COP 13



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

2B



REPORT 145

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A.G.L. PAINE, D.E. CLARKE,
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A.G.L. PAINE,* D.E. CLARKE,**
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* Bureau of Mineral Resources
** Geological Survey of Queensland

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# SUMMARY


The northern half of the Bowen Sheet area was mapped by the Bureau of Mineral Resources and Geological Survey of Queensland in 1964-65. The survey also extended into the southern half of the Sheet area, which was mapped by a different field party in 1961.

Bowen (pop. about 5000), in the northeastern part of the area, lies midway between Townsville and Mackay, on the coastal highway and railway between Brisbane and Cairns. The climate is tropical. Most of the area receives between 600 and 750 mm of rain per year, and there is a marked wet season between December and April. The topographic relief varies considerably, and isolated high peaks, up to 1055 m, near the coast give way to extensive ranges and tablelands inland. The northern end of the Bowen Basin forms a broad depression in the south. Most of the area is drained by the Burdekin River.

Early Palaeozoic to Permian granites, volcanics, sediments, and minor metamorphics crop out in the west, Permian to Triassic sediments and volcanics in the centre and south, and Carboniferous to Cretaceous granitoid rocks and Permian volcanics in the east and north. The southern part of the area is occupied by part of the Permo-Triassic Bowen Basin and the northeastern end of the Lower Carboniferous Drummond Basin. The granitoid rocks in the east form a large composite batholith at the northern end of the Connors Arch. In the southern half of the Sheet area the rocks examined include the granitoid rocks of the Connors Arch and the Lower Permian volcanics to the east, and the sediments of the Drummond Basin to the north of the Burdekin River.

The oldest rocks (Cape River Beds), near the western edge of the Sheet area, consist of volcanics and metamorphics, which are probably of Cambrian to Ordovician age. The small remnants of low-grade metasediments near the Burdekin River are possibly of the same age. The Ravenswood Granodiorite Complex consists mainly of Middle Ordovician granodiorite and adamellite and a younger series of granites and adamellites of Upper Silurian or Lower Devonian age. The complex forms a large mesozonal batholith which has metamorphosed the Cape River Beds.

The Upper Devonian to Lower Carboniferous continental sediments and volcanics of the Drummond Basin are faulted against the Ravenswood Granodiorite Complex in the Bowen Sheet area, but to the west they rest nonconformably on it. The Drummond Basin sequence is moderately folded, and the margins of the basin are generally faulted or obscured by younger intrusions and volcanics. The almost vertical Edgecumbe Beds, in the extreme northeast, consist of marine sediments equivalent to the upper part of the Drummond Basin succession.

Much of the northern end of the Connors Arch consists of a suite of dioritic rocks of Upper Carboniferous age. They are generally foliated, and are intruded by numerous dykes. Parts of the Urannah Igneous Complex, which represents the undivided relatively inaccessible part of the Connors Arch in the southeast, were also intruded at this stage. Somewhat later, in the uppermost Carboniferous, the Bulgonunna Volcanics and similar unnamed acid volcanics were extruded in the west. They are associated with irregular dykes and masses of intrusive rhyolite and porphyry. The residual magma cooled beneath a shallow volcanic cover to form a large epizonal batholith of adamellite and minor other rock types, which is at least 100 km long. Most of the large intrusions of adamellite and granodiorite in the north and northeast were probably emplaced at the same time.

Lower Permian volcanics and associated sediments (Lizzie Creek, Mount Aberdeen, and Kurungle Volcanics and the Carmila Beds) crop out in the north, centre, and east. In the north and centre, intermediate to basic volcanics form a thin platform cover on a granitic basement of probable Upper Carboniferous age; to the south they thicken markedly and dip beneath the Bowen Basin. In the east a thick sequence of intermediate to acid pyroclastics and minor flows and sediments (Carmila Beds) dips regularly to the east-northeast, off the Connors Arch.

Several cylindrical epizonal stocks of granodiorite and adamellite were probably emplaced by ring-fracturing and cauldron subsidence in the Lower Permian; they intrude early Palaeozoic granitic basement in the northwest; another ring complex nearby, of probable similar age, is partly outlined by ring dykes and cone sheets. The Thunderbolt Granite is a mesozonal batholith which was intruded at the same time into the deeply depressed northern end of what is now the Connors Arch. Parts of the Urannah Igneous Complex may also be of this age.

The extrusive and intrusive Mount Wickham Rhyolite, which was formed at the end of the Permian or early in the Triassic, occupies scattered areas in the centre of the Sheet area.

The Hecate Granite is a large mesozonal adamellite-granodiorite batholith which was intruded into the northern end of the Connors Arch in Lower Cretaceous time. The discovery of a Cretaceous batholith of this magnitude (1000 km²) will have important implications in studies of the evolution of the Tasman Geosynclinal Zone in Queensland. Similar isotopic ages (125 m.y.) have been obtained on parts of the Urannah Igneous Complex in the Proserpine and Mackay Sheet areas, and from a group of minor intrusives in the Bowen Basin.

Mount Abbot, the highest peak in the area (1055 m), consists of a quartz syenite stock, an alkali granite stock, and a series of cone sheets (Mount Abbot Igneous Complex), all of which were emplaced slightly later in the Cretaceous (115 m.y.).

A single Triassic isotopic age has been obtained on the granite of Gloucester Island, but as no other Triassic granites are known north of about Gladstone (600 km to the south) the granite on Gloucester Island and similar high-level leucocratic granites near Bowen are regarded as Lower Permian or Lower Cretaceous until they can be dated more precisely.

The numerous dykes in the area are mainly of late Palaeozoic age, but some of them are Lower Cretaceous. They are especially common in the Connors Arch.

The Cainozoic era is represented by a thin veneer of probable Pliocene outwash sediments southeast of Edgecumbe Bay, by plugs and other remnants of olivine basalt, and by Quaternary alluvium, residual and colluvial sandy soil, outwash and talus deposits, and coastal sand ridges and mud flats.

Most of the faults in the eastern half of the area trend northwest, but this trend is not so apparent in the pre-Permian rocks west of the Millaroo Fault Zone. The Almoola Hinge Zone has been a locus of uplift of the northern end of the Connors Arch. Zones of severe shearing were formed during the emplacement of the Hecate Granite in the Lower Cretaceous. The Lizzie Creek Volcanics in the northern half of the Sheet are only slightly folded, except in places along the Millaroo Fault Zone. The Carmila Beds, however, dip consistently at a moderate angle to the east-northeast, and the Edgecumbe Beds dip steeply in the same direction.

Gold is the most important mineral which has been produced in the area. The production came from numerous small mines that had short productive lives, the most important being the Dittmer mine. The gold and minor base metal mineralization in the northeast appears to be related to the Lower Cretaceous Hecate Granite.

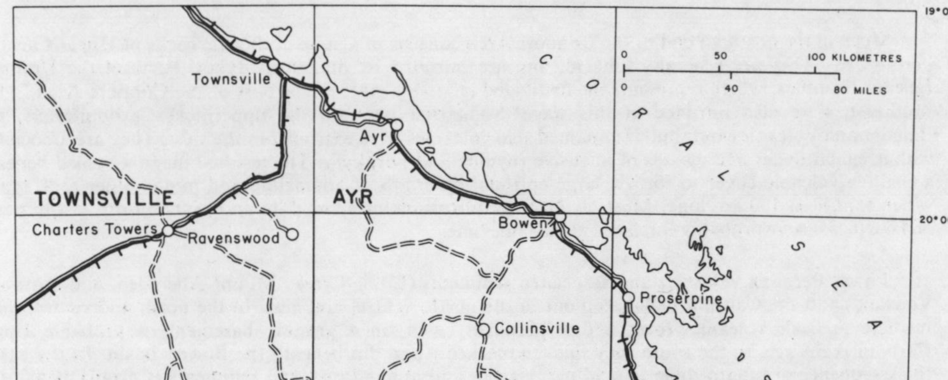


**Fig. 1. Locality map and 1:250 000 Sheet index.**

# INTRODUCTION

The Bowen 1:250 000 Sheet area lies near the central Queensland coast, midway between Brisbane and Cape York. It extends from latitude 20°S to 21°S and from longitude 147°E to 148°30'E (Fig. 1).

The northern half of the Sheet area was mapped in 1964-65 by a joint field party of the Australian Bureau of Mineral Resources (BMR) and the Geological Survey of Queensland (GSQ). The mapping was part of a joint survey of the Burdekin River region from 1963 to 1966. The granitoid rocks of the Connors Arch, the Lower Permian volcanics east of the Connors Arch, and the Drummond Basin sediments to the north of the Burdekin River in the southern half of the Sheet area were also examined. In 1965 A.W. Webb (BMR) collected specimens for isotopic dating, and also did some geological mapping. W.B. Dallwitz (BMR) and G.W. Tweedale (GSQ) helped with the mapping for short periods in 1965.

*Communications and Industries*

Bowen (pop. 5134) lies on the western shore of Edgecumbe Bay in the northeastern corner of the area. The irrigation farms on the left bank of the Burdekin River are served by two villages, Millaroo (pop. 294) and Dalbeg (pop. 102), each of which has a general store and post office. There are a number of sugar farms at Kelsey Creek and Crystal Brook in the east and scattered fruit and vegetable farms in the delta west of Bowen. Cattle station homesteads occur throughout the area.

The narrow gauge (106 cm) North Coast Railway, which connects Brisbane with Cairns, traverses the northeastern part of the area. A branch line (also narrow gauge) runs from Bowen to Collinsville (pop. 1884), a coal mining town 90 km to the southwest.

The main coast road from Brisbane to Cairns, the Bruce Highway, passes through the northeastern corner of the area; other bitumen-sealed roads connect Collinsville with Bowen and Dalbeg with Ayr (Ayr Sheet area). Formed gravel roads run from Binbee siding to Strathalbyn homestead, and to a new cattle property in the Normanby goldfield; from the Binbee-Strathalbyn road to the Bruce Highway (in the Ayr Sheet area); from the Bowen-Collinsville road at Mount Buckley to Pretty Bend homestead; and from Kelsey Creek to Proserpine. Roads of similar quality give access to other station properties. Station tracks suitable for Land Rovers are well distributed in the less hilly parts of the area, but large areas in the southwest and southeast are inaccessible even by Land Rover. A helicopter, a launch, and a light aircraft were chartered for short periods. Bowen is served by scheduled airline flights between coastal towns and cities. A few of the larger cattle stations have their own airstrips.

Beef cattle raising is the main industry in the area, and there is a large meatworks at Merinda 8 km west of Bowen. Sugar cane is grown under irrigation at Dalbeg and Millaroo, but some farmers have been experimenting with rice as an alternative crop; water is obtained from the Burdekin River. Non-irrigated sugar cane is grown in minor quantities in the Kelsey Creek area. Tomatoes, mangoes, melons, and other fruit are grown on the Don River delta. Groundwater from the delta is used for irrigation. The deep water harbour at Bowen is a regular port of call for ocean-going ships. The main cargo is beef, but small quantities of coal from Collinsville have been shipped for export in recent years (18 783 tons in 1967). Most of the coal mined at Collinsville (476 810 tons in 1969) is railed to Merinda, and thence to Mount Isa. The State Coke Works at Bowen produced 32 440 tons of coke in 1968, most of which was sent to Mount Isa. A solar salt works operates on tidal flats east of Bowen aerodrome, and there is a small but growing tourist industry.

*Climate*
(Atlas of Australian Resources, 1952-53)

The climate is tropical, the normal maximum temperature is 31°C to 34°C in January and 24°C in July, and the normal minima are 21°C to 24°C in January and 10°C to 13°C in July.

On average there are fewer than five frosts per year. The average annual rainfall at Bowen is 1145 mm, but most of the northern part of the area lies between the 630 and 760-mm isohyets; the driest part (580 mm) is in the southwest. The summit of the Clarke Range receives over 1250 mm of rain, and south of Mount Hector the rainfall exceeds 2150 mm (Irrigation & Water Supply Commission, 1963, unpubl.). Most of the rain falls in the wet season from about November to April, but the climate is less seasonal than west of the

Great Dividing Range. The average deviation is between 30 and 35 percent, and the number of rainy days per year ranges from 40 in the west to 80 in the east.

### *Surface Water*

Most of the streams dry up in the dry season, but some flow is maintained throughout the year in the Burdekin River, and to a lesser extent in the Bowen River. In the 1965 dry season the field party obtained an ample supply of drinking water from a spear driven 2 m into the sand in the bed of the Don River at Mount Dangar.

### *Maps and Air-Photographs*

The area is covered by cadastral maps at a scale of 1 inch to 4 miles produced by the Department of Lands, Brisbane. The general topography is indicated by hill shading on the 1:250 000 scale map produced by the Division of National Mapping in 1967. Contoured maps at 1:100 000 scale are currently being produced by the Division of National Mapping.

The area is covered by air-photographs at a scale of about 1:85 000 taken by Adastra Airways Pty Ltd in 1960, and by RAAF air-photographs at a scale of about 1:46 000 flown in 1945. Air-photographs of selected 1-mile Sheet areas have been flown by Adastra at a scale of about 1:25 000 for the Department of Lands, Brisbane, as follows: Scottville, 1956; Bald Hill and Exmoor, 1959; Bowen, 1960; Monte Christo, 1961; Hidden Valley, 1962; Mount Glenroy, 1965; and Glendon, 1967.

Photomosaics at a scale of about 1 inch to 1 mile are available for all 12 of the 1 mile Sheet areas; a more recent set of six photomosaics at a nominal scale of 1:100 000 is also available. Both sets of photomosaics were produced by the Division of National Mapping.

### *Previous and Contemporary Investigations*

Jack & Maitland (Jack, 1890) produced a rudimentary geological map of the Bowen-Mackay hinterland at a scale of 1 inch to 12 miles, and in 1927 Stanley described the physiography of the Bowen district and the Cumberland Islands. From time to time, officers of the Geological Survey of Queensland reported on gold and other mineral discoveries. The first reports were by Jack (1879a,b) on the Bowen River coalfields and the Normanby and Marengo goldfields. Of the many subsequent reports the more important are: Saint-Smith (1918, Ben Lomond limestone), Morton (1921a,b, Normanby and Marengo goldfields), Reid (1940, Dittmer gold mine), Ridgway (1947, scheelite near Rangeview homestead), Levingston (1962, Mount Dangar gold prospect), and Wyatt (1962, Lucky Strike gold prospect).

In his study of the physiography (Stanley, 1927) carried out a rapid geological reconnaissance and produced a map (his text-fig. 2) on which he recorded the widespread occurrence of granite in the northeastern corner of the area. The area investigated by Stanley extended as far inland as latitude 20°35' S and longitude 147°40'E. Part of his paper, including several panoramic sketches, is devoted to the Bowen district.

Most of the northern half of the Sheet area was examined by Traves (1951, unpubl.) during a geological reconnaissance of the Townsville-Bowen hinterland. Traves' work was part of a comprehensive land-use survey by CSIRO in connexion with the proposed Burdekin Dam scheme, and is based mainly on photogeological interpretation (he mapped 12 000 km$^2$ in 7 weeks). Nevertheless his map shows the general distribution of the main rock types. An abbreviated version of Traves' report was published by CSIRO (Christian et al., 1953).

The Australian Oil and Gas Corp. Ltd (1962, unpubl.) carried out a reconnaissance aeromagnetic survey of the east coast of Queensland, part of which extended into the northern half of the Bowen Sheet area. Brown (1963, unpubl.), in a report to Ampol Exploration (Qld) Ltd on the petroleum potential of the Proserpine district, described the geology of the extreme northeastern corner of the area, and measured a section of the fossiliferous Lower Carboniferous sediments (Edgecumbe Beds of this Report).

In 1963 a reconnaissance gravity survey of the Sheet area was carried out as part of a regional helicopter gravity program (Darby, 1969). In 1965 a seismic refraction survey was carried out for the Mines Department to determine the position of the water table and thickness of alluvium in the Don River delta; the results were later re-interpreted by BMR (Kevi et al., 1968, unpubl.).

Specimens from what is now called the Thunderbolt Granite were dated isotopically by Webb et al. (1963). Webb (1969) and Webb & McDougall (1968) have published the results of a study of the geochronology of eastern Queensland undertaken by BMR and the Australian National University. Many of the specimens were collected from the northern half of the Bowen Sheet area.

Reports and Explanatory Notes on the geology of the adjoining Sheet areas are as follows: *Townsville,* Wyatt et al. (1970), Wyatt (1968); *Charters Towers,* Wyatt et al. (1971), Clarke & Paine (1970): *Buchanan,* Olgers (1970, and in press); *Mount Coolon,* Malone et al. (1964), Malone (1969); *Mackay,* Jensen et al. (1966), Jensen (1965); *Proserpine,* Clarke et al. (1971), Paine (1972); *Ayr,* Paine et al. (1970), Gregory (1969); *Bowen* (southern half), Malone et al. (1966); and *Ravenswood 1 mile (Charters Towers 1:250 000),* Clarke (1971).

A summary of the geology and mineral deposits of the Burdekin-Townsville Region, including a 1:1 000 000 scale map, has been recently published by the Geographic Branch of the Department of National Development (Paine & Smith, 1972).

## *Acknowledgements*

Miss R. Cameron helped to compile Tables 1, 2, and 3.

The permission of Ampol Exploration (Qld) Ltd to quote from an unpublished company report (Brown, 1963, unpubl.) is acknowledged.

One of us (A.G.L.P.) wishes to pay a personal tribute to Mr. B. Harris of Helicopter Utilities Pty Ltd for his skill and courage during helicopter operations in the Clarke Range, and is grateful to Mr J.E. Thompson of Amax Exploration (Aust.) Inc. (pers. comm., 1971) for suggesting that the country rock at the Mount Pring magnesite deposit is probably a lateritized ultramafic rock.

We are grateful to many of the landholders for their co-operation during the course of the survey, in particular Mr H. Klopp of Dalbeg, Mr H. Elphinstone and the Teitzel family of Mount Dangar, Mr J. Gordon of Mount Pleasant Station, and Mr A. Williams of Normanby Range Holding.

Information from a report by Malone et al. (1966) on the geology of the southern half of the Sheet area has been incorporated in the descriptions of the structure and geological history.

## *Petrography*

Petrographic descriptions of some of the specimens collected during the survey were supplied under contract by the Australian Mineral Development Laboratories (AMDEL); the petrography of others was described by the authors. W.R. Morgan, formerly of BMR, described the petrography of several specimens from in and around the town of Bowen.

The nomenclature followed by Hatch et al. (1961) has been used throughout the Report, except that the name tonalite is used instead of granodiorite if potash feldspar amounts to less than 10 percent of the total feldspar. In the phanerocrystalline rocks those with more than 10 percent modal quartz are classed as acid. Rocks containing plagioclase with an anorthite content of over 50 percent are classed as gabbro, dolerite, and basalt, and those with less than 50 percent anorthite as diorite, microdiorite, and andesite.

Most of the petrographic descriptions are based on rapid examinations made to establish rock names. The mineral percentages quoted are based on averaged visual estimates of several fields. The rubidium decay constant used by Webb (Appendix) in the calculation of isotopic ages is $^{87}Rb\,\lambda = 1.47 \times 10^{-11}$ yr $^{-1}$.

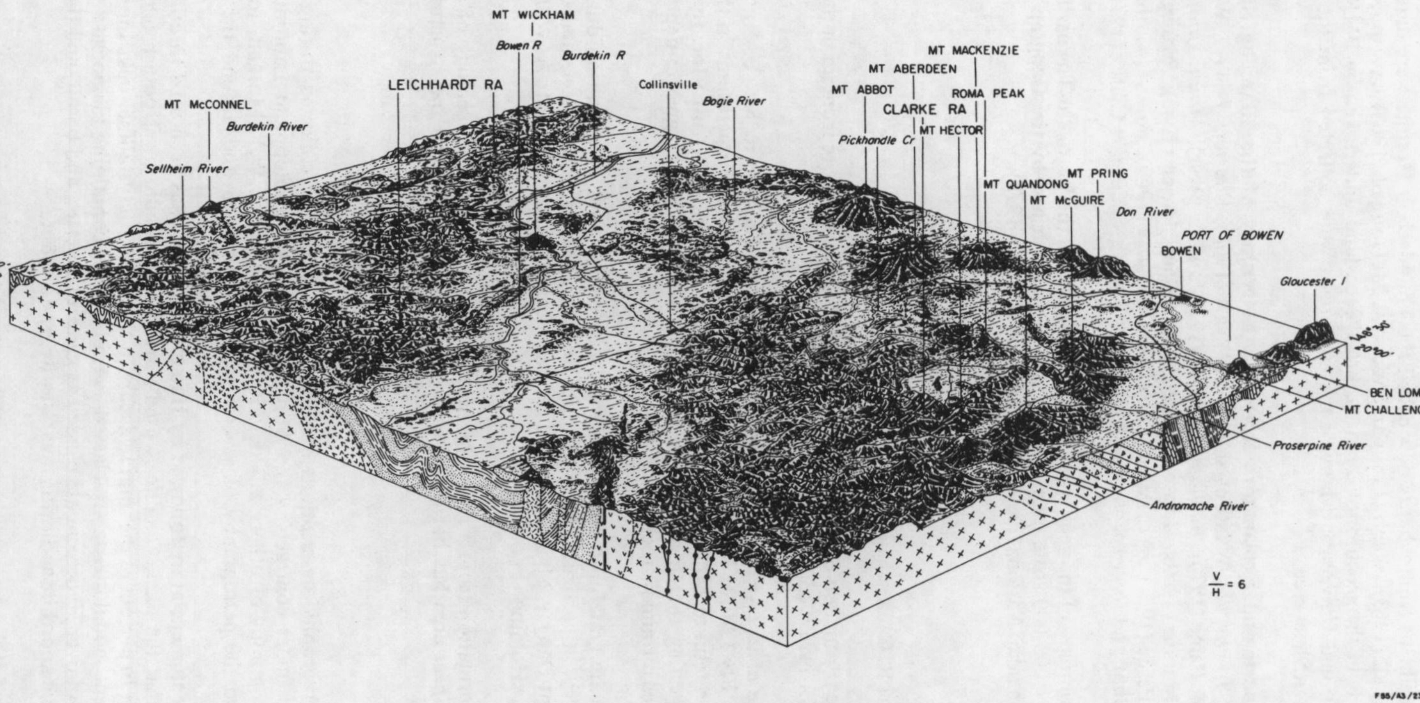


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**Fig. 2. Physiographic block diagram.**

## *Physiography*
(Fig. 2)

The main divide in the northern half of the Sheet area is the watershed of the Bogie River, which separates the drainage basin of the Burdekin River from the short coastal streams to the northeast. The Burdekin River flows into the Coral Sea through a large delta near Ayr. Its main tributaries are the Bowen and Bogie Rivers. The river bed is from 500 to 1000 m wide over the lower 100 km of its course. The largest coastal streams are the Don and Proserpine Rivers, which rise in the ranges west of Proserpine. Although the Don River is only 80 km long, its bed is 200 to 300 m wide over the lower half of its course.

Much of the area is hilly to mountainous, especially in the west and southeast. In the north, Mount Abbot (1055 m) rises about 1000 m above the plains, and Mount Aberdeen, 20 km to the southeast, has an elevation of 890 m. Other isolated mountains in the northeast that rise steeply from sea level or near it include Mount Mackenzie (619 m), Mount Pring (420 m), Mount Roundback (760 m; northwest of Mount Pring; summit just north of Bowen Sheet area), a peak (560 m) near Mount Challenger, Gloucester Island (566 m), the Cape Gloucester range (399 m), and Ben Lomond (435 m).

South of about latitude 20° 15'S rugged mountain ranges separate the basin occupied by the headwaters of the Proserpine River from the plains in the east. The highest peaks in the ranges are Mount McGuire (738 m) and Mount Quandong (792 m). Between the Proserpine River and longitude 147°45'E the topography is more subdued, and the valleys are narrower. Roma Peak (660 m) is an isolated spire which overlooks low ranges west of the Proserpine River.

In the west, the deeply dissected Leichhardt Range forms the eastern edge of a plateau that gradually loses height to the west. Much of the plateau has an elevation of 400 to 500 m, but it approaches 600 m in places. The relief along the eastern edge of the range is 300 to 400 m.

East from the Burdekin River to about longitude 147°45'E there are uplands and rugged ranges separated by plains.

Plains, some of which are co-extensive with the coastal plain, occur along the Burdekin and Bogie Rivers in the northeast and to the south of the western part of the Clarke Range. The coastal plain and its inland extensions (e.g. Burdekin River plain) are depositional features, which are being eroded and reduced in size owing to the relative lowering of sea level since they were formed. Much of the Bogie River plain and the plain south of the western part of the Clarke Range have been formed by erosion of easily weathered Lower Permian basalt.

The watershed between the westerly flowing Bogie River and the shorter coastal streams flowing north and east passes through Mount Abbot and trends southeast to the south of Mount Aberdeen, meeting latitude 20°30'S in the headwaters of Thunderbolt Creek. The watershed, especially in the indented scarp east of Pickhandle Creek, is migrating to the southwest, and the tributaries of the Bogie River are being captured by the headwaters of the northeasterly flowing streams, which are graded to a level about 150 m lower. For instance, further headward erosion by Euri Creek for another 4 km to the south will eventually result in capture of the headwaters of the Bogie River.

The geomorphology of each rock unit is discussed in the main part of the Report. There is limited correspondence between geology and topography, owing to the overriding influence of scarp retreat, compounded by the complex inter-relationships of different drainage basins at various stages of evolution. The most rugged country is generally formed from leucocratic granites, and the dykes commonly form ridges in the areas of intermediate to basic plutonic rocks. In the Leichhardt Range the topography is more closely related to the geology than elsewhere, and it has been possible to photo-interpret several major features with confidence.

Stanley (1927) discussed the physiography of the Bowen District.

**Fig. 3. Panorama from Roma Peak (600 m). On left, Mount Challenger (516 m) with Gloucester Island (566 m) directly behind. The range in the centre is unnamed. Mount McGuire (738 m) on right is 16 km east-northeast of Roma Peak.**

Figures 3, 4, 5, 6, and 15 give general impressions of the topography in the northeastern part of the Sheet area.

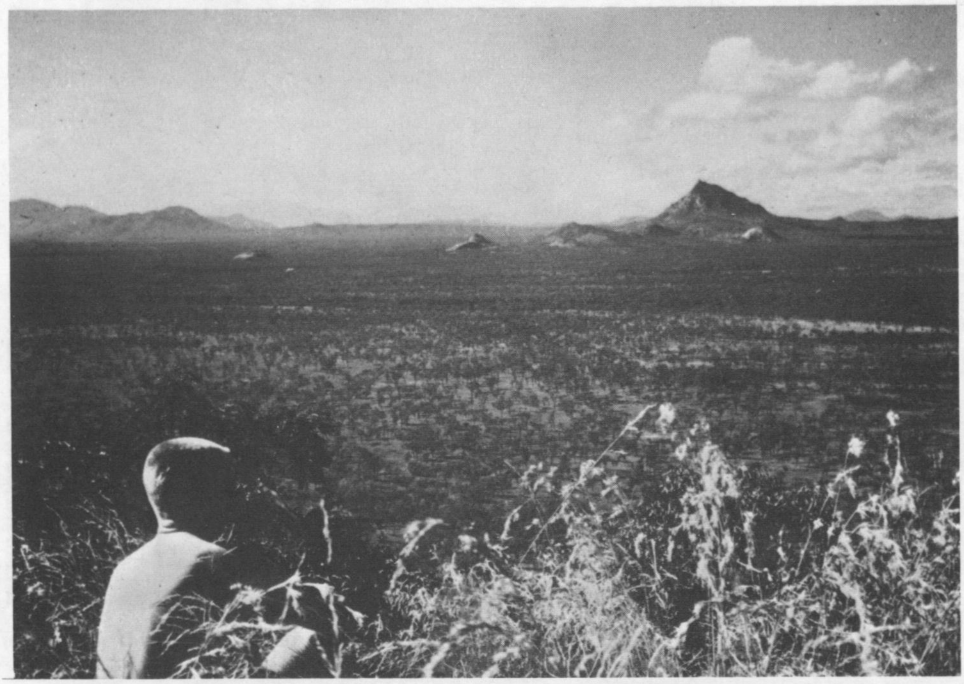

**Fig. 4. View from Mount Marengo (265 m) to Roma Peak (660 m), 13 km to the southeast. Large whalebacks of adamellite (Hecate Granite) in middle distance — Bald Rock on right and Sixpenny Hill on left.**

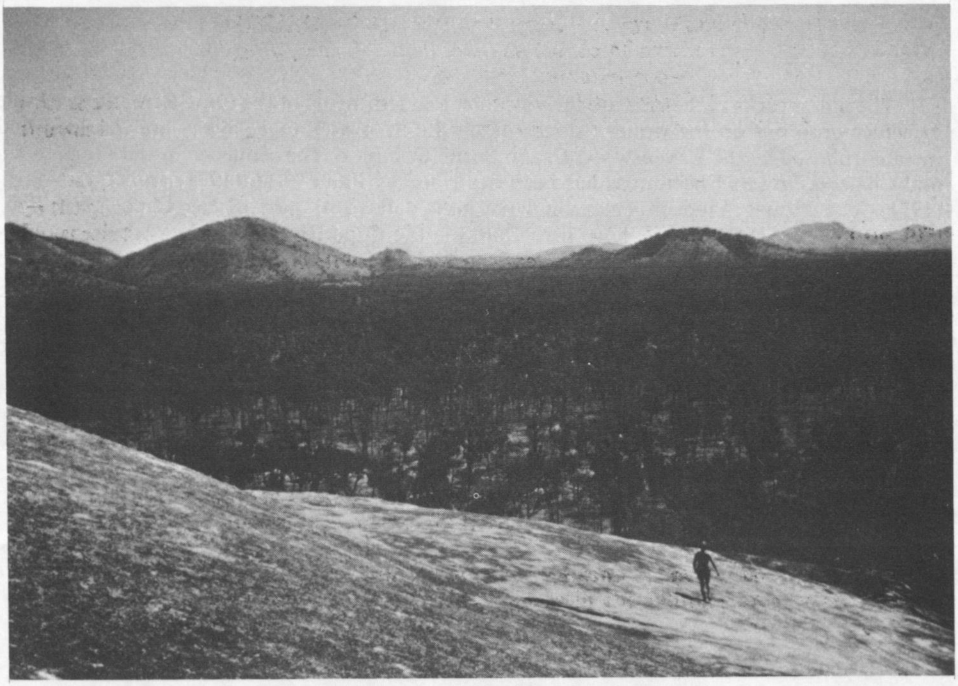

**Fig. 5. View west from Sixpenny Hill to The Three Brothers (375 m) on left and Mount Marengo (265 m) on right.**

**Fig. 6. Northerly view from helicopter of the Upper Carboniferous diorite suite (Cud) on western slopes of Clarke Range between the Normanby Goldfield and Pretty Bend homestead.**

## CAMBRIAN TO ORDOVICIAN (?)

### *Cape River Beds*

The oldest rocks in the area are the volcanics and sediments of the Cape River Beds (Table 1), which crop out on the western slopes of the Leichhardt Range. They are intruded and metamorphosed by the Ravenswood Granodiorite Complex. The sequence in the Hughenden and Charters Towers Sheet areas has been described by Paine et al. (1971) and Wyatt et al. (1971). The Mount Windsor Volcanics have been defined as part of the Cape River Beds (Wyatt et al., 1971). No fossils have been found in the Cape River Beds, but provisional isotopic analyses of the Mount Windsor Volcanics, which form part of the sequence (Wyatt et al., 1971), suggest that they are Upper Cambrian.

#### *Distribution and Topography*

The Mount Windsor Volcanics crop out over an area of 300 km$^2$ southeast of Rangeview homestead, and occupy a smaller area in the headwaters of Landers Creek. They form steep closely dissected hills rising to an elevation of 400 to 500 m near Landers Creek and 300 to 400 m near Rangeview homestead.

The roof pendants of metamorphics in the Ravenswood Granodiorite Complex on the western edge of the Sheet area may represent altered blocks of Mount Windsor Volcanics. They are mapped as undivided Cape River Beds, and form low rises from 250 to 300 m above sea level.

#### *Lithology*

The Mount Windsor Volcanics consist mainly of fine-grained porphyritic rhyolite, but rhyodacite and rhyolite breccia are locally abundant, and dacite and andesite have been observed in places. The volcanics grade into gneiss and schist near the Ravenswood Granodiorite Complex. Fine-grained laminated quartzite, argillite, and coarse arkose, similar to those in the Mount Windsor Volcanics in the Charters Towers Sheet area, occur only at Stuart Pocket, 10 km north-northeast of Glenroy homestead.

In the headwaters of Six Mile Creek the Mount Windsor Volcanics consist mainly of pale grey to brown rhyolite, which generally contains phenocrysts of quartz with or without feldspar. Contorted flow banding is visible on some weathered surfaces. The rhyolite commonly contains disseminated crystals of pyrite, which also occurs as small aggregates and as thin coatings on joints. Volcanic breccia composed of fragments of rhyolite and granite and dark blue-black dacite(?) are subordinate.

The roof of the Ravenswood Granodiorite Complex probably dips gently to the east, and for some 3.5 km east of the contact the rhyolite is cleaved, and biotite has been developed along the cleavage planes. Similar rocks occur in Glenroy Creek 3 to 6 km northeast of Mount Glenroy, although here some of the metamorphism may have been caused by the late Palaeozoic(?) granodiorite (CPg) immediately to the north. The volcanic texture has been preserved in many of the rocks, although it is masked by strong shearing in places. The groundmass of most of the rocks at the contact with the Ravenswood Granodiorite Complex has a granoblastic texture. Relict phenocrysts of quartz and alkali feldspar have been preserved in the less metamorphosed rhyolites, but in the more highly sheared rocks the fractured, sheared, and recrystallized quartz phenocrysts are represented by lenticular aggregates of quartz. Abundant biotite and a little muscovite and sericite have been developed in the altered rhyolites, and the rare hornblende phenocrysts have been converted to aggregates of fine biotite. Recrystallization of the more strongly sheared rhyolites has produced strongly foliated gneissic rocks.

The metamorphosed rhyodacites and dacites also have a granoblastic or blastoporphyritic texture, but the original texture is preserved in some of them. The recrystallized rhyodacite from near the contact consists of plagioclase (30%), quartz, hornblende, and potash feldspar (20% each), biotite and iron oxide (5% each). The texture is granoblastic, but a few relict phenocrysts of quartz, plagioclase, and potash feldspar have been preserved. The more highly altered dacites and rhyodacites can be distinguished by their dark colour.

Many of the less altered volcanics within 3.5 km of the contact have a slight sheen due to the development of secondary micas, but still farther away from the contact most of the rocks appear to be little altered.

Eight kilometres northwest of Glenroy homestead, near the headwaters of Boundary Creek, there is a gradual transition from only slightly metamorphosed porphyritic rhyolite to biotite gneiss, and there is little doubt that most of the metamorphics west of Stones Creek were derived from volcanics. There is a gradual transition from recrystallized brownish yellow rhyolite, containing phenocrysts of quartz, into muscovite-biotite-microcline-quartz granofels, in which no relict phenocrysts remain, which in turn grades into strongly foliated biotite-feldspar-quartz gneiss.

The northern outcrops of Mount Windsor Volcanics are an extension of the strongly jointed, but generally unmetamorphosed, acid volcanics in the Charters Towers Sheet area. The volcanics are intruded in the east by the late acid phase (ODa) of the Ravenswood Granodiorite Complex.

*Undivided Cape River Beds.* Most of the roof pendants of altered Cape River Beds consist of fine-grained biotite-quartz-feldspar-mica schist and gneiss, muscovite-biotite-feldspar-quartz granofels, and amphibolite. The granofels represents metamorphosed acid volcanic rocks, and the schist, gneiss, and amphibolite may also have been derived from volcanic rocks.

North of Rangeview homestead the Cape River Beds include biotite-feldspar-quartz granofels, andalusite-cordierite-biotite-muscovite-quartz gneiss, quartz-hornblende-oligoclase granofels, and sphene-andesine-hornblende amphibolite.

