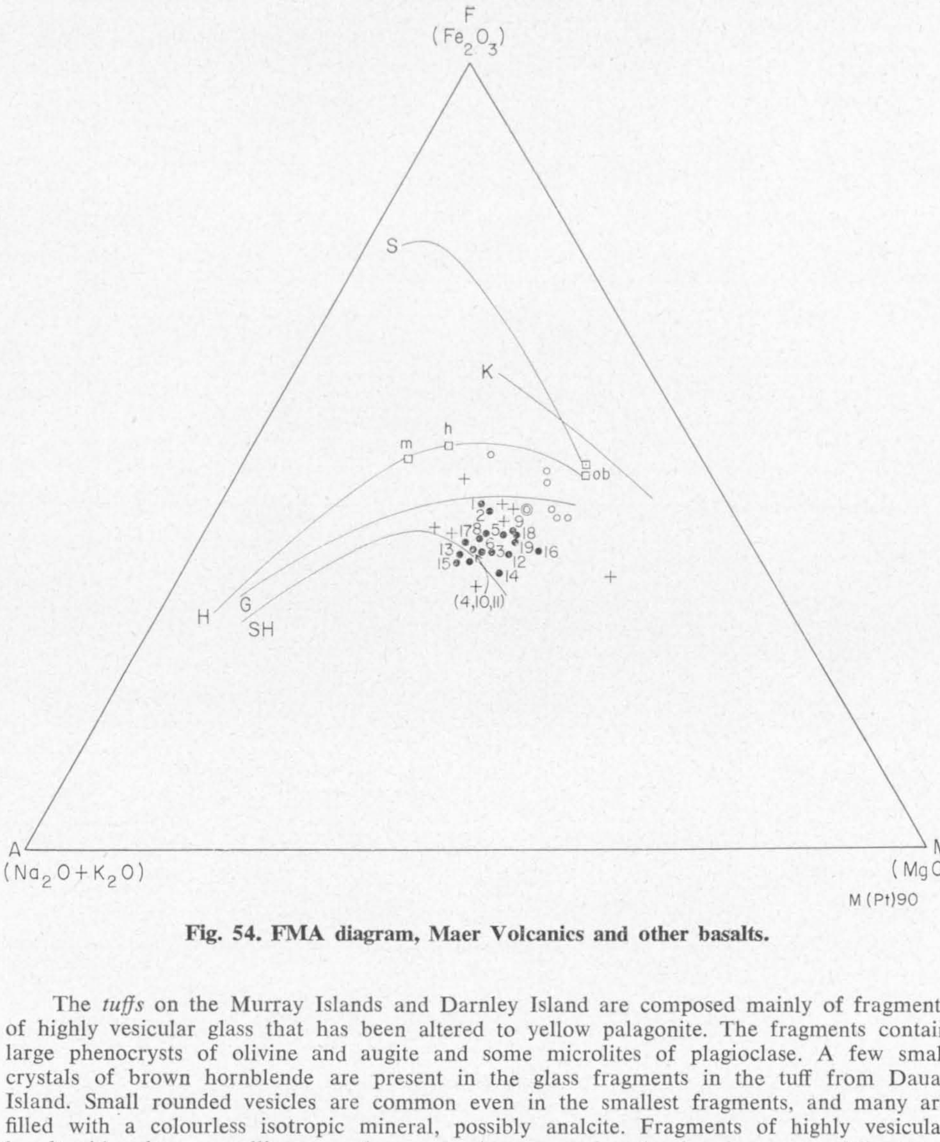


Fig. 54. FMA diagram, Maer Volcanics and other basalts.

The *tuffs* on the Murray Islands and Darnley Island are composed mainly of fragments of highly vesicular glass that has been altered to yellow palagonite. The fragments contain large phenocrysts of olivine and augite and some microlites of plagioclase. A few small crystals of brown hornblende are present in the glass fragments in the tuff from Dauar Island. Small rounded vesicles are common even in the smallest fragments, and many are filled with a colourless isotropic mineral, possibly analcite. Fragments of highly vesicular basalt with a hypocrystalline groundmass are also common, and a few fragments of limestone are generally present. The limestone fragments in the tuffs on the Murray Islands contain shell debris. The margins of the fragments only are recrystallized, while the fragments from Darnley Island are completely recrystallized. The matrix of the tuffs is composed of very small fragments of glass, fragments of olivine and pyroxene crystals, granules of opaque minerals, and interstitial calcite and analcite. The tuffaceous sediments at Daru, which contain less glass and fewer fragments, have a matrix composed predominantly of calcite and analcite(?).