At the junction of Oaky and Stones Creeks porphyritic acid dykes intrude the metamor-

TABLE 1. CAMBRIAN TO LOWER CARBONIFEROUS STRATIGRAPHY AND IGNEOUS INTRUSIONS

| *Age* | *Rock Unit (map symbol)* | *Lithology* | *Topography* | *Remarks* |
|---|---|---|---|---|
| LOWER CARBONIFEROUS | (Clg) | Adamellite, minor granodiorite, tonalite, and diorite. Numerous roof pendants | Plains and low rises; scattered tors | Mesozonal batholith. Intrudes Ukalunda Beds and Mt Wyatt Beds. Unconformably overlain by Bulgonunna Volc and Suttor Fm |
| | Edgecumbe Beds (Cle) | Shale, greywacke, limestone; feldspathic and clayey sandstone, siltstone, and pebble conglomerate, andesite lavas and pyroclastics | Exposed mainly in creeks. Some low hills and rises | Intruded by adamellite (PKg). Upfaulted against Carmila Beds (relationship concealed). Shallow marine environment. Marine fossils. M. to u. Tournaisian. Thickness at least 4700 m (including Proserpine Sheet area) |
| | Star of Hope Formation (Cls) | Lapilli tuff, welded tuff, tuffaceous sandstone, volcanolithic sandstone, sandstone with quartz pebbles, conglomerate | Wide soil-covered flats and areas of long strike ridges. Relief reaches 75 m just N of Burdekin Falls | Overlaps Mt Hall Fm onto Scartwater Fm; unconformably overlain by Bulgonunna Volc, Suttor Fm, and Tertiary basalt. Intruded by adamellite (Cug, CPg), porphyry (Cur), and dolerite (CPi). Fluvial. Plant fossils. About 1800 m thick |
| | Mount Hall Formation (Clh) | Pebbly and conglomeratic quartz sandstone, coarse quartz sandstone | | Interfingers with top of Scartwater Fm; overlapped by Star of Hope Fm. Intruded by dolerite (CPi). Fluvial. Wood fragments. Thickness 0 to about 100 m in Bowen Sheet area; up to 3000 m in main part of Drummond Basin |
| | Scartwater Formation (Clc) | Fine feldspathic sandstone, interbeds of calcarenite, algal limestone, olive mudstone, lithic tuff | Wide soil-covered flats and areas of long strike ridges. Relief | Disconformably overlies St Anns Fm and volcanics (DCv); overlain by and interfingers with Mt Hall Fm; unconformably overlain by Bulgonunna Volc, intruded by Mt Wickham Rhyolite at Mt McConnell, rhyolite and porphyry (Cur), and dolerite (CPi). Plant fossils. Thickness about 300 m |

Table 1 (Cont.)

| *Age* | *Rock Unit (map symbol)* | *Lithology* | *Topography* | *Remarks* |
|---|---|---|---|---|
| UPPER DEVONIAN TO LOWER CARBONIFEROUS | St Anns Formation (DCa) | Acid and intermediate volcanics and algal limestone at top; labile sandstone, minor green mudstone and phosphatic sandstone | reaches 75 m just N of Burdekin Falls | Unconformably overlies Ukalunda Beds; disconformably overlain by Scartwater Fm; unconformably overlain by Bulgonunna Volc. Intruded by granodiorite (CPg), dolerite (CPi), porphyry (Cur), and basalt (Tb). Plant fossils. Basal part paralic; upper part terrestrial? |
| | (DCv) | Acid to intermediate volcanics and associated sediments | Plains with some hills and ridges | Unconformable on Mt Windsor Volc; faulted against Ravenswood Granodiorite Complex; disconformably overlain by Scartwater Fm; unconformably overlain by Bulgonunna Volc. Intruded by adamellite (CPg), rhyolite and porphyry (Cur), and dolerite (CPi); probably equivalent to Mr Wyatt Fm and St Anns Fm. Probably terrestrial. About 600 m thick |
| | Connors Volcanics (DCo) | Andesite, rhyolite, and dacite lavas, agglomerate, volcanic breccia | Mainly high rugged hills and ridges | Intruded by diorite suite (Cud) and Urannah Igneous Complex; unconformably overlain by Lizzie Cr Volc |
| UPPER DEVONIAN | Mount Wyatt Formation (Dum) | Siltstone, shale, labile sandstone and conglomerate, mudstone, tuff | Soil-covered plains with some hills | Unconformable on Ukalunda Beds; unconformably overlain by Bulgonunna Volc and Suttor Fm. Intruded by adamellite (Clg). Marine and plant fossils. Partly marine. At least 1500 m thick |
| MIDDLE DEVONIAN | Ukalunda Beds (Dk) | Lithic and quartzose sandstone, shale, conglomerate, siltstone (calcareous in places), limestone, chert. Quartz veining, silicification, and low-grade metamorphism in places | High hills and ridges with smooth slopes; plains with scattered hills and rises | Unconformably overlain by Mt Wyatt Fm, St Anns Fm, Bulgonunna Volc, and Suttor Fm. Intruded and metamorphosed by adamellite batholith (Clg); intruded by porphyry (Cur). Marine, probably moderately deep water. Fossils (Couvinian). Thickness unknown, but at least 1200 m |

**Table 1 (Cont.)**

| *Age* | *Rock Unit (map symbol)* | *Lithology* | *Topography* | *Remarks* |
|---|---|---|---|---|
| M. ORDOVICIAN AND U. SILURIAN OR L. DEVONIAN | Ravenswood Granodiorite Complex (ODa) | Biotite adamellite, granite, and microgranite, minor granodiorite | Mainly rugged; some low country in Burdekin valley | Large composite batholith mainly exposed in Charters Towers Sheet area. Late acid phase (ODa) intrudes main granodiorite (ODr). Batholith intrudes Cape R Beds and is nonconformably overlain by volcanics (Cuv). Intruded by adamellite and granodiorite stocks (CPg, Plg) and batholith (Cug), and by ring dykes (Plr) |
| | Ravenswood Granodiorite Complex (ODr) | Granodiorite, adamellite, minor quartz diorite, diorite, meladiorite, trondhjemite, and granite | Gently undulating country | |
| CAMBRIAN TO ORDOVICIAN? | Cape River Beds (COc) | Schist, gneiss, granofels, amphibolite, metavolcanics | Low rises above general level of Ravenswood Granodiorite Complex | Intruded and metamorphosed by Ravenswood Granodiorite Complex; intruded by adamellite batholith (Cug), granitic stocks (Plg, CPg), rhyolite and porphyry masses (Cur, Mt Wickham Rhyolite), and small meladiorite stock (CPi). Unconformably overlain by Bulgonunna Volc and unnamed volcanics (DCv). Thickness unknown but probably great |
| | Mount Windsor Volcanics (COw) | Rhyolite, rhyodacite, rhyolite breccia, dacite, minor andesite, quartzite, argillite, arkose, locally metamorphosed to gneiss, granofels, and schist | Steep closely dissected hills | |
| | (Pzu) | Quartz-sericite schist, quartzite, phyllite, hornfels, micaceous siltstone | Low ridges and other small scattered outcrops | Age problematical. Intruded by adamellite tentatively correlated with Ravenswood Granodiorite Complex |

phics. The dykes contain xenoliths of gneiss and amphibolite derived from the country rocks, and have themselves been metamorphosed to foliated biotite-albite-potash-feldspar granofels. It seems therefore that there were two periods of metamorphism, both before and after the intrusion of the dykes. The larger roof pendants are intruded by many post-metamorphic dykes of granite, felsite, pegmatite, microdiorite, and acid and intermediate porphyries. Most of the dykes are concordant with the east-northeasterly foliation in the metamorphics.

*Structure and Thickness*

It is generally impossible to determine the original attitude of the volcanics. They are characteristically strongly jointed and are cut by northeasterly faults, along some of which they have been severely mylonitized. The strong southeasterly trend visible on the air-photographs between Stones and Glenroy Creeks corresponds with the direction of cleavage and foliation observed in the field, but in most cases it is not known whether the ill defined trends on the air-photographs indicate bedding, cleavage, or a fracture pattern. On the air-photographs the roof pendants have a well defined northeasterly trend, which is probably parallel to the foliation. The trends are accentuated by numerous concordant dykes.

*Age and Relationships*

No fossils have been found in the Cape River Beds, but preliminary Rb/Sr whole rock analyses (A.W. Webb, pers. comm.) on the unmetamorphosed acid volcanics from Six Mile Creek have yielded an isochron of $510 \pm 100$ m.y. (Upper Cambrian)*. If confirmed, this is the first dated occurrence of Cambrian rocks in the Tasman Geosynclinal Zone in Queensland.

The Cape River Beds are intruded by the Middle Ordovician Ravenswood Granodiorite Complex, and by younger intrusions.

*Mineralization*

Scheelite has been recorded by Ridgway (1947) in quartz pipes in rhyolite, 10 km east-northeast of Mount Glenroy. The exact location is unknown, but is evidently within the Mount Windsor Volcanics, close to the contact with one of the Upper Carboniferous granites (Cug).

### *Unnamed Metasediments (Pzu)*

The small ridges and other outcrops of metamorphosed fine-grained sediments at the junction of Expedition Pass Creek and the Burdekin River, and in the Burdekin River at the northern boundary of the Sheet area, are intruded by granite mapped as Ravenswood Granodiorite Complex.

South of Expedition Pass Creek green-brown and blue-grey micaceous siltstone is both faulted against and intruded by red leucocratic biotite granite. This granite has been mapped as part of the late acid phase of the Ravenswood Granodiorite Complex (ODa), although there is no proof of its age. The fine-grained quartz-cordierite-biotite-muscovite hornfelses between the road and the river are strongly sheared, brecciated, and intruded by thick dykes of flow-banded felsite. Quartz breccia zones occur in hornfelsed siltstone. A few prospecting pits have been sunk on faults, but no trace of mineralization was seen. North of Expedition Pass Creek similar green-grey hornfelsed micaceous siltstones are faulted against the granite.

Quartz-sericite schist, quartzite, and spotted sericite-andalusite(?) phyllite occur in the Burdekin River at the boundary of the Sheet area. The metamorphosed arenites are pebbly and strongly sheared; the pebbles are usually elongated parallel to the foliation, which is defined by the alignment of the interstitial sericite.

A small localized occurrence of mica schist was reported by Gloe (1951, unpubl.) on top of a ridge on the left bank of the Burdekin River, near the weir.

*The geological scale used in this Report is that of Harland et al. (1964), unless stated otherwise.

The metasediments are unfossiliferous, and are remnants of a sequence which appears to be older than the Ravenswood Granodiorite Complex. For this reason they are regarded broadly as early Palaeozoic. Similar metamorphic remnants have been described in the Ayr Sheet area (Paine et al., 1970).

## MIDDLE ORDOVICIAN AND UPPER SILURIAN OR LOWER DEVONIAN

### *Ravenswood Granodiorite Complex*

The oldest granitic rocks northwest of the Burdekin River are continuous with the early Palaeozoic Ravenswood Granodiorite Complex in the northeast quadrant of the Charters Towers Sheet area. The rocks in the Bowen Sheet area have not been dated.

The Ravenswood Granodiorite Complex has been defined by Wyatt et al. (1970, 1971). In the Charters Towers Sheet area the complex consists mainly of granodiorite with subordinate diorite and gabbro (ODr), and a late granite and adamellite phase (ODa). In the Bowen Sheet area the late acid phase is predominant. In 1966 Clarke (1971) distinguished several more phases in the Ravenswood 1-mile Sheet area.

*Distribution and Topography*

The granodiorite forms undulating country, with an elevation of 200 to 250 m and a fairly close drainage pattern. It crops out in a belt, about 25 km long and 5 to 10 km wide, between Rangeview homestead and the Burdekin River to the north. Granodiorite occupies a further 25 $km^2$ in the northwest corner of the Sheet area, where it is only 100 to 150 m above sea level; there are also several small outcrops in the Burdekin River near Millaroo. The pocket of diorite in the Mount Windsor Volcanics on the western edge of the Sheet area has also been mapped as part of the complex.

The late acid phase crops out in rugged hills and forms much of the Leichhardt Range.

*Lithology*

The *main granodiorite* (ODr) south of Rangeview homestead consists of hornblende-biotite granodiorite and adamellite, biotite-hornblende adamellite, and minor quartz diorite, diorite, and granite. To the northwest, melanocratic fine to medium-grained hornblende-biotite granodiorite, grading into biotite-hornblende diorite, is intruded by thick dykes of aplitic granite of the late acid phase.

Granodiorite, adamellite, and coarse white hornblende-biotite trondhjemite occur in the northwest corner of the Sheet area.

The pocket to the south of the headwaters of Landers Creek consists of hornblende meladiorite and grey biotite-hornblende diorite. The diorite is cut by thin dykes of aplite, and the surrounding Mount Windsor Volcanics are intruded by dykes of banded meladiorite and microdiorite.

The *late acid phase* (ODa) consists predominantly of biotite adamellite and granite.

The granite forms most of the Leichhardt Range north of Rangeview homestead, and is intruded by Upper Carboniferous and Permian granites (Cug, Plg), and nonconformably overlain by Upper Carboniferous volcanics (Cuv.). In the lower country, between the Leichhardt Range and the Burdekin River, the position of the boundary with the Upper Carboniferous granite (Cug) is uncertain.

The grey-white biotite adamellite around Marlborough Pocket grades in places into granodiorite. The volcanics (Cuv) forming McGregors Bonnet are underlain by coarse biotite granite grading into porphyritic microgranite. The granite is cut by northeasterly trending faults filled with quartz veins, some of which have been pitted by prospectors. Numerous dykes and irregular masses of aplitic microgranite occur in the rugged hills of alkali granite and adamellite southwest of McGregors Bonnet. Near the head of Landers Creek the Mount Windsor Volcanics are cut by coarse porphyritic biotite granite with sharp intrusive contacts. The country rock along the eastern contact of the Landers Creek stock (Plg) consists of altered leucocratic biotite granite or adamellite, with associated pegmatites and quartz veins.

Between the Leichhardt Range and the Burdekin River, where the granite is deeply weathered, outcrops are confined to a few low hills.

The hills immediately north of Oaky Creek, in the headwaters of Expedition Pass Creek, are composed of medium-grained red leucocratic biotite granite, which is locally porphyritic and foliated by shearing. The granite intrudes metasediments (Pzu) near the junction of Expedition Pass Creek and the Burdekin River.

*Structure*

South and west of Rangeview homestead the roof of the main granodiorite dips gently east beneath the Mount Windsor Volcanics. The main granodiorite was intruded syntectonically, and caused dynamic and thermal metamorphism of the country rocks. The presence of numerous large roof pendants indicates that only the roof of the intrusion is exposed.

The contacts between the main granodiorite and the late acid phase are sharp and there is comparatively little shearing and foliation. The acid phase was probably mainly post-tectonic and was emplaced at a higher level than the main granodiorite. The acid phase is cut by numerous northeasterly faults.

*Age and Relationships*

The Ravenswood Granodiorite Complex intrudes the Cape River Beds and is nonconformably overlain by volcanics (Cuv) of probable Upper Carboniferous age. In the Townsville Sheet area the complex is overlain nonconformably by upper Middle Devonian sediments (Wyatt et al., 1970). The rocks in the Bowen Sheet area have not been dated isotopically, but Rb/Sr whole rock analyses on 17 specimens from the Charters Towers and Townsville Sheet areas show that most of the granodiorites were emplaced about 455 m.y. ago (Middle Ordovician), and that there was a second intrusive epoch 395 m.y. ago (at about the Silurian-Devonian boundary) (Webb, 1969).

## UPPER DEVONIAN TO LOWER CARBONIFEROUS

### *Volcanics and Sediments of the Drummond Basin*

The Upper Devonian to Lower Carboniferous volcanics and sediments of the Drummond Basin north of the Burdekin River were briefly examined by Malone and others in 1961 (Malone et al., 1966), and were mapped in more detail during the present survey in 1964. Apart from the Mount Wyatt Formation, the entire succession was mapped as one unit in 1961, but later Olgers (1972) traced the main formations from their type areas to the southwest into the Bowen Sheet area. The succession in the Bowen Sheet area consists of the Mount Wyatt and St Anns Formations, the unnamed volcanics (DCv), and the Scartwater, Mount Hall, and Star of Hope Formations.

The following observations were made during the present survey in 1964, when the whole of the Upper Devonian/Lower Carboniferous succession was mapped as a single unit. A few observations were also made around Cockatoo Creek to the south of the Burdekin River.

The Drummond Basin succession consists mainly of freshwater sediments laid down on the Ravenswood Granodiorite Complex and Cape River Beds in the north, and on the lower Middle Devonian Ukalunda Beds (Malone et al., 1966; Hill et al., 1967) in the south. In the area mapped in 1964 the succession consists mainly of volcanics in the northwest limb of a southwesterly plunging synclinorium

The formations crop out in wide soil-covered flats and long strike ridges. The maximum relief is 75 m north of the Burdekin Falls and a few kilometres southeast of Mount McConnell.

*Lithology*

The base of the sequence is poorly exposed, and has been intruded by porphyry and rhyolite (Cuv), and by granite (CPg). In the east the sequence is unconformably overlain by the Bulgonunna Volcanics. The lowest exposed beds are andesite breccia, agglomerate, coarse tuff, and tuffaceous sandstone, overlain by over 1500 m of dark red deeply weathered sediments and pyroclastics, which form a broad soil-covered flat north of Mount Graham. The top of the sequence consists of fine tuff, mud-ball tuff, coarse feldspathic tuffaceous sandstone, andesite breccia, agglomerate, tuffaceous siltstone and mudstone, conglomerate, and rare algal and inorganic argillaceous limestone. Thin lenses of grey algal limestone crop out 5 km north-northwest of Mount McConnell, and 1.5 km northeast of Glenroy homestead. The limestones contain concentric algal structures up to 30 cm in diameter, and are interbedded with fine tuffaceous sediments.

The upper part of the succession, south and east of Mount Graham, crops out in prominent strike ridges of acid welded tuff, devitrified felsitic tuff, rhyolite breccia, rhyolite, andesite, feldspathic sandstone, tuffaceous siltstone, and conglomerate.

Some of the sediments in the sequence have a calcareous cement. Sudden facies variations were observed in places.

*Structure and Thickness*

The sequence forms the northwest limb of a southwesterly plunging synclinorium, and the axis is probably continuous with the tight synclinal axis 8 km southeast of Mount McConnell. The northern margin of the basin is faulted in places, and this accounts for the steep marginal dips.

Olgers (1972) has estimated a thickness of about 2500 m for this part of the Drummond Basin succession.

*Age and Relationships*

Lower Carboniferous plant fossils occur in the Drummond Basin in the Charters Towers and Bowen Sheet areas (Wyatt et al., 1971; Malone et al., 1966), and the Upper Devonian plant *Protolepidodendron* has been recorded at the base of the Drummond Group at the St Anns crossing of the Suttor River near the northeastern corner of the Buchanan Sheet area (Malone et al., 1964). For a more detailed discussion of the age of the sequence the reader is referred to Olgers (1972).

The Drummond Basin sequence unconformably overlies the Mount Windsor Volcanics and is intruded by Upper Carboniferous or Lower Permian granite, granophyre, microgranite, diorite, porphyry, and rhyolite, and by a volcanic plug (Mount Wickham Rhyolite) forming Mount McConnell. It is overlain unconformably by the Upper Carboniferous Bulgonunna Volcanics, and by Tertiary olivine basalt.

*Origin*

The sequence is regarded as of freshwater origin because only plant fragments have been found in it. In the Bowen Sheet area most of the sediment was the product of contemporaneous volcanism, but the pebbles of schist, gneiss, and quartzite in the conglomerates were derived from the Cape River Beds.

# LOWER CARBONIFEROUS

## *Edgecumbe Beds*

The Edgecumbe Beds consist mainly of marine sediments of Lower Carboniferous age (Clarke et al., 1971). They are exposed over a limited area southeast of Edgecumbe Bay, but are generally covered by superficial Cainozoic deposits.

The limestone at Ben Lomond has been described by Saint-Smith (1918) and Stanley (1927). Brown (1963, unpubl.) measured a thickness of 1272 m in the type section in Ten Mile Creek, above its junction with the Gregory River. Brown correlated the Edgecumbe Beds with the Campwyn Beds (Jensen et al., 1966; Clarke et al., 1971) because of their similarity in age, but we consider that the two sequences cannot be directly correlated.

The Edgecumbe Beds have generally been removed by erosion in interfluvial areas, but they are well exposed in Ten Mile Creek, which has cut through the veneer of Cainozoic sediments. Elsewhere a few resistant beds form scattered outcrops in interfluves. East of Ben Lomond the beds crop out in low soil-covered hills.

### *Lithology*

In the type section the sequence consists (in decreasing order of abundance) of shale, greywacke, limestone, feldspathic sandstone, siltstone, clayey sandstone, and pebble conglomerate. The shale and fine siltstone have a slight sheen owing to incipient recrystallization and the development of platy chloritic and micaceous minerals. These finer sediments could be called argillites. The labile detrital material in the arenites is mainly of volcanic origin.

Some of the light brown shales and siltstones contain a rich fauna of bryozoans, brachiopods, gastropods, trilobites, pelecypods, plants, and tracks of worms and other animals (Brown, 1963, unpubl.).

The limestones range from thin-bedded fossiliferous bioclastic rocks to thick-bedded unfossiliferous oolites, with some sandy and crystalline varieties. The thick oolitic limestones are best exposed at the junction of Ten Mile Creek and the Gregory River, from where they extend discontinuously to Ben Lomond in the north-northwest. Recrystallized oolitic limestone, flanked by skarns developed from calcareous tuffaceous sediments, forms a roof pendant in the Ben Lomond adamellite stock (PKg). Rare crinoid plates have been observed in the roof pendant.

East of the Gregory River the proportion of volcanic detritus increases, and to the east of the Sheet area the greywackes give way to pyroclastics and lava flows. On the northeast side of Ben Lomond the volcanics consist of andesite, coarse tuff, breccia, and agglomerate overlying limestone.

### *Thickness*

Brown (1963, unpubl.) estimated the thickness, including the beds in the Proserpine Sheet area, at 4700 m, but the total thickness is much greater as neither the base nor the top of the sequence are exposed.

### *Structure*

The Edgecumbe Beds strike consistently north-northwest, and are either vertical or dip steeply to the east-northeast. The rare cross-bedding indicates that the sequence dips to the east-northeast, and this has been confirmed by the fossils collected at four different horizons (McKellar *in* Brown, 1963, unpubl.).

The shale and siltstone are cleaved at a low angle to the bedding, but no folds have been recognized, and there is no repetition of the sequence.

In the Longford Creek area, the Lower Permian Carmila Beds to the west of the Edgecumbe Beds dip at moderate angles to the east-northeast. Although the contact is obscured by a wide belt of Tertiary sediments, the structure and difference in age between the two units indicate that the contact is faulted. The contact is inferred to be a major strike fault or system of faults, upthrown to the northeast, which may be an extension of the O'Connell Fault or Foxdale Fault Zone in the Proserpine Sheet area (Clarke et al., 1971).

*Age and Relationships*

Fossils were collected by Brown at four horizons in his measured section along Ten Mile Creek. The fossils in the lower two horizons were determined by McKellar (*in* Brown, 1963, unpubl.) as middle or upper Tournaisian, and those in the other two as upper Tournaisian.

The Edgecumbe Beds are intruded by the Lower Permian or Lower Cretaceous adamellite of Ben Lomond, and by diorite (also mapped as Lower Permian or Lower Cretaceous) in the Proserpine Sheet area. The Edgecumbe Beds are probably an upfaulted block of the basement upon which the Lower Permian Carmila Beds were laid down.

*Environment of Deposition*

Most of the sequence was laid down in a shallow sea, but the presence of unfossiliferous limestone and the increasing abundance of volcanics towards the top of the sequence suggest that the sea retreated before the uppermost beds were deposited.

## UPPER CARBONIFEROUS

(Table 2)

### *Diorite Suite (Cud)*

In the northeast the acid plutonic rocks (Hecate Granite, Thunderbolt Granite, and unnamed granite 'CPg') have been separated from the older diorite suite (Cud). The acid rocks are mainly Lower Permian and Lower Cretaceous, but include some late Upper Carboniferous intrusions, while the Rb/Sr isotopic analyses suggest that the diorite suite is probably entirely Upper Carboniferous. In the relatively inaccessible southeastern part of the Sheet area the acid and intermediate rocks have been mapped as a single unit (Urannah Igneous Complex).

Most of the northern half of the diorite suite is readily accessible, but the only access to the southern half is along the road from Binbee to the old Normanby goldfield and Sutherland homestead.

*Topography*

In general the relief and altitude increase to the south.

Northeast of a line between Roma Peak and Mount Abbot the diorite suite crops out mainly as low hills and rises separated by gently undulating areas of black soil. North-northwesterly trending ridges have been developed between the Bogie River and Collinsville, but the most rugged country occurs along Grant Creek, northwest and west of Fairfield hut, and in the Humbug Creek area north of Mount Roundback, where the relief is up to 350 m. There are numerous summits between 600 and 700 m, and one peak rises to 820 m.

Most of the ridges in the south are buttressed by numerous parallel northwesterly trending dykes, especially in the drainage basins of Emu and East Creeks. South of the latitude of Crompton Creek there are relatively few dyke ridges, probably because of the higher relief and wide open type of valley. The ill defined plateau around Parada homestead is a remnant of an earlier erosion cycle which reduced both the diorite and the dykes to the same level.

In general the diorite suite has smoother slopes (Fig. 6) than the younger acid intrusions, and the drainage pattern is more regular and more widely spaced. This is illustrated by the contrast in topography between the Lower Permian adamellite stock west of Crompton Creek and the surrounding hills of diorite.

*Lithology*

The suite consists mainly of diorite with subordinate quartz diorite, tonalite, gabbro, and granodiorite, and rare adamellite, norite, monzonite, granite and ultramafics. The suite can be distinguished from the younger acid intrusions by the presence of numerous dykes, and by the presence of foliation.

*Northeastern area* (northeast of a line between Mount Abbot and the village of Kelsey Creek). Lateritized serpentinite(?), apparently surrounded by diorite and gabbro, forms the country rock of the Mount Pring magnesite deposit, 17 km west-southwest of Bowen. The deposit occurs on a steep spur composed of the ferruginous and siliceous zones of a laterite profile, which appears to have been derived from serpentinite. The nearby spurs are formed of fine and coarse banded gabbro and diorite which have not been lateritized. The boundary between the lateritized ultramafic rock and non-lateritized basic rocks is sharp, and the lateritized ultramafic area (which measures about 600 m by 400 m) may be a small down-faulted block. This is the only known occurrence of ultramafic rock in the Bowen Sheet area, although a small area of diallagite has been recorded on Camp Island in the Ayr Sheet area (Paine et al., 1970). Fine and coarse hornblende gabbro forms ridges near the magnesite deposit, and severely uralitized (hornfelsed?) gabbro crops out 1.5 km west-northwest of the mine.

The roof pendant of Mount Greentop and the Knobbies consists of hornblende gabbro and diorite. Four kilometres southeast of The Knobbies the gabbro has been intruded and altered by muscovite granite dykes and quartz veins.

Banded diorite and gabbro, which are sheared in places, form the southwest spur of Mount Cavana at the southern end of the Bodes Range. One specimen (2081)* consists of highly altered olivine gabbro containing corona textures. Similar banded diorite and gabbro crop out as low hills between Mount Cavana and the Don River. Some of the gabbro contains feldspars up to 2 cm across and poikilitic amphibole crystals up to 3 cm long. The gabbro and diorite between Mount Cavana and the Don River, and to the north, are intruded by dykes of adamellite, granite, and pegmatite (CPg). The diorite between Grasstree Creek and the northwest end of the Bodes Range is brecciated and faulted against biotite adamellite (CPg). Over much of its length the fault is filled by a thick dyke of flow-banded spherulitic felsite.

The hills drained by the headwaters of Police Camp Creek and Hay Creek are composed of coarse diorite and hornblende gabbro, which are intruded by granite dykes.

Mount Gordon, 5 km south-southwest of Bowen, is a roof pendant of medium-grained diorite resting on adamellite (CPg). The diorite is cut by adamellite dykes. Mount Lee consists of meladiorite and hornblende gabbro, intruded by adamellite of the Hecate Granite. On the eastern side of the hill the diorite and gabbro are brecciated, sheared, and intruded by numerous east-southeasterly dykes of microdiorite.

In the *northwestern area* (west and northwest of the Thunderbolt Granite and as far south as Amoola siding) the suite consists of coarse equigranular diorite and subordinate granodiorite, cut by numerous dykes of microdiorite and occasional dykes of gabbro, basalt, granophyre, microgranite, and pegmatite. Most of the faults and dykes have a persistent north-northwesterly trend. The granodiorites are commonly strongly sheared, and appear to grade into the diorite. Granodiorite also occurs as xenoliths in the diorite. A xenolith of hornfelsed feldspathic arenite, at least 6 m long and 2 m wide, crops out in the Bogie River, near its junction with Sundown Creek. The widespread alteration of the rocks has resulted in the development of epidote, chlorite, and calcite, which commonly occur in small veinlets.

* Specimen numbers have been abbreviated by omitting the first four numbers 6515.

TABLE 2. UPPER CARBONIFEROUS TO PERMIAN STRATIGRAPHY AND IGNEOUS INTRUSIONS

| *Age* | | *Rock Unit (map symbol)* | *Lithology* | *Topography* | *Remarks* |
|---|---|---|---|---|---|
| U. PERMIAN | | Blackwater Group (Puw) | Cross-bedded well sorted lithic sandstone, siltstone, quartzose sandstone; carbonaceous shale with some coal seams, pebble and cobble conglomerate, dolomitic and calcareous sandstone, tuff | Soil-covered plains and rises, some strike ridges. Rugged hills where hornfelsed | Conformably overlain by Rewan Fm; conformable on Blenheim Sub-gp. Lacustrine, fluvial, and paludal. Plant fossils, 1900 m thick |
| LOWER TO UPPER PERMIAN | BACK CREEK GROUP | Blenheim Sub-group (Pue) | Siltstone, pebbly sublabile sandstone, fossiliferous calcareous siltstone and sandstone, coquinite, limestone | Generally low rises; subdued cuestas near Parrot Cr | Conformable on Gebbie Sub-gp or on Collinsville Coal Measures. Moderately deep to shallow water; transgressive marine phase. Abundant marine fossils. About 450 m in W part of basin, 800 in E |
| | | Gebbie Sub-group (Plb) | Quartzose sandstone, sublabile sandstone (carbonaceous in part), siltstone, mudstone, calcareous sandstone and siltstone, minor conglomerate and coal | Prominent strike ridges separated by rises | Conformable on Tiverton Sub-gp, conformably overlain by Blenheim Sub-gp. Moderately shallow marine, transgressive in part. Marine fossils. Up to 600 m thick |
| | | Collinsville Coal Measures (Plc) | Quartzose sandstone, conglomerate, siltstone, calcareous sublabile sandstone, coal seams, carbonaceous shale | Subdued, some hills | Grades laterally into marine sediments of Gebbie Sub-gp. Deltaic to paludal, marine at times. One fossiliferous marine horizon. Up to 430 m thick |
| | | Tiverton Sub-group (Plp) | Sublabile sandstone and siltstone containing calcareous and fossiliferous beds, lenses, and nodules; some limestone, coquinite, and sandy limestone | Long low strike ridges and soil-covered plains | Possibly unconformable on Lizzie Cr Volc. Conformably overlain by Gebbie Sub-gp. Moderately deep water marine environment. 550 m thick |

Table 2 (Cont.)

| *Age* | *Rock Unit (map symbol)* | *Lithology* | *Topography* | *Remarks* |
|---|---|---|---|---|
| LOWER PERMIAN | Thunderbolt Granite (Plg) | Adamellite, minor microadamellite; aplitic microgranite dykes | Rugged plateau flanked by low-lying country in N and uneven hills and slopes in S | Mesozonal batholith. Intrudes U. Carboniferous diorite suite (Cud) by which it is surrounded. Intruded by Hecate Granite in N and by small boss of altered granodiorite (PKs) in SE |
| | (Plg) | Adamellite, granodiorite | Adamellite forms rugged hills and mountains; granodiorite generally forms low-lying country | Cylindrical subvolcanic stocks emplaced by ring-fracturing. Intrude Ravenswood Granodiorite Complex, U. Carboniferous volcanics (Cuv), Mt Windsor Volc, and U. Carboniferous diorite suite (Cud) |
| | (Plr) | Porphyritic rhyolite and microtrondhjemite | Steep ridges and peaks | Ring dykes and possible cone sheets. Intrude U. Carboniferous volcanics (Cuv), Ravenswood Granodiorite Complex, U. Carboniferous granite (Cug), and L. Permian granite (Plg) |
| | Mount Aberdeen Volcanics (Pld) | Andesite, dacite, rhyolite, dacite welded tuff, lithic-crystal tuff, crystal tuff, agglomerate | Rugged crags at Mt Aberdeen and Mt Inbetween | Nonconformably overlie late Palaeozoic adamellite (CPg). Intruded by Hecate Granite. Thickness about 500 m |
| | Kurungle Volcanics (Plk) | Andesite, andesite breccia, flow-banded rhyolite, agglomerate, tuff | Steep hills with relief approaching 400 m | Apparently both nonconformable on and intruded by late Palaeozoic granite (CPg). Faulted against and intruded by Mt Abbot Igneous Complex ($Ka_1$). Possibly 300 to 400 m thick |
| | Carmila Beds (Pla) | Massive dacite and andesite pyroclastics and subordinate lavas; bedded pyroclastics and labile sediments | Smooth but high hills and mountains partly covered by rain forest; low strike ridges | Intruded by Hecate Granite; downfaulted against Edgecumbe Beds. Rare plant fossils. Probably same age as Lizzie Cr Volc. Probably at least 7500 m thick |
| | Lizzie Creek Volcanics (Plz) | Basalt, andesite, agglomerate, lithic and tuffaceous sediments, minor acid volcanics | Gentle rises and black-soil plains in N, with some hilly country near Mt Wickham Rhyolite. Some low strike ridges to W and E of Bowen Basin. High hilly country in E | Nonconformably overlie granite (Cug, CPg) Faulted against and nonconformable on diorite suite (Cud) and Connors Volc. Unconformable on Bulgonunna Volc. Possibly unconformably overlain by Tiverton and Gebbie Sub-gps. Intruded by and unconformably overlain by Mt Wickham Rhyolite. Marine fossils at top in Mt Coolon Sheet area. Up to 6000 m thick |

TABLE 2 (cont.)

| Age | Rock Unit (map symbol) | Lithology | Topography | Remarks |
|---|---|---|---|---|
| UPPER CARBONIFEROUS or LOWER PERMIAN | (CPg) | Adamellite, granodiorite, granite, minor quartz diorite, granophyre, microgranite, and microtrondhjemite | Mainly low-lying undulating country | Batholiths and stocks of more than one age. Intrude Ravenswood Granodiorite Complex, Mt Windsor Volc, unnamed volcanics (DCv), Star of Hope Fm, diorite suite (Cud), Carmila Beds. Intruded by granite (PKg), Mt Wickham Rhyolite, Hecate Granite, and Mt Abbot Igneous Complex. Faulted against adamellite (Cug). Nonconformably overlain by Lizzie Cr Volc and Mt Aberdeen Volc |
| | (CPi) | Pyroxene diorite, meladiorite, minor olivine diorite, gabbro, and pyroxene monzonite | Low rises of black soil with rare outcrops | Small intrusions, locally concordant. Intrude Drummond Basin succession and Mt Windsor Volc. Intruded by granodiorite (CPg) |
| UPPER CARBONIFEROUS | (Cug) | Adamellite, granite, granodiorite, minor marginal granophyre and porphyry | Faults divide rugged broken plateau to W (Leichhardt Ra) from gently undulating to uneven country in Burdekin and Bowen valleys and in SE | Large batholith. Intrudes Bulgonunna Volc, unnamed volcanics (Cuv), Mt Windsor Volc, Ravenswood Granodiorite Complex, and Scartwater Fm. Intruded by adamellite (Plg). Nonconformably overlain by Lizzie Cr Volc. Intruded by and nonconformably overlain by Mt Wickham Rhyolite. Probably comagmatic with Bulgonunna Volc |
| | (Cur) | Rhyolite and porphyry | Low sparsely vegetated hills and ridges | Irregular intrusive masses and dykes. Intrude Drummond Basin sequence, Mt Windsor Volc, and Ukalunda Beds. Intrusive phase of Bulgonunna Volc and unnamed volcanics (Cur) |
| | Bulgonunna Volcanics (Cub) | Rhyolite, rhyodacite, and dacite welded tuffs, lavas, and air-fall pyroclastics, minor andesite and tuffaceous sediments | Generally rugged, plateau-forming | Probably mainly cauldron subsidence type eruptions. Unconformably overlie Mt Windsor Volc, unnamed volcanics (DCv), Scartwater Fm, Star of Hope Fm, St Anns Fm, Ukalunda Beds, Mt Wyatt Fm, and granite (Clg). Intruded by adamellite (Cug). Unconformably overlain by Lizzie Cr Volc, Collinsville Coal Measures, and Suttor Fm |

TABLE 2 (cont.)

| *Age* | *Rock Unit (map symbol)* | *Lithology* | *Topography* | *Remarks* |
|---|---|---|---|---|
| UPPER CARBONIFEROUS | (Cuv) | Rhyolite, rhyodacite, and dacite welded tuffs, acid lavas and agglomerate, minor andesite | Rugged hills and ranges; some plateaux | Nonconformable on Ravenswood Granodiorite Complex. Intruded by adamellite (Cug, Plg), and ring dykes (Plr). Equivalent to Bulgonunna Volc |
| | (Cud) | Diorite, quartz diorite, tonalite, gabbro, granodiorite. Rare adamellite, norite, monzonite, granite, and ultramafics | Hills and rises in NE. Elsewhere rugged, with many NNW-trending dyke ridges | Composite mesozonal batholith. Intruded by Hecate Granite and Thunderbolt Granite, and in places by late Palaeozoic granitic rocks (CPg). Intrudes Connors Volc. Faulted against and nonconformably overlain by Lizzie Cr Volc |

*Main area.* In the bed of the Don River at the Mount Dangar crossing massive to feebly foliated medium to coarse biotite-hornblende tonalite grades into quartz diorite and granodiorite. The ferromagnesian minerals, particularly biotite, form phenocrysts up to 1 cm across. The tonalite contains xenoliths of meladiorite, some of which are strongly foliated, and in places the meladiorite is extensively net-veined by the tonalite. Some of the tonalite is net-veined by fine-grained porphyritic to aplitic and pegmatitic pinkish grey biotite granite. These contacts are similar to those described by Allaart (1967) in south Greenland. A dyke of banded pegmatite and aplite, 2 m thick, is exposed a few metres north of the concrete causeway at the crossing. The meladiorite-tonalite-granite suite near the crossing is intruded by a succession of acid to basic dykes, many of which are strongly sheared parallel to their margins (Figs 16, 17).