Chemistry

Chemical analyses of 19 basalts from the various islands and CIPW norms of some are given in Tables 22 and 23; plots of the analyses are compared in Figures 52, 53, and 54.

The chemical composition of the basalts is somewhat unusual, and they do not compare closely with any of the well known basaltic magma types. On the SiO_2:Na_2O+K_2O diagram (Fig. 52) they plot between hawaiite and mugearite of the alkali basalt association, but are richer in potash and magnesia and poorer in total iron (Figs 53, 54). These features are characteristic of the potash-rich shoshonite association of Joplin (1968b), although in the Maer Volcanics they are less pronounced. Compared with volcanics of similar age to the north and south the Maer Volcanics are transitional between the slightly potash-rich alkali basalts of the Cairns and Cooktown regions (Morgan, 1968a,b) and the potash-rich basic and intermediate lavas of the central Highlands of Papua New Guinea, which Jakes & White (1969) have referred to the shoshonite association. The progressive increase in the potash content to the north may be related to changes in the tectonic environment towards the northern margin of the Australian craton.

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APPENDIX 1

ISOTOPIC AGE DETERMINATIONS, TORRES STRAIT.

by J. R. Richards

Isotopic ages obtained by the K/Ar method on biotites from four samples of the Badu Granite in Torres Strait were presented in Richards & Willmott (1970). The results are repeated in Table A below:

TABLE A

ANU No.	*BMR* No.	*K* (%)	*Radiogenic* ^{40}Ar (standard cc/g x 10^{-5})	*Air Correction* (%)	*Age* (m.y.)
69-770	68480132	$7.07_5 \pm .00_2$	8.95	4.2	294 ± 4
69-771	68480134	$6.66_6 \pm .03_5$	8.41	2.5	293 ± 5
69-772	68480177	$6.63_9 \pm .02_6$	8.68	1.8	302 ± 5
69-957	68480133	$7.05_5 \pm .02_7$	8.69	2.6	286 ± 3

The best estimate of the age of these granites is thus 294 ± 5 m.y., which falls in the Upper Carboniferous according to Harland et al. (1964).

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APPENDIX 2

PLANT FOSSILS FROM THE PASCOE RIVER BEDS

by Mary E. White*

Plant fossils were collected from two localities in the Pascoe River Beds by W. D. Palfreyman in 1967. At both, *Stigmaria ficoides* Bgt., the root buttress of *Lepidodendron* is associated with a species of *Cardiopteris* which shows diversity of pinnule form. A Lower Carboniferous age is suggested by the flora.

Locality 1. In Hamilton Creek, 6 km above its confluence with the Pascoe River and 35 km west of Portland Roads. Grid reference E6492, N33912 on the Cape Weymouth Sheet. Specimen Nos CPC13522-5†, F22964-5, F22967-8.

Two plant species are identified from locality 1. *Stigmaria ficoides* Bgt., the root buttress of *Lepidodendron,* is present in a number of specimens; specimen CPC13523 is illustrated in Figure B. The circular markings are attachment points for stigmarian roots which had a central vascular strand. This appears as a spot in the centre of the rootlet scar in many specimens. Among the stem-like impressions in the specimens are some smooth, ribbon-like impressions which may have a median sulcus. There are impressions of stigmarian rootlets.

The other plant present is a series of *Cardiopteris.* The material consists of a great quantity of dissected leaf tissue impressions. Some of the specimens consist of an almost solid mass of plant impressions. Much of the leaf material is broken up into fragments of single pinnules and on first inspection the fragments appear to be referable to *Rhacopteris.* However, there is diversity of pinnule type, depending on the position of the pinnule on the pinna; furthermore the frond is a bipinnate one. This feature precludes it from *Rhacopteris,* which is by definition once-pinnate with alternate, commonly overlapping flabelliform pinnules, which range from entire to deeply dissected.

Examples of pinnule type are illustrated in Figures A, C, D, and E. In Figure A is an example of the *Cardiopteris* type pinna. In figure C are pinnules of the *Rhacopteris* type. Figure D shows the bipinnate nature of the frond, and Figure E shows one *Cardiopteris* type frond and many pinnule fragments which look like *Rhacopteris.*

* 34 Beatty Street, Balgowlah, N.S.W.