Fine-grained plagioclase-quartz-hornblende amphibolite and melanocratic cataclasites occur sporadically in the Mount Dangar Shear north of the Don River. Boulders of medium-grained diorite (2103), with phenocrysts of hornblende, were observed at the foot of the northern slopes of Mount Dangar.

The Collinsville-Bowen road, where it climbs the escarpment 6 to 8 km north of Binbee, traverses quartz-hornblende-biotite diorite which has an undulating subhorizontal cataclastic foliation.

One Mile Mountain appears to consist of a dyke of altered medium-grained trondhjemite (2125). The rock contains small ironstained patches of epidote and fine-grained malachite; some small gold-copper occurrences have been worked nearby.

The outcrops near the station track 3.5 km southeast of One Mile Mountain consist of fine to medium-grained biotite-hornblende quartz diorite, containing poikilitic quartz (2104).

Low outcrops of massive fine to medium-grained hypersthene-hornblende diorite (2106) emerge from undulating rises 1 km east of the summit of Mount Marengo (Fig. 5), but foliated fine-grained quartz-poor alkali granite (2137) crops out on the eastern slopes of the hill, and the summit ridge which is possibly a dyke, is composed of fine-grained aplitic leucogranite in which the only mafic mineral is magnetite.

Massive to foliated medium-grained hypersthene gabbro (2109), medium to coarse olivine-hypersthene gabbro (2110), and medium-grained augite-hornblende norite (2213) crop out on the northern slopes of the northernmost of The Three Brothers. The norite contains clear and glassy plagioclase. Jack (1879b) recorded occasional small areas of gneiss, schist, shale, and greywacke in the Marengo goldfield, but none were observed during the present survey.

Where the road to Pretty Bend homestead crosses Ida Creek there is a large outcrop of massive inequigranular to porphyritic fine-grained diorite or quartz diorite. The diorite is intruded by irregular veins and pipes of medium to coarse tonalite or granodiorite, containing large phenocrysts of hornblende and biotite, and finally by a set of rectilinear biotite trondhjemite (?) veins (Figs 7-9). Banded fine and coarse to very coarse diorite crops out in the bed of a tributary of Ida Creek, 1.5 km south of the crossing.

Massive medium-grained biotite-hornblende quartz diorite (2108) occurs near the contact of the Thunderbolt Granite 7 km southeast of Binbee, and massive quartz diorite and diorite crop out in the indented scarp forming the watershed between Pickhandle Creek and Boundary and Oaky Creeks. In places the diorite contains lenses and small pods of siliceous pegmatite, some of which contain sparse hematite-rimmed boxworks in which individual crystals (presumably pyrite) are up to 3 cm in diameter. In places the pegmatites grade into greisen.

Massive medium-grained biotite-hornblende quartz diorite, containing disseminated pyrite, crops out in a creek beside the road 1.5 km south of the confluence of Rocky Creek and the Bogie River.

On a hill north of the road 3.5 km northwest of the homestead between Boundary and Alick Creeks, fine and coarse gabbros, including gabbro pegmatite, are present. Flow-foliated

**Fig. 7.** Dark fine-grained diorite cut by irregular veins of porphyritic tonalite(?), containing xenoliths of diorite, and later rectilinear veins of biotite trondhjemite(?). Ida Creek crossing on road to Pretty Bend homestead. Same outcrop as Figures 8 and 9. Photograph by J.E. Zawartko.

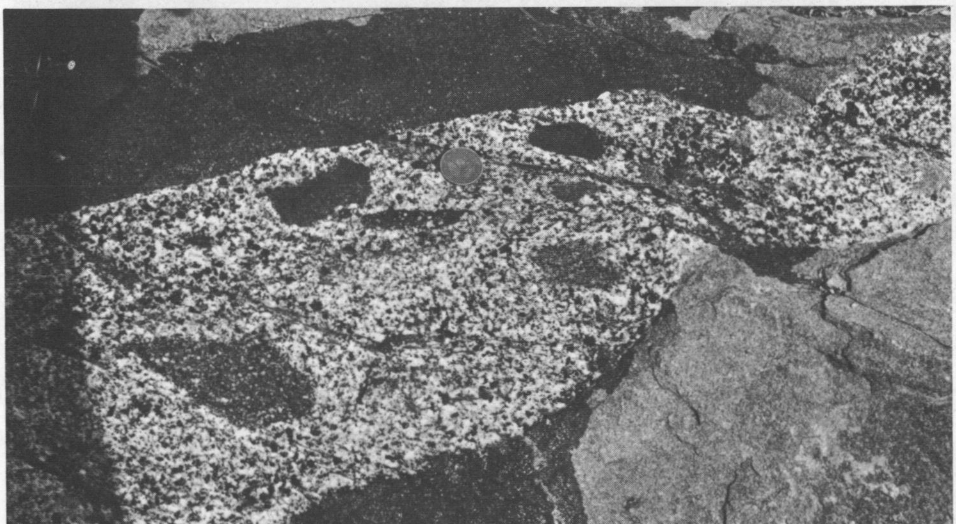

**Fig. 8.** Close-up of part of tonalite(?) vein shown in Figure 7. The tonalite contains xenoliths of the diorite into which it is intrusive. Photograph by J.E. Zawartko.

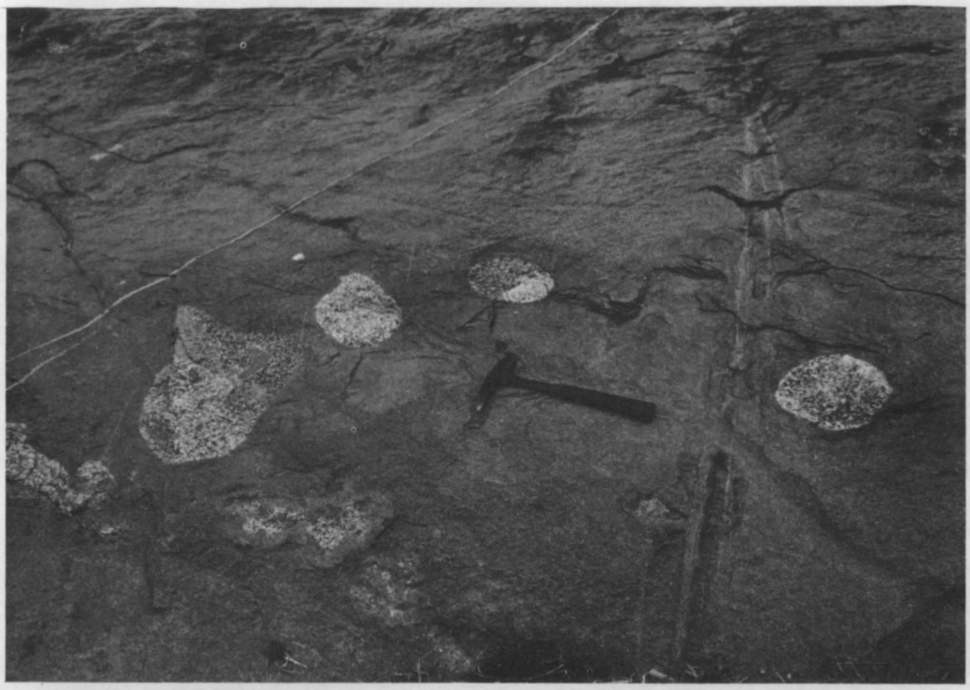

Fig. 9. Pipes of tonalite(?) in fine-grained diorite. The pipes contain xenoliths of the surrounding fine-grained diorite, and are similar in composition to the irregular veins shown in Figures 7 and 8. Photograph by J.E. Zawartko.

Fig. 10. Schlieren in foliated quartz diorite (Cud) in bed of creek 12 km west-southwest of Pretty Bend homestead. The ends of the schlieren are bent against small faults, several of which cross the outcrop. Two thin basic or intermediate dykes cut the quartz diorite in the foreground, and there is a thicker one in the top left-hand corner.

biotite-hornblende quartz diorite (2101) forms the bed of the creek at the homestead; the quartz diorite contains schlieren, which are bent where offset by small faults (Fig. 10).

The diorite in Boundary Creek, 1.5 km above its junction with the Don River, is net-veined by younger diorite intrusions. The diorite and tonalite are intruded by a dyke of biotite granite aplite, containing xenoliths of microdiorite, and is itself intruded by a synkinematic dyke of microdiorite with hornblende phenocrysts (Figs 17, 18).

Where the road to Pretty Bend homestead crosses the Don River there are extensive outcrops of foliated medium to coarse biotite-hornblende quartz monzonite (2206). The absence of dykes in the quartz monzonite suggests that it may be a contaminated marginal variety of the Hecate Granite. Crystals of orthoclase and oligoclase-andesine (each about 35%) have been rounded and granulated, and the albite twins in some of the plagioclase crystals are slightly bent. The hornblende (12%) is fresh, and at least one large crystal has been formed by the replacement of pyroxene. Biotite (5-7%) is also fresh, and is strongly foliated. Sphene (1%) forms crystals up to 2 mm long, but also occurs as narrow rims between biotite and the opaque minerals. Other accessories are zircon, apatite, and rutile. Similar foliated quartz monzonite or granodiorite, mainly devoid of dykes, forms the Ida Creek Ranges northeast of the Don River crossing. Outcrops of massive quartz monzonite (2201) occur in the left bank of the Don River 1.5 km north of Pretty Bend homestead.

**Fig. 11. Close-up of margin of xenolith-bearing slice in tonalite in bed of the Don River, 7 km southeast of Pretty Bend homestead. The foliation is contorted and truncated at the margin of the slice, which is probably part of the contaminated marginal zone of the tonalite.**

Tonalite in the Don River, 7 km southeast of Pretty Bend homestead, may also represent a contaminated phase of the Hecate Granite (Fig. 11). The foliated medium-grained hornblende-biotite tonalite or granodiorite contains a slice of darker tonalite, rich in xenoliths, aligned parallel with the foliation. The xenoliths are angular and consist of medium to coarse diorite or quartz diorite, with zones of diorite pegmatite. The dark tonalite is also foliated, but the absence of foliation in the xenoliths suggests that the foliation developed before the tonalite had completely crystallized. The foliation in the darker tonalite is generally concordant with that in the paler tonalite on either side, but in places it is truncated at the margins of the slice.

Moderately to strongly foliated medium to fine-grained diorite (2217) containing clear untwinned andesine crops out in the bed of Monte Christo Creek, at its confluence with the Don River. Outcrops of dark coarse hypersthene diorite (2214) occur at the junction of Dingo and Simon Creeks. The rock consists of andesine (55%), hypersthene (13%), microperthite (12%), clinopyroxene (8%), biotite (7%), and a little quartz, apatite, and opaque minerals.

One kilometre north of the junction of Humbug Creek and the Don River, large pieces of coarse gabbro (2208) are enclosed in white powdery calcium carbonate (earth lime) in the bank of a small rightbank tributary of the Don River. The gabbro consists of large fresh laths of sodic bytownite (60%) up to 1 cm long and aggregates of mafic minerals composed of cores of magnetite or ilmenite and pyrite, surrounded by amphibole and minor hypersthene, and a thin selvedge of granular green spinel against plagioclase. The amphibole is weakly pleochroic and has a low birefringence.

The strongly foliated medium-grained hornblende-biotite tonalite cropping out in the hills between Rocky and Alick Creeks is intruded by sheets of aplitic microgranite, which are probably offshoots of the Thunderbolt Granite. The rock consists mainly of sutured laths of oligoclase-andesine with an incipient granoblastic texture, and aggregates and stringers of biotite.

The country rock in the old Normanby goldfield consists mainly of massive and foliated diorite and quartz diorite, but the waste rock beside the old mine shafts shows that minor intrusions of granite, adamellite, microgranite, aplite, and pegmatite are common.

Hypersthene-hornblende-olivine melagabbro (2199) and porphyritic hornblende diorite crop out in Grant Creek 1.5 km north of Crompton Creek. The melagabbro consists of augite (50%). plagioclase ($An_{70}$, 20%), olivine (15%), hornblende (10%), hypersthene (5%), and accessory opaque minerals and talc. The ragged phenocrysts of augite range from 5 mm to 1 cm in diameter, and are partly altered to hornblende. Olivine forms phenocrysts from 2 to 7 mm long, and occurs as inclusions in augite. In places the olivine crystals are intergrown with hypersthene, and they are commonly outlined by fractures containing regularly oriented plates of dendritic ilmenite similar to those illustrated by Hatch et al. (1961, p. 394). The interstitial laths of plagioclase are about 1 mm long. The plagioclase crystals contain rare inclusions of green hornblende. The hornblende occurs as groups of isolated grains in optical continuity between the other minerals. The hypersthene is closely associated with olivine.

*Structure*

Most of the foliation was probably formed after the rocks had consolidated, but in some areas, as for example in the Don River 7 km southeast of Pretty Bend homestead (Fig. 11) it probably developed while the rocks were still partly mobile. Within a few kilometres of the contact with the Hecate Granite the foliation is generally steep or vertical, and trends parallel to the contact. Elsewhere it is generally less steeply dipping, and has no clear regional trend. It is possible that the diorite suite along much of the western contact of the Hecate Granite represents a contaminated marginal zone of the granite, and the foliation may have been formed during the intrusion of the granite.

The great majority of the dykes have a north-northwesterly trend (see map). Most of the dykes shown on the map were identified by photo-interpretation, but in some areas the dykes are not visible on the photographs. Near Humbug Creek and Boundary Creek, west-northwesterly and northeasterly dyke swarms have been observed or photo-interpreted. Collectively the dykes in the diorite suite represent a considerable extension of the crust in an east-west direction.

Most of the faults in the diorite suite have also been photo-interpreted. They are particularly common along and parallel to the contact with the Lizzie Creek Volcanics and granite (CPg) in the west. This zone was an important hinge-line that accommodated the differential uplift of the northern end of the Connors Arch in post-Lower Permian time (see Webb & McDougall, 1968, pp. 324-5).

The margins of the diorites have been involved in movements along major shear zones (see Hecate Granite and unnamed granite 'CPg').

*Age and Relationships*

The diorite suite is intruded by the Lower Permian Thunderbolt Granite and the Lower Cretaceous Hecate Granite, and apparently also by the unnamed late Palaeozoic granite (CPg) south of the Bowen and west as far as the Elliot River. Between Mount Abbot and the Clarke Range the relationship with the unnamed granite (CPg) is unknown.

The contact with the Lizzie Creek Volcanics is partly faulted, and elsewhere the two units are probably nonconformable. The contact with the Connors Volcanics is intrusive (Malone et al., 1966).

On the geological map the undivided Urannah Igneous Complex to the southeast is separated from the diorite suite and acid plutonic rocks to the north by an arbitrary sinuous line.

Most of the K/Ar isotopic analyses indicate a Lower Permian age for the diorites (265-280 m.y.), but the Rb/Sr analyses of some of the diorites, and of the Urannah Igneous Complex farther south, indicate an isochron of 288 + 31 m.y. (Webb & McDougall, 1968, pp. 320-4). The large uncertainty factor is due to low. $^{87}Sr$ enrichment of the total rock samples. Webb & McDougall conclude that the most realistic minimum age, based partly on data from the Sheet areas to the southeast, is 305 to 310 m.y.

One of the intrusive contacts in the headwaters of Devlin Creek suggests that at least some of the diorite may have been derived from the Lizzie Creek Volcanics by granitization and subsequent upfaulting.

### *Acid Volcanics (Cuv)*

Isolated areas of acid to intermediate lavas and pyroclastics crop out in parts of the Leichhardt Range. Coarse blue-black dacite welded tuff is predominant, but many other rock types are present. The volcanics are similar to the Upper Carboniferous Bulgonunna Volcanics to the north, to which they are probably related.

*Distribution and Topography*

The volcanics crop out in the Rangeview ring complex, about 10 km northeast of Rangeview homestead, and in a discontinuous zone along the east side of the Leichhardt Range. Small outcrops have also been mapped on the western boundary of the Sheet area 15 km north-northwest of Rangeview homestead, and near Kirknie Creek in the north.

The volcanics in the Rangeview ring complex form part of the Leichhardt Range plateau. Those along the east side of the range and north-northwest of Rangeview homestead form rugged hills and ranges 400 to 650 m above sea level. McGregors Bonnet is rugged, and rises to 570 m above sea level. Near Kirknie Creek the volcanics form small rounded hills, strewn with angular blocks.

*Lithology*

The volcanic rocks in the Rangeview ring complex consist of rhyolite, porphyritic alkali rhyolite, coarse dacite welded tuff, pyritic porphyritic felsite, hornblende dacite, and saussuritized porphyritic andesite. Some of the volcanics contain blocks of red biotite granite. Recrystallized dacite is predominant in the range west of Dalbeg. Rhyolite, porphyritic rhyodacite, porphyritic alkali rhyolite, dacite welded tuff, rhyolite breccia, andesite breccia, porphyritic andesite, agglomerate, and dacite porphyry have been recorded in the ranges between Expedition Pass Creek and the northern edge of the Sheet area. Similar rocks occur on the western edge of the Sheet area, northwest of Marlborough Pocket. Rhyolite and coarse andesite welded tuff predominate in the two small outcrops east of Millaroo Creek. The outcrops at Kirknie Creek, east of the Burdekin River, consist of deeply weathered pale pink, green, or white leucocratic rocks, with or without phenocrysts of quartz and feldspar.

*Structure*

The volcanics in the Rangeview ring complex are downfaulted. No bedding was seen in the field, but on the air-photographs the volcanics appear to be horizontal. The vertical flow banding seen in places may be due to faulting. Near Fence Creek the volcanics are faulted against the acid phase of the Ravenswood Granodiorite Complex. Along the eastern side of the Fence Creek/McGregors Bonnet belt the volcanics have been fractured by north-northwest-trending faults; there is a prominent set of joints parallel to the faults. On the air-photographs the volcanics northwest of Marlborough Pocket appear to dip steeply and form a northeast-trending syncline. At Kirknie Creek the flow banding is steep, and in places highly contorted.

*Age and Relationships*

At several localities the volcanics contain blocks of biotite granite similar to the late acid phase of the Ravenswood Granodiorite Complex, and at Oaky Creek and in the McGregors Bonnet/Fence Creek area they can be seen resting nonconformably upon the granite. Near Fence Creek the pyroclastics also include fragments of coarse sandstone similar to the sandstone (Pzu) in the Ayr Sheet area. The volcanics in the Rangeview ring complex appear to be intruded by the Upper Carboniferous adamellite (Cug.), but the relationship has not been proved; west of Dalbeg the volcanics have been recrystallized by the same granite. East of Millaroo Creek, welded tuff is intruded and extensively hornfelsed by granodiorite dykes. Some of the contact metamorphism may have been caused by small bodies of alkali microgranite associated with the volcanics.

Because of their close similarity to the Bulgonunna Volcanics the volcanics are considered to be Upper Carboniferous.

### *Bulgonunna Volcanics*

The Bulgonunna Volcanics north of the Burdekin River were mapped in 1964. They rest unconformably on the Mount Windsor Volcanics, unnamed Devono-Carboniferous volcanics (DCv), and the Scartwater Formation, and are downfaulted against the Star of Hope Formation; they are intruded by several granites (Cug, CPg) in the upper reaches of Bull Creek and near the Burdekin Weir.

The Bulgonunna Volcanics consist of acid pyroclastic flows. In the Mount Coolon Sheet area they have been described by Malone et al. (1964), and in the southern half of the Bowen Sheet area by Malone et al. (1966). The unnamed volcanics (Cuv) that crop out in separate areas farther north may be broadly equivalent.

The Bulgonunna Volcanics form a belt of sparsely vegetated hills and plateaux. Between Bull Creek and the Burdekin Weir the plateaux have an elevation of 300 to 350 m.

*Lithology*

East of Glenroy homestead, where the formation rests unconformably on the unnamed volcanics (DCv) and the Scartwater Formation, the basal sequence consists of well bedded green-grey tuffaceous siltstone and sandstone, volcanic breccia and agglomerate, crystal and vitric tuff, tuffaceous mudstone, and minor andesite overlain by a thick sequence of acid to intermediate volcanic breccia, flow-banded rhyolite, and minor tuffaceous sediments. The altered agglomerates and breccias contain fragments, ranging from 0.2 mm up to boulder size, of silicified acid volcanics, andesite, fine-grained feldspathic sandstone, aphyric and porphyritic felsite, and shale. The tuffs consist largely of devitrified shards.

At the Burdekin Falls reddish brown to blue-grey rhyodacite welded tuff is downfaulted against the Star of Hope Formation. The welded tuff contains a wealth of angular rock fragments including rhyolite, quartz porphyry, and occasional blocks of coarse biotite granite. The proportion of fragments decreases away from the contact. The welded tuff consists of fragments of andesine, hornblende, quartz, and iron oxide set in a felsitic matrix with an eutaxitic texture. Pink rhyolite and dark grey dacite welded crystal tuffs are exposed in Charlie Creek, 8 km northeast of Glendon homestead.

The waterworn outcrops in the Burdekin River at the weir consist of well jointed dacite and agglomerate intruded by dykes of dacite and microdiorite. The dacite contains up to 20 percent phenocrysts of plagioclase, a few crystals of potash feldspar, and rounded and embayed grains of quartz set in a granular microcrystalline groundmass containing abundant chlorite. The feldspar is saussuritized and epidotized in places. The microdiorite dykes consist of fine-grained subhedral plagioclase, interstitial quartz, chlorite, and accessory pyrite, and magnetite.

*Structure and Thickness*

The Bulgonunna Volcanics are gently folded, and are cut by numerous faults. Our observations support the statement by Malone et al. (1966, p. 21) that many of the dips are primary. North of the Burdekin River the formation consists of a complex suite of extrusives and high-level intrusives, which were probably emplaced by cauldron subsidence. The dip of the volcanics is moderate, and appears to be irregular.

The Bulgonunna Volcanics are particularly well jointed. The jointing near the Burdekin Falls has been described by Whitehouse (1949, unpubl.) in his report on the proposed dam site.

The thickness of the formation is unlikely to be over 1000 m, and may be considerably less.

*Age and Relationships*

Malone et al. (1966) consider the Bulgonunna Volcanics to be Upper Carboniferous because they rest unconformably on Lower Carboniferous formations and are overlain unconformably by the Lower Permian Lizzie Creek Volcanics and Collinsville Coal Measures. The Rb/Sr isochron of 287 ± 12 m.y. obtained on the Bulgonunna Volcanics (Webb & McDougall, 1968) has confirmed the stratigraphic evidence.

The Bulgonunna Volcanics are intruded by adamellite (Cug) along Bull Creek and near the Burdekin Weir. The adamellite is part of a large batholith which extends for 100 km from Expedition Pass Creek to southeast of Heidelberg homestead. It has yielded an Rb/Sr whole rock isochron of 298 ± 25 m.y. Webb & McDougall (1968, pp. 319-20) state that if the granites and volcanics are comagmatic the combined isotopic analyses yield an isochron of 289 ± 9 m.y.

Whitehouse (1949, unpubl.) has reported the presence of numerous rhyolite porphyry dykes in the volcanics in the Burdekin Gorge, and south of the Burdekin Weir the volcanics are intruded by dark microdiorite dykes.

We agree with Malone et al. (1966) that the Bulgonunna Volcanics are terrestrial deposits erupted from many separate volcanic centres. The sediments near the base of the sequence east of Glenroy homestead are probably lacustrine.

### *Intrusive Rhyolite and Porphyry (Cur)*

The intrusions of rhyolite and porphyry near the western edge of the Sheet area are probably high-level intrusive equivalents of the Bulgonunna Volcanics.

Along the northern margin of the Drummond Basin several irregular intrusions of cream flow-banded rhyolite and numerous thick porphyritic felsite dykes intrude the unnamed volcanics (DCv) and the Scartwater Formation and Mount Windsor Volcanics north and west of Glenroy homestead. Some of the smaller intrusions shown on the map are thick gently dipping discordant sheets which cap small hills. The rhyolite grades into quartz porphyry in places.

In the southeast the rhyolite west of Glenroy homestead is faulted against the Scartwater Formation and unnamed volcanics (DCv), but elsewhere the contact is intrusive. Whitehouse (1949, unpubl.) has recorded quartz porphyry and rhyolite porphyry dykes in the Bulgonunna Volcanics in the Burdekin Gorge. Faulting has occurred repeatedly along the northern margin of the Drummond Basin, and the rhyolites appear to have been intruded into this zone of weakness.

The intrusive complex 3.5 km north of the junction of the Suttor and Burdekin Rivers consists of pale green quartz-feldspar porphyry, epidotized feldspar porphyry, and grey quartz porphyry. The complex, which covers an area of 8 km$^2$, crops out as low sparsely vegetated hills which have a light grey tone on the air-photographs. The porphyries are faulted against the Ravenswood Granodiorite Complex in the north and are inferred to intrude the unnamed volcanics (DCv) in the south. The swarm of large cream-brown felsite dykes in the volcanics near the southern contact of the porphyries is probably related to the porphyries.

Some of the small intrusions of red quartz-feldspar porphyry near the southwestern edge of the Sheet area have been traced by F. Olgers (pers. comm.) into long arcuate dykes which probably represent some of the feeder dykes to the Bulgonunna Volcanics.

### *Adamellite, etc. (Cug)*

The granitic rocks in the Burdekin River valley and the high rugged plateau in the Leichhardt Range to the west of the Burdekin Weir are regarded as a northerly extension of the Upper Carboniferous batholith mapped by Malone et al. (1966) to the south and west of the Bowen River. Granites of three different ages have been recognized in this area: namely Middle Ordovician (Ravenswood Granodiorite Complex), Upper Carboniferous, and Lower Permian. The granite that is nonconformably overlain by the Upper Carboniferous volcanics (Cuv) is probably early Palaeozoic, but is similar to the granite intruding the volcanics southwest of Eight Mile Creek. The latter is probably only slightly younger than the volcanics, because it is intruded by ring dykes (Plr) that are probably of the same age as the Lower Permian stock (Plg) south of Expedition Pass Creek. The position of the northern boundary of the Upper Carboniferous granite is uncertain because it is difficult to distinguish from the acid phase of the Ravenswood Granodiorite Complex.

#### *Topography*

The faults extending southeast from the headwaters of Eight Mile Creek to the Burdekin Weir separate the rugged Leichhardt Range to the west, which has an elevation of 350 to 450 m, from the gently undulating country in the Burdekin River valley. South of Pine Creek most of the soil has been stripped from the granite, and the pattern of ravines along the joints stands out boldly on the air-photographs.

#### *Lithology*

In the *Leichhardt Range* 11 km northeast of Mount Glenroy the pink to grey medium to coarse biotite adamellite generally contains large corroded crystals of quartz. In places, where the texture is graphic to pegmatitic and drusy, the rock contains a little muscovite. Six kilometres northeast of Mount Glenroy the marginal zone consists of pink porphyritic granophyric muscovite-biotite granite and muscovite-biotite granophyre. Numerous druses containing quartz, feldspar, and muscovite occur throughout the granite. Near the contact the granite and granophyre are cut by stringers of dark green hornblende-muscovite-quartz porphyry, and by closely spaced dykes of aplite, microgranite with phenocrysts of quartz, and feldspar-quartz porphyry. The dykes have indistinct contacts with the granite and granophyre, and may represent late phases of the main intrusion. The granophyre contains corroded bipyramidal quartz phenocrysts up to 4 mm in diameter. Away from the contact coarse pink biotite adamellite and granite with a graphic texture predominate. The shearing, brecciation, and quartz veining along the margin of the granite strongly suggest that the contact is faulted.

Grey medium-grained biotite adamellite, containing a little hornblende and accessory red-brown sphene, predominates in the headwaters of Bull Creek, where the batholith forms an embayment in the Bulgonunna Volcanics. Near the southern contact dykes(?) of fine-grained biotite adamellite crop out as low ridges within the main mass. In the south the adamellite is strongly sheared and faulted where it intrudes welded dacite tuff. The chilled margin along the western contact consists of fine-grained biotite-hornblende dellenite porphyry containing numerous euhedral phenocrysts of bipyramidal quartz. Half a kilometre from the contact the phenocrysts range from about 0.05 to 8 mm in diameter. The rock consists of phenocrysts of slightly sericitized and strongly zoned plagioclase, partly kaolinized potash feldspar, bipyramidal quartz, and rare crystals of biotite and actinolitic hornblende enclosed in a fine-grained groundmass of the same composition. At the contact the porphyry contains xenoliths of unaltered intermediate volcanics, but away from the contact the inclusions have been altered to microdiorite. The colour index of the dellenite porphyry increases away from the contact, probably because most of the xenoliths have been completely digested. The colour of the actinolitic hornblende ranges from pale green at the contact to brownish green 1 km from the contact.

*Burdekin River valley.* The low hills north of Bluewater Creek consist of hornblende-biotite granodiorite, and the low conical hill 1 km south of Expedition Pass Creek is composed of grey biotite adamellite. Grey leucocratic biotite microadamellite, intruded by dykes of quartz-hornblende diorite, forms the country rock on the northeast side of the Lower Permian stock in the Leichhardt Range south of Expedition Pass Creek. There is a small outcrop of massive fresh hornblende adamellite beside the Expedition Pass Creek track where it crosses Eight Mile Creek, but between the track and Eight Mile Creek the bedrock is obscured by sand. East of the Burdekin River the rocks are weathered and ironstained, but most of the exposures consist of coarse leucocratic adamellite, intruded in places by dykes, ranging from basalt to rhyolite, which are probably related to the Lizzie Creek Volcanics and Mount Wickham Rhyolite. The low-lying country southwest and south of Dalbeg includes granite, adamellite, granodiorite, and microgranodiorite.

### *Structure, Relationships, and Age*

The Upper Carboniferous adamellite is a post-tectonic epizonal batholith. It intrudes the Upper Carboniferous volcanics and older rocks, and is nonconformably overlain by the Lower Permian Lizzie Creek Volcanics. The basal conglomerate of the Lizzie Creek Volcanics contains pebbles of granite. The contacts with the Upper Carboniferous volcanics and Lizzie Creek Volcanics are faulted in places. In the Millaroo Fault Zone the granite and volcanics are strongly brecciated. Brecciation and minor quartz veining suggest the presence of a northeast-trending fault east of Dalbeg. The granite has been granulated and partly recrystallized along the northwest to north fault 3.5 km west of the confluence of the Burdekin and Bowen Rivers. West of the Burdekin Weir the contact of the granite with the Bulgonunna Volcanics is essentially vertical. West of Bull Creek the Bulgonunna Volcanics are strongly hornfelsed for over 0.5 km from the contact. The extensive contact metamorphism and the presence of bipyramidal quartz in the chilled margin suggest that the granite was intruded at a high temperature.

The granite is probably related to the Bulgonunna Volcanics. The 17 K/Ar mineral ages range from 276 to 293 m.y., and the 9 Rb/Sr whole rock analyses define an isochron of 298 $\pm$ 25 m.y. (Webb & McDougall, 1968). No isotopic analyses are available for the area to the north of the junction of the Burdekin and Bowen Rivers.

## UPPER CARBONIFEROUS OR LOWER PERMIAN

(Table 2)

### *Diorite, etc. (CPi)*

A poorly exposed body of medium-grained pyroxene diorite, with subordinate gabbro and pyroxene monzonite, intrudes the Scartwater Formation south of the Suttor River, near its junction with the Burdekin River. Blocks of olivine dolerite occur in the black soil. The diorite extends into the Charters Towers Sheet area. A second occurrence has been photo-interpreted to the north of the Suttor River. These rocks are similar to the intermediate to basic intrusives in the Drummond Basin sequence in the Charters Towers Sheet area. The olivine dolerite is similar to the Tertiary olivine basalt flow 10 km to the east.

The biotite-hornblende meladiorite intruding the Mount Windsor Volcanics 5 km east-northeast of Mount Glenroy is bounded by an arcuate fault on its northwest side. The meladiorite consists of dark green fibrous hornblende (60%), andesine-labradorite, abundant biotite, and interstitial quartz (5%). It is intruded by dykes of porphyritic microgranodiorite.

The intrusions are regarded as Upper Carboniferous or Lower Permian.

### *Adamellite, etc. (CPg)*

The large intrusions and occasional small stocks of adamellite, granodiorite, and granite between Bowen and the Burdekin River are probably Upper Carboniferous or Lower Permian.

#### *Western Part of Sheet Area*

The grey medium to coarse leucocratic granodiorite, forming a cuspate depression about 7 km long in the upper reaches of Glenroy Creek, is bounded by faults. The rock is porphyritic in places, and consists of oligoclase-andesine (50%), quartz (30%), potash feldspar (15%), and biotite and hornblende (2½% each). The prisms of dark green hornblende are up to 3 cm long.

The northeasterly trending dykes of saussuritized and albitized basalt, andesite, and feldspar porphyry intruding the granodiorite at the northern end of the depression may be associated with the Rangeview ring complex. Near Glenroy Creek the granodiorite is cut by northeasterly trending dykes of aplite and biotite granite. Along the central part of the southern faulted contact the granodiorite is intruded by a swarm of southeasterly felsite dykes that are probably associated with the fault forming the southern boundary of the intrusion.

An oval stock of well jointed coarse leucocratic biotite adamellite, with a body of leucocratic microadamellite along its southern margin, intrudes the Mount Windsor Volcanics near the confluence of Glenroy and Six Mile Creeks. The adamellite forms hills only slightly higher than the Mount Windsor Volcanics, but can be readily distinguished on the air-photographs by its more widely spaced drainage pattern and thinner cover of trees. The microadamellite contains occasional phenocrysts of quartz and feldspar up to 3 mm across, and consists of oligoclase (30%), quartz (40%), sericitized potash feldspar (30%), and a little chloritized biotite and muscovite. The microadamellite is cut by veins of quartz and occasional narrow zones of greisen. The Mount Windsor Volcanics along the southern contact have been altered to andalusite-alkali feldspar-biotite-quartz hornfels. The medium-grained quartz diorite intruding the Mount Windsor Volcanics in Glenroy Creek is faulted against the adamellite. It contains phenocrysts of quartz and plagioclase, and is intruded by both acid and intermediate dykes.

An irregular intrusion of red biotite adamellite, with some red porphyritic biotite-hornblende microadamellite and altered porphyritic hornblende microgranodiorite(?), crops out between Stones and Boundary Creeks. The adamellite intrudes the Ravenswood Granodiorite Complex, the Mount Windsor Volcanics, and the unnamed volcanics (DCv), and is cut by microdiorite dykes.

Mount Graham, a small hill 100 m high, consists of a central plug of white microtrondhjemite surrounded by a ridge of hornfelsed Star of Hope Formation. The microtrondhjemite, which contains occasional phenocrysts of feldspar and quartz, is variable in texture, and in places consists of closely packed blocks of biotite-hornblende microtrondhjemite, up to 25 cm long, enclosed in biotite microtrondhjemite.

An irregular body of pinkish brown granophyre intrudes the Star of Hope Formation north of the Burdekin Falls. The rock is composed of plagioclase crystals surrounded by granophyric intergrowths of quartz and alkali feldspar, chloritized biotite (3%), hematite, and epidote, and a little zircon and apatite.

The granodiorite on the edge of the Sheet area southwest of the Sellheim River is part of a hornblende-biotite granodiorite that cuts the St Anns Formation in the Charters Towers area.

*North-central Part of Sheet Area*

The deeply weathered granitic rocks in the north-central part of the area, which range from granite to quartz diorite, occupy an area of 500 km$^2$. In the west and south they are unconformably overlain by the Lizzie Creek Volcanics, in the north they are obscured by sand and soil, and to the east they are intruded by the Mount Abbot Igneous Complex and overlain nonconformably by the Kurungle Volcanics. The relationship between these granitic rocks and the dioritic rocks (Cud) to the east is unknown, and in the south the contact appears to be faulted.