† Commonwealth palaeontological type collection.

There are many stem impressions in the material. Some of these show regular pitting of the surface with a pattern of horizontally elongated depressions. Others have a fine vertical striation. Some, as for example the forking stem in Figure A, show both pitting and striation, and have different decortication levels. The ornamentation of the fork has a strongly psilophyte appearance. The stems are presumably referable to *Cardiopteris* sp.

Diversity of pinnule form is a well known phenomenon in Carboniferous plants of *Cardiopteris* type and it is difficult to classify plant fragments from the Carboniferous fern-like genera. A large collection showing the full range of variation of pinnule form, as in the present case, is necessary before safe determination can be made; even then the choice of a generic name remains somewhat arbitrary. It has been suggested that the genus *Ultopteris* should be used for plants bearing both *Rhacopteris* and *Cardiopteris* pinnules. Positive identification to either of the other genera would take into account the bipinnate nature of the frond in *Cardiopteris.*

Cardiopteris in the form of examples of the most variable species *Cardiopteris polymorpha* Goeppert is abundant in the Lower Carboniferous in Australia. *C. polymorpha* is a much larger and more robust plant than the species under investigation. All pinnules and pinnae of the species are delicate and fern-like and the plant must have been very different in gross form from the substantial *Cardiopteris polymorpha.*

The range of *Cardiopteris* covers the Carboniferous Period; it may be present in the passage beds in the Permian in association with *Glossopteris.* In view of evidence on a *Glossopteris-Cardiopteris* assemblage in middle Carboniferous rocks (Black, Morgan, and White, 1972) there is reason to doubt its extension into the Permian.

Locality 2. In the Pascoe River, 2 km above its confluence with Hamilton Creek and 40 km west of Portland Roads. Grid reference E6473, N33931 on the Cape Weymouth Sheet.
Specimen Nos F22985-F22996.

The specimens from locality 2 are poorly preserved. Most of them contain indeterminate plant remains in the form of stem impressions, minute branching filaments, and some macerated plant material. Specimens F22990 and F22992 include fragments of *Cardiopteris* sp. of the same kind as at locality 1. Some of the stem-like impressions are probably stigmarian roots. The specimens are of the same age as those at locality 1.

Age: Plant evidence indicates a Carboniferous age for the fossil horizon.

REFERENCE

BLACK, L. R., MORGAN, W. R., and WHITE, M. E., 1972—Age of a mixed *Cardiopteris-Glossopteris* flora from Rb-Sr measurements on the Nychum Volcanics, north Queensland. *J. geol. Soc. Aust.,* 19, 189-96.

Fig. A. *Cardiopteris* **sp. Stems and pinnules. Specimen CPC13522.**

Fig. B. *Stigmaria ficoides* **Bgt. Specimen CPC13523.**

Fig. C. *Cardiopteris* **sp. Specimen CPC13524.**

Fig. D. *Cardiopteris* **sp., showing bipinnate nature of frond. Specimen CPC13525. X 2.**

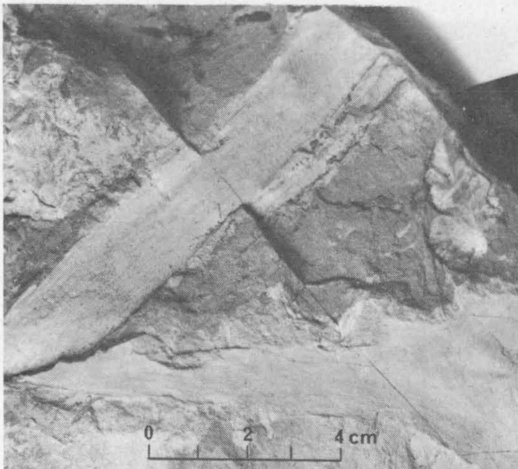


Fig A

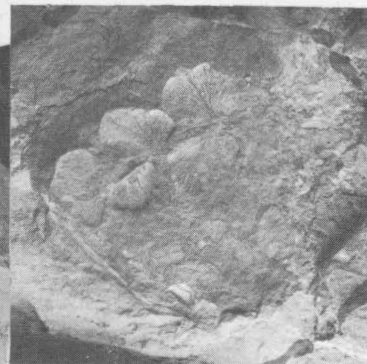


Fig C

Fig D

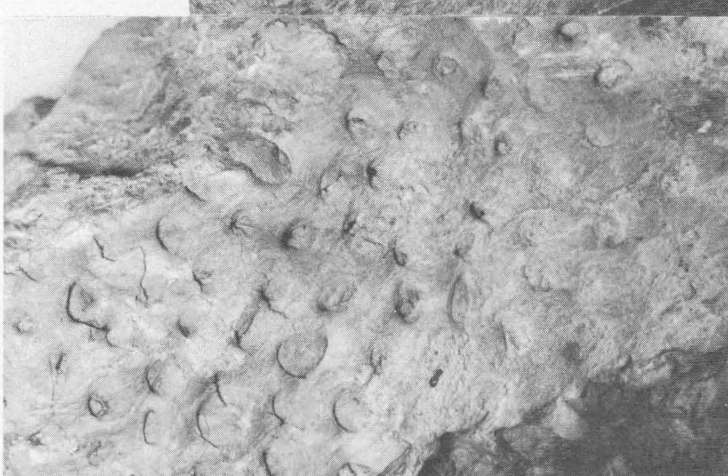


Fig B

IGNEOUS AND METAMORPHIC ROCKS

CAPE YORK PENINSULA AND TORRES STRAIT

QUEENSLAND AND PAPUA

1972

Scale 1:500,000

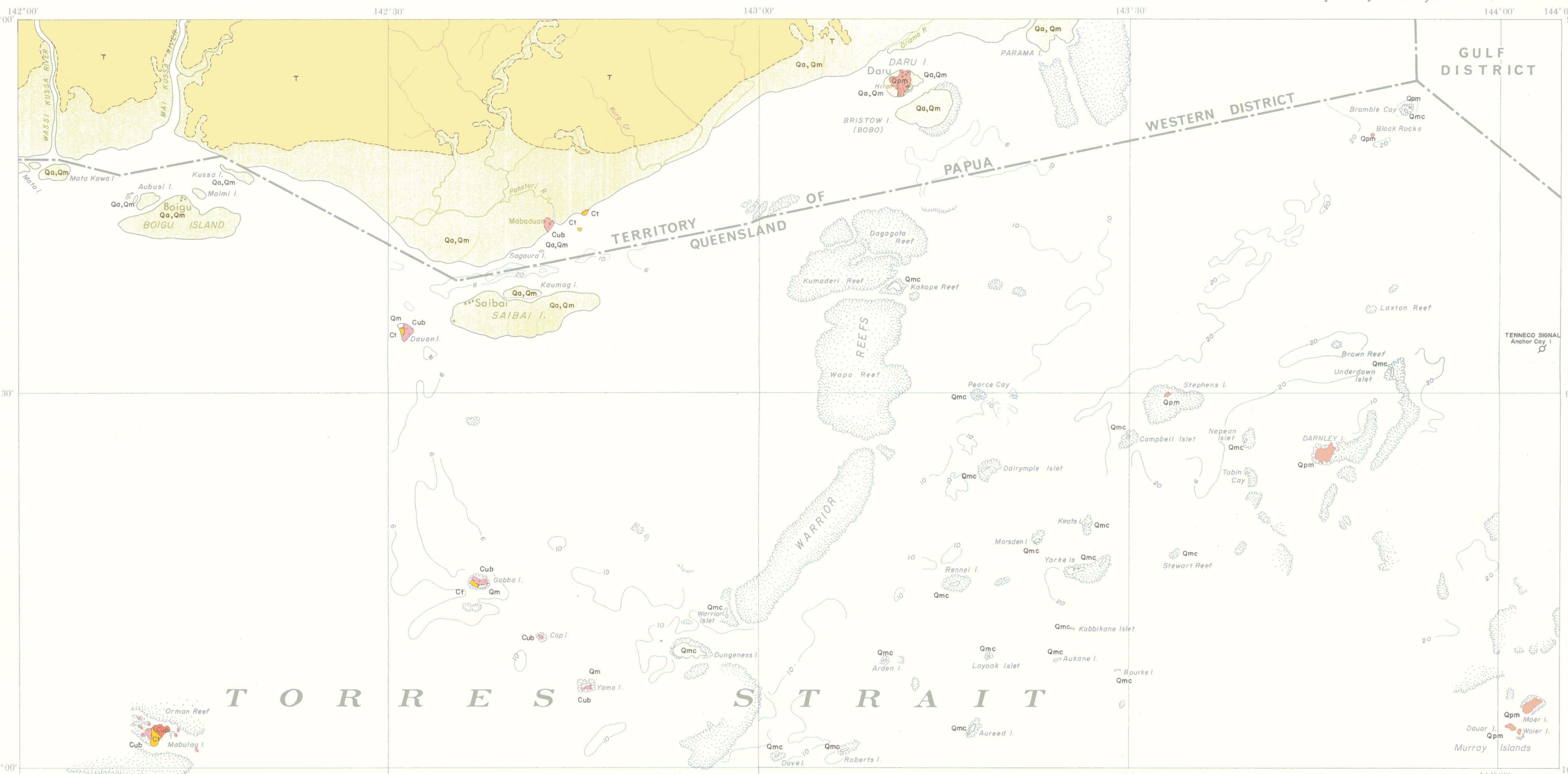
10 5 0 10 20 30 40 50 Kilometres

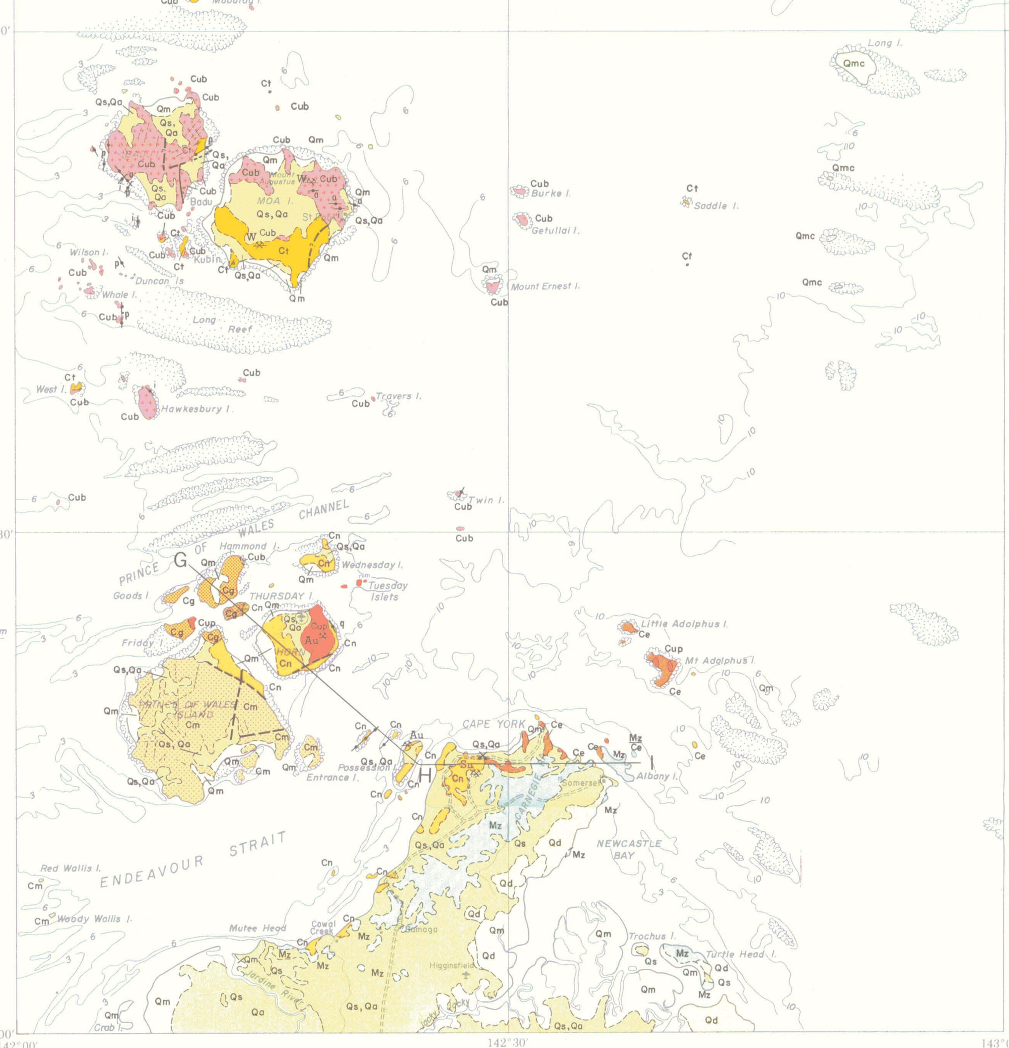