The granites form low-lying gently undulating country, with a few low ranges. Specimens F55/3/67 and F55/3/95 (see Appendix) have yielded Lower Permian K/Ar ages similar to those obtained on the Lizzie Creek Volcanics. This probably indicates reheating of the Upper Carboniferous granite by the Lizzie Creek Volcanics (as in the case of the Urannah Igneous Complex and the diorite suite 'Cud', Webb & McDougall, 1968), but it is just possible that some of the stocks are Lower Permian.

Between Edinburgh Castle and the western slopes of Mount Abbot biotite adamellite predominates, except in the Glen Blazes Creek area, where biotite-hornblende granodiorite grading into biotite adamellite is cut by the cone sheets of the Mount Abbot Igneous Complex. East of the cone sheets the granite is foliated in a northeasterly direction. Biotite-hornblende granodiorite crops out both north and south of Mount Abbot. Farther east, near Finley Creek, the biotite adamellite in places contains rosettes of tourmaline up to 8 cm across.

Between the Bogie River and the Clarke Range, weathered granite, granodiorite, adamellite, and quartz diorite crop out in the larger streams. Abundant criss-crossing veinlets of calcite, in places accompanied by quartz, are common in most of the outcrops. The numerous dykes of microdiorite, microgranite, basalt, and aplite are also deeply weathered. The only faults which can be seen on the air-photographs are at Sandy Creek in the southeast, but the intense fracturing and veining of the rocks suggest that numerous faults may be present. The zone of deep weathering coincides roughly with the Lower Permian land surface upon which the Lizzie Creek Volcanics were laid down.

*Elliot River/Bowen Area*

The granite in the east is less deeply weathered than in the north-centre. The boundary between the Palaeozoic granite and the Lower Cretaceous Hecate Granite is only approximate because the rocks are so similar, and the boundary at Mount Buckley siding is arbitrary.

The graphic biotite adamellite underlying the Mount Aberdeen Volcanics around Mount Aberdeen is assumed to be Palaeozoic, but its extent is not well known. Mount Mackenzie, Mount Greentop, and the nearby hills consist of coarse biotite adamellite and granite. Farther west towards the Elliot River, granodiorite is cut by many thick dykes of felsite and thinner dykes of microdiorite. The western slopes of Mount Mackenzie consist of medium-grained biotite granite which in places is strongly foliated and recrystallized. The southern slopes of Mount Roundback (7 km northwest of Mount Pring) consist of grey medium-grained biotite adamellite cut by a few thin dykes of aplite. Adamellite dykes intrude the nearby diorite (Cud) on the southern slopes of the mountain. Weakly foliated medium-grained biotite granodiorite is exposed in the valley of Greentop Creek, west of Summer Hill.

The town of Bowen is underlain by two types of granite, the older of which is regarded as late Palaeozoic. The order of emplacement of the various igneous rocks at Bowen is as follows: (1) volcanics (mapped as Carmila Beds); (2) adamellite (CPg); (3) northwesterly dark dykes; (4) meridional dark dykes; (5) leucogranite (PKg); and (6) meridional microgranite dykes. The altered adamellite contains phenocrysts of saussuritized zoned oligoclase, rimmed by microcline antiperthite, which is semigraphically intergrown with quartz in places; the mafic minerals are chlorite, epidote, opaque minerals, and apatite. Similar altered adamellite and granodiorite, contaminated in places by xenoliths, occur between Mount Gordon and Mount Williams. South of Intaburra siding the adamellite is less altered. The biotite in the hornblende-biotite adamellite from a hill 3.5 km southwest of the siding has been dated as Upper Carboniferous (297-298 m.y.) by the K/Ar method. At Mount Mary the adamellite is porphyritic and contains xenoliths of andesitic volcanics. The pink leucocratic microgranite on the east slopes of a southerly trending ridge resembles the groundmass of the porphyritic adamellite. Southwest of the Port of Bowen it has not been possible to demonstrate that the granite is nonconformably overlain by the Lower Permian Carmila Beds, but the sequence mapped as Carmila Beds may include Carboniferous or older rocks.

In the northeast the contacts between the granitic rocks (CPg) and the diorite and gabbro (Cud) appear to dip gently. In many localities the biotite adamellite has been converted into biotite-hornblende adamellite or granodiorite by assimilation of basic material. The contaminated acid rocks are strongly foliated, and contain flow-aligned blocks of diorite and gabbro in various stages of assimilation. In the Mount Greentop/Mount Mackenzie area there are several southeasterly faults along which the granite has been mylonitized and recrystallized. Quartz veins containing magnetite and pyrite occur in the faults, and irregular quartz veins cut the sheared muscovite-biotite adamellite on the northern and southern slopes of Mount Mackenzie.

*Southeastern Part of Sheet Area*

Massive pink and white adamellite or granodiorite, similar to the Lower Cretaceous Hecate Granite, crops out in a cirque-like valley in rugged country at the head of the Don River, northeast of the Normanby goldfield. Biotite from this granite (spec. F55/3/106 and F55/3/136) has been dated at 186/187 m.y. and 132 m.y.; the results are interpreted to mean that the granite is late Palaeozoic, and that there was a loss of argon as a result of the intrusion of the Hecate Granite. To the southeast, the high valley at the head of Grant Creek, west of Raspberry Creek, is underlain by massive pink biotite adamellite, which contains a few phenocrysts of potash feldspar and xenoliths and schlieren of diorite aligned in a southeasterly direction.

*Shear Zones Near Bowen*

Several large shear zones have been mapped between Edgecumbe Bay and the Elliot River. In places the shearing appears to have begun in the diorite country rocks (Cud) before the granite was intruded (perhaps in response to the rising granite magma), and was continued in the granite both during and after cooling. Swarms of microgranite and aplite dykes, which are probably late differentiates of the granite, are common within and parallel to the shear zones. Only a few of the dykes are shown on the map. Many of the dykes have been foliated and recrystallized in the plane of shear, but in others the planar structures appear to be due to flow. Shearing appears to have continued while the granite cooled, and the later differentiates were emplaced into shears in the newly cooled granite. Similar dyke-filled shear zones occur in the Hecate Granite, and they may all be of Lower Cretaceous age, although they occur in granites mapped as late Palaeozoic and Lower Cretaceous.

In the Glenore Shear, strongly sheared and recrystallized diorite (Cud) is intruded by weakly foliated biotite adamellite. The diorite is cut by dykes of greisenized aplite trending parallel to the contact. The greisenized aplites consist mainly of quartz and white mica, but contain some pyrite and a little rutile, zircon, and topaz(?). The spurs at the north end of the Bodes Range consist of a swarm of sheared and greisenized aplite dykes. Granite crops out on both sides of the shear, but sheared and brecciated diorite occurs between some of the dykes. The dykes are generally much better exposed than the country rock. Mount Williams, a pinnacle 12 km south-southwest of Bowen, consists of sheared greisen composed of quartz, iron oxides, and a little feldspar and white mica. Weathered biotite adamellite is exposed near the foot of the pinnacle. Pits and costeans have been dug in an altered greisen beside the Bruce Highway, 1.5 km to the east-northeast. Most of the pyrite in the rock has been oxidized. The small pinnacle of Mount Williams is composed of angular quartz grains, interstitial muscovite, and altered pyrite. A ridge of sheared and brecciated greisenized aplite occurs west of the North Coast Railway, 1.5 km west-northwest of Mount Williams. Fine-grained gneissic biotite adamellite, containing quartz phenocrysts and a little muscovite, is exposed in a small creek to the south of the ridge.

## LOWER PERMIAN

(Table 2)

### *Lizzie Creek Volcanics*

(Malone et al., 1969)

The Lizzie Creek Volcanics in the centre of the Bowen Sheet area consist of a sequence of intermediate to basic volcanics, with subordinate sediments and acid volcanics, which nonconformably overlies the late Palaeozoic granite (CPg). They were formerly called the Lower Bowen Volcanics (Malone et al., 1964, 1966). North and west of Collinsville there is a relatively thin sequence of volcanics resting on granite, but to the southeast (Malone et al., 1966) the sequence underlying the Bowen Basin succession is several thousand metres thick. The strip of basalt to the west of the Mount Wickham Rhyolite at Glenmore Creek was mapped by Malone et al. (1966) as Tertiary, but in this Report it is included in the Lizzie Creek Volcanics.

*Topography*

The topography on the andesitic volcanics is gently undulating, with some steep hills where they are buttressed by the Mount Wickham Rhyolite. The basalt is generally covered with black soil, and outcrops are usually confined to creeks. The sediments interbedded with the basalt in the lower half of the formation stand out as strike ridges, and also crop out on the lower slopes of hills capped by volcanics.

*Lithology*

The basalts and sediments forming the basal part of the sequence are overlain by andesite and minor acid volcanics.

The basalt and sediments crop out between Strathbogie homestead and the Millaroo Fault Zone, and in the low-lying country between the Clarke Range and the Bowen River. The basalt is generally weathered to a purple crumbly material. Some of the basalts contain olivine, and some contain glass in the groundmass. The highly vesicular or amygdaloidal basalts are generally deeply weathered. The amygdales are composed mainly of zeolites, and range from about 5 mm to 25 cm in diameter; chalcedony and agate are abundant in the weathered basalt northwest of Collinsville, but most of the agate is fractured. The sequence includes beds of deeply weathered basaltic tuff and agglomerate up to 10 m thick. The basalt dykes in the lower part of the sequence do not extend up into the overlying andesites.

The interbedded sediments comprise boulder, cobble, and pebble conglomerates, lithic, tuffaceous, and feldspathic arenites, siltstone, calcareous siltstone, and shale. There are large exposures of conglomerate in the Bogie River at Tondarra homestead, in the Bowen River about 7 km southeast of Mount Wickham (where conglomerate overlies deeply weathered basalt), and in a small tributary of Pelican Creek about 5 km north of Collinsville. Some of the beds of boulder conglomerate are up to 30 m thick. Boulders and cobbles form up to 90 percent of the conglomerate in the Bowen River; two-thirds of them consist of acid volcanics, and the rest of weathered granite and occasional fragments of sedimentary rock. The conglomerate at Tondarra homestead contains more granite boulders, and occasional fragments of gabbro and labile arenite. Thin beds of quartz-pebble conglomerate, some only one layer of pebbles thick, occur throughout the sequence. The labile arenites are green to brown and consist mainly of flaggy tuffaceous and lithic arenites and a little subarkose. The rocks are generally poorly sorted and commonly contain cobbles of volcanic material. The arenites are interbedded with grey-green thinly bedded siltstone, calcareous siltstone, and shale. Fragments of poorly preserved plants occur in some of the finer arenites, siltstones, and shales.

The structureless pile of andesites and associated minor acid flows and pyroclastics probably overlies the basalts and sediments. The intermediate and acid volcanics cover large areas north of the Strathbogie-Strathalbyn road and in the Clarke Range.

*Structure and Thickness*

The dips in the lower part of the sequence are low to moderate and, except near the Millaroo Fault Zone, no well developed trends are apparent. Sudden reversals of dip and occasional steep dips occur in places, especially near the Millaroo Fault Zone, where the strike of the volcanics is consistently parallel to the fault zone. This part of the sequence is estimated to be 70 to 100 m thick, and the andesites may be at least 200 m thick. In the northern half of the Sheet area there has been no folding of the formation on a regional scale.

*Depositional Environment and History*

The sediments were probably laid down near the shores of shallow lakes, and the material was probably derived from uplands of Bulgonunna Volcanics and granite to the southwest and from islands and uplands of granite to the north and northeast. Sedimentation was interspersed with intermittent periods of eruption of basalt and pyroclastics. Most of the pyroclastics were reworked and mixed with terrigenous material to form labile tuffaceous sediments. The basaltic volcanism was followed by andesite volcanism, apparently without a significant time break.

*Relationships*

The Lizzie Creek Volcanics rest nonconformably on granitic basement (Cug, CPg). In the Millaroo Fault Zone they have been downfaulted against granite (Cug) and the Bulgonunna Volcanics. They are both intruded by and nonconformably overlain by the Mount Wickham Rhyolite.

In the southern half of the Sheet area the Lizzie Creek Volcanics are overlapped by the Collinsville Coal Measures, and appear to rest unconformably on and are downfaulted against the Upper Carboniferous diorite and gabbro (Cud).

*Age*

The presence of *Noeggerathiopsis hislopi* Bunb. (M.E. White, pers. comm.) in the poorly preserved plants from near Mount Pollux indicates a Lower Permian or Upper Carboniferous age.

Lower Permian marine fossils have been collected from the top of the Lizzie Creek Volcanics in the Mount Coolon Sheet area (Malone et al., 1964).

The K/Ar analyses on plagioclase from the basalts in the north indicate an approximate age of 270 m.y. (Webb & McDougall, 1968, p. 328).

## *Carmila Beds*

The Carmila Beds (Jensen et al., 1966; Clarke et al., 1971) are a sequence of continental volcanics and volcanolithic sediments cropping out along the east side of the Connors Arch (Fig. 20). They occupy a north-northwesterly belt in the northeastern part of the Sheet area.

The Carmila Beds were defined by Jensen et al. (1966). The balance of evidence indicates a Lower Permian age, but an uppermost Carboniferous age cannot be ruled out, and it is conceivable that some of the volcanics near the base may be even older.

*Topography*

In the west, where the Carmila Beds have been hornfelsed by the Hecate Granite, they form a prominent meridional range of hills, which is partly covered by rain forest. Peaks include Mount Challenger (516 m), Mount McGuire (738 m), Mount Pluto (560 m), and Mount Quandong (792 m). In the west the range of hornfels ends abruptly against the Hecate Granite, which underlies the low country of the Proserpine River valley. In the east the range falls away gradually in a series of long northeasterly spurs and northwesterly strike ridges. North of Longford Creek, where the outcrop is relatively narrow, the hills are smaller. Near Bowen the Carmila Beds form Stone, Thomas, and Poole Islands, all of which are low-lying, and Flagstaff Hill (58 m). There are also small isolated outcrops on North Head, in a quarry between the town and Flagstaff Hill, on a low spur on the northeast edge of the main town area, and on the esplanade near the wharf.

*Lithology*

The Carmila Beds consist of massive acid and intermediate lavas and pyroclastics passing up into bedded pyroclastics and volcanolithic sediments. Neither the base nor the top of the sequence has been observed. The base is everywhere intruded by granite, and the top is downfaulted against the Edgecumbe Beds and covered by Cainozoic sediments.

*South of the Andromache River,* where the Urannah Igneous Complex is apparently intrusive into the Carmila Beds, the lowest beds preserved are epidotized agglomerate, dacite crystal tuff, and volcanic breccia. The breccia is bedded in places. The volcanic breccia cropping out above the left bank of the Andromache River 1 km southwest of the old Prospect gold battery contains pieces of pink medium-grained granite. Massive rhyolite or rhyodacite forms a small hill west of the Andromache River, 3.5 km south of Amelia Vale homestead. The presence of numerous small flakes of biotite in the groundmass suggests that the rock has been hornfelsed. The hills and rises southeast of the old battery and in the watershed between Scrub and Spring Creeks consist of massive green andesite agglomerate and purple crystal-lithic tuff with subordinate porphyritic andesite. The strike ridges south of Scrub Creek are composed of moderately well bedded pyroclastics and volcanolithic sediments. The steep west-facing escarpment south of Hill Rise homestead consists of altered quartz latite or andesite, rhyodacite crystal-lithic-vitric tuff, well bedded alternating medium and coarse volcanolithic greywacke, and volcanic pebble to cobble conglomerate. The clasts in the greywacke are densely packed, unsorted, and moderately rounded; there are a few detrital biotite crystals and some laminated carbonaceous fragments. Well bedded volcanolithic sediments with slumped lenses of volcanic pebble conglomerate form small bars in the south bank of the Andromache River 1.5 km east of Hill Rise homestead.

The sequence *between the Andromache River and Eden Lassie Creek* consists of massive dacite and andesite crystal tuff and agglomerate and subordinate flows, which pass up into bedded tuffaceous and labile sediments, containing interbeds of more mature sediments in the upper part of the section. White kaolinitic quartz sandstone crops out on the low slopes immediately west of the road between Victoria and Albert Creeks, and at the southern end of a low strike ridge 3.5 km west of the settlement of Kelsey Creek. Several hundred metres northwest of a fork in the road north of Goorganga Creek the sequence consists of coarse pebbly volcanolithic sediments overlain by impure kaolinitic quartz sandstone with interbeds of white siltstone and carbonaceous siltstone. The white siltstone contains numerous impressions of stems, leaves, and seeds of *Cordaites australis* and *Cordaicarpus* (White, 1966, unpubl.). Massive green lithic tuff, agglomerate, and labile sediments also crop out farther up the section, 1 km northwest of Kelsey Creek settlement. The volcanics near the contact with the Hecate Granite have been partly recrystallized, and actinolite has been developed in some areas. The presence of abundant chlorite and epidote in most of the rocks is probably due to contact metamorphism by the Hecate Granite. The quartz veinlets, some of which contain pyrite, and the disseminated pyrite in the volcanics may also have been introduced during the intrusion of the Hecate Granite.

The northern and western slopes of *Mount Challenger* are composed of lithic-crystal tuff, lithic tuff, andesite, rhyolite, welded dacite crystal tuff, and tuffaceous sediments. The beds have been thermally metamorphosed to spotted micaceous hornfels (2096), and microfaulting is common in the finer-grained sediments. Andesite, lithic crystal tuff, welded tuff, volcanic breccia, rhyolite, and finely bedded crystal tuff rich in potash feldspar (2092) occur in the headwaters of Duck Creek, 3.5 km north of the Birthday Gift mine. The crystal tuff has been partly recrystallized. The basal part of the fine-grained acid lavas, andesite, and coarse rhyolite tuff forming the steep hill at the head of Jochheim Creek is intruded by adamellite (CPg). The tors of diopside-hypersthene-labradorite hornfels immediately west of the Bruce Highway, between Jochheim and Eden Lassie Creeks, probably represent an altered porphyritic basalt.

The Carmila Beds form most of the undulating to hilly country *between the Bruce Highway and Edgecumbe Bay*. Between Yeates Creek and Mount Mary a sequence of amygdaloidal andesite, dacite tuff and breccia, and lithic tuff has been hornfelsed by hornblende adamellite (CPg). Andesite, lithic tuff, and very fine tuff or tuffaceous siltstone are exposed along Kangaroo Creek just east of the Bruce Highway. The Carmila Beds are particularly well exposed along the coast at Brisk Bay. Green lithic tuff, andesite, and tuffaceous sediments predominate northeast of Mount Maria, but to the south of the mouth of Duck Creek the sequence consists of greyish white acid lithic tuff, volcanic breccia, rhyolite, and andesite. The green tuff and tuffaceous sediments are well bedded, but the more acid tuff and breccia are massive and probably welded. Many of the tuffs have been reworked; they contain well rounded lithic pebbles and are interbedded with thin beds of tuffaceous pebble conglomerate. The acid tuffs are usually pyritic and are interbedded with pyritic rhyolite. The southeasterly fault between Mount Maria and the coast is marked by intense epidotization and minor silicification. Numerous blue-grey microdiorite dykes intrude the volcanics. The blue-black porphyritic rhyolite and rhyodacite (2059) cropping out along the shore on the northeast side of Mount Bramston are intruded by swarms of microdiorite dykes. Both the volcanics and the dykes have been severely brecciated and locally epidotized. Similar rhyolite and rhyodacite crop out on the western and southern slopes of Mount Bramston. The coarse lithic tuff (2060), porphyritic rhyodacite, crystal tuff, and andesite at Adelaide Point are intruded by sills, from 1 to 3 m thick, of flow-banded rhyolite and microgranite. The cream rhyolite consists of a few phenocrysts of quartz set in a fine-grained granular groundmass of alkali feldspar and quartz. At Mount Bramston both the lavas and the pyroclastics are pyritic. The nearby adamellite is intrusive into the volcanics.

The Carmila Beds also crop out *in and around Bowen*. Much of Stone Island consists of low outcrops of massive and well bedded pyroclastics and subordinate lavas. The altered pyroclastics at the northern point of the island include massive acid to intermediate devitrified vitric and lithic tuffs containing fragments of felsite, andesite, basalt and rare sandstone. A few flows of felsitic alkali rhyolite are interbedded with the tuffs. Both the tuff and rhyolite contain scattered patches of jasper. The eastern point of the island consists of massive volcanic breccia with interbeds of coarse lapilli tuff. Part of the small islet off North Head consists of volcanics, and Flagstaff Hill is composed of dark aphanitic recrystallized lavas intruded by swarms of dykes. The porphyritic dacite, grading into quartz andesite, on a rocky spur at the northeast edge of the central town area has been intruded and recrystallized by adamellite (CPg) and several swarms of dykes. The quarry at Magazine Creek, midway between the town and Flagstaff Hill, is sited in an isolated residual of porphyritic quartz andesite and dykes.

*Structure and Thickness*

The structure of the massive pyroclastics and lavas at the base of the sequence is uncertain, but the well bedded sediments and tuffs in the upper half of the sequence dip east-northeast at about 30°. The structure of the upper part of the sequence does not show up clearly on the air-photographs, except to the south of the Proserpine River, where strike ridges have been developed. The whole sequence is probably a simple east-facing homocline with an average dip of about 30°. No sections have been measured, but if an average dip of 30° is assumed over a width of 15 km, from Amelia Vale homestead to west of Proserpine airport (Proserpine Sheet area), the preserved thickness is about 7500 m.

*Relationship and Age*

Lower Permian marine fossils (Malone et al., 1969) have been recorded near the top of the Carmila Beds at several places in the St Lawrence Sheet area. In the Bowen Sheet area, plant fossils have been found between Goorganga and Victoria Creeks, about 3600 m above the base of the sequence. The plants include *Cordaites australis* and *Cordaicarpus*, which are assigned to the Upper Carboniferous or Lower Permian (White, 1966, unpubl.). The plants in the Proserpine Sheet area include *Noeggerathiopsis hislopi* and *Glossopteris*, which have also been assigned by White to the Upper Carboniferous or Lower Permian (Clarke et al., 1971).

The Carmila Beds are intruded by the Lower Cretaceous Hecate Granite, but their relationship to the granites to the north and south is uncertain. Specimens of the granites from widely separated localities (spec. F55/3/94, 3.5 km southwest of Intaburra siding, and spec. F55/3/135 in the Urannah Igneous Complex at the eastern edge of the Sheet area) have yielded Upper Carboniferous isotopic ages ranging from 282 to 298 m.y. Some of the granites may be older than the Carmila Beds, but some of the volcanics at the base of the beds may be older than the Upper Carboniferous granites.

The consistent dip of the Carmila Beds away from the granite suggests that the granite was emplaced mainly by doming of the cover rocks rather than by stoping and assimilation, and that the present base of the Carmila Beds corresponds roughly with the original depositional base. The Rb/Sr whole rock analyses by Webb & McDougall (1968) have shown that much of the granite in the Connors Arch has an isotopic age of about 310 m.y. (mid-Upper Carboniferous), which is older than the Carmila Beds.

A Lower Permian minimum isotopic age has been obtained on the Lizzie Creek Volcanics northwest of Collinsville, and in the absence of more definite evidence it is assumed that the Carmila Beds are essentially of the same age as the Lizzie Creek Volcanics.

### *Kurungle Volcanics*

(new name)

The Kurungle Volcanics consist of a sequence of andesite and rhyolite flows and pyroclastics in a small isolated structural basin at the east end of Mount Abbot. The name is derived from Kurungle Holding. The type area is the upper 5 km of Finley Creek. The volcanics form steep hills with a relief of up to 400 m.

The sequence in the type area consists of blue-grey andesite, andesite breccia, flow-banded rhyolite, agglomerate, and tuff. The andesite in places is sparsely porphyritic, and some of it is vesicular. The agglomerate in Finley Creek consists of closely packed well rounded pieces of andesite, up to boulder size, set in a sparse matrix of andesite tuff. The flow-banded rhyolite between Finley and Abbot Creeks forms prominent dip-slopes. The thickness is estimated to be 300 to 400 m. In the southwest the volcanics appear to lie nonconformably on biotite granodiorite (CPg), but 5 km southwest of Glenore homestead they are intruded and moderately hornfelsed by fine-grained porphyritic biotite-hornblende quartz diorite (also CPg). In the west the volcanics are intruded by quartz syenite of the Mount Abbot Igneous Complex, but the contact is generally faulted. The volcanics are intruded by felsite dykes, which are probably related to the alkali granite stock in the Mount Abbot Igneous Complex.

No fossils have been found in the Kurungle Volcanics, but they are regarded as broadly equivalent to the Lizzie Creek Volcanics.

### *Mount Aberdeen Volcanics*

(new name)

Mount Aberdeen, 40 km southwest of Bowen, is a rugged mountain rising abruptly to an elevation of 890 m. The uppermost 300 m of the mountain consists of intermediate to acid volcanics resting nonconformably on late Palaeozoic adamellite (CPg). Similar volcanics form crags at the summit of a mountain (known locally as Mount Inbetween) 4 km to the southwest. The Aberdeen Volcanics are named after Mount Aberdeen, which is the type area.

The sequence at Mount Aberdeen consists of andesite, dacite, rhyolite, coarse dacite welded tuff lithic-crystal tuff, crystal tuff, and agglomerate. The pyroclastics contain fragments of the underlying porphyritic adamellite. The abundance of flattened glass shards imparts a banded appearance to the welded tuff. Flow-banded porphyritic andesite and dacite occur at Mount Inbetween.

The welded tuff on the northeast flank of Mount Aberdeen dips at 40° to the southwest, but farther south the sequence of andesite, agglomerate, and tuff is subhorizontal or dips gently west. The flow banding in the andesite and rhyolite at the north end of Mount Aberdeen is vertical.

The contact between volcanics and the adamellite is exposed high on the east flank of the mountain, but to the west the volcanics extend all the way down the side of the mountain, and it appears therefore that the contact dips west at a moderate angle. The attitude of the volcanics at Mount Inbetween is unknown, but they appear to be confined to the top of the mountain. The thickness of the Mount Aberdeen Volcanics is possibly about 500 m.

Along the west side of Mount Aberdeen, and north of Mount Inbetween, the volcanics are intruded by a biotite adamellite that is regarded as part of the Hecate Granite. Dykes of biotite adamellite and pegmatite also intrude the volcanics near the contact. The volcanics have been hornfelsed, and in places the pyroxene has been converted to green amphibole, biotite, and opaque minerals. Some pyritic mineralization occurs along the contact.

At several places on the northern and southern slopes of Mount Aberdeen dykes and small masses of sparsely porphyritic medium to fine-grained biotite-hornblende diorite(?) intrude the basement granite (CPg); in the north it intrudes the overlying volcanics also. In the small irregular intrusions the diorite grades into andesite or dacite porphyry. The diorite may be an intrusive phase of the Mount Aberdeen Volcanics. The diorite at the north end of Mount Aberdeen is intruded by dykes of rhyolite and microdiorite.

No fossils have been found in the Mount Aberdeen Volcanics, and the age of the surrounding granites has not been firmly established. For the present, the volcanics are regarded as Lower Permian, by analogy with the Lizzie Creek Volcanics.

### *Ring Dykes(?) and Cone Sheets (?) (Plr)*

Acid magma has been intruded along arcuate fractures in the Rangeview ring complex in the Leichhardt Range. The larger dykes, which crop out as ridges, are probably ring dykes, and the swarm of smaller dykes parallel to the northwest margin of the complex may be cone sheets.

The east-west dyke of microtrondhjemite north of the Tableland yard contains rare phenocrysts of plagioclase ($An_{33}$) and biotite. The adamellite on both sides of the dyke is strongly sheared and epidotized. The other arcuate dykes consist of porphyritic rhyolite composed of phenocrysts of plagioclase, quartz, and biotite set in a fine groundmass of quartz, alkali feldspar, biotite, and iron oxides. A few xenoliths of felsite, possibly derived from the volcanics (Cuv), are present.

The swarm of thinner dykes (cone sheets?) generally consists of spherulitic and porphyritic rhyolite.

The ring dykes post-date the Upper Carboniferous volcanics (Cuv), and the cone sheets cut the granodiorite (Plg) of Marlborough Pocket. The dykes and cone sheets may be comagmatic with the Lower Permian oval plutons in Marlborough Pocket and Expedition Pass Creek.

*Granodiorite and Adamellite (Plg)*

Lower Permian K/Ar isotopic ages have been obtained on biotite from two widely separated adamellite stocks, one immediately south of Expedition Pass Creek in the northwestern part of the Sheet area (270 m.y.) and the other at Grant Creek in the southeast (268 m.y.). The stocks in the Leichhardt Range near Expedition Pass Creek are probably of the same age.

The oval stock drained by *Landers and Fence Creeks* in the northwest corner of the Sheet area has been dissected into high spurs and broad valleys with a relief of 400 m. The stock is composed of medium-grained pink leucocratic granodiorite containing about 5 percent biotite and actinolitic hornblende. Small xenoliths of diorite are ubiquitous. In the northwest and east the granodiorite intrudes the Ravenswood Granodiorite Complex, and photogeological interpretation suggests that it intrudes the Mount Windsor Volcanics in the southwest. No dykes were seen in the granodiorite, but they are abundant in the surrounding Ravenswood Granodiorite Complex.

The small boss of hornblende-biotite granodiorite intruding the volcanics (Cuv) in *Millaroo Creek,* 1.5 km southeast of McGregors Bonnet, grades into porphyritic adamellite on its southwest margin. The adamellite contains biotite, green amphibole, chlorite, sericite, sphene, clinozoisite, epidote, allanite, apatite, carbonates, and iron oxides. It contains xenoliths of volcanics and coarse biotite granite.

The two adamellite stocks in the headwaters of *Expedition Pass Creek* are separated by a narrow valley (Expedition Pass) eroded in the less resistant Ravenswood Granodiorite Complex. The stocks form some of the most rugged hills in the Leichhardt Range, and have a relief of up to 400 m. Both consist of medium-grained pink leucocratic biotite adamellite. The larger stock to the south consists of perthite, oligoclase, quartz, and clusters of chlorite, biotite, apatite, zircon, and allanite. A brown-grey sparsely porphyritic medium-grained hornblende-biotite granodiorite crops out along the lower slopes of the northern stock. Both plutons are massive, and no dykes were seen to intrude them. The volcanics adjacent to the northern stock have been hornfelsed and veined by microgranite. A K/Ar isotopic age of 270 m.y. was obtained on biotite from the southern stock. The subcircular shape of these high-level intrusions suggests that they may have been emplaced by ring-fracture stoping.

The large oval depression known locally as *Marlborough Pocket* lies about 100 m below the general level of the Leichhardt Range. The impression is underlain by a granodiorite stock, which may also have been emplaced by ring-fracture stoping. The close dendritic drainage pattern on the Marlborough stock contrasts strongly with the widely spaced jointing in the surrounding Ravenswood Granodiorite Complex, and the negative relief of the stock is probably due to the difference in jointing.

The Marlborough stock ranges from medium-grained hornblende-biotite granodiorite to adamellite. The hornblende occurs as prisms up to 1 cm long, and rarely exceeds biotite in abundance.

In the southeast the main stock is intruded by a small body of leucocratic biotite microadamellite, which forms a steep hill about 30m high. It contains phenocrysts of plagioclase, perthite, quartz, and biotite. The numerous large dykes of aplite, leucocratic microadamellite, and microgranite intruding the granodiorite nearby are probably related to the microadamellite. Rare dykes of feldspar-hornblende porphyry cut the microgranite dykes. The felsite dykes striking at about 070° near the southwest margin of the stock are probably cone sheets related to the Rangeview ring complex. Thus it seems that the Marlborough Pocket stock is older than the ring complex, but the difference in age is probably not great.

An oval stock of massive pink and white biotite adamellite, surrounded by foliated diorite and tonalite (Cud), crops out in the rugged country drained by Grant Creek, 8 km northeast of its junction with the Broken River. The stock is less resistant to erosion than the surrounding more basic rocks, probably because it is more closely jointed. A K/Ar isotopic age of 268 m.y. has been obtained on biotite from the stock.

**Fig. 12. Isolated outcrop of granitic augen gneiss (Thunderbolt Granite) in bed of the Bogie River, 500 m downstream from Binbee. The gneiss possibly represents the contaminated margin of the granite which was remobilized during emplacement of the batholith.**

### *Thunderbolt Granite*

(new name)

The Thunderbolt Granite is a Lower Permian adamellite batholith with an area of 400 $km^2$ in the headwaters of the Bogie River, northeast of Collinsville. The name is derived from Thunderbolt Creek, and the type area is the hills drained by Pelican, Sandy, Rocky, and Reedy Creeks. Part of the batholith lies in the southern half of the Sheet area, and was included in the Urannah Complex of Malone et al. (1966).

#### *Distribution and Topography*

The Thunderbolt Granite extends for about 50 km from the headwaters of Flagstone Creek in the south to west of Mount Aberdeen in the north. In the north the composition of the batholith is variable, and the boundaries with other granites in the area have not been established. The centre of the batholith consists of a rugged plateau fragmented by ravines and fringed by cliffed spurs and re-entrants; elsewhere the topography is variable. The plateau rises about 300 m above the undulating country in the north and 60 to 120 m above the hills in the south.

*Lithology*

South of Binbee the Thunderbolt Granite consists mainly of massive hornblende-biotite adamellite composed of large pink phenocrysts and porphyroblasts of orthoclase microperthite (15-30%), quartz (20-40%), oligoclase-andesine (about 20%), biotite and subordinate hornblende (5-7%), and accessory iron oxide, sphene, apatite, and zircon. Intermediate to basic dykes are rare, but swarms of aplitic microgranite dykes are common near the margins and in the country rock.

North and west of Binbee the composition and texture are variable, and there are some swarms of basic to intermediate dykes. Scrub Top Mountain consists of porphyritic microadamellite grading into medium-grained biotite adamellite.

An isolated outcrop of granite gneiss (Fig. 12) protrudes from the sandy bed of the Bogie River, 500 m downstream from Binbee. It contains augen of quartz and feldspar up to 8 cm long. The foliation in the gneiss has been intricately folded, and the folds have been dislocated along small subparallel shear planes. No other metamorphic rocks are known in the region, and the gneiss may represent part of the Thunderbolt Granite that has been squeezed and remobilized during the emplacement of the batholith.

*Structure*

In the south the contact of the Thunderbolt Granite appears to dip steeply, but is faulted in places. Along the Bogie River, for a few kilometres upstream from Binbee, the presence of a roof pendant (Cud) and a cupola suggests that the northeastern contact dips relatively gently to the northeast (see map).

Many lineaments, some of which may be faults, can be seen in the central rugged plateau. The main direction is northwest, but some trend northeast. Other lineaments or faults may be present where the topography is more subdued.

Scrub Top Mountain and Highlanders Bonnet are elongate ridges along a prominent fault. The fault passes along the west side of Scrub Top Mountain, where it is marked by fracturing, vuggy quartz veins, and swarms of dykes.

*Relationships and Age*

The Thunderbolt Granite intrudes the surrounding Upper Carboniferous quartz diorite suite (Cud), and is younger than most of the dykes in the diorites, which are truncated by the granite. The relationship between the Thunderbolt Granite and the Mount Aberdeen Volcanics has not been established. In the north the Thunderbolt Granite is intruded by the Lower Cretaceous Hecate Granite, and in the southeast it is intruded by a small boss of altered granodiorite (PKs).

The mean K/Ar isotopic age of 265 ± 1.3 m.y. obtained on biotite was confirmed by two Rb/Sr measurements, also on biotite (Webb & McDougall, 1968, p. 325).

*Mineralization*

The southern boundary of the Thunderbolt Granite probably lies just south of an old silver mine (probably the 'Flagstone' of Cameron, 1902) near the Binbee-Normanby road, 4 km east of Parada homestead. The lode is parallel to an altered microdiorite dyke intruding the fine-grained margin of the granite.

TABLE 3. LATE PALAEOZOIC TO CAINOZOIC STRATIGRAPHY AND IGNEOUS INTRUSIONS

| *Age* | *Rock Unit (map symbol)* | *Lithology* | *Topography* | *Remarks* |
|---|---|---|---|---|
| QUATERNARY | Qm | Coastal mud, minor evaporites | Flat | Superficial, merges with stream alluvium. Estuarine and littoral mud flats and salt pans |
| | Qr | Sand in beach ridges and coastal dunes | Low ridges | Superficial. Ancient and present strandline dunes |
| | Qu | Outwash and scree | Steep slopes in places | Superficial. Piedmont fans |
| | Qa | Alluvium, semi-consolidated in places | Flat | Superficial. Merges with coastal mud flats (Qm) and outwash fans (Qu). Up to 30 m thick along Burdekin R. Groundwater |
| | Qs | Colluvial and residual soil, sand, rubble | Gently undulating | Max thickness probably 3 m |
| TERTIARY | To | Coarse clayey sandstone, sandy claystone, conglomerate | Flat, low-lying | Thin veneer on Edgecumbe Beds and granite (PKg). Outwash deposits 30-60 m thick. Ferricrete capping preserved in places |
| | Suttor Formation (Ts) | Coarse clayey sandstone, sandy claystone, polymictic pebble and cobble conglomerate, minor oil shale. Lateritized | Isolated mesas and plateaux | Unconformable on Devonian to Triassic rocks; probably disconformable on Tertiary basalt (Tb). Extensive shallow lakes, swampy in places, on uneven basement. Few dicotyledonous plants. Opalized wood in Mt Coolon Sheet area. Thickness 60-120 m |
| | Tb | Olivine basalt | Rounded steep hills or small mesas; soil-covered flats with low rubble-covered hills | Plugs and small remnants of flows. Intrude and unconformably overlie Bowen Basin sediments and Star of Hope Fm |

TABLE 3 (cont.)

| *Age* | *Rock Unit (map symbol)* | *Lithology* | *Topography* | *Remarks* |
|---|---|---|---|---|
| LOWER CRETACEOUS | Mount Abbot Igneous Complex (Ka$_2$) | Alkali granite | Steep rugged mountains (1055 m) | Subvolcanic complex, probably associated with ring-fracturing. Alkali granite (Ka$_2$) intrudes quartz syenite (Ka$_1$): both intrude late Palaeozoic granite (CPg). Felsite cone sheets associated with alkali granite (Ka$_2$) |
| | Mount Abbot Igneous Complex (Ka$_1$) | Quartz syenite | | |
| | Hecate Granite (Kh$_1$) | Aplitic microgranite | Isolated spire of Roma Peak (660 m) | Large, possibly mesozonal batholith. Intrudes late Palaeozoic plutonic rocks (Urannah Igneous Complex, Thunderbolt Granite, Cud, CPg), Carmila Beds, Mt Aberdeen Volc. Responsible for gold mineralization in E part of Sheet area |
| | Hecate Granite (Kh) | Granodiorite, adamellite; late-stage leucocratic phases | Mainly rolling low-lying country, although rugged in S; leucocratic phases form distinct hills | |
| | (Ki) | Granodiorite, diorite, rhyolite, porphyry, gabbro, microdiorite | Mainly pockets surrounded by hills of hornfelsed volcanics and sediments. Low tors | Small laccoliths and bosses. Intrude Lizzie Cr Volc and Bowen Basin sediments. Local copper mineralization |
| TRIASSIC | Clematis Sandstone (TRe) | Cross-bedded sublabile and quartzose sandstone, pebbly in places, some fine conglomerate and grey and red mudstone | Steep-sided tablelands and mesas | Conformable on Bowen Fm. Fluvial. 300-350 thick |
| | Rewan Formation (TRr) | Red mudstone, green labile and sublabile sandstone, siltstone | Mainly soil-covered plains and rises. Some strike ridges. Locally rugged where hornfelsed | Conformable on Blackwater Gp. Predominantly fluvial. 1000 m thick |

TABLE 3 (cont.)

| *Age* | *Rock Unit (map symbol)* | *Lithology* | *Topography* | *Remarks* |
|---|---|---|---|---|
| L. PERMIAN or L. CRETACEOUS | PKg | Leucogranite, microgranite, minor adamellite, micro-adamellite, and diorite | Rugged mountains, hills, and islands | Epizonal stocks. Intrude Upper Carboniferous diorite suite (Cud), U. Carboniferous or L. Permian granitic rocks (CPg), and Carmila Beds |
| | PKs | Altered granodiorite | Prominent conical hill | Boss. Intrudes Thunderbolt Granite near contact with U. Carboniferous diorite suite (Cud). Patchy sericite and carbonate alteration |
| U. CARBONIFEROUS, L. PERMIAN, and L. CRETACEOUS | Urannah Igneous Complex (CKr) | Undivided acid, intermediate, and minor basic plutonic rocks; abundant dykes | Rugged mountains up to 990 m. Access limited | Large complex batholith. Undivided SE continuation of U. Carboniferous, L. Permian, and L. Cretaceous batholiths to N. Intrudes Connors Volc; some phases may intrude Carmila Beds. Relationship with Lizzie Cr Volc poorly known, but appears to be faulted or nonconformable in places |
| U. PERMIAN or L. TRIASSIC | Mount Wickham Rhyolite (PTRr) | Mainly flow-banded porphyritic rhyolite and rhyolite breccia; subordinate trachyte, dacite, obsidian, and agglomerate | Steep hills and ranges. Cliffs | Plugs and flows. Intrude and unconformably overlie Lizzie Cr Volc, U. Carboniferous granite (Cug), Mt Windsor Volc, and Scartwater Fm. Thickness 30 to 200 m |

## UPPER PERMIAN OR LOWER TRIASSIC

(Table 3)

### *Mount Wickham Rhyolite*

(new name)

The Mount Wickham Rhyolite comprises a group of flows, plugs, and dykes of rhyolite overlying and intruding the Lizzie Creek Volcanics between the Bowen and Bogie Rivers in the centre of the Sheet area. The type area is Mount Herbert, a prominent steep plug 40 km northwest of Collinsville. The acid volcanics between Glenmore Creek and the Bowen River were mapped by Malone et al. (1966) as Tertiary ('Brawl Creek block'), but in view of the isotopic ages obtained in the Mount Wickham/Clarke Range area, we have included them in the Mount Wickham Rhyolite. Mount Glenroy and Mount McConnell, near the western edge of the Sheet area, and the dyke-like intrusives between Sandalwood Creek and the Millaroo Fault Zone have also been included.

#### *Topography*

The intrusive rhyolites generally form isolated hills rising steeply above the Lizzie Creek Volcanics and basement granite (CPg). Many of the hills, as for example Mount Herbert (about 420 m), are surmounted by cliffs up to 30 m high. Mount Wickham (530 m) rises about 450 m above the Bowen River to the south; Edinburgh Castle (about 525 m) rises about 350 m above the surrounding country; Mount McConnell (450 m) is a prominent circular plug which rises 300 m above the Scartwater Formation; and Mount Glenroy (530 m) is a pinnacle rising 150 m above the summits of the surrounding hills.

#### *Lithology*

The rhyolites and associated breccias contain phenocrysts of feldspar and quartz up to about 3 cm long, and generally have an aphanitic groundmass, although in places they grade into microgranite. The quartz phenocrysts at Mount Wickham are commonly over 1 cm in diameter. The flow banding is usually contorted and steeply dipping. Large dykes of rhyolite crop out around Mount Wickham, Mount Herbert, and Edinburgh Castle. Table Mountain is capped by a flow dipping gently northeast, and the southern scarp of the mountain is probably a feeder dyke.

The volcanics between Glenmore Creek and the Bowen River include trachyte, rhyolite, dacite, obsidian, and agglomerate (Malone et al., 1966).

Mount McConnell consists of grey and white flow-banded rhyolite and porphyritic rhyolite, capped by rhyolite breccia. Porphyritic felsite dykes associated with the plug intrude the Scartwater Formation near the base of the mountain. The sediments near the contact are indurated.

A helicopter traverse over Mount Glenroy showed that the dark grey rock at the summit is closely jointed.

#### *Relationships*

The rhyolite plugs of the Mount Wickham Rhyolite intrude the Lizzie Creek Volcanics, and the rhyolite flows probably rest disconformably on the Lizzie Creek Volcanics. Malone et al. (1966) have recorded dolerite dykes up to 4 m thick in the rhyolite in the Glenmore Creek area. The maximum thickness of the flows in the Clarke Range is about 30 m, although Malone et al. (1966) recorded a thickness of 200 m or more in the Glenmore Creek area.

#### *Age*

The Rb/Sr whole rock analyses of specimens collected from scattered localities (Webb & McDougall, 1968, pp. 328-9) indicate an age of 230 ± 15 m.y., which is close to the Permian-Triassic boundary.

# UPPER CARBONIFEROUS, LOWER PERMIAN, AND LOWER CRETACEOUS

(Table 3)

### *Urannah Igneous Complex*

In their report on the southern half of the Sheet area Malone et al. (1966) gave the name Urannah Complex to the large composite batholith to the east of the Bowen Basin. We have amended the name to Urannah Igneous Complex because metamorphic rocks are now known to be absent. The name is used for the acid, intermediate, and basic plutonic rocks in the south-east corner of the Sheet area which have not yet been subdivided. The northern limit of the undivided Urannah Igneous Complex is indicated by an arbitrary sinuous line on the map.

#### *Topography*

Except for a small area of low-lying country around the Mount Hector goldfield in the northeast, the Urannah Igneous Complex has a rugged topography with a relief of about 800 m. Some of the peaks southeast of Urannah homestead are over 900 m high; Mount Hector has an elevation of 890 m and a peak north of the headwaters of Amelia Creek rises to 990 m. A maximum elevation of 1280 m is reached at Mount Dalrymple (Fig. 13) a few kilometres to the southeast of the Sheet area.

In places the dykes in the complex form prominent ridges, but it is only between Ernest Creek and Long Creek that a series of close parallel dyke ridges, such as those in the diorite suite (Cud) to the north, occur.

Access by vehicle is restricted to the roads shown on the map, of which only the road from Eungella in the Mackay Sheet area to Urannah homestead is suitable for regular use by conventional vehicles. Most of our observations were made in the more accessible part of the complex in the northeast, but a few helicopter landings were made in Urannah Creek to the south of Mount Crompton. The complex is well exposed in many of the streams on the western slopes of the Clarke Range, but outcrops are rare in the small area of rain forest east of Mount Crompton (Fig. 14).

#### *Lithology*

The outwash fans south and southwest of Mount Hector are composed of strongly sheared and mylonitized granite and less acid rocks. The blastomylonites are similar to those in the shear zones southwest of Bowen (see Hecate Granite and unnamed granite 'CPg'); the prominent northwesterly lineaments in the mountains west of Mount Hector are probably also shear zones. The debris also includes sheared and greisenized ironstained aplite.

Weathered biotite microgranite and granite crop out as low knobbly rises and small hills east and southeast of Mount Hector homestead. Exposures are poor in the Mount Hector goldfield, but mine dumps provide some information. The host rock at the Gumoller mine is a white hornblende-biotite trondhjemite intruded by dykes of microdiorite containing pheno-crysts of hornblende and by dykes of grey microtrondhjemite(?) containing phenocrysts of plagioclase and biotite. The small hills 2 to 4 km southeast of Mount Hector homestead are composed of closely jointed silicified and slightly ironstained pink aplitic microgranite; greisenized microgranite crops out on a small hill at the foot of the Clarke Range, 5 km south-east of the homestead.

The diorite between Pine Mountain and Fairfield hut is commonly net-veined by tonalite and adamellite.

The granite or adamellite near the contact with the Carmila Beds between the Mixer mine and Palm Tree Creek is weakly brecciated and chloritized, but south of Palm Tree Creek the granite is unaltered. The granite extends west at least as far as the forestry track to the head of Sandy Creek on the Clarke Range. Fine-grained diorite dykes are abundant in the area. Beside the track at the head of Long Creek (sample loc. F55/3/113) massive medium to coarse urali-tized quartz-augite-biotite diorite (2210) crops out.

**Fig. 13. Aerial view of the Urannah Igneous Complex looking east up Massey Gorge (400 m deep) towards Mount Dalrymple (1280 m) in the Mackay Sheet area.**

In Urannah Creek weakly foliated biotite adamellite or granodiorite predominates. Locally it is hornblende-bearing, and in places intrudes quartz diorite. A few of the boulders in the creek consist of quartz-feldspar porphyry.

*Structure*

Many strong northwesterly lineaments are visible on the air-photographs of the Urannah Igneous Complex, especially in the northeast. The presence of sheared and mylonitized rocks near Mount Hector indicates that at least some of the lineaments represent shear zones. Dyke ridges are predominant between Mount Crompton and the southern edge of the Sheet area.

There is a weak vertical foliation in Urannah Creek and Dick Creek; in the east the foliation has an easterly trend, but near Urannah homestead it swings to the southeast.

*Relationships and Age*

The Urannah Igneous Complex is the undivided southeasterly continuation of the Upper Carboniferous, Lower Permian, and Lower Cretaceous batholiths to the north.

In the southwest the complex intrudes the Connors Volcanics, which are regarded tentatively as Upper Devonian or Lower Carboniferous. In the northeast, no intrusive contacts were seen, but some of the microgranite near the contact may be intrusive into the Carmila Beds. Although the gold mineralization in the Mount Hector goldfield straddles the contact between the granite and the Carmila Beds, it is probably related to the microdiorite dykes. with which it is closely associated, rather than to the granite.

The K/Ar isotopic ages range from 250 to 314 m.y. (see Appendix). Webb & McDougall (1968, pp. 320-4) consider that the minimum age of most of the complex is 305 to 310 m.y. (Upper Carboniferous), but some Lower Permian and Lower Cretaceous intrusions, similar to those farther north and southeast, may be present.

**Fig. 14. Rain forest on the Urannah Igneous Complex east of Mount Crompton.**

# LOWER PERMIAN OR LOWER CRETACEOUS

(Table 3)

*Altered Granodiorite (PKs)*

An isolated boss of altered granodiorite intrudes the Thunderbolt Granite in the headwaters of Thunderbolt Creek, 22 km east-northeast of Collinsville.

The boss is about 1 km in diameter, and forms a prominent conical hill (548 m) that rises 150 m above its neighbours. The slopes of the hill are mantled by large boulders.

The rock along the western margin is extensively altered. It consists of medium-grained to inequigranular pink and grey granodiorite in which most of the biotite has been replaced by muscovite and chlorite and the feldspars by sericite. The rock also contains much calcite and siderite, and occasional rectangular pseudomorphs of hematite after pyrite.

The boss intrudes the Thunderbolt Granite near its contact with diorite and gabbro (Cud). Several strong lineaments, one of which passes through the centre of the boss, are visible on the air-photographs, and it is probable that its emplacement was controlled by faults. The boss may be an outlying cupola of the Lower Cretaceous Hecate Granite.

*Granite (PKg)*

Granite stocks probably of either Lower Permian or Lower Cretaceous age occur in the northeastern part of the Sheet area. The granites are mainly leucocratic, and tend to occur as subcircular masses. Only very rarely are they intruded by dark dykes.

The southern face of *Mount Pring* rises steeply to an elevation of 420 m above the alluvial plain of Euri Creek. Most of the mountain consists of a stock of granite which intrudes the surrounding diorite and gabbro. In the Bowen Sheet area the stock is roughly semicircular in plan, but in the Ayr Sheet area to the north, it has been only partly unroofed. The western side of the stock consists of fine-grained pale pink-brown leucocratic biotite granite. In places the granite contains drusy knots of quartz and feldspar up to 8 cm across, which are surrounded by zones of biotite-rich granite. There is a prominent ridge of shear-foliated leucocratic granodiorite (CPg) along most of the western side of the stock. To the northwest of the railway the stock consists of massive fresh pink-brown leucocratic biotite microgranite containing large phenocrysts of ironstained quartz and feldspar. The two swarms of aplite, felsite, and microgranite dykes, which intrude the diorite and gabbro north and south of Mount Pring, are evidently related to the granite.

*North Head,* a rocky islet between Flagstaff Hill and Stone Island, consists largely of pink and brown fine to medium-grained biotite leucogranite. The granite intrudes the Carmila Beds and two separate swarms of dark dykes (Fig. 19), and is probably part of the intrusion forming Mount Mother Beddick and Cape Edgecumbe, 5 km to the north in the Ayr Sheet area. The leucogranite is intruded by irregular northerly trending dykes of microgranite.

Well jointed sparsely porphyritic leucocratic microgranite crops out extensively at the south end of *Kings Beach,* and numerous dykes of microgranite, grading into spherulitic rhyolite, intrude the Carmila Beds on Flagstaff Hill. The microgranite is probably a marginal variant of the leucogranite at Edgecumbe Heights.

*Gloucester Island* rises steeply on all sides to a central sawtooth ridge 566 m abovc sea level. The west side of the island is covered with scree and scrub, and slopes gently down to the sea. Most of the outcrops along the coast consist of pink and brown medium-grained biotite leucogranite, but several large outcrops of diorite, veined by the leucogranite, were seen from a launch at Round Hill Point, and 1 km to the north a massive blue-grey medium-grained biotite-hornblende diorite, containing veins and patches of diorite pegmatite, crops out. The pegmatite contains occasional aggregates of pyrite up to 3 cm across. Veins of leucocratic granite, some of which contain small pyrite crystals, cut the diorite and pegmatite. The biotite from the leucogranite has been dated by the K/Ar method at 216 m.y. (Middle or Upper Triassic).

The rugged granite range (399 m) between *Sinclair Bay* and *Cape Gloucester* consists of leucogranite similar to the granite on Gloucester Island, except that the biotite is usually chloritized. Biotite adamellite crops out 1 km east-northeast of the tourist resort at Gloucester Park. South of Sinclair Bay the granite intrudes the Edgecumbe Beds.

Ben Lomond (435 m), a conical mountain on the southeast shore of Edgecumbe Bay, is a small circular stock about 2.5 km across, which intrudes the Edgecumbe Beds. The northeast margin consists of grey and pink porphyritic microadamellite containing biotite and a little pale green amphibole. The microadamellite contains many small resorbed xenoliths, and probably represents the chilled and contaminated margin of the stock. A roof pendant of hornfelsed limestone of the Edgecumbe Beds crops out near sea level on the north side of Ben Lomond (Saint-Smith, 1918; Connah, 1953b).

*Age and Structural Setting*

The relationship of these granites to the Hecate Granite and other granites is uncertain. The K/Ar Triassic age obtained on a specimen from Gloucester Island is regarded as provisional only (A.W. Webb, pers. comm.). Granites of Triassic age appear to be confined to southeast Queensland, south of about Gladstone (Webb & McDougall, 1968), some 600 km to the southeast of Bowen. These Triassic or older granites, probably epizonal, now occupy the same level of the crust as the nearby, but probably deeper-level, Lower Cretaceous Hecate Granite. This enigma can perhaps be explained by major movements in the zone of faulting south of Edgecumbe Bay, which is probably a northwesterly continuation of the major faults that resulted in the formation of the Hillsborough Basin in the Tertiary or late Cretaceous in the Proserpine Sheet area (Clarke et al., 1971). However, the sense of movement necessary (northeast block down) is the opposite to that required to explain the present relationship between the Edgecumbe and Carmila Beds.

## LOWER CRETACEOUS
(Table 3)

### *Minor Intrusives (Ki)*

The Lower Cretaceous laccoliths and sills intruding the Bowen Basin sequence have been described briefly by Malone et al. (1966).

In addition to these, the granitic stock in the Lizzie Creek Volcanics north of Mount Poole has also been dated as Lower Cretaceous (123 m.y., spec. F55/3/127, Appendix). The stock underlies a deep pocket surrounded by hills of hornfelsed volcanics and sediments. It probably consists mainly of medium to coarse hornblende-biotite granodiorite or adamellite, but biotite quartz diorite crops out near the central-southern edge of the intrusion, where several shafts have been sunk on a narrow quartz-pyrite-chalcopyrite vein trending east-southeast over a length of at least 600 m.

An abandoned small gold mine (Malone et al., 1966, p. 59) is situated about 1.5 km to the south of the intrusion.

### *Hecate Granite*
(new name)

The Lower Cretaceous Hecate Granite in the northeastern part of the Sheet area has been delineated by a combination of field mapping, petrography, and isotopic dating. The name is derived from Hecate homestead, 55 km south-southeast of Bowen. The type area is Simon and Emu Creeks, upstream from latitude 20° 24'25"S and longitude 148° 10'30"E.

The batholith consists mainly of granodiorite and adamellite, and has an area of about 1000 km$^2$. It is surrounded by minor occurrences of gold and base metal mineralization.

Most of the Hecate Granite is unaltered, unfoliated, sparsely jointed, and devoid of dark dykes, and strongly resembles the Lower Permian Thunderbolt Granite.

*Topography and Access*

The Hecate Granite weathers somewhat more easily than the diorite and gabbro (Cud), and much more easily than the volcanics (Pla, Pld), and generally forms rolling low-lying country (Figs 3, 4), although there are many exceptions. The boundaries of the batholith are difficult to photo-interpret, except in the east where it is flanked by a range of hornfelsed volcanics.

The most prominent feature is Roma Peak, a spectacular isolated rocky pyramid 40 km south of Bowen, which rises 660 m above sea level (Figs 4, 15). The peak consists of a resistant boss of aplitic microgranite, and its northeastern face rises almost sheer for 300 m. Besides Roma Peak, other late leucocratic granites tend to form distinct hills, especially when emplaced into shear zones (e.g. Mount Buckley). Several large whalebacks of massive granite (e.g. Sixpenny Hill), some of which rise up to 100 m sheer above the surrounding gently undulating country, stretch in a line for 8 km to the northwest of Roma Peak (Fig. 4). At Mount

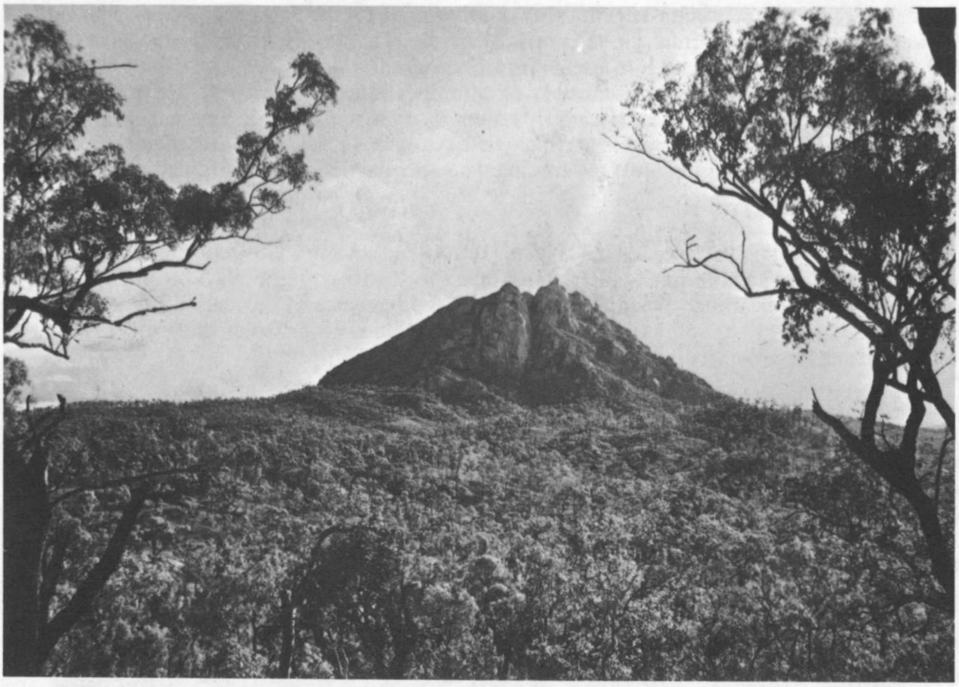

**Fig. 15. Roma Peak (660 m) 37 km south of Bowen, from the east. The peak is a boss of aplitic micro-granite, one of the late leucocratic phases of the Hecate Granite which surrounds the boss. Photograph by J.E. Zawartko.**

Gibralter (295 m) hills and ridges of granite are buttressed by a swarm of dykes. The topography in the drainage basins of the Don and Proserpine Rivers is gently undulating, but the broad valley of the Proserpine River (Fig. 2) lies abut 100 m below the valley of the Don River to the west. The watershed between the rivers consists of an indented east-facing scarp in the north which broadens and gains height towards the south where it culminates in the deeply dissected mountains at the head of the Don and Andromache Rivers with a relief of about 600 m.

The Bowen-Collinsville road in the northwest, and the well maintained gravel roads to Pretty Bend and Roma Peak homesteads, and the roads in the Proserpine and Andromache River valleys provide access to the Hecate Granite. There is also a track suitable for Land Rovers from Roma Peak homestead to the old Normanby goldfield, and other useful tracks.

*Lithology*

The Hecate Granite, *3.5 km southwest of Roma Peak,* consists of massive white and pink medium to coarse biotite-hornblende granodiorite composed of zoned oligoclase-andesine (45%), strained quartz (25%), perthitic alkali feldspar (15%), hornblende (5%), biotite (3-5%), magnetite (1%), coarse crystals of sphene (less than 1%), and a trace of apatite. The grainsize of the plagioclase, quartz, hornblende, and biotite is generally about 2 to 4 mm, but ranges up to 8 mm. Most of the perthite occurs as poikiloblasts between 2 and 3 cm long, but some smaller crystals are also present. The hornblende is generally fresh, but some of the biotite is chloritized. Most of the outcrops in *Simon Creek* consist of fresh massive unjointed white and pink adamellite or granodiorite.

The low-lying sand-covered rises south and west of *Pretty Bend homestead* consist of massive medium to coarse biotite adamellite, but thick sheets of leucocratic granite and microgranite crop out in the rugged country farther south and west, including the steep peak of Monte Christo (about 500 m). The sheets form a semicircular swarm with a focal point at an isolated hill in the sandy plain 1.5 km south-southwest of Pretty Bend homestead. The valleys between the concentric granite sheets consist of diorite. The leucogranite, forming the central hill near the homestead, grades in places into microgranite and more rarely into pegmatite. It contains scattered xenoliths composed of biotite (about 50%), quartz, feldspar, and red garnet. Occasional crystals of garnet up to 1.5 cm in diameter occur in the leucogranite. The leucogranite consists of orthoclase perthite (65%), quartz (25%), unzoned oligoclase (10%), and a little biotite and muscovite. One specimen contains xenocrysts of strained and fractured quartz.

In the *Proserpine River valley* the Hecate Granite ranges from granodiorite to adamellite, with a little granite and diorite in places. Most of the rocks are equigranular, but some of them have a speckled appearance owing to the presence of aggregates of biotite, and most of them contain small pod-like xenoliths of microdiorite. On the floor of the valley the granite is deeply weathered and largely obscured by coarse sand.

*In the north* biotite adamellite is probably more common than granodiorite. Sixpenny Hill, a whaleback about 30 m high, consists of massive medium-grained inequigranular adamellite containing euhedral phenocrysts of biotite. Several larger whalebacks occur between Sixpenny Hill and Roma Peak.

The small circular boss northwest of *Mount Aberdeen* is composed of biotite-hornblende adamellite with phenocrysts of plagioclase.

*Mount Pleasant* (about 450 m) consists of a body of hornblende-biotite adamellite which is probably intrusive into the Thunderbolt Granite. To the south an offshoot of medium-grained hornblende granodiorite intrudes sheared diorite.

The late-stage leucogranites, microgranites, aplites, and pegmatites are commonly associated with shear zones. Aplite and pegmatite dykes are particularly common between Roma Peak and the Proserpine River, and around Roma Peak. Some of the dykes are 3 m thick and show up clearly on the air-photographs. Many of the dykes dip at low angles, and some consist of pegmatite, with feldspar crystals up to 20 cm long, grading into aplite. Some of the dykes contain occasional crystals of tourmaline. Roma Peak is an isolated plug of resistant pink and buff leucocratic aplitic biotite microgranite. The plug is oval in cross-section, and has a maximum diameter of just over 1 km.

*Shear Zones*

In the north the leucogranites, microgranites, and aplites are commonly associated with large shear zones. The large lineaments in the rugged country at the head of the Don and Andromache Rivers are probably also shear zones; shear zones also occur in the late Palaeozoic granite (CPg).

*Mount Buckley* (256 m), which rises 200 m above the surrounding undulating country, consists of buff and pink leucocratic aplitic granite which was intruded along the Mount Buckley Shear. On the northeast side of Mount Buckley the aplitic microgranite grades into blastomylonite. Blastomylonites also crop out in washaways in the low country for several hundred metres normal to the shear. The finely banded blastomylonites were formed by mylonitization and recrystallization of the Hecate Granite and the surrounding diorite and gabbro. The dark colour of many of the blastomylonites is due partly to their fine grainsize and partly to the presence of very fine biotite. Similar aplitic granites and blastomylonites crop out as an irregular hill to the northwest of Mount Buckley on the other side of Five Mile Creek.

The cataclasites range from biotite microadamellite or microgranite, with an incipient granoblastic texture, to blastomylonite. The microadamellite contains 5 to 10 percent brown biotite, a little green hornblende and sphene, scattered crystals of magnetite(?), and a few small prisms of tourmaline. The blastomylonites consist of granoblastic quartz (70%), orthoclase (10%), microcline (5%), sodic plagioclase (5%), bands of biotite (10%), sphene, epidote, and clinozoisite. Finely disseminated opaque minerals and apatite are included in the quartz and potash feldspar. The grainsize ranges from 0.03 to 0.025 mm. Another blastomylonite, which was possibly derived from tonalite, consists of quartz (60%), epidote (20%), actinolite (15%), and sodic andesine (5%). In some of the blastomylonites small octahedra of magnetite(?) are surrounded by bleached reaction rims.

The foliation in the Mount Buckley Shear is vertical or dips steeply southwest. In the blastomylonites it is generally defined by alternating bands rich and poor in biotite. The foliation is essentially planar, and in places it is marked by ill defined felsic rods set in a groundmass rich in biotite. The vertical alignment of the long axes of the rods and the alignment of the intermediate axes in the plane of the shear indicate horizontal movement. The intermediate to basic xenoliths in the blastomylonites have been deformed into rods with the same vertical orientation. Horizontal movement is also indicated by the occurrence of thin convolute veins of quartz trending across the shear. The fold axes of the veins are vertical, and the tightness and orientation of the folding indicate considerable shortening at right angles to the shear. The blastomylonites are commonly intruded by veins and complex networks of slightly sheared biotite adamellite.

The resistant aplitic granite generally contains bands of fine magnetite(?) parallel to the plane of foliation. Most of the aplitic granites have a planar banded structure that was probably created by shearing during intrusion, but some have a contorted flow-banded structure. The undeformed veins of pegmatite along the middle limbs of small vertically plunging monoclines in the banding were evidently emplaced after shearing had ceased. The flakes of white mica in the shear zone are probably the result of incipient greisenization. Some of the granite veins in the Mount Buckley Shear grade from massive granite into foliated and incipiently boudinaged rocks. All these features indicate that the intrusion of the granite and the shearing were largely contemporaneous.

The *Mount Dangar Shear* may be connected with the Mount Buckley Shear, although there is a 30° difference in strike. The Mount Dangar Shear dips steeply west at about 65°. Gneissic blastomylonite is well exposed in the bed of the Don River where it crosses the shear. The proportion of orthoclase to oligoclase-andesine differs widely in two specimens collected within a few metres of each other, and it appears that there has been some redistribution of constituents. One specimen contains rare small metacrysts of garnet, but opaque minerals are absent. The medium to coarse leucoadamellite at Mount Dangar (216 m) has been shattered as a result of its proximity to the shear. Between Mount Dangar and Mount Buckley the Mount Dangar Shear forms the boundary between the Hecate Granite and the diorite and gabbro (Cud). Some of the aplite dykes, up to 3 m thick, which intrude the foliated and schistose amphibolite formed by the alteration of quartz diorite in the plane of the shear, have been foliated and greisenized. A large mass of quartz containing blocks of greisenized adamellite also occurs in the shear.

The ironstained ridges of foliated greisen in the sheared quartz diorite several kilometres southwest of *Mount Challenger* (516 m) are probably sheared and altered aplite dykes similar to those at Mount Buckley. The greisens contain abundant disseminated pyrite, and in places are brecciated. The Mount Challenger Shear is near the contact with the diorite and gabbro (Cud), which have been sheared, brecciated, and intruded by a network of thin veins of biotite granite. Two generations of quartz veins are present in places; the first generation has been ptygmatically folded, and the second is associated with the breccias. In conclusion it may be said that the late Palaeozoic diorite and gabbro (Cud) are almost invariably weakly foliated, and that the Hecate Granite is massive and unfoliated. The abundance of shear zones in the Hecate Granite suggests that the batholith was injected under considerable pressure.

*Relationship and Contacts*

The Hecate Granite intrudes the late Palaeozoic plutonic rocks (Urannah Igneous Complex, Thunderbolt Granite, 'Cud', and 'CPg'), the Carmila Beds, and the Mount Aberdeen Volcanics. The boundaries of the batholith are not well known. In the east, where the granite has intruded and hornfelsed the Carmila Beds, the boundary can be delineated on the air-photographs, and the contacts with the diorite and gabbro (Cud), which generally have a smoother pattern and darker tone than the granite, have been approximately located. The contacts with the Palaeozoic granites (CPg) to the north and the south, however, cannot be photo-interpreted. Isotopic analyses have shown that the massive pink and white adamellite or granodiorite (CPg) at the head of the Don River is probably late Palaeozoic, although it is indistinguishable from the Hecate Granite.

Net-veining and xenoliths are common along the complex contacts with the Palaeozoic diorite and gabbro. In Bluff Creek near its junction with the Don River the diorite (Cud) is net-veined by foliated granodiorite of the Hecate Granite. The foliation is apparently confined to the contact zone and dies out a few metres downstream. Another net-veined contact zone crops out in the hills to the east of the Don River, 5 km east-southeast of Mount Monte Christo. North from Simon Creek to Ida Creek the position of the contact is uncertain. The contact has been drawn along the western boundary of the massive adamellite and granodiorite, but it is possible that the large exposures of foliated tonalite and quartz diorite in the Ida Creek Ranges and in the Don River at the crossing north of Pretty Bend may represent the contaminated margins of the Hecate Granite. Net-veined outcrops containing blocks of diorite and gabbro in various stages of assimilation are common along the northern contact of the batholith. There is a good example in Stockyard Creek, 5 km south of Mount Lee. In places the contact is sheared. In Mares Nest Creek, near Roma Peak homestead, the margins of some of the large gabbro roof pendants have been converted into gneiss and amphibolite by shearing. Biotite-hornblende syenite and monzonite have been formed by contamination of adamellite in a contact zone west of Pine Hill, near Mount Aberdeen. Stoped blocks of microdiorite up to 2.5 m across occupy half of a large outcrop in Eden Lassie Creek 6 km southwest of the Bruce Highway.

*Dykes*

The Hecate Granite is cut by comagmatic dykes of aplite, pegmatite, and leucocratic microgranite, and by other dykes which are not generally related to the batholith, especially in the northwest. The younger dykes include microdiorite, dolerite, quartz porphyry, dacite, and microtonalite. The most prominent swarm is at Mount Gibralter, where the easterly trending dykes form pronounced ridges, linked in places by less common meridional ridges. The younger dykes may be related to the Mount Abbot Igneous Complex.

*Age*

The nine K/Ar determinations on biotite and hornblende from seven widely spaced localities fall within the time-span of 120 to 128 m.y., and average 125 m.y. (see Appendix).

*Mineralization*

The distribution of gold and minor base metal mineralization around the Hecate Granite indicates that the mineralization is related to the granite. Webb (1969) has used this, together with other known Lower Cretaceous intrusives and mineralization west of Mackay, as the basis for identifying a major new metallogenic epoch in eastern Queensland, which he has called the Mackay Epoch. The deposits are described in the section on economic geology. The following indications of minor mineralization were found during the course of the regional mapping:

(1) The presence of pseudomorphs of hematite after pyrite in a quartz-filled breccia in pegmatitic granite, 1 km northeast of Pretty Bend homestead.

(2) The presence of small clots of pyrite and chalcopyrite in fine biotite adamellite 4 km southwest of Roma Peak. One kilometre to the northeast a large body of ironstained quartz intrudes a coarse adamellite, which in places has been reddened, epidotized, and sericitized.

(3) Weak local greisenization of the leucocratic pegmatitic granite on the northern slopes of a conical hillock 1 km northeast of Mount Monte Christo. Some of the granite outcrops are coated with patches of scarlet ochre, and others have been stained by the alteration of sulphide minerals. In the less weathered parts of the granite a few small crystals of pyrite and thin stringers of pyrite along grain contacts can be seen.

(4) The coarse white biotite granite, which probably occurs as thick concentric sheets in diorite, in the hills between Pretty Bend homestead and Boundary Creek (grid ref. E639800, N2443800), is cut by patches and veins of pegmatite containing aggregates of hematite and limonite after pyrite up to 3 cm across.

*Depth of Emplacement*

The zone of strong hornfelsing along the eastern margin and the widespread development of pegmatite and aplite dykes suggest that the Hecate Granite was emplaced beneath a substantial cover of country rock.

*Mount Abbot Igneous Complex*
(new name)

The Mount Abbot Igneous Complex is a high-level intrusive complex which forms Mount Abbot, 50 km west of Bowen, near the northern edge of the Sheet area. The complex consists of a quartz syenite stock ($Ka_1$), an alkali granite stock ($Ka_2$), and a swarm of cone sheets. The two stocks form the prominent landmark of Mount Abbot (1055 m) which rises abruptly from surrounding low-lying country. The cone sheets crop out in a semi-circle of low ridges and hills around the western end of Mount Abbot.

The quartz syenite forming the main stock is very variable in grainsize, and is composed of alkali feldspar intergrown with interstitial quartz (about 10%) and green to green-brown amphibole. The coarser varieties contain druses, up to 3 cm in diameter, lined with euhedral crystals of quartz and alkali feldspar and minor filiform amphibole. The quartz syenite is intruded by a smaller stock of fine-grained leucocratic biotite granite. The granite contains occasional phenocrysts, but opaque minerals, sphene, green amphibole, apatite, and zircon are present in accessory amounts only. The cone sheets consist mainly of flow-banded rhyolite, which commonly contains phenocrysts of feldspar, quartz, and biotite, and some microgranite.