10 5 0 10 20 Miles

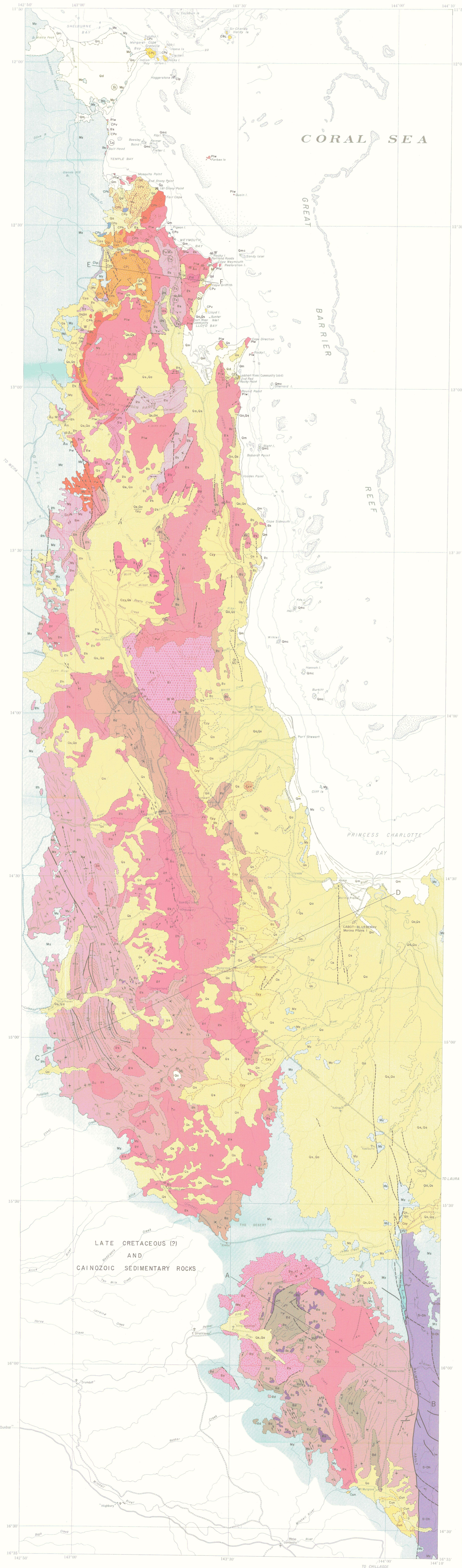
Published by the Bureau of Mineral Resources, Geology and Geophysics, in conjunction with the Geological Survey of Queensland. Issued under the authority of the Hon. R.W. Swartz, M.B.E. E.D., Minister for National Development
Transverse Mercator Projection

Copies of this map may be obtained from the Bureau of Mineral Resources, Geology and Geophysics, Canberra, A.C.T., or the Geological Survey of Queensland, Brisbane

Geology, 1966–68 by D.S. Trail, W.F. Willmott, W.D. Palfreyman, I.R. Pontifex, R.F. Spark (B.M.R.)
W.G. Whitaker (G.S.Q.)
Compiled, 1969–70 by W.F. Willmott and I. Chertok
Cartography by Geological Branch, B.M.R.
Drawn, 1970 by I. Chertok
Printed by Mercury-Walch Pty. Ltd. Hobart, Australia