The stocks have sharp subvertical contacts. Most of the cone sheets are inclined at 20° to 70° towards a focus beneath the alkali granite stock, but some are near-vertical. The swarm of felsite dykes to the north is truncated by the syenite stock, and is therefore probably older than the cone sheets.

A specimen of quartz syenite from a loose block in the low country to the south of Mount Abbot (spec. F55/3/119, Appendix) has yielded a K/Ar hornblende age of 116 m.y. (Lower Cretaceous).

## DYKES

Swarms of microdiorite dykes are particularly common in the eastern half of the Sheet area. They occur mainly in the diorite suite (Cud). Their orientation and distribution are shown on the geological map.

*Mount Dangar Crossing*

The large outcrops of tonalite and diorite in the bed of the Don River to the north of the Mount Dangar crossing are intruded by numerous dykes. The sequence of events is given in Table 4. The outcrops are transected by a northwesterly fault, to the northeast of which many of the dykes are strongly sheared, especially along their margins. The shearing evidently represents adjustment of blocks of country rock along narrow lines of weakness, along which the dykes were intruded.

Southwest of the fault the dykes are not affected by shearing. There are several northwesterly pale grey porphyritic microgranodiorite dykes cut by multiple easterly to east-southeasterly dark greenish blue microdiorite dykes, which are severely epidotized in places. Isolated circular zones of advanced epidotization occur along the centres of some of the microdiorite dykes.

Northeast of the fault, east-northeasterly to east-southeasterly microdiorite dykes are cut by meridional microgranodiorite dykes, which in turn are cut by a second group of easterly microdiorite dykes. North-northwesterly microdiorite dykes, dipping west at 50°, also intrude

TABLE 4. CYCLICAL SEQUENCES OF TENSIONAL FRACTURING, DYKE INTRUSION, AND SHEARING IN DON RIVER JUST NORTH OF MOUNT DANGAR CROSSING

| *Sequence of Events* | *Tensional Fracturing* | *Dyke Intrusion* | *Shearing* |
|---|---|---|---|
| 9 | – | – | N (local brecciation only) |
| 8 | – | Microdiorite | – |
| 7 | E, NW | – | – |
| 6 | – | – | N |
| 5 | – | Microgranodiorite | – |
| 4 | N | – | – |
| 3 | – | – | E, NW, N |
| 2 | – | Microdiorite | – |
| 1 | E, NW, N | – | – |

the tonalite, but their relationships to the other swarms are unknown. The first group of microdiorite dykes and the microgranodiorites are generally sheared along the margins. The tonalite country rock is generally massive, and it appears that the shearing was mainly confined to the fractures filled by the dykes. In one case, however, the shear plane passes at a low angle from the margin of a microgranodiorite dyke into the tonalite for several centimetres (Fig. 16). This suggests that the shearing took place after the dykes had cooled. Weak renewed movements along the shear planes is indicated by minor brecciation of an unsheared microdiorite dyke where it cuts an earlier sheared microgranodiorite.

The sheared dykes north of the Mount Dangar crossing are blastomylonites. The grainsize of the microgranodiorite (2116) ranges from 0.02 to 0.07 mm. The rock consists mainly of

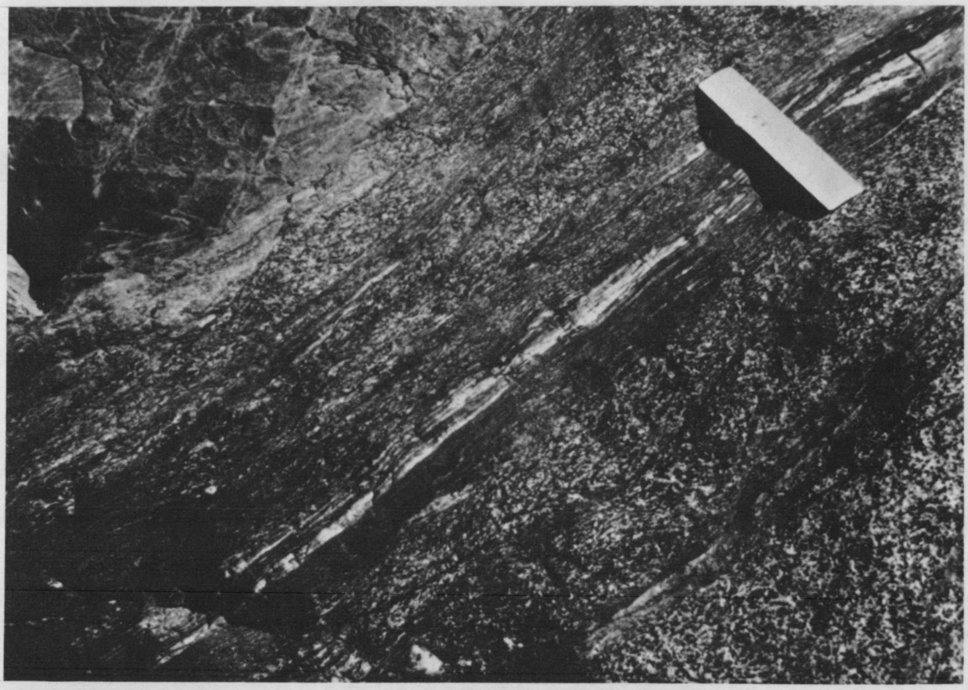

**Fig. 16. Mylonite zone in tonalite (Cud) in bed of the Don River upstream of the Mount Dangar crossing. Part of a sheared microgranodiorite dyke is visible in the top left-hand corner. The scale is 15 cm long.**

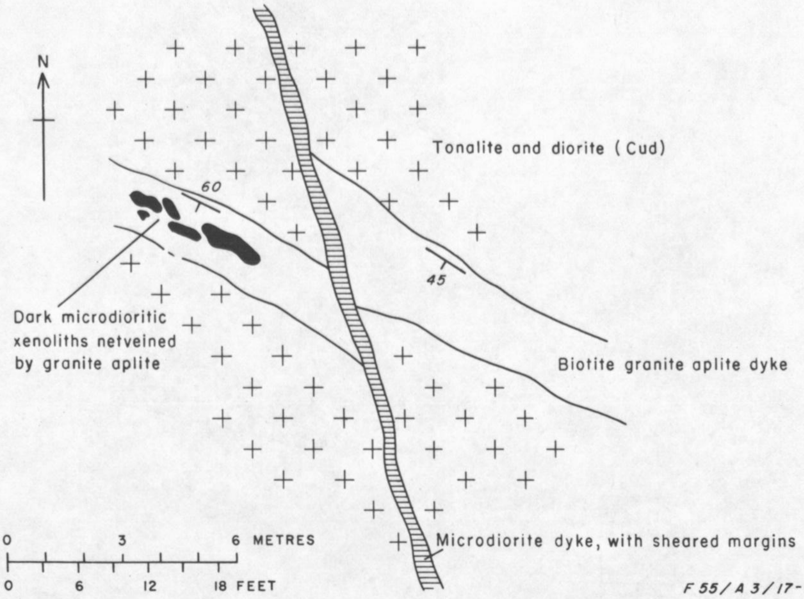


**Fig. 17. Dykes in bed of Boundary Creek, 1.5 km upstream from confluence with the Don River.**

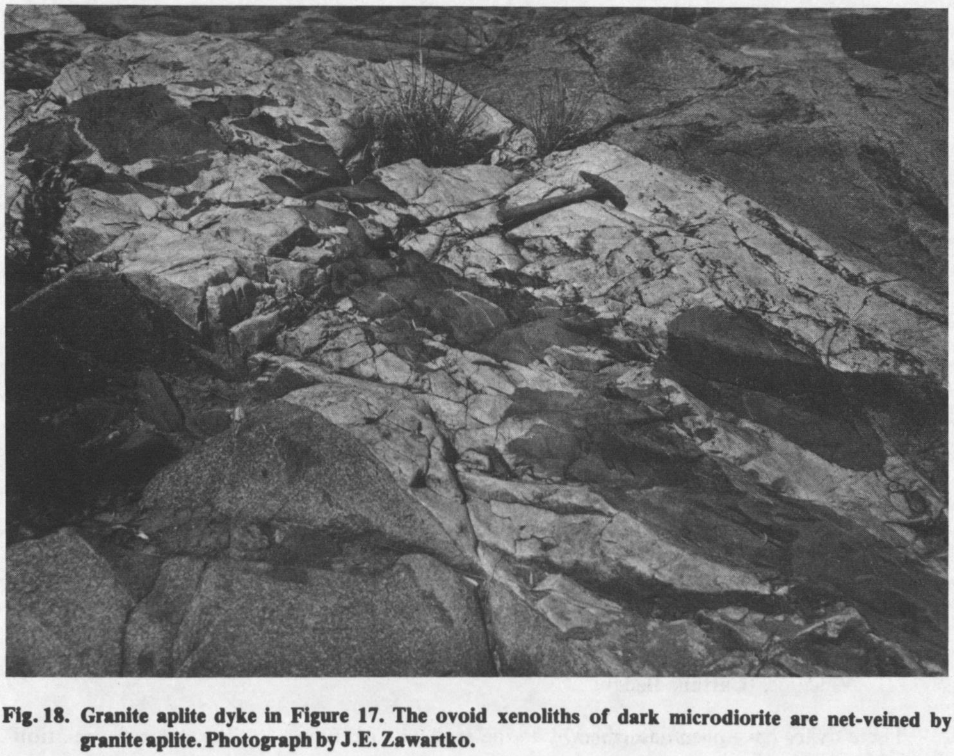

**Fig. 18. Granite aplite dyke in Figure 17. The ovoid xenoliths of dark microdiorite are net-veined by granite aplite. Photograph by J.E. Zawartko.**

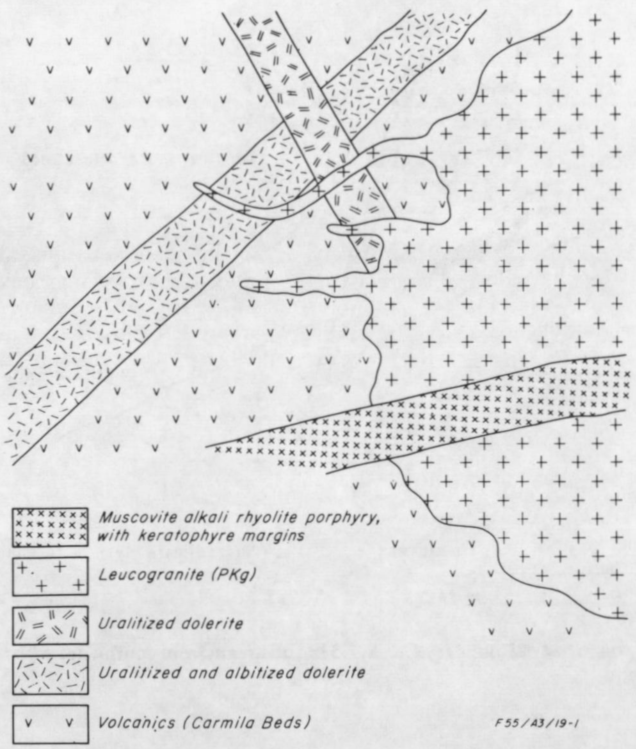


**Fig. 19. Diagram showing relationships of volcanics, granites, and dykes at North Head, near Bowen.**

grains of quartz (60%), some of which probably represent recrystallized phenocrysts, orthoclase (25%), andesine-labradorite (15%), and aggregates and laths of biotite (10%). The other microdiorite examined (2117) is similar in grainsize, but contains about 15 percent hornblende in addition to biotite, but very little quartz. The orientation of the mafic minerals imparts a pronounced foliation to the rock.

*Boundary Creek*

In the bed of Boundary Creek, 1.5 km upstream from its junction with the Don River, a microdiorite dyke whose margins are sheared cuts a thicker dyke of biotite granite aplite (Figs 17, 18). The granite aplite contains ovoid xenoliths of dark microdiorite net-veined by the granite aplite. It appears that the granite aplite dyke was intruded into a fracture occupied by a microdiorite dyke, or that granite aplite and microdiorite liquids, which failed to mix, were injected simultaneously into the fracture.

*Bowen Town District*

The following sequence of intrusion is evident in and around the town of Bowen:

(6) Meridional microgranite dykes
(5) Leucogranite stocks (PKg)
(4) Meridional basic to intermediate dykes
(3) Northwesterly basic to intermediate dykes
(2) Adamellite stocks or batholith (CPg)
(1) Volcanics (Carmila Beds)

These dykes have been described by Paine et al. (1970). Figure 19 illustrates the relationships at North Head.

*Mount Gibralter*

Localized swarms of east-west and subordinate meridional dykes intrude the Hecate Granite around Mount Gibralter. The dykes consist of spherulitic alkali rhyolite, leucocratic alkali microgranite, porphyritic microtonalite, porphyritic micrograncdiorite, and porphyritic fine-grained diorite.

*Age of the Dykes*

In the Lizzie Creek Volcanics the basic dykes only intrude the basalts, and andesite dykes only intrude the basalts and overlying andesites. Some of the dykes may have been feeders to the flows. Acid dykes, which are probably related to the Mount Wickham Rhyolite, intrude both the Lizzie Creek Volcanics and the Mount Wickham Rhyolite. Basalt and andesite dykes appear to be absent from the Mount Wickham Rhyolite northeast of the Bowen River, although Malone et al. (1966) record dolerite dykes intruding the rhyolite in the Glenmore Creek area.

There are relatively few dykes of microdiorite in the Thunderbolt Granite and most of the dykes in the diorite suite (Cud) northeast of the Bowen Basin are probably older than the Thunderbolt Granite. Some of the dykes were probably feeders to the Lizzie Creek Volcanics, and possibly also to the Carmila Beds. There are a few swarms of intermediate to basic dykes in the Thunderbolt Granite near Scrub Top Mountain, and a K/Ar hornblende age of 255 m.y. was obtained on one of the microdiorite dykes (spec. K55/3/107, Appendix) near Mount High in the Normanby goldfield. The relative scarcity of dark dykes in the Thunderbolt Granite may be due to the paucity of fractures in the granite compared with the numerous fractures in the diorite suite rather than a difference in age between the diorite suite and the Thunderbolt Granite.

The presence of a variety of dykes in the Hecate Granite at Mount Gibralter proves that some of the dykes are Lower Cretaceous or younger. Swarms of acid dykes, many of which are probably cone sheets, are associated with the Mount Abbot Igneous Complex, which appears to be about 10 m.y. younger than the Hecate Granite.

## TERTIARY
(Table 3)

### *Sediments (To)*

The flat-lying Tertiary sediments in the low-lying country southeast of Edgecumbe Bay are largely covered by superficial sand and alluvium. The sediments occupy the northern end of the Bowen-Proserpine Lowland, and are believed to be equivalent to the much thicker sequence in the Hillsborough Basin, a Tertiary graben in the Proserpine Sheet area. Seismic surveys indicate a maximum thickness of about 2200 m immediately southeast of Proserpine (Clarke et al., 1971), but the sequence thins rapidly to the northwest, and in the Bowen Sheet area the sediments are probably only 30 to 60 m thick.

In the Bowen Sheet area the sequence consists chiefly of coarse argillaceous sandstone, sandy claystone, and conglomerate. Polymictic cobble to boulder conglomerate and sandy claystone are well exposed at White Cliffs on the shore of Edgecumbe Bay. The clasts in the conglomerates consist mainly of volcanic rocks, but the sand content and the matrix were probably derived mainly from the Hecate Granite. Weakly lateritized conglomerate and sandstone are exposed along the Bruce Highway immediately southeast of Greta Creek. Ferruginous pisolites have been developed on the surface of the mottled sandstone to the north of where the Bruce Highway crosses Longford (Eden Lassie) Creek.

The silicified wood reported to occur in Greta Creek, was presumably derived from the Tertiary sediments. Palynological evidence from the Proserpine 1 well southeast of Proserpine suggests that the sediments are of late Tertiary or late Cretaceous age (Evans *in* Clarke et al., 1971). The sediments in the Bowen Sheet area are considered to be late Tertiary because of their strong resemblance to the Campaspe Beds in the Charters Towers Sheet area.

### *Basalt (Tb)*

Remnants of an olivine basalt flow, about 2 m thick, were found 3.5 km northeast of Mount Graham at the western edge of the Sheet area.

The basalt consists of phenocrysts of zoned plagioclase ($An_{68}$-$An_{50}$) and olivine, up to 2 mm long, set in a fine-grained groundmass of plagioclase laths, granular to prismatic colourless augite, and iron oxide, with some interstitial pigmented glass and pale green chlorite.

The basalt overlies the deeply weathered Star of Hope Formation. Its freshness suggests that it may be younger than the late Oligocene(?) basalts which intrude and overlie the sediments of the Bowen Basin.

## QUATERNARY

(Table 3)

### *Residual and Colluvial Sandy Soil (Qs)*

Large expanses of residual sandy soil and some colluvial material mask the bedrock along the northern edge of the Sheet area. The sand and soil-covered areas have a gently undulating surface at a higher elevation than the depositional plains developed on the adjoining areas of alluvium. Some of the sand and soil is semi-consolidated, and may be Tertiary. Small areas of residual sandy soil occur elsewhere in the Sheet area, but are not shown on the map. The maximum thickness of the sand and soil is about 3 m.

### *Alluvium (Qa)*

Extensive alluvial plains have been developed along the larger streams, such as the Burdekin, Don, Proserpine, and Andromache Rivers, and Euri Creek. Most of the alluvial plains are co-extensive with the coastal plain, and were probably formed during the same cycle of degradation and aggradation. As a result of recent uplift some of the streams, notably the Burdekin River, flow in well incised channels up to 25 m below the level of the plains. Elsewhere, as for example in the upper reaches of the Don and Proserpine Rivers, most of the alluvium was removed by erosion when the streams were rejuvenated.

Most of the alluvium is probably of Quaternary age. The consolidated pebbly grit and lenses of conglomerate, exposed in the beds and banks of some of the creeks, as for example Expedition Pass Creek, north of the cattle yard, are probably of the same age as the late Tertiary sediments in the Bowen-Proserpine Lowland and the Campaspe Beds in the Charters Towers Sheet area.

The alluvium bordering the Burdekin River in the Bowen Sheet area is probably up to 30 m thick, and the thickness in the Don River delta is about the same (Kevi et al., 1968, unpubl.)

### *Coastal Mud Flats (Qm)*

Littoral and estuarine mud flats, which are periodically inundated by high tides and floods, occupy an area of several square kilometres along the foreshore of Edgecumbe Bay, notably at the mouths of the Gregory River and Eden Lassie Creek. On the seaward side the flats are commonly overgrown by mangroves, whereas on the landward side they are generally blanketed by a thin layer of salt. The salt has a white tone on the air-photographs, and the mangrove swamps a contrasting black tone. The mud flats merge into the stream alluvium.

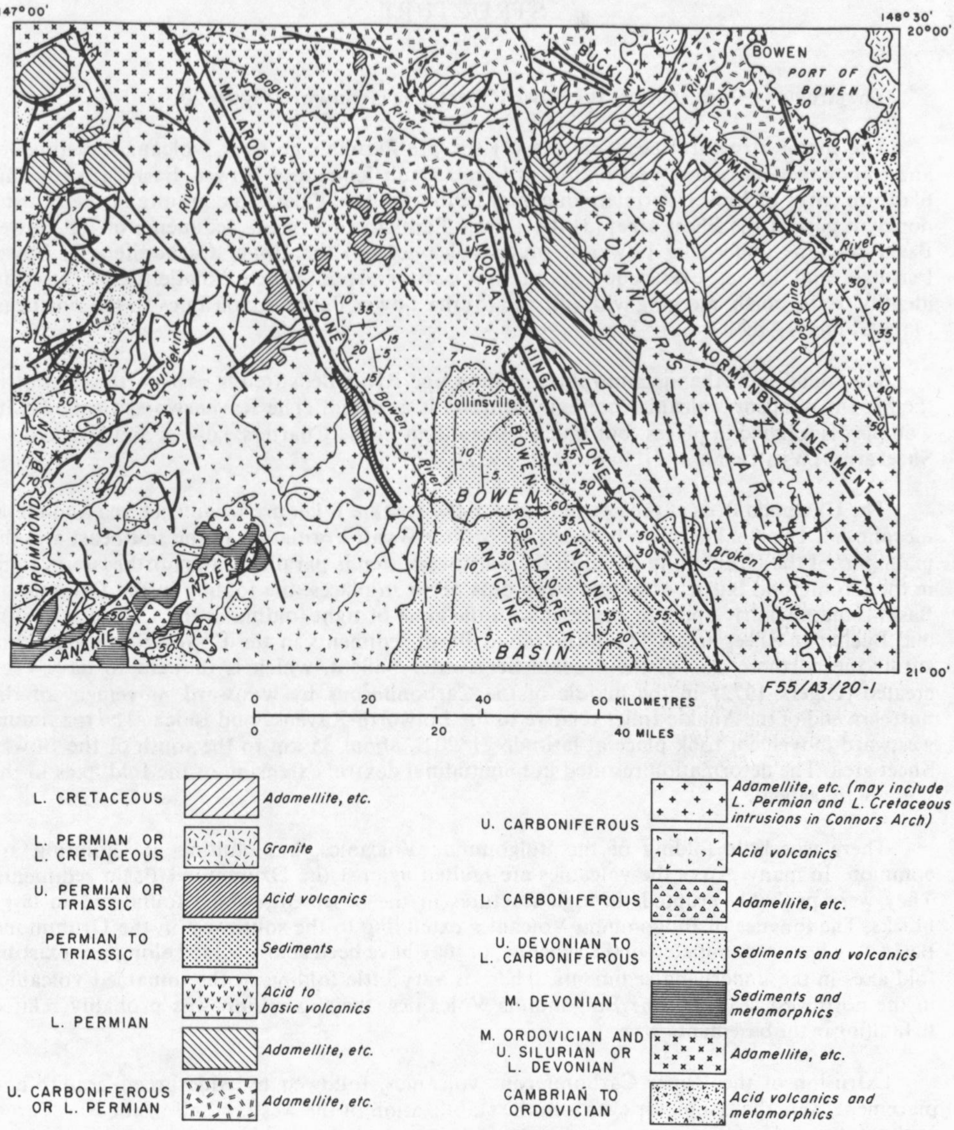


**Fig. 20. Structural framework.**

## *Coastal Sand Ridges (Qr)*

In places the shores of Edgecumbe Bay are fringed by beach ridges and sand dunes. Some of the ridges extend several kilometres inland. Beach rock with a calcareous cement occurs between tide marks in places, notably just west of Gloucester Park tourist resort.

## *Outwash and Talus Deposits (Qu)*

Tongues of talus, now largely stabilized by vegetation, occur around Mount Roundback and along the west side of Gloucester Island. The tongues at Mount Roundback are now being eroded, and were probably formed during a different climate.

Low-angle outwash fans, which are being dissected by the present stream system, occur along the east side of McGregors Bonnet and at the foot of the low hills between McGregors Bonnet and the Burdekin River.

# STRUCTURE

The structural framework of the Bowen Sheet area is shown in Figure 20.

The major structural elements are (1) the pre-Permian granites, volcanics, sediments, and minor metamorphics west of the Millaroo Fault Zone and Bowen Basin; (2) the thin platform cover of Lower Permian volcanics resting on late Palaeozoic granite in the central-northern part of the Sheet area; (3) the Lower Permian to Triassic sediments of the Bowen Basin and the underlying Lower Permian volcanics; (4) the Upper Carboniferous, Lower Permian, and Lower Cretaceous granitoid Connors Arch, which broadens and loses its identity to the north, merging with (2); and (5) the Lower Permian volcanics to the northeast of the Connors Arch.

The foliation in the metamorphics of the Cape River Beds trends east-northeast, but in the Mount Windsor Volcanics no regional trend is apparent. The Ravenswood Granodiorite Complex is foliated in places, but much less so than in the Charters Towers and Hughenden Sheet areas (Wyatt et al., 1971; Paine et al., 1971).

The Ukalunda Beds at the northern end of the Anakie Inlier are locally cleaved and metamorphosed. The Anakie Inlier, between the Mount Wyatt Formation to the southeast and the main part of the Drummond Basin to the northwest, trends parallel to the northeasterly folds in the Drummond Basin. Although steep dips occur in places, the folding in the Drummond Basin is mainly fairly open, in contrast with the zone of tight folding in the Charters Towers and Buchanan Sheet areas. The Drummond Basin sediments in the Bowen Sheet area constitute the northern arm of the arcuate Scartwater Salient, which is thought to have been created (Olgers, 1972) in the middle of the Carboniferous by westward movement of the northern end of the Anakie Inlier relative to the Lolworth-Ravenswood Block. The maximum westward movement took place at latitude 21°20'S, about 35 km to the south of the Bowen Sheet area. The deformation resulted in longitudinal dextral extension of the fold axes in the limbs of the salient.

There was little folding of the Bulgonunna Volcanics, but faulting and jointing are common. In many places the volcanics are faulted against the Drummond Basin sediments. They were probably erupted through fractures in the basement, which foundered in large blocks. The tongues of Bulgonunna Volcanics extending to the southwest in the Drummond Basin may have accumulated in the syncline, or may have been gently folded along pre-existing fold axes in the underlying sediments. There is very little folding in the unnamed volcanics in the northwest, and like the Bulgonunna Volcanics, their extrusion was probably related to faulting in the basement.

Extrusion of the Upper Carboniferous volcanics, followed by widespread granite emplacement, were the last major events in the stabilization of the western half of the Sheet area. In the eastern half, tectonic movements continued into the Permian Mesozoic.

The thin sequence of Lizzie Creek Volcanics resting on granite in the north is relatively undeformed. The volcanics are bounded to the west by the Millaroo Fault Zone. This shelf is a northerly extension of the Springsure Shelf in the western part of the Bowen Basin. The sequence on the shelf is relatively thin and only gently folded. The Collinsville Coal Measures overlap the Lizzie Creek Volcanics in the shelf zone.

To the east, 6000 to 9000 m of volcanics and sediments was laid down in a trough which extended east from the axis of the Bowen Syncline and overlapped the area now occupied by the Connors Arch. The trough varied considerably in size during the Lower Permian. During the Upper Permian and Triassic it contracted westwards to the area now mainly occupied by the Bowen Syncline. The most conspicuous structure in the Bowen Basin is the steeply dipping east flank of the Bowen Syncline, which is outlined by the Back Creek Group. The group trends north-northwest and dips to the west-southwest at 40° or more. The axis of the syncline is occupied by discontinuous outcrops of Clematis Sandstone, and lies east of the centre of the Bowen Basin. The asymmetry is due to the greater thickness of sediment laid down in the eastern trough, and to stronger folding. The Rosella Creek Anticline is a major modification of the otherwise simple synclinal structure of the basin. It bifurcates at the southern end into several smaller anticlines. The dips on its flanks are steep in places.

The Connors Arch (Malone, 1964) is a belt of Upper Carboniferous and younger granitoid rocks which separates the Bowen Basin from the complementary volcanics to the northeast. To the north, the Almoola Hinge Zone dies out and the arch broadens and loses its identity.

It was probably not until the Upper Permian that the arch began to assume its present structural significance, and its major uplift took place at the end of the Triassic, simultaneously with the main folding in the Bowen Basin. Further uplift probably occurred in the Lower Cretaceous, during or after the intrusion of the Hecate Granite.

The Carmila Beds dip away from the Connors Arch to the east-northeast in a large homocline at an average dip of 30° to 40°. No reversals of dip have been recorded in the Bowen Sheet area. The older Edgecumbe Beds occupy a homocline that has a similar strike, but dips east much more steeply. The relative positions of the homoclines can be explained only by postulating a major fault with an upthrow to the east.

*Faults and Shear Zones*

Two regimes of faulting, separated by the Millaroo Fault Zone, are recognizable: in the west there is no one predominant direction, but in the centre and east most of the faults trend northwest to north-northwest.

The faults in the basement in the west are of small extent. The most common trends are southwest, south, and southeast. Two arcuate faults in the southwest are occupied by dykes which were probably feeders to the Bulgonunna Volcanics.

In the centre and east there are several major faults and fault zones. The Almoola Hinge Zone has been the main locus of uplift at the northern end of the Connors Arch. One of the main faults in the Almoola Hinge Zone is the Collinsville Fault (Webb & Crapp, 1960) on which the movement was high-angle reverse, east block up. The Lizzie Creek Volcanics were upthrown against the lower beds of the Blenheim Sub-group, cutting out the Collinsville Coal Measures, which are 215 m thick, but the throw is probably much greater. At its southern end the fault dies out and passes into steeply dipping sediments. The Collinsville Coal Measures are cut by other north-northwesterly faults, most of which are high-angle reverse faults downthrown to the west. To the east there is a series of faults parallel to the Collinsville Fault, one of which forms the boundary between the Lizzie Creek Volcanics and the Upper Carboniferous diorites in the Connors Arch. This fault also dies out to the south, where its displacement is taken up by folding. Near the southern edge of the Sheet area the Urannah Igneous Complex and Connors Volcanics are separated from the overlying Lizzie Creek Volcanics and Back Creek Group by north-south faults. The relative movement is west block down, and the faults are probably related to the uplift of the Connors Arch.

The Millaroo Fault Zone forms the general western limit of the Lower Permian volcanics. Local folds occur in the volcanics along the fault zone.

Major shears, in which the movement appears to have been horizontal, occur in the Buckley Lineament and to a lesser extent in the Normanby Lineament. The Mount Buckley, Mount Dangar, and Mount Challenger Shears (see map) were formed during the intrusion of the Lower Cretaceous granites, and the other shears, although apparently cutting Palaeozoic granitoid rocks, may have originated at the same time. The sense of movement on the inferred major fault in the northeast, between the Carmila Beds and Edgecumbe Beds, is also west block down.

## GEOLOGICAL HISTORY

In the Cambrian and possibly Lower Ordovician a sequence of sediments and acid volcanics (Cape River Beds) was deposited in the western part of the Sheet area. The presence of small remnants of similar rock (Pzu) near the Burdekin River suggests that the sequence may once have extended farther east. In the Middle Ordovician (455 m.y. ago), and possibly again in the Upper Silurian or Lower Devonian (395 m.y. ago), the sediments and volcanics were intruded by a large composite batholith (Ravenswood Granodiorite Complex) that converted part of the sequence to schist, gneiss, and granofels. These events led to the formation of the Lolworth-Ravenswood Block (Wyatt et al., 1970).

In the lower Middle Devonian (Couvinian Stage), while the Lolworth-Ravenswood Block was being uplifted and eroded, the area to the southeast subsided, and a considerable thickness of sediment (Ukalunda Beds) accumulated in a moderately deep marine basin. During the Givetian and Frasnian Stages the Ukalunda Beds were folded, uplifted, and partly eroded.

In the central and eastern parts of the Sheet area all evidence of these events has been obliterated.

In the uppermost Devonian (Fammenian Stage) deposition was resumed on both sides of a northeasterly trending axis of folded Middle Devonian sediments (Anakie Inlier). Freshwater conditions prevailed to the northwest (St Anns Formation), and a shallow marine environment to the southeast (Mount Wyatt Formation). The two environments (Drummond Basin) probably interfingered across the inlier. To the northwest, deposition persisted into the Lower Carboniferous (Scartwater, Mount Hall, and Star of Hope Formations), and sedimentation was accompanied at times by the eruption of acid volcanics. At the same time a thick sequence of strata (Edgecumbe Beds) was laid down 150 km to the northeast, in the northeastern corner of the Sheet area; to begin with the Connors Arch to the east was covered by the sea, but after a time volcanics were erupted, and still farther east in the Proserpine Sheet area volcanics predominate to the exclusion of sediments. Remnants of acid volcanics of possibly similar age (Connors Volcanics) unconformably underlie the Lizzie Creek Volcanics in places along the eastern edge of the Bowen Basin.

Probably in the late Lower Carboniferous (330 m.y. ago) granite (Clg) invaded the crust in the southwest. The granite was probably emplaced at a moderate depth in the crust (mesozone) and was probably responsible for the dynamo-thermal metamorphism of the Ukalunda Beds.

The isotopic ages (Webb & McDougall, 1968, pp. 320-4) indicate that the oldest of the granitic rocks forming the Connors Arch were emplaced in the Upper Carboniferous (310-305 m.y. ago). They comprise the diorite suite (Cud), and parts of the Urannah Igneous Complex and undivided late Palaeozoic granite (CPg).

In the uppermost Carboniferous (about 290-285 m.y. ago) the crust in the southwest was fractured, and a great volume of acid magma rose to the surface. Much of the magma was erupted as continental pyroclastic flows (Bulgonunna Volcanics and unnamed unit 'Cuv'), and the rest cooled to form a large adamellite batholith (Cug). Intrusive activity was probably renewed in places in the Connors Arch, and in areas occupied by the late Palaeozoic granites. The small intermediate to basic intrusions (CPi) in and around the Drummond Basin may also have been emplaced at this time. The Lizzie Creek Volcanics in the centre of the Sheet area are probably underlain mainly by granite of this age.

During the period of quiescence which followed the cover rocks of the Upper Carboniferous granite were partly eroded away. In the Lower Permian, magma once again rose to the surface. To the east of the Millaroo Fault Zone and north of the Bowen Basin a thin sequence of basalt and andesite, with intercalated continental sediments (Lizzie Creek Volcanics), was deposited on a stable platform of granite. At the same time the area now occupied by the Connors Arch subsided, and several thousand metres of basalt and andesite, with marine sediments near the top (Lizzie Creek Volcanics), was laid down on and along the southwest edge of the arch. In the northeast a thick sequence of continental acid to intermediate volcanics and sediments (Carmila Beds) was laid down. The isolated Kurungle and Mount Aberdeen Volcanics were probably also erupted during this period of volcanism.

The intrusion of an enormous number of dykes in the Connors Arch was presumably accompanied by a considerable extension of the crust in an east-west direction. Some of the dykes (e.g. spec. F55/3/107, Appendix) were emplaced in the Permian, but most of them are regarded as feeders to the Lizzie Creek Volcanics and Carmila Beds, which dip off the arch to either side. The extension may have been due to subsidence, and there was not necessarily any compression in the adjoining areas.

At about the same time as the volcanics were erupted, and while the area now occupied by the Connors Arch was being downwarped, ring fractures were formed in the Leichhardt Range, and a number of high-level oval granite stocks (Plg) and ring dykes (Plr) were emplaced in the early Palaeozoic granite. Meanwhile, a mesozonal adamellite batholith (Thunderbolt Granite) was emplaced in the Upper Carboniferous diorites. During the deep burial and reheating of the diorite suite and Urannah Igneous Complex all the radiogenic argon in the ferromagnesian minerals was expelled and the K/Ar radiometric 'timer' was reset to Lower Permian time.

In the middle of the Lower Permian the volcanic activity waned, and after a short break, downwarping of the Bowen Basin began afresh, and a thick sequence of sediments (Tiverton Sub-group) was laid down in a basin which was still open to the sea. At first, the sediments accumulated only in the zone of most active downwarping near the eastern edge of the basin, where deposition kept pace with subsidence. The Gebbie Sub-group was then laid down in a shallow sea which extended much farther to the north and west, and the Collinsville Coal Measures were formed in deltas and swamps around the margin of the basin. The Blenheim Sub-group was then laid down during an even more widespread marine transgression which came to a close early in the Upper Permian, when the shoreline retreated and freshwater conditions prevailed. In the Upper Permian the sediment (Blackwater Group) was derived largely from the volcanics on the emerging Connors Arch.

At the end of the Permian, or early in the Triassic (230 m.y. ago), acid magma rose to the surface to form the volcanic plugs and flows (Mount Wickham Rhyolite) piercing and overlying the Lizzie Creek volcanics and Upper Carboniferous granite. At times volcanic ash drifted to the southeast and was incorporated in the sediment laid down in the Bowen Basin.

The Triassic sequence in the Bowen Basin (Rewan Formation and Clematis Sandstone) conformably overlies the Upper Permian strata. The Rewan Formation contains abundant redbeds, but is abruptly overlain by the pebbly quartzose Clematis Sandstone. The change in the type of sediment laid down was probably brought about by a slowing down in the rate of subsidence, which resulted in more thorough reworking of the detritus. The folding of the sediments in the Bowen Basin possibly began during sedimentation and was probably completed towards the end of the Triassic. The birth of the Connors Arch in its present form took place about the same time as the folding of the sediments in the Bowen Basin. The uplift along the western side of the arch took place along the Almoola Hinge Zone (Fig. 20).

The next main structural event was the intrusion of a large granodiorite-adamellite batholith (Hecate Granite) into the northern part of the Connors Arch in the Lower Cretaceous (125 m.y. ago). The metamorphic aureoles and pegmatites associated with the Hecate Granite indicate that it was emplaced at a relatively deep level. The entire northern end of the Connors Arch may have been uplifted as a result of renewed movements on the Almoola Hinge Zone. Most of the gold and minor base metal deposits in the Connors Arch appear to be related to the Hecate Granite.