Reference

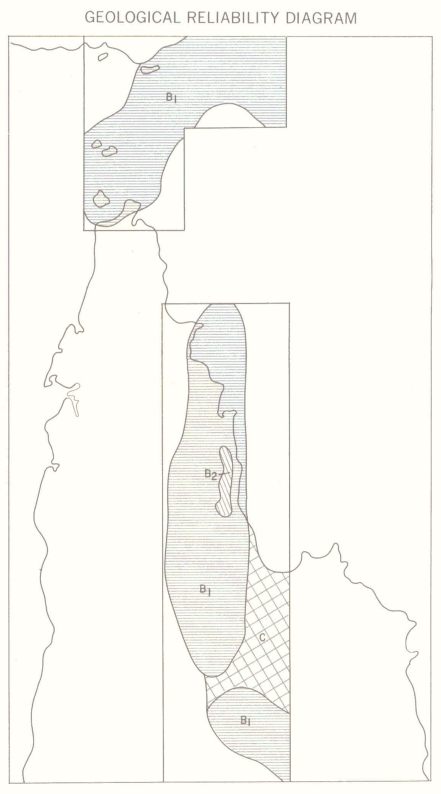
Era	Period	Unit	Symbol	Description
CAINOZOIC	QUATERNARY		Qm	*Estuarine and coastal mud, beach sand; beach rock*
			Qmc	*Coral sand, shingle and beach rock*
			Qd	*Dune sand*
			Qa	*Alluvium, mainly silt*
			Qs	*Residual sand*
	PLEISTOCENE	Maer Volcanics	Qpm	*Basalt lava and tuff*
	TERTIARY TO QUATERNARY	Yam Creek Beds	Cza	*Poorly consolidated sandstone, some conglomerate*
		Lilyvale Beds	Czy	*Poorly consolidated sandstone and conglomerate*
			Czn	*Olivine nephelinite*
	TERTIARY		T	*Limestone, some mudstone, sandstone, conglomerate*
MESOZOIC			Mz	*Sandstone, conglomerate, siltstone*
PALAEOZOIC	UPPER PERMIAN	Little River Coal Measures	Pur	*Sandstone, shale, impure coal, limestone*
		Twin Humps Adamellite	Put	*Hornblende–biotite adamellite*
	PERMIAN ?	Wolverton Adamellite	Pw	*Leucocratic biotite adamellite and granite*
	LOWER PERMIAN	Weymouth Granite	Plw	*Biotite granite and adamellite, commonly porphyritic; some microgranite*
			Pld	*Biotite-hornblende diorite and tonalite*
	LOWER CARBONIFEROUS TO LOWER PERMIAN		CPh	*Granophyric and hybrid adamellite, granodiorite and granite*
			CPo	*Dolerite*
		Cape Grenville Volcanics	CPc	*Bedded volcanic breccia and tuff, welded tuff, rhyolite*
		Kangaroo River Volcanics	CPk	*Acid welded tuff, rhyolite, andesite; dacite ? and rhyodacite ? welded tuff*
		Janet Ranges Volcanics	CPj	*Rhyolite welded tuff, rhyolite, welded pumice-flow breccia; volcanic breccia, agglomerate; some hornfels*
			CPv	*Acid welded tuff, agglomerate; some andesite and meta-basalt*
	UPPER CARBONIFEROUS		Cup	*Porphyritic microgranite*
		Badu Granite	Cub	*Leucocratic biotite granite, porphyritic biotite granite and adamellite, hornblende-biotite adamellite and granodiorite*
		Nychum Volcanics	Cun	*Rhyolite welded tuff, andesite, basalt tuff, arkose, shale, coaly shale*
	CARBONIFEROUS ?	Torres Strait Volcanics	Ct	*Acid welded tuff, hornfels*
		Muralug Ignimbrite	Cm	*Grey rhyolite welded tuff; some rhyolite, volcanic breccia, and dacite ? welded tuff*
		Goods Island Ignimbrite	Cg	*Dark grey dacite, rhyodacite and dellenite welded tuff; some siltstone and sandstone*
		Endeavour Strait Ignimbrite	Cn	*Greenish grey rhyolite welded tuff, some agglomerate, volcanic breccia, rhyolite and andesite; local hornfels*
		Eborac Ignimbrite	Ce	*Light grey rhyolite welded tuff, some rhyolite and agglomerate*
	LOWER CARBONIFEROUS	Pascoe River Beds	Clp	*Sandstone, arkose, greywacke, siltstone, shale; some chert, tuff, coal and conglomerate*
	MIDDLE DEVONIAN TO LOWER CARBONIFEROUS	Hodgkinson Formation	D-Ch	*Greywacke, siltstone, slate; some chert, andesite, spilite and conglomerate*
	LOWER SILURIAN TO LOWER DEVONIAN	Chillagoe Formation	S-Dh	*Limestone, chert, quartz greywacke, siltstone, sandstone, conglomerate, basalt*
	MIDDLE PALAEOZOIC (Cape York Peninsula Batholith)	Blue Mountains Adamellite	Ꝑb	*Biotite adamellite, hornblende-biotite adamellite*
		Morris Adamellite	Ꝑm	*Porphyritic biotite adamellite*
		Wigan Adamellite	Ꝑw	*Biotite adamellite and granite*
		Lankelly Adamellite	Ꝑl	*Porphyritic biotite adamellite; some leucocratic muscovite granite and banded pegmatitic granite*
		Kintore Adamellite	Ꝑk	*Biotite-muscovite adamellite, leucocratic muscovite granite and banded pegmatitic granite*
		Aralba Adamellite	Ꝑa	*Porphyritic biotite-muscovite adamellite*
		Flyspeck Granodiorite	Ꝑf	*Biotite granodiorite, hornblende-biotite tonalite, biotite-hornblende diorite*
PRECAMBRIAN	PROTEROZOIC ?		Ꝑo	*Dolerite*
		Sefton Metamorphics	Ꝑs	*Muscovite schist, quartzite, mica-feldspar schist, hematite and magnetite-bearing schist and quartzite, greenstone amphibolite, calc-silicate rocks, limestone*
				Mainly greenstone
		Holroyd Metamorphics	Ꝑh	*Fine to coarse mica schist, phyllite, slate, indurated sediments, quartzite, greenstone, amphibolite; some feldspathic schist, gneiss and migmatite*
				Mainly quartzite
				Greenstone
		Coen Metamorphics	Ꝑc	*Mica schist, quartzite, biotite gneiss, amphibolite; some garnet-amphibole gneiss and calc-silicate rocks*
				Mainly biotite gneiss and amphibolite
		Dargalong Metamorphics	Ꝑd	*Biotite gneiss, feldspar-mica schist, quartzite, amphibolite and migmatite*
				Mainly sillimanite–muscovite schist and quartzite

Geological boundary
Anticline
Overturned anticline, showing direction of plunge
Syncline
Overturned syncline, showing direction of plunge
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
Shear zone
Strike and dip of strata
Vertical strata
Dip < 15°
Dip 15°–45° } *air-photo interpretation*
Dip > 45°
Trend lines
Joint pattern

Strike and dip of foliation
Vertical foliation
Plant fossil locality
Dyke: a – acid, i – intermediate, b – basic, q-quartz, p – porphyry
Oil exploration well, abandoned
Mine, abandoned
Alluvial working, abandoned
Unworked deposit
Au *Gold*
Mi *Mica*
W *Wolfram*
Fe *Iron*
Mn *Manganese*

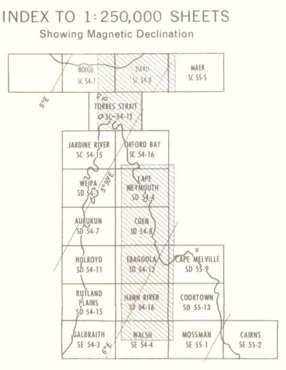
Sn *Tin*
Si *Silica*
Ls *Limestone*
Road
Vehicle track
Telephone line
"Kimba" *Homestead*
Airport
Landing ground
Trigonometrical station
Coral reef
10 *Fathom line*
Building
Built up area

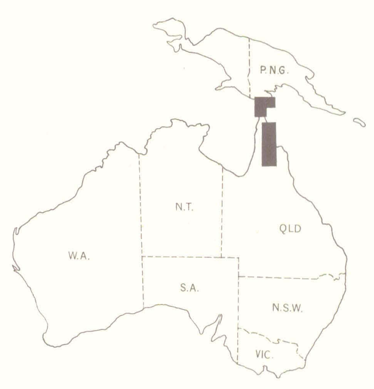
GEOLOGICAL RELIABILITY DIAGRAM



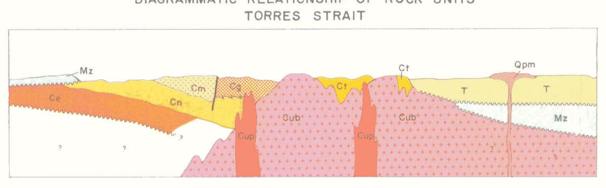
B_1 Detailed reconnaissance and air-photo interpretation
B_2 General reconnaissance and air-photo interpretation
C Air-photo interpretation

INDEX TO 1:250,000 SHEETS
Showing Magnetic Declination

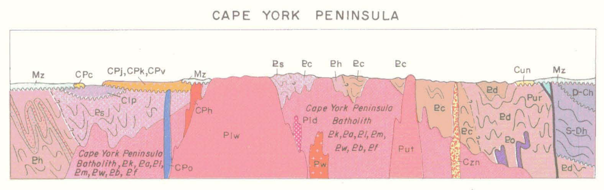




DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS
TORRES STRAIT



CAPE YORK PENINSULA



Unconformity   Geographical boundary

Sections

Cainozoic sediments omitted
Folding schematic
Scale: $\frac{V}{H} = 4$