The small heterogeneous laccoliths and sills (Ki) in the Bowen Basin were emplaced at about the same time, but probably at a much higher level than the Hecate Granite. Ten million years later the subvolcanic Mount Abbot Igneous Complex was emplaced in the late Palaeozoic granites in the north. The mechanism of intrusion was probably similar to that of the Lower Permian stocks in the Leichhardt Range.

In the Oligocene or early Miocene, a thin sequence of terrestrial sediments (Suttor Formation) and plateau basalts (Tb) were laid down in the south and southwest. The basalts and the sediments were lateritized during a period of prolonged deep weathering. As a result of subsequent erosion only remnants now remain. The veneer of semi-consolidated and weakly lateritized outwash deposits (To) southeast of Edgecumbe Bay was probably deposited late in the Tertiary.

The most recent alluvial (Qa), residual (Qs), and outwash (Qu) deposits are now being dissected, but deposition of littoral mudflats (Qm) and sandbars (Qr) is still going on.

# ECONOMIC GEOLOGY

The economic geology of the northern and southeastern parts of the Bowen Sheet area are described in this Report. The coal deposits of the Bowen Basin and the silver deposits in the Sellheim-Ukalunda area, which were not mapped during the present survey, have been described by Malone et al. (1966). A resume of the economic geology of the whole Sheet area appears in the Explanatory Notes (Paine & Cameron, 1972).

Gold accounts for most of the mineral production in the area covered in this Report. The gold was produced from numerous small mines which had short productive lives, the most important of which was the Dittmer mine near the eastern edge of the Sheet area. A little silver and copper were also won, mainly from the Dittmer mine. The gold and minor base metal mineralization in the northeast appears to be related to the Lower Cretaceous Hecate Granite, and represents the Mackay metallogenic epoch of Webb (1969).

Some gold almost certainly remains at Normanby, but the area is relatively inaccessible. Substantial reserves of limestone occur in the northeast. There are three small occurrences of magnesite, ochre, and tungsten. An uneconomic skarn-type deposit of magnetite is described. A reported radioactive occurrence is listed, and there are large reserves of granite suitable for facing stone.

Apart from the coal mines at Collinsville, no mines or quarries are in production at present.

All the gold mined in the eastern part of the Sheet area was associated with primary base metal sulphides, and many of the mines, notably those at Normanby, were abandoned because the ores were difficult to treat. The area is considered to have some potential for the discovery of small mesothermal gold and base metal deposits, and large low-grade copper (and possibly also molybdenum) deposits of the porphyry type, particularly southeast of Mount Aberdeen and southwest of Birralee homestead.

### *Gold*

*Kelsey Creek area.* There are many gold occurrences in the ranges west of Kelsey Creek, including the Dittmer, the most important metalliferous mine in the Sheet area. The following geologists have carried out inspections, most of which were at the Dittmer mine: Cameron (1907), Conolly (1947, unpubl.), Denmead (1946a,b,c, 1947, all unpubl.), McKeown (1944, unpubl.), Morton (1921a, 1946), Munn (1950, unpubl.), Reid (1935c, 1936, 1937a, 1940), Ridgway (1935b, 1939b; 1939a, 1940a,b, 1941,a,b,c,d, 1942, all unpubl.), and Zimmerman & Branch (1961, unpubl.). In addition, petrographic reports have been written by Knight (1940a,b, 1945, all unpubl.), and reports have been prepared by the Mineragraphic and Ore Dressing Sections of CSIRO (1940a,b,c,d; 1944, 1948, 1949, 1954, all unpubl.).

The ore at the *Dittmer* mine was unusually rich, and the total recorded production (Table 5) is about 55 000 oz of gold, 23 000 oz of silver, and 296 tons of copper from 17 000 tons of ore.

The mine is situated at the head of Kelsey Creek, 52 km south-southeast of Bowen. Almost all production came from the Duffer vein, which averages 13 cm in width and is at least 500 m long. The vein strikes south-southwest, and has been worked over a length of about 275 m, and to an inclined depth of between 150 and 180 m. The country rock is fine-grained silicified, epidotized, and pyritized andesite of the Carmila Beds, with subordinate andesite and dacite breccia. The vein crops out close to a boss of diorite, which is possibly a contaminated cupola of the Hecate Granite. The main contact with the Hecate Granite is less than 1 km from the mine.

Production begin in 1935. Morton (1946) estimated that average recovery to the end of 1944 was 5 oz of gold, 2 oz of silver, and 2.5 percent copper per ton. By 1947 the reserves of ore became depleted, and in 1948 the mine closed down. The firm was reorganized into a public company with the aim of milling the remaining lower-grade ore and the accumulated dumps (see CSIRO, 1945). Production resumed in 1949 and continued to 1951, but the ven-

TABLE 5. RECORDED PRODUCTION FROM DITTMER GOLD MINE

| *Year* | *Ore (long tons)* | *Gold (fine oz)* | *Silver (oz)* | *Copper (long tons)* |
|---|---|---|---|---|
| 1935 | 52.76 | 368.26 | 219.05 | 0.89 |
| 1936 | 115.05 | 700.45 | 106.80 | 1.13 |
| 1937 | 359.89 | 2 338.51 | 869.33 | 12.42 |
| 1938 | 892.45 | 4 998.54 | 2 218.92 | 26.13 |
| 1939 | 1 393.78 | 6 370.02 | 2 927.90 | 32.17 |
| 1940 | 1 317.53 | 5 142.06 | 2 353.73 | 27.62 |
| 1941 | 1 364.78 | 7 793.52 | 3 194.78 | 45.17 |
| 1942 | 1 367.38 | 6 972.02 | 3 211.12 | 35.77 |
| 1943 | 1 167.66 | 5 146.22 | 2 047.78 | 25.73 |
| 1944 | 700.17 | 3 553.49 | 1 702.77 | 22.78 |
| 1945 | 981.60 | 4 585.84 | 2 308.27 | 30.08 |
| 1946 | 775.54 | 3 857.74 | 1 762.05 | 28.12 |
| 1947 | 227.19 | 1 074.54 | 456.44 | 7.55 |
| 1948 | – | – | – | – |
| 1949 | 1 920 (dumps) | 334.5 | – | – |
| 1950 | 3 906 | 369.82 | 31.82 | – |
| 1951 | 585.3 | 931.41 | 7.38 | – |
| *Total* | 17 126.78 | 54 536.94 | 23 418.4 | 295.56 |

ture proved unprofitable, and the company failed to discover further ore. Operations were abandoned in 1952.

An adit (Young Crusader mine) was driven 235 m into the hill immediately north of the Dittmer mine, but the Duffer vein, where intersected by the adit, was found to be barren (Morton, 1946; Denmead, 1946b, unpubl.). Three diorite dykes were intersected by the adit.

The Dittmer ore (CSIRO, 1940d, unpubl.) consists of pyrite and chalcopyrite, with subordinate sphalerite, galena, and bournonite, and a trace of pyrrhotite. The pyrite has been partly replaced by the base metal sulphides. The fractured coarse crystals of pyrite contain thin zones which have been recemented by quartz and later sulphides. Most of the chalcopyrite was introduced later, and tends to be aligned parallel to the fracture planes.

Most of the gold occurs as fine grains in the pyrite crystals. The gold content increases in the presence of chalcopyrite, galena, and bournonite. Coarse particles of gold occur only in association with galena and bournonite. Some of the gold was introduced with the pyrite, but some of it was introduced after the pvrite was shattered.

In the *'Lady Denise'* area (Denmead, 1947, unpubl.) small gold-bearing veins occur along the faulted contacts between andesite roof pendants and granite 1.5 km south of the Dittmer No. 1 shaft.

Auriferous quartz veins in the Carmila Beds were worked in the Happy Valley area north of Dittmer between 1874 and 1909. The main producers were the *Golden Fleece* (260 oz), *Lamington* (about 500 oz), and *Commonwealth* (about 90 oz). As at Dittmer, chalcopyrite was an important ore mineral. Most of the ore was produced from the oxidized zone, and some alluvial gold was won in the early years of the field.

In a report on the *Silver Wattle* claim on the northwest slopes of Mount Quandong, Ridgway (1941a, unpubl.) noted that the ore shoots in the Dittmer area commonly occur where veins cut porphyry dykes in andesite.

The *Rise and Shine* (or Loch Neigh) mine was located 1 km west of the Dittmer mine, on the western slope of a range of hornfelsed Carmila Beds. The auriferous vein was up to 30 cm wide; in 1939 20 oz of gold was produced from 12 tons of ore (Ridgway, 1939a, unpubl.).

The *Golden Hill* mine (Ridgway, 1940a, unpubl.) was situated in highly indurated arkosic conglomerate about 7 km southeast of the Dittmer mine. The conglomerate is intruded by fine-grained diorite and porphyry dykes. The reef contains pyrite, chalcopyrite, and a little sphalerite.

Zimmerman & Branch (1961, unpubl.) examined a prospect 400 m south of the Dittmer mine, and reported that the granite nearby (Hecate Granite) had an aplitic contact zone rich in pyrite. Gold was found in a vein of green pug in the volcanics, and slugs of gold and molybdenite were found in a gully in the granite close to the contact.

Morton (1921a) inspected some auriferous veins which had been found in the Hecate Granite, 5 km south of Proserpine homestead, but no production is recorded.

*The discovery of the Normanby Goldfield* (Fig. 21) resulted in a short-lived gold rush in the 1870s. There was a revival in 1887, and the population reached 300 in 1891, but owing to the inaccessibility of the field, and the absence of facilities for treating sulphide ore, the mines closed down one by one, and all work ceased in 1908. More auriferous veins were discovered in rugged country east of Grant Creek in 1920. Jack (1879b, 1889, 1893), Morton (1920, 1921a; 1926, unpubl.), and Ridgway (1937, unpubl.) have reported on the field. The workings are situated in rugged country in the Clarke Range; Morton (1920) accurately described the lie of the land when he wrote 'The whole surface of the country is very much broken, and for miles in any direction it would be difficult to find one acre of level ground'.

The discovery of Normanby before a successful method of extracting gold from sulphide ore had been developed prompted Jack (1889) to remark that the field had been discovered too early. The oxidized zone was thin and quickly exhausted, and the dispirited miners left to join the rush to the Palmer River. As early as 1872 some of the mines had been abandoned 'on account of the mundic difficulty' (Shakespeare, 1889). In the temporary revival in the 1880s and 1890s attempts were made to reclaim the gold by simple amalgamation, but as the gold occurs as fine particles in the sulphides the method proved to be ineffective. The effectiveness of amalgamation was further reduced by the presence of copper, arsenic, and bismuth. Morton (1920) concludes that 'All the evidence goes to show that the reefs did not cut out entirely in depth; in many cases they certainly pinched in size . . . ' but 'in other cases the influx of water at the water level proved too much for the means then in vogue of dealing with it'.

Total recorded production to 1906 is about 6000 oz of reef gold and 2000 oz of alluvial gold, but the records, especially of alluvial production, are incomplete. Morton (1920) recorded a total of 39 producing mines.

Most of the auriferous veins strike northwest to north-northwest, and dip between 60° and 85° to the northeast; there is a subsidiary series of easterly trending veins dipping north at a high angle. The veins were generally from 15 to 30 cm wide with bulges up to 1 m; the largest was the Albion, which was commonly 2 m thick, swelling in places to 3 m. The primary minerals were pyrite, chalcopyrite, galena, and rare sphalerite, arsenopyrite, and bismuthinite. A little secondary chalcocite was noted by Morton (1920) in the Glengarry mine. Bismuthinite at the Grace Darling P.C. contained particles of gold visible under a hand lens. This mine has the deepest shaft (130 m), but few of the other workings on the field went below 30 m. The zone of oxidation was thin, averaging less than 15 m, and in nearly all cases sulphides were found at the surface. Most of the gold occurred in pyrite of a paler colour than normal.

Diorite is the principal host rock, but some of the veins occur in granite (Morton, 1920); both the granite and diorite are intruded by numerous dykes of fine-grained diorite. The coarse diorite grades into hornblende gabbro and hornblendite, and many of the melanocratic varieties, including the dykes, contain disseminated pyrite.

Morton (1921a) noted that the auriferous veins are the youngest component of the complex sequence of intrusions, and that most of the veins have the same trend as the northwesterly to north-northwesterly dykes.

*The Mount Hector area* (Fig. 21) was the centre of considerable mining activity in the

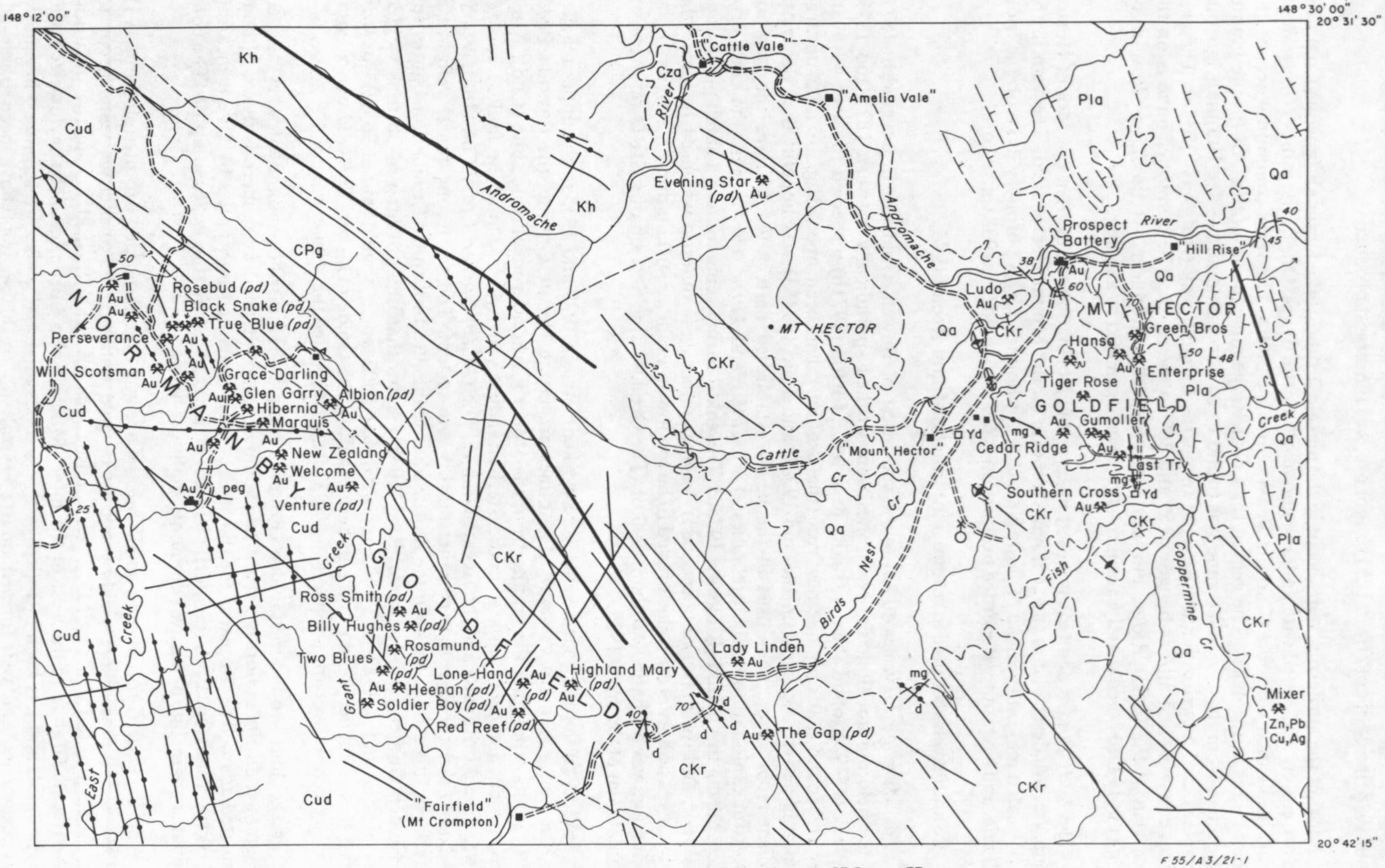


**Fig. 21. Mines in the Normanby Goldfield and east of Mount Hector.**

1930s. Inspections were made by East (1946), Reid (1935b, unpubl.), and Ridgway (1935a,b,c ). The Cedar Ridge mine, which was worked between 1932 and 1939 for a total output of 1928 fine oz of gold from 1255 tons of ore, was the largest producer.

Most of the auriferous veins occur in the marginal zone of the Urannah Igneous Complex, and are closely associated with andesite and microdiorite dykes. One of the mines *(Green Bros)* occurs in silicified volcanics (Carmila Beds) near the contact. The veins commonly occupy the same fissures as the dykes. The vein in the Cedar Ridge mine has a footwall of biotite granite (a specimen from the *Gumoller* mine was found to be a trondhjemite — see Urannah Igneous Complex), and a pyritized andesite dyke forms the hanging wall (Ridgway, 1935a). The vein strikes east-west and dips at between 25° and 30° to the north. The Gumoller mine is on the same vein as the Cedar Ridge, but was a much smaller producer. At the *Tiger Rose* mine Ridgway (1935b) noted that the auriferous vein was displaced by a dyke.

The *Lady Linden* and *Gap* mines are nearer the Normanby mines than the Mount Hector group, but are described in the geologists' reports on the Mount Hector field. The vein in the Lady Linden mine at the head of Birds Nest Creek is bounded by a porphyry dyke on the footwall side, and by granite. Recorded production is 601 oz of gold from 938 tons of ore.

Bismutite was recorded in several mines on the Mount Hector field.

*The Marengo Field* lies 40 km to the southwest of Bowen. Gold was discovered in 1871, but the field did not flourish. The mines were worked sporadically between 1871 and 1879, but Jack (1879b) found them virtually deserted. Morton (1921b) inspected the area 42 years later and found that only one new reef (the *Brilliant*), had been opened up. A mild upsurge of mining activity occurred in the mid-1930s, and Reid (1935d) was hopeful that the more efficient recovery methods used in the newly established battery would pave the way for successful exploitation of the orebodies. The *Motley* and *Lorna Doone* were the chief producers during this period (Ridgway, 1935d). The gold-bearing veins contain a small percentage of copper, and the presence of secondary copper minerals in outcrop was used to locate the gold veins. The auriferous veins proved to be too low in grade to sustain mining activity. Total production was probably less than 1000 oz. The Ore Dressing Section of CSIRO reported on the treatment of the ore in 1939.

Several auriferous quartz veins were worked between 1930 and 1935 in the upper reaches of *Eden Lassie (Longford) Creek*. The mines are in the Hecate Granite, the Carmila Beds, and in faults separating the granite from the Upper Carboniferous diorite suite (Cud). Most of the production came from a southeasterly trending vein system along the faulted contact between the diorite suite and the Hecate Granite. The *Golden Gusher, Crazy Cat, Anniversary,* and *Lady Ellen* are close to each other on this vein system. The auriferous quartz vein in the Lady Ellen fills a fault between the diorite and adamellite footwall. Production figures for the Golden Gusher are incomplete. Reid (1935e) states that one crushing of 38 tons yielded 81 oz of gold, and in 1937 (1937b) he reported that £400 worth of gold (about 90 oz) was won from a shaft 18 m deep, next to the underlie shaft of the Golden Gusher. The gold was accompanied by minor silver and copper. Reid (1937c) also inspected the *Albion* mine.

The geology around the Golden Gusher is complex. Thin roof pendants of recrystallized fine-grained diorite in hornblende-biotite adamellite are intruded by numerous dykes of contaminated adamellite. In places the diorite has been converted into gneiss by severe shearing and recrystallization. Both the diorite and adamellite are cut by thin dykes of aplite. The contaminated adamellite dykes are commonly slightly foliated.

The *Birthday Gift* mine was small, but the ore was rich. Recorded production from 1931 to 1935 is 351 tons of ore yielding 606 oz of gold bullion. The auriferous veins occur in greisenized diorite (Morton, 1932). The greisen was probably formed during the intrusion of the Hecate Granite to the west of the mine. Much of the diorite has been mylonitized and recrystallized, and has been intruded by dykes of sheared and greisenized aplite. The quartz veins are vuggy, and well formed quartz crystals up to 30 cm long have been observed. Ridgway (1935e, unpubl.) also visited the area.

At the *Lucky Strike* mine, Wyatt (1962) observed lenticular auriferous quartz veins between well defined walls in strongly sheared felsite. Production has been negligible.

At the *Elusive* mine on Mount McGuire, quartz veins containing pyrite, free gold, and bismuth telluride cut dark lavas and pyroclastics (Morton, 1934, unpubl.). Production is believed to have been small.

*Isolated occurrences.* Levingston (1962) described the *Armistice* prospect, 3 km northwest of Mount Dangar. Auriferous quartz veins occur in the sheared margin of a diorite dyke in the Hecate Granite. Only a very small amount of gold was recovered.

Ridgway (1935f, unpubl.) described the *Welcome* reef in coarse biotite granite 1.5 km south of Bootooloo siding. A diorite dyke forms the hangingwall, and a silicified quartz-feldspar porphyry dyke the footwall. The reef was followed for a length of 15 m. Morton (1941, unpubl.) also described the copper and gold workings 2.5 km south-southeast of Mount Gordon.

Reid (1931, unpubl.) reported on the *Pharlap* gold prospect, near the junction of Spring Creek and the Don River, about 10 km south-southeast of Pretty Bend homestead. The auriferous quartz vein, which is up to 15 cm wide, hugs a thin diorite dyke. A sample from the widest part of the vein assayed 2 oz 4 dwt per ton. This is probably the prospect previously visited by Morton (1927b, unpubl.).

A mine known as *Mount Poole* (Morton, 1922, unpubl.) about 20 km southeast of Collinsville, is located in altered volcanics and sediments (Lizzie Creek Volcanics) close to the contact with granite and diorite (Ki). The auriferous veins dip to the southwest and northeast at 50° to 90°; one quartz vein occurs in diorite. The veins were rich, but not rich enough to offset the high cost of cartage.

Cribb (1940, unpubl.) described a small occurrence of gold 300 m east of a graphite deposit about 11 km south-southeast of Collinsville.

Low gold values were detected in several thin quartz veins in faulted and steeply dipping altered shale and sandstone. The sediments are intruded by a swarm of thin diorite dykes, and granite crops out 150 m to the south of the veins.

Alluvial gold has been discovered from the bed of the Burdekin River at the Falls, but production was small. Morton (1931) has discussed the occurrences. The main obstacle to successful mining is the presence of large boulders and the highly irregular shape of the bedrock.

There is a group of gold prospects near the head of Millaroo Creek, known locally as Lionel Diggings, but no production has been recorded.

### *Silver and Base Metals*

Copper and silver were useful by-products at the Dittmer gold mine, where recorded production to the end of 1951 is 23 418 oz of silver and 296 tons of copper.

Small amounts of copper, lead, and zinc accompany the gold in many of the mines in the eastern part of the Sheet area, especially in the Mount Marengo field, where copper-stained outcrops were useful indicators of gold mineralization.

Several scattered small mines and prospects known as the Flagstone Creek silver-lead workings were worked from 1888 to 1890. They were the *Tent Hill* (about 3.5 km east-southeast of Emu Plains homestead), *King Solomon* (about 5 km north-northeast of Emu Plains homestead), and *Flagstone* (about 23 km north of Emu Plains homestead). No production figures are available. The Tent Hill and King Solomon lodes are in the Lizzie Creek Volcanics, the Arbroath is in the diorite suite (Cud), and the Flagstone is just within the Thunderbolt Granite, near its contact with the diorite suite.

Maitland (1889) gave a brief description of the copper-silver ores, and Cameron (1902, unpubl.) visited the mines 10 years after they had closed down. Short notes on development appear in the Annual Reports of the Mines Department (1888, p. 76; 1889, p. 81; 1890, pp. 83, 127).

At the Tent Hill two inclined shafts, about 30 m apart, were sunk on a narrow galena-bearing quartz vein, which dips southwest parallel to the bedding of the Lizzie Creek Volcanics (described by Cameron as 'clay-slate rock') Cameron states that samples of the surface ore assayed 13.9 percent lead and 13 oz of silver per ton.

A considerable amount of work was done at the King Solomon. Several inclined shafts and a vertical shaft were sunk on two parallel lodes 'within a few feet of each other' (Cameron, 1902, unpubl.). The ore mined is said to have assayed between 300 and 8000 oz of silver per ton.

The Arbroath mine was developed on a galena-bearing quartz vein in diorite. The vein is up to 1 m thick, and was followed for a distance of about 40 m.

The old workings of what was probably the Flagstone mine were inspected during the regional mapping. Five shafts up to 15 m deep have been sunk in a dyke of heavily limonitized microdiorite (?) dipping to the northwest at 70°. The ore consisted of thin lenticular quartz-siderite veins that are concordant with the dyke. Quartz occurs as dogtooth crystals, normal to the veins, in a matrix of crystalline siderite. A little chalcopyrite and galena were noted in the waste rock. Cameron interpreted the wall rock as slate and quartzite.

Morton (1925, unpubl.), Cribb (1954), and Shepherd (1954, unpubl.) have described the *Mixer* (or Godkin) silver-lead-zinc-copper mine at the eastern edge of the Sheet area, 15 km southeast of Mount Hector. The lode was first worked about 1880 for silver-lead as the German Mission mine, and again to a small extent in 1924-25 as the Godkin mine. Two or three adjacent shafts were reopened in 1952, and were developed to a limited extent.

The lode occurs in microgranite of the Urannah Igneous Complex which, in the vicinity of the mine, is strongly sericitized and kaolinized, and locally contains tourmaline. Morton described the mineralization as extremely erratic; it fills a fissure zone and also replaces country rock. Shepherd (1954, unpubl.) reported that the mineralization possibly follows a zone of fissuring that dips to the southwest, a monoclinal fold occurs in the lode where the No. 1 shaft passes through it.

In the early years of the mine all ore was shipped to Germany, and no production figures are available. The 43 tons of handpicked silver-lead ore produced in 1924-25 assayed 9 oz 8 dwt of silver per ton, a trace of gold, 10 percent lead, and 19.2 percent zinc. In 1952-54 over 30 tons of ore were produced, but it proved hard to treat. A trial shipment of 5.4 tons smelted at Port Kembla returned 1.06 tons of copper and 110.5 oz of silver. The minerals identified in the ore include sphalerite, chalcocite, galena, chalcopyrite, pyrite, azurite, malachite, native copper, cuprite, covellite, cerussite, anglesite, and smithsonite.

Morton (1927a, unpubl.) and Ridgway (1940c, unpubl.) described an occurrence of copper, lead, zinc, and silver 13 km southwest of Birralee homestead, which lies 23 km southwest of Collinsville. The mineralization occurs in gossanous quartz outcrops within a small isolated outcrop of biotite granite surrounded by massive acid and basic volcanics. The siliceous gossan contains carbonates of copper and lead, in addition to galena, pyrite, chalcopyrite, and sphalerite. Morton observed that the lode appears to dip gently to the west, but is too poorly exposed even to estimate its thickness. Some specimens of the ore are reported to have contained 5.9 percent copper and 23 oz of silver per ton. Ridgway reports that there were seven shafts on the reef, which was proved over a length of at least 500 m. He also noted that the reefs are intersected by aplite intrusions.

Knight (1949, unpubl.) has described three pipe-like bodies of silicification and weak copper mineralization in pink granite near the head of Frederick Creek, about 7 km southwest of *Birralee homestead.* He estimated the possible ore reserves at 3000 tons per vertical foot, with a maximum grade of 1.5 percent copper.

Saint-Smith (1919a) reported on a copper occurrence *between Mount Aberdeen and Moss Vale homestead.* Gouging was carried out 200 m south of a small knob of ironstained brecciated(?) granite, to the south of a small hill known as the Pinnacle. Carbonates and oxides of copper occur on the joint planes in the sericitized and strongly jointed fine-grained granite. Operations were carried on for four years, and a 5-ton parcel of ore is said to have been shipped to Mount Morgan in 1914. Although the tenor of the ore was much too low to be profitable at the time, the prospect may be worthy of further investigation as a potential porphyry copper prospect.

Jack (1879b) recorded the presence of numerous specimens composed of zeolites and malachite along the Bowen River between the mouth of Pelican Creek and Birralee homestead, but did not have the opportunity to trace them to their outcrop.

Several shafts have been sunk on a persistent east-southeasterly trending chalcopyrite-bearing quartz vein in a Lower Cretaceous granodiorite in the headwaters of Devlin Creek, but the quantity of ore produced is unknown. A small occurrence of copper carbonate was discovered a few years ago at the southern margin of the Lower Cretaceous intrusion at Mount Leslie, and in late 1971 the intrusion was being tested for disseminated copper mineralization of the porphyry copper type.

### *Tungsten*

A gently dipping pipe-like deposit of scheelite was reported by Ridgway (1947) in rhyolite about 10 km northeast of Mount Glenroy, in the Leichhardt Range. The position of the deposit is unknown, but it probably occurs in the Mount Windsor Volcanics, near the contact with an Upper Carboniferous adamellite batholith (Cug).

The pipe was found to be small and the ore low in grade, and after thorough sampling the deposit was abandoned.

### *Iron*

Connah (1953a, unpubl.) examined a deposit of disseminated magnetite in a contact metamorphic zone in the Ukalunda Beds, 2.5 km due east of Mount Wyatt. The deposit is situated about 400 m from the Golden Ridge gold lode (Morton, 1935), and at one time was worked on a small scale as a flux for smelting carbonate ore (Reid, 1928).

Small segregations and scattered grains of magnetite have been reported in a hornblende-garnet-epidote skarn interbedded with quartz-mica hornfels. Connah (1953a, unpubl.) suggests that the skarn is a metamorphosed basic sill. The skarn is no more than 30 m thick, and contains scattered local concentrations of magnetite which have an average iron content of 39 percent. The deposit is mentioned to draw attention to the skarn type of mineralization, whose base metal potential may not have been fully investigated.

### *Radioactive Minerals*

Connah (1954, unpubl.) followed up a reported occurrence of radioactive granite, south of Goodbye Creek, 18.5 km west of Bowen. The granite forms a small hill on the north side of the North Coast Railway, just within the Ayr Sheet area. Connah tested the hill with a Geiger counter, and recorded counts between 100 and 200 per minute, which is higher than normal for igneous rocks. Selected samples of the granite were tested for uranium with negative results.

### *Limestone*

Reserves of good-quality limestone (Edgecumbe Beds) occur at Ben Lomond (Dunstan, 1917; Saint-Smith, 1918). Saint-Smith estimated reserves at 1 million tons, but Connah (1953b, unpubl.) inspected the deposit in more detail, and suggested that reserves are considerably less (Connah, 1958). The limestone is interbedded with tuffaceous sediments and pyroclastics, all of which have been hornfelsed by the adamellite (PKg) of Ben Lomond. Brooks (1953, unpubl.) has described the petrography of the limestone from Ben Lomond.

Farther south-southeast massive oolitic argillaceous limestone of the Edgecumbe Beds is exposed in Ten Mile Creek (Brown, 1963, unpubl.). The scattered limestone outcrops between Ben Lomond and the confluence of Ten Mile Creek and the Gregory River suggest that the reserves are substantial.

A deposit of powdery calcium carbonate, known locally as earth lime, occurs 2 km northwest of Mookarra siding (Connah, 1958). The deposit has been mined from time to time for use in agriculture, and is similar to the deposits of earth lime near Home Hill (Connah, 1958; Paine et al., 1970). Another small deposit of earth lime was found during the regional mapping near the right bank of the Don River, 1 km north of its junction with Humbug Creek.

Limestone is also reported to occur 'at Police Camp on the Don River, near Bootooloo Siding' (Connah, 1958).

### *Magnesite*

An occurrence of magnesite 2 km southwest of Mount Pring has been described by Saint-Smith (1919b). The magnesite forms veins up to 75 cm thick, in a restricted area of lateritized ultrabasic rock. Small veinlets of chromite and asbestiform anthophyllite are also present. The recorded production is 25 tons, with a $MgCO_3$ content of about 97 percent.

### *Ochre*

A small deposit of boulder-type ochre of varied colour (Iron Knob) crops out in the right bank of Greta Creek at the base of a hill of 'silicified slates, tuffs and andesitic lavas' (Denmead, 1949, unpubl.) of the Carmila Beds. Denmead attributed the deposit to the leaching and redeposition of iron with clay at the base of the hill. He estimated reserves at 6000 tons, but pointed out that the ochre is of variable quality. Subsequent attempts to work the deposit confirmed his opinion that the material is too variable in quality to be of value. The ochre is underlain by gypsiferous clay.

### *Gemstones*

A vein containing amethyst was discovered in 1965 near Binbee during the reconstruction of the Bowen-Collinsville road. Chalcedony and agate are abundant in the weathered basalt of the Lizzie Creek Volcanics northwest of Collinsville, but most of the stone is fractured.

### *Facing Stone*

Large whalebacks of fresh medium to coarse adamellite (Hecate Granite), with few vertical joints, occur a few kilometres west and northwest of Roma Peak (e.g. Sixpenny Hill, Fig. 5; and Bald Rock). The adamellite contains euhedral phenocrysts of biotite, and appears to be suitable for use as a facing stone. The hills are readily accessible. Smaller whalebacks of inequigranular granite (PKg), containing fresh fine-grained biotite crystals, occur beside the Bruce Highway west of Euri Creek siding.

### *Groundwater*

In the Don River delta shallow wells are sunk in alluvium for the irrigation of vegetables and fruit trees. The production of fruit and vegetables, especially mangoes and tomatoes, is an important local industry. Kevi et al. (1968, unpubl.) have interpreted a geophysical survey of the Don delta, which was carried out to determine the capacity of the aquifers in the delta. Elsewhere, the use of the land is generally related to the local rainfall.

The alluvium along the larger streams such as the Don and Proserpine Rivers probably contains adequate supplies of groundwater for pastoral needs, and considerable quantities of water can be obtained during the dry season by sinking spears into the sandy beds of the larger watercourses. The sugar farms along the Burdekin River at Dalbeg and Millaroo draw their supplies from the river, the flow of which is regulated by a weir at the foot of the Leichhardt Range.

Some geological and geophysical observations have been made from time to time during the examination of possible dam sites.

Gloe (1950, 1951, both unpubl.) and Connah (1952, unpubl.) reported on the geology of the proposed Burdekin River dam site and the Burdekin River diversion dam site. The proposed line of the main Burdekin dam is about 400 m downstream from the fault between the Bulgonunna Volcanics and the Star of Hope Formation. Seven diamond drill holes were put down at the main site, and several more to test the foundations of the embankments, which would extend for 7 km to the northwest of the main dam.

The Irrigation and Water Supply Commission (1963, unpubl.) investigated the geology of proposed dam sites on Pelican Creek and the Broken River which were considered as alternative sources of supply for the Collinsville power station. The Bureau of Mineral Resources (Mann, 1962, unpubl.) carried out geophysical studies of the dam sites.

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## APPENDIX

### ISOTOPIC AGE DETERMINATIONS FROM THE BOWEN 1:250 000 SHEET AREA

**(Analytical error in individual K/Ar determinations is ± 3%)**

**By A. W. WEBB**

| *Rock Unit or Map Symbol* | *BMR No* | *ANU No* | *Military Grid Reference E* | *N* | *Rock Type* | *Material Analysed* | *Method* | *Age* ($\times 10^6$ yr) | *Remarks* |
|---|---|---|---|---|---|---|---|---|---|
| Mt Abbot Igneous Complex | F55/3/119 | GA5531 | 600600 | 2480200 | Quartz syenite | Hornblende | K/Ar | 116 | Rolled block, not in situ |
| Hecate Granite | F55/3/ 61 | GA5331 | 665100 | 2434500 | Adamellite | Biotite | K/Ar | 123 | |
| Hecate Granite | F55/3/ 62 | GA5330 | 669800 | 2440950 | Granodiorite | Biotite | K/Ar | 125 | |
| Hecate Granite | F55/3/ 62 | GA5330 | 669800 | 2440950 | Granodiorite | Hornblende | K/Ar | 127 | |
| Hecate Granite | F55/3/ 91 | GA5398 | 641250 | 2444200 | Adamellite | Biotite | K/Ar | 128 | |
| Hecate Granite | F55/3/ 97 | GA5529 | 621250 | 2467200 | Adamellite | Biotite | K/Ar | 120 | |
| Hecate Granite | F55/3/100 | GA5399 | 629100 | 2466400 | Adamellite | Biotite | K/Ar | 123 | |
| Hecate Granite | F55/3/117 | GA5355 | 644350 | 2458500 | Adamellite | Biotite | K/Ar | 124 | |
| Hecate Granite | F55/3/118 | GA5356 | 648000 | 2445500 | Adamellite | Biotite | K/Ar | 124 | |
| Hecate Granite | F55/3/118 | GA5356 | 648000 | 2445500 | Adamellite | Hornblende | K/Ar | 126 | |
| Ki | F55/3/ 33 | GA5272 | 636700 | 2373900 | Gabbro | Plagioclase | K/Ar | 133 | |
| Ki | F55/3/127 | GA5358 | 624100 | 2411700 | Adamellite | Biotite | K/Ar | 123 | |
| Pkg | F55/3/ 35 | | 678950 | 2492900 | Adamellite | Biotite | K/Ar | 216 | See text |
| Urannah Igneous Complex | F55/3/110 | GA5734 | 679800 | 2419600 | Adamellite | Biotite | K/Ar | 250 | Altered sample. Minimum age only |
| Urannah Igneous Complex | F55/3/113 | GA5346 | 683100 | 2397300 | Diorite | Biotite | K/Ar | 283 | |
| Urannah Igneous Complex | F55/3/114 | GA5396 | 679800 | 2401700 | Adamellite | Biotite | K/Ar | 289 | |
| Urannah Igneous Complex | F55/3/114 | GA5396 | 679800 | 2401700 | Adamellite | Biotite | Rb/Sr | 309 | |
| Urannah Igneous Complex | F55/3/114 | GA5396 | 679800 | 2401700 | Adamellite | Whole rock | Rb/Sr | * | |
| Urannah Igneous Complex | F55/3/115 | GA5392 | 681100 | 2399000 | Granodiorite | Whole rock | Rb/Sr | * | |
| Urannah Igneous Complex | F55/3/115 | GA5392 | 681100 | 2399000 | Granodiorite | Biotite | Rb/Sr | 314 | |
| Urannah Igneous Complex | F55/3/115 | GA5392 | 681100 | 2399000 | Granodiorite | Biotite | K/Ar | 289 | |
| Urannah Igneous Complex | F55/3/115 | GA5392 | 681100 | 2399000 | Granodiorite | Hornblende | K/Ar | 294 | |
| Urannah Igneous Complex | F55/3/135 | GA5354 | 684500 | 2408500 | Adamellite | Biotite | K/Ar | 282 | |
| Urannah Igneous Complex | F55/3/135 | GA5354 | 684500 | 2408500 | Adamellite | Biotite | Rb/Sr | 290 | |
| Urannah Igneous Complex | F55/3/135 | GA5354 | 684500 | 2408500 | Adamellite | Whole rock | Rb/Sr | * | |
| Mt Wickham Rhyolite | F55/3/ 69 | GA5520 | 562050 | 2475700 | Acid volcanic | Whole rock | Rb/Sr | ★ | |
| Mt Wickham Rhyolite | F55/3/ 72 | GA5524 | 572700 | 2455600 | Acid volcanic | Whole rock | Rb/Sr | ★ | |
| Mt Wickham Rhyolite | F55/3/ 74 | GA5521 | 565100 | 2448600 | Acid volcanic | Whole rock | Rb/Sr | ★ | |
| Mt Wickham Rhyolite | F55/3/ 75 | GA5522 | 565100 | 2448700 | Acid volcanic | Whole rock | Rb/Sr | ★ | |
| Mt Wickham Rhyolite | F55/3/ 76 | GA5523 | 564800 | 2448500 | Acid volcanic | Whole rock | Rb/Sr | ★ | |
| Mt Wickham Rhyolite | F55/3/ 78 | GA5525 | 577200 | 2443700 | Acid volcanic | Whole rock | Rb/Sr | ★ | |
| Mt Wickham Rhyolite | F55/3/143 | | 569300 | 2436200 | Acid volcanic | Whole rock | Rb/Sr | ★ | |
| Dyke | F55/3/107 | GA5329 | 654000 | 2423100 | Microdiorite | Hornblende | K/Ar | 225 | |

APPENDIX (cont.)

| *Rock Unit or Map Symbol* | *BMR No* | *ANU No* | *Military Grid Reference E* | *N* | *Rock Type* | *Material Analysed* | *Method* | *Age (× 10⁶ yr)* | *Remarks* |
|---|---|---|---|---|---|---|---|---|---|
| Thunderbolt Granite | F55/3/ 14 | GA473 | 620700 | 2447700 | Adamellite | Hornblende | K/Ar | 270 | |
| Thunderbolt Granite | F55/3/ 26 | GA5252 | 619700 | 2457000 | Adamellite | Hornblende | K/Ar | 264 | |
| Thunderbolt Granite | F55/3/ 26 | GA5252 | 619700 | 2457000 | Adamellite | Hornblende | Rb/Sr | 260 | |
| Thunderbolt Granite | F55/3/ 27 | GA5253 | 614300 | 2446800 | Adamellite | Hornblende | K/Ar | 261 | |
| Thunderbolt Granite | F55/3/ 38 | GA5338 | 629200 | 2437450 | Adamellite | Hornblende | K/Ar | 259 | |
| Thunderbolt Granite | F55/3/ 86 | GA5332 | 615700 | 2458100 | Adamellite | Hornblende | K/Ar | 264 | |
| Thunderbolt Granite | F55/3/ 86 | GA5332 | 615700 | 2458100 | Adamellite | Hornblende | Rb/Sr | 271 | |
| Thunderbolt Granite | F55/3/109 | GA5380 | 630300 | 2432800 | Adamellite | Hornblende | K/Ar | 265 | |
| Plg | F55/3/ 25 | GA5251 | 532900 | 2471900 | Adamellite | Biotite | K/Ar | 272 | |
| Plg | F55/3/125 | GA5365 | 662600 | 2398700 | Granite | Biotite | K/Ar | 268 | |
| Lizzie Creek Volcanics | F55/3/ 55 | GA5373 | 565800 | 2455500 | Basalt | Plagioclase | K/Ar | 274 | Minimum age |
| Lizzie Creek Volcanics | F55/3/ 56 | GA5374 | 568850 | 2452500 | Basalt | Plagioclase | K/Ar | 229 | Argon loss, or related to Mt Wickham Rhyolite? |
| Lizzie Creek Volcanics | F55/3/ 68 | GA5375 | 566700 | 2476000 | Basalt | Plagioclase | K/Ar | 264 | Minimum age |
| CPg | F55/3/ 67 | GA5530 | 584600 | 2487300 | Adamellite | Biotite | K/Ar | 272 | |
| CPg | F55/3/ 94 | GA5534 | 656100 | 2475100 | Adamellite | Biotite | K/Ar | 297, 298 | |
| CPg | F55/3/ 95 | GA5513 | 609000 | 2490700 | Granodiorite | Biotite | K/Ar | 269, 272 | |
| CPg | F55/3/106 | GA5347 | 656100 | 2424700 | Adamellite | Biotite | K/Ar | 186, 187 | Argon loss by contact metamorphism by Hecate Granite |
| CPg | F55/3/136 | GA5560 | 655900 | 2427800 | Adamellite | Biotite | K/Ar | 132 | Possible argon loss by contact metamorphism by Hecate Granite |
| Cug | F55/3/ 1 | GA832 | 552700 | 2441800 | Adamellite | Biotite | K/Ar | 278 | |
| Cug | F55/3/ 1 | GA832 | 552700 | 2441800 | Adamellite | Whole rock | Rb/Sr | + | |
| Cug | F55/3/ 3 | GA729 | 569400 | 2411200 | Adamellite | Whole rock | Rb/Sr | + | |
| Cug | F55/3/ 3 | GA729 | 569400 | 2411200 | Adamellite | Biotite | Rb/Sr | + | |
| Cug | F55/3/ 3 | GA729 | 569400 | 2411200 | Adamellite | Biotite | K/Ar | 283, 286 | |
| Cug | F55/3/ 8 | GA831 | 536500 | 2415600 | Granodiorite | Biotite | K/Ar | 276, 288 | |
| Cug | F55/3/ 8 | GA831 | 536500 | 2415600 | Granodiorite | Biotite | K/Ar | 293, 283 | |
| Cug | F55/3/ 8 | GA831 | 536500 | 2415600 | Granodiorite | Whole rock | Rb/Sr | + | |
| Cug | F55/3/ 9 | GA5292 | 528700 | 2402900 | Granodiorite | Hornblende | K/Ar | 281, 283 | |
| Cug | F55/3/ 16 | GA5532 | 575200 | 2417300 | Adamellite | Whole rock | Rb/Sr | + | |
| Cug | F55/3/ 20 | GA1243 | 532500 | 2400000 | Granodiorite | Whole rock | Rb/Sr | + | |
| Cug | F55/3/ 20 | GA1243 | 532500 | 2400000 | Granodiorite | Biotite | K/Ar | 280 | |
| Cug | F55/3/ 20 | GA1243 | 532500 | 2400000 | Granodiorite | Hornblende | K/Ar | 280 | |
| Cug | F55/3/ 22 | GA5528 | 567200 | 2411300 | Adamellite | Whole rock | Rb/Sr | + | |
| Cug | F55/3/ 23 | GA5198 | 574900 | 2423500 | Adamellite | Biotite | K/Ar | 278, 283, 289 | |

# APPENDIX (cont.)

| Rock Unit or Map Symbol | BMR No | ANU No | Military Grid Reference E | Military Grid Reference N | Rock Type | Material Analysed | Method | Age (x $10^6$ yr) | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| Cug | F55/3/ 23 | GA5198 | 574900 | 2423500 | Adamellite | Hornblende | K/Ar | 282, 291 | |
| Cug | F55/3/ 42 | GA5391 | 546900 | 2440500 | Adamellite | Biotite | K/Ar | 282 | |
| Cug | F55/3/ 42 | GA5391 | 546900 | 2440500 | Adamellite | Biotite | Rb/Sr | + | |
| Cug | F55/3/ 42 | GA5391 | 546900 | 2440500 | Adamellite | Whole rock | Rb/Sr | + | |
| Bulgonunna Volcanics | F55/3/ 40 | GA5514 | 546950 | 2438900 | Welded tuff | Whole rock | Rb/Sr | Ø | |
| Bulgonunna Volcanics | F55/3/ 41 | GA5515 | 546950 | 2438850 | Rhyolite | Whole rock | Rb/Sr | Ø | |
| Bulgonunna Volcanics | F55/3/ 81 | GA5517 | 564000 | 2408200 | Acid volcanic | Whole rock | Rb/Sr | Ø | |
| Bulgonunna Volcanics | F55/3/ 84 | GA5518 | 561700 | 2407500 | Acid volcanic | Whole rock | Rb/Sr | Ø | |
| Bulgonunna Volcanics | F55/3/131 | GA5556 | 538700 | 2394300 | Rhyolite | Whole rock | Rb/Sr | Ø | |
| Bulgonunna Volcanics | F55/3/132 | GA5557 | 555900 | 2389700 | Andesite | Whole rock | Rb/Sr | Ø | |
| Bulgonunna Volcanics | F55/3/134 | GA5559 | 573400 | 2429700 | Toscanite | Whole rock | Rb/Sr | Ø | |
| Cud | F55/3/ 11 | GA1072 | 662700 | 2393300 | Muscovite-biotite granite | Muscovite | K/Ar | 268, 271, 281 | |
| Cud | F55/3/ 11 | GA1072 | 662700 | 2393300 | Muscovite-biotite granite | Whole rock | Rb/Sr | * | |
| Cud | F55/3/ 12 | GA472 | 660900 | 2393300 | Tonalite | Biotite | K/Ar | 271, 277 | |
| Cud | F55/3/ 12 | GA472 | 660900 | 2393300 | Tonalite | Biotite | Rb/Sr | 284 | |
| Cud | F55/3/ 12 | GA472 | 660900 | 2393300 | Tonalite | Hornblende | K/Ar | 271, 266 | |
| Cud | F55/3/ 13 | GA812 | 647500 | 2409300 | Adamellite | Biotite | | 270 | |
| Cud | F55/3/ 13 | GA812 | 647500 | 2409300 | Adamellite | Whole rock | Rb/Sr | * | |
| Cud | F55/3/ 15 | GA474 | 628400 | 2455900 | Granodiorite | Biotite | K/Ar | 271, 272 | |
| Cud | F55/3/ 15 | GA474 | 628400 | 2455900 | Granodiorite | Hornblende | K/Ar | 258, 258 | |
| Cud | F55/3/ 24 | GA1162 | 625000 | 2423900 | Diorite | Biotite | K/Ar | 268 | |
| Cud | F55/3/ 24 | GA1162 | 625000 | 2423900 | Diorite | Hornblende | K/Ar | 273 | |
| Cud | F55/3/ 36 | GA5378 | 630350 | 2423600 | Tonalite | Biotite | K/Ar | 268 | |
| Cud | F55/3/ 37 | GA5335 | 643000 | 2410900 | Granodiorite | Biotite | K/Ar | 270 | |
| Cud | F55/3/ 37 | GA5335 | 643000 | 2410900 | Granodiorite | Hornblende | K/Ar | 273 | |
| Cud | F55/3/ 87 | GA5336 | 612700 | 2458300 | Diorite | Hornblende | K/Ar | 273 | |
| Cud | F55/3/ 87 | GA5336 | 612700 | 2458300 | Diorite | Biotite | K/Ar | 266 | |
| Cud | F55/3/101 | GA5333 | 622900 | 2462200 | Diorite | Hornblende | K/Ar | 270 | |
| Cud | F55/3/104 | GA5328 | 626800 | 2446300 | Quartz diorite | Hornblende | K/Ar | 266 | |
| Cud | F55/3/104 | GA5328 | 626800 | 2446300 | Quartz diorite | Biotite | K/Ar | 265 | |
| Cud | F55/3/105 | GA5327 | 631150 | 2443750 | Diorite | Biotite | K/Ar | 263 | |
| Cud | F55/3/105 | GA5327 | 631150 | 2443750 | Diorite | Hornblende | K/Ar | 279 | |
| Cud | F55/3/108 | GA5379 | 647800 | 2413700 | Gneissic granite | Hornblende | K/Ar | 270 | |
| Clg | F55/3/ 7 | GA5288 | 540700 | 2385500 | Granodiorite | Hornblende | K/Ar | 327, 330 | |

## APPENDIX (cont.)

| *Rock Unit or Map Symbol* | *BMR No* | *ANU No* | *Military Grid Reference E* | *N* | *Rock Type* | *Material Analysed* | *Method* | *Age (x $10^6$ yr)* | *Remarks* |
|---|---|---|---|---|---|---|---|---|---|
| Clg | F55/3/ 17 | GA1160 | 536900 | 2387000 | Granodiorite | Hornblende | K/Ar | 294 | |
| Clg | F55/3/ 17 | GA1160 | 536900 | 2387000 | Granodiorite | Biotite | K/Ar | 294 | |
| Clg | F55/3/ 18 | GA1161 | 532800 | 2387100 | Adamellite | Biotite | K/Ar | 290 | |
| Mt Windsor Volcanics | F55/3/137 | GA5714 | 535400 | 2443000 | Acid volcanic | Whole rock | Rb/Sr x | | |
| Mt Windsor Volcanics | F55/3/138 | GA5715 | 535200 | 2442850 | Acid volcanic | Whole rock | Rb/Sr x | | |
| Mt Windsor Volcanics | F55/3/139 | GA5716 | 535150 | 2442900 | Acid volcanic | Whole rock | Rb/Sr x | | |
| Mt Windsor Volcanics | F55/3/140 | GA5717 | 535050 | 2442950 | Acid volcanic | Whole rock | Rb/Sr x | | |
| Mt Windsor Volcanics | F55/3/141 | GA5718 | 534700 | 2443050 | Acid volcanic | Whole rock | Rb/Sr x | | |
| Mt Windsor Volcanics | F55/3/142 | GA5719 | 534300 | 2443050 | Acid volcanic | Whole rock | Rb/Sr x | | |

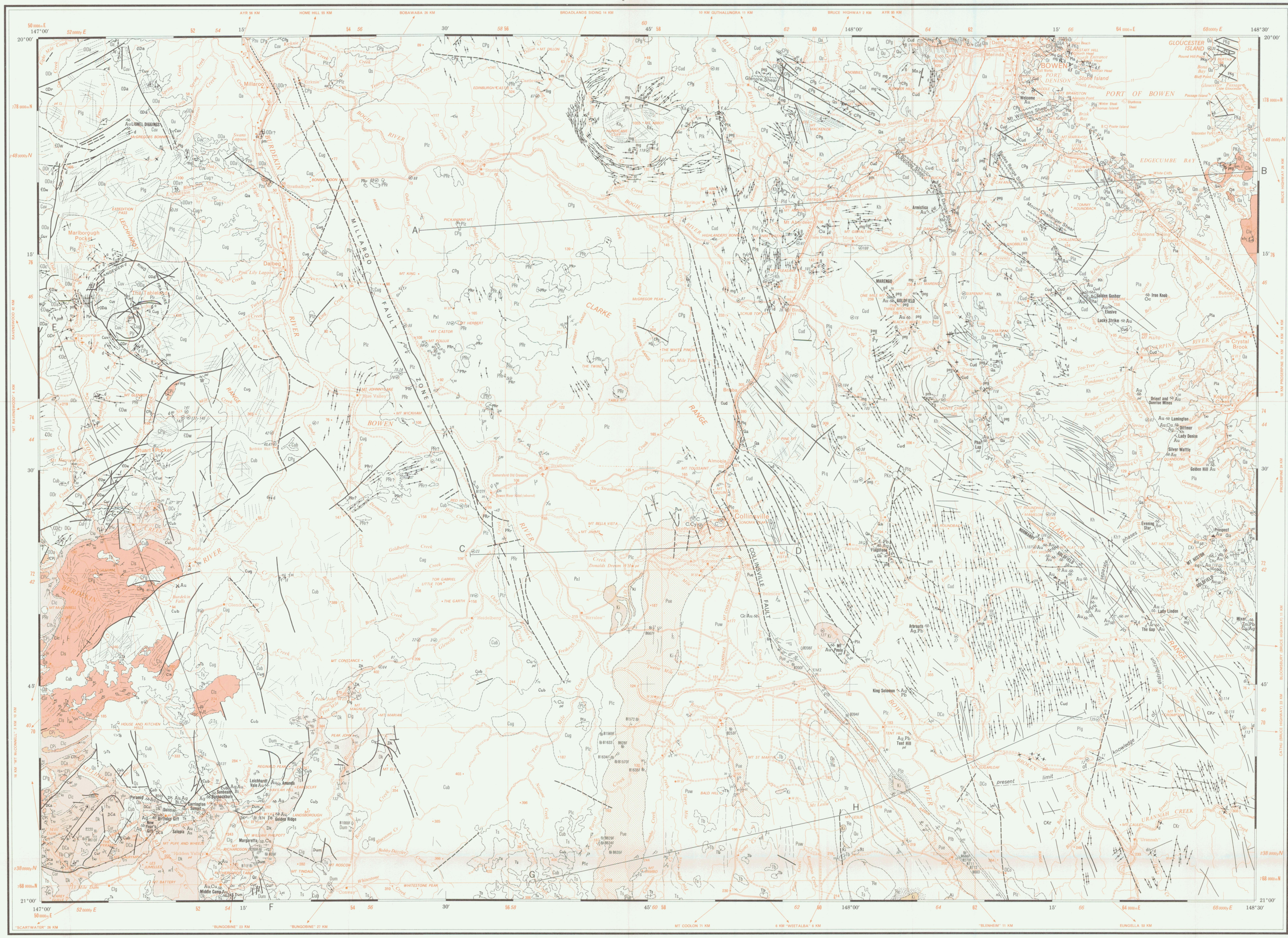
*Rb/Sr Isochrons:* ★ 230 ± 15 m.y. * 288 ± 31 m.y. + 286 ± 3 m.y. ∅ 287 ± 12 m.y. x 510 ± 100 m.y.

# BOWEN

QUEENSLAND

AUSTRALIA 1:250 000 GEOLOGICAL SERIES

SHEET SF 55-3




## Reference

- Geological boundary
- Anticline showing plunge
- Syncline
- Fault
- High angle reverse 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
- 20 Strike and dip of strata
- Prevailing dip of strata
- Vertical strata
- Horizontal strata
- Dip < 15° (air-photo interpretation)
- Dip 15°–45° (air-photo interpretation)
- Joint pattern (air-photo interpretation)
- Trend-lines, with dip direction (air-photo interpretation)
- Trend of beach ridges and coastal dunes (air-photo interpretation)
- Lineament (air-photo interpretation)
- 60 Strike and dip of foliation
- Unmeasured foliation
- Vertical foliation
- Horizontal foliation
- 80 Strike and dip of cleavage
- Vertical cleavage
- 50 Strike and dip of platy flow
- Vertical platy flow
- Marine macrofossil locality — B1633F collection described in BMR Report No 100
- Plant fossil locality — B1633F collection described in BMR Report No 100
- Fossil wood locality
- 27 Isotopic dating specimen with locality number
- EM2 Measured stratigraphic section, with reference number
- 70 Dyke, showing dip where inclined: a — aplite, d — dolerite/microdiorite, di — diorite, f — felsite, g — granite/adamellite, gd — granodiorite, mg — microgranite/microadamellite, peg — pegmatite, pm — microdiorite porphyry, q — quartz. Absence of rock-type symbol indicates air-photo interpretation
- Metamorphic aureole
- •Py Minor mineral occurrence
- Ls Unworked deposit
- Prospect
- Major mine
- Abandoned mine
- Quarry or open cut
- Abandoned quarry or open cut
- Abandoned alluvial workings
- Abandoned battery

| | | | |
|---|---|---|---|
| Ag | Silver | Gt | Graphite |
| As | Arsenic | Ls | Limestone |
| Au | Gold | Ms | Magnesite |
| Bi | Bismuth | Oc | Ochre |
| C | Coal | Pb | Lead |
| Cu | Copper | Py | Pyrite |
| Cy | Clay | W | Tungsten |
| Fe | Iron | Zn | Zinc |

- Bore
- Water well
- E Earth tank
- Windpump
- Dam
- WH Waterhole
- Spring
- Bank of major watercourse
- Irrigation channel
- Swamp
- 3 Bathymetric contour — converted to nearest metre
- Highway
- Road
- Vehicle track
- Railway — with station and siding
- Airport
- Landing ground
- Homestead
- Building
- Yd Yard
- Town
- Fence
- Telephone line
- Power transmission line
- Trigonometrical station
- Astronomical station
- •284 Elevation in metres, approximate
- pa Position approximate
- pd Position doubtful

## Reference

| | | | | |
|---|---|---|---|---|
| CAINOZOIC | QUATERNARY | | Qm | Coastal mud, minor evaporites |
| | | | Qr | Sand in beach ridges and coastal dunes |
| | | | Qu | Outwash and scree |
| | | | Qa | Alluvium, semi-consolidated in places |
| | | | Qs | Colluvial and residual soil, sand, and rubble, semi-consolidated in places |
| | TERTIARY | | To | Coarse clayey sandstone, sandy claystone, conglomerate |
| | | Suttor Formation | Ts | Coarse clayey sandstone, sandy claystone, polymictic pebble and cobble conglomerate, minor oil shale. Lateritized |
| | | | Tb | Olivine basalt |
| MESOZOIC | LOWER CRETACEOUS | Mount Abbot Igneous Complex | $Ka_2$ | Alkali granite |
| | | | $Ka_1$ | Quartz syenite |
| | | Hecate Granite | $Kh_1$ | Aplitic microgranite |
| | | | Kh | Granodiorite and adamellite; late stage leucocratic phases |
| | | | Ki | Granodiorite, diorite, rhyolite, porphyry, gabbro, microdiorite |
| | TRIASSIC | Clematis Sandstone | Re | Cross-bedded sublabile and quartzose sandstone, pebbly in places; some fine conglomerate, and grey and red mudstone |
| | | Rewan Formation | Rr | Red mudstone, green labile and sublabile sandstone, siltstone |
| | LOWER PERMIAN OR LOWER CRETACEOUS | | PKg | Leucogranite, microgranite; minor adamellite, microadamellite, diorite |
| | | | PKs | Altered granodiorite |
| | UPPER CARBONIFEROUS LOWER PERMIAN AND LOWER CRETACEOUS | Urannah Igneous Complex | CKr | Undivided acid, intermediate, and minor basic plutonic rocks; abundant dykes |
| | UPPER PERMIAN OR LOWER TRIASSIC | Mount Wickham Rhyolite | PRr | Mainly flow-banded porphyritic rhyolite, rhyolite breccia; subordinate trachyte, dacite, obsidian, agglomerate |
| PALAEOZOIC | UPPER PERMIAN | Blackwater Group | Puw | Cross-bedded well sorted lithic sandstone, siltstone, quartzose sandstone; carbonaceous shale with some coal seams, pebble and cobble conglomerate, dolomitic and calcareous sandstone, tuff. Plant fossils |
| | LOWER TO UPPER PERMIAN | Back Creek Group: Blenheim Sub-Group | Pue | Siltstone, pebbly sublabile sandstone, fossiliferous calcareous siltstone and sandstone, coquinite, limestone. Marine fossils |
| | | Back Creek Group: Gebbie Sub-Group | Plb | Quartzose sandstone, sublabile sandstone (carbonaceous in part), siltstone, mudstone, calcareous sandstone and siltstone, minor conglomerate and coal. Marine fossils |
| | | Back Creek Group: Collinsville Coal Measures | Plc | Quartzose sandstone, conglomerate, siltstone, calcareous sublabile sandstone, coal seams, carbonaceous shale. Plant and marine fossils |
| | | Back Creek Group: Tiverton Sub-Group | Plp | Sublabile sandstone and siltstone containing calcareous and fossiliferous beds, lenses, and nodules; some limestone, coquinite, sandy limestone. Marine fossils |
| | LOWER PERMIAN | Thunderbolt Granite | Plq | Adamellite, minor microadamellite; aplitic microgranite dykes |
| | | | Plg | Adamellite, granodiorite |
| | | | Plr | Porphyritic rhyolite and microtrondhjemite |
| | | Mount Aberdeen Volcanics | Pld | Andesite, dacite, rhyolite, dacite welded tuff, lithic-crystal tuff, crystal tuff, agglomerate |
| | | Kurungle Volcanics | Plk | Andesite, andesite breccia, flow-banded rhyolite, agglomerate, tuff |
| | | Carmila Beds | Pla | Massive dacite and andesite pyroclastics and subordinate lavas; bedded pyroclastics and labile sediments |
| | | Lizzie Creek Volcanics | Plz | Basalt, andesite, agglomerate, lithic and tuffaceous sediments, minor acid volcanics |
| | UPPER CARBONIFEROUS OR LOWER PERMIAN | | CPg | Granodiorite, adamellite, granite, minor quartz diorite, granophyre, microgranite, microtrondhjemite |
| | | | CPi | Pyroxene diorite, meladiorite, minor olivine dolerite, gabbro, pyroxene monzonite |
| | UPPER CARBONIFEROUS | | Cug | Adamellite, granite, granodiorite, minor marginal granophyre and porphyry |
| | | | Cur | Intrusive rhyolite and porphyry |
| | | Bulgonunna Volcanics | Cub | Rhyolite, rhyodacite, and dacite welded tuffs, lavas, and air-fall pyroclastics, minor andesite and tuffaceous sediments |
| | | | Cuv | Rhyolite, rhyodacite, and dacite welded tuffs, acid lavas, and agglomerate, minor andesite |
| | | | Cud | Diorite, quartz diorite, tonalite, gabbro, granodiorite. Rare adamellite, norite, monzonite, granite |
| | LOWER CARBONIFEROUS | | Clg | Adamellite, minor granodiorite, tonalite, diorite. Numerous roof pendants |
| | | Edgecumbe Beds | Cle | Shale, greywacke and limestone; feldspathic and clayey sandstone, siltstone, and pebble conglomerate; andesite lavas and pyroclastics. Marine fossils |
| | | Star of Hope Formation | Cls | Lapilli tuff, welded tuff, tuffaceous sandstone, volcanolithic sandstone, sandstone with quartz pebbles, conglomerate. Plant fossils |
| | | Mount Hall Formation | Clh | Pebbly and conglomeratic quartz sandstone, coarse quartz sandstone. Wood fragments |
| | | Scartwater Formation | Clc | Fine feldspathic sandstone; interbeds of calcarenite, algal limestone, olive mudstone, lithic tuff. Plant fossils |
| | UPPER DEVONIAN TO LOWER CARBONIFEROUS | Saint Anns Formation | DCa | Acid and intermediate volcanics and algal limestone at top; labile sandstone; minor green mudstone and phosphatic sandstone. Plant fossils |
| | | | DCv | Acid to intermediate volcanics and associated sediments |
| | | Connors Volcanics | DCo | Andesite, rhyolite and dacite lavas, agglomerate, volcanic breccia |
| | UPPER DEVONIAN | Mount Wyatt Formation | Dum | Siltstone, shale, labile sandstone and conglomerate, mudstone tuff. Marine and plant fossils |
| | MIDDLE DEVONIAN | Ukalunda Beds | Dk | Lithic and quartzose sandstone, shale, conglomerate, siltstone (calcareous in places), limestone, chert. Quartz veining, silicification, and low grade metamorphism in places. Marine fossils |
| | MIDDLE ORDOVICIAN AND UPPER SILURIAN OR LOWER DEVONIAN | Ravenswood Granodiorite Complex | ODa | Biotite adamellite, granite and microgranite; minor granodiorite |
| | | | ODr | Granodiorite, adamellite, minor quartz diorite, diorite, meladiorite, trondhjemite, granite |
| | CAMBRIAN TO ORDOVICIAN ? | Cape River Beds | €Oc | Schist, gneiss, granofels, amphibolite, metavolcanics |
| | | Mount Windsor Volcanics | €Ow | Rhyolite, rhyodacite, rhyolite breccia, dacite; minor andesite, quartzite, argillite, arkose; locally metamorphosed to gneiss, granofels, and schist |
| | | | Pzu | Quartz-sericite schist, quartzite, phyllite, hornfels, micaceous siltstone |

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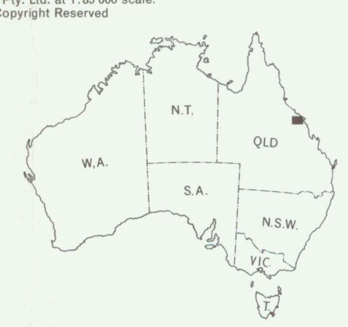


### INDEX TO ADJOINING SHEETS

Showing Magnetic Declination 1970

| | | | | |
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| EINASLEIGH SE 55-9 | INGHAM SE 55-10 | | | |
| CLARKE RIVER SE 55-13 | TOWNSVILLE SE 55-14 | AYR SE 55-15 | CORAL | |
| HUGHENDEN SF 55-1 | CHARTERS TOWERS SF 55-2 | BOWEN SF 55-3 | PROSERPINE SF 55-4 | SEA |
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ANNUAL CHANGE 1'10"E

Scale 1:250 000

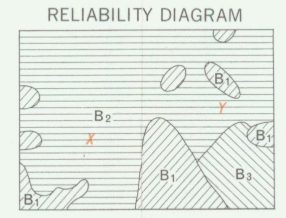
5 0 5 10 15 20 25 KILOMETRES

5 0 5 10 MILES

BROWN NUMBERED LINES ARE 20 000 METRE INTERVALS OF THE AUSTRALIAN MAP GRID, ZONE 55
BROWN TICKS WITH ITALIC NUMBERS INDICATE THE 20 000 YARD GRID, ZONE 7 (AUSTRALIA SERIES)
TRANSVERSE MERCATOR PROJECTION

Geology 1961 and 1964–67 by C. M. Gregory, E. J. Malone, A. R. Jensen, A. G. L. Paine, F. Olgers (B.M.R.); D. E. Clarke, V. R. Forbes (G.S.Q.).
Some geological data (1961) from E. A. Webb and C. E. Crapp (Bowen Consolidated Coal Mines Pty. Ltd.)
Compiled 1962 by E. J. Malone, 1965–70 by A. G. L. Paine
Cartography by Geological Branch B.M.R.
Drawn by Mercury-Walch Pty. Ltd. Hobart

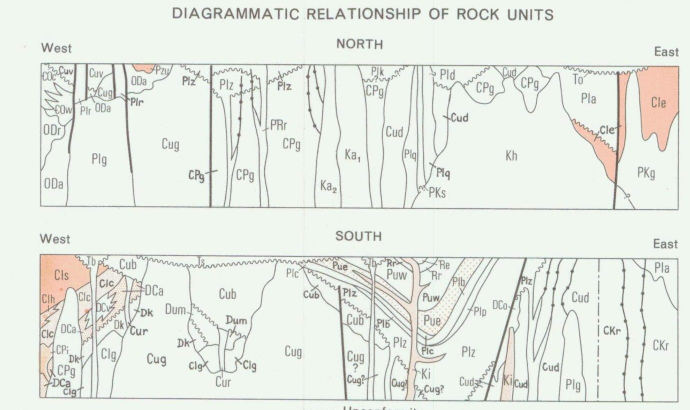
### RELIABILITY DIAGRAM




$B_1$ Detailed reconnaissance
$B_2$ Reconnaissance with air-photo interpretation
$B_3$ Some traverses, mainly air-photo interpretation

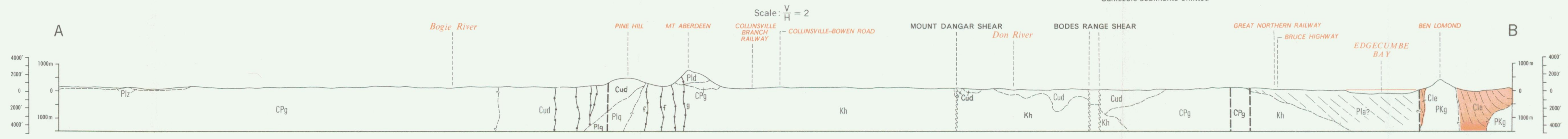
Utility of air-photo interpretation
X Good to moderate
Y Moderate to poor

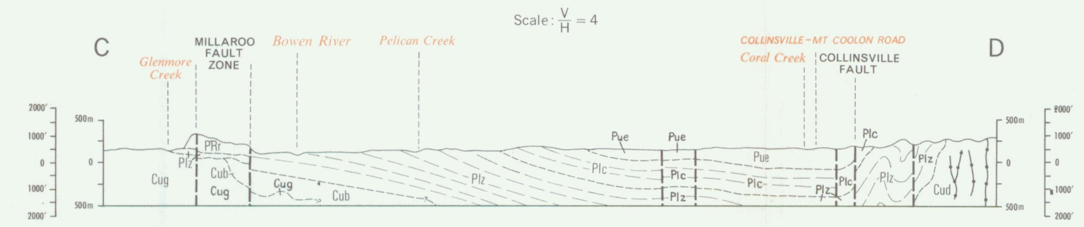

### DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS

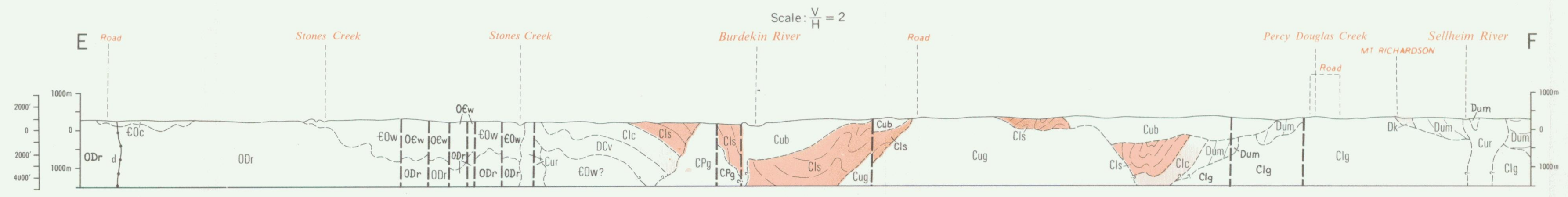


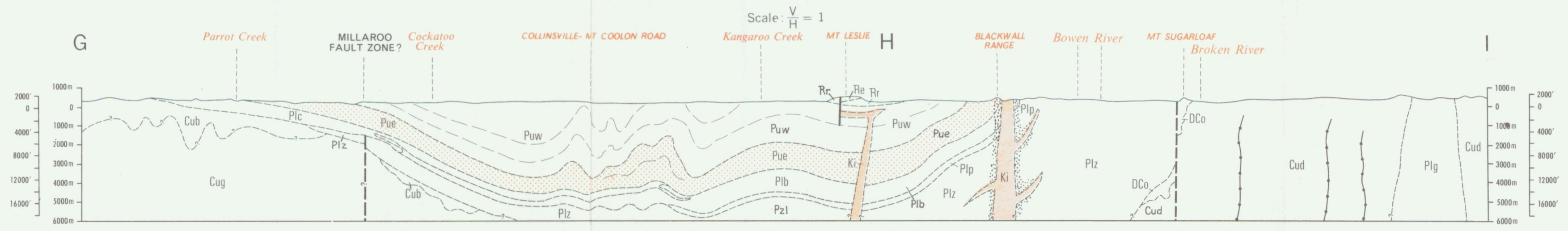

### Sections

Attitude of faults not known Folding schematic
Cainozoic sediments omitted




BOWEN

SHEET SF 55-3

PRELIMINARY EDITION 1973

SUBJECT TO AMENDMENT