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Record No. 1970 / 50

Geology of the Northern Half of the Bowen 1:250,000 Sheet Area, Queensland (with Additions to the Geology of the Southern Half)

by

A.G.L. Paine, D.E. Clarke, and C.M. Gregory*

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SUMMARY

The northern half of the Bowen 1:250,000 Sheet area in eastern Queensland was mapped by the Bureau of Mineral Resources and the Geological Survey of Queensland in 1964-65. The Survey also extended into the southern half of the Sheet area, which had been mapped by a different field party in 1961.

Bowen (population about 5,000), in the northeast of the Sheet area, is midway between Townsville and Mackay, on the coastal highway and railway between Brisbane and Cairns. The climate is tropical. Most of the Sheet area receives between 600 and 750 mm of rain per year, and there is a marked wet season between December and April. Topographic relief varies a great deal throughout the Sheet area; isolated high peaks (up to 1055 m) near the coast give way to more extensive ranges and tablelands inland. The northern end of the Bowen Basin forms a broad depression in the south. Most of the Sheet area is drained by the Burdekin, one of the largest Australian rivers.

The Sheet area covers early Palaeozoic to Permian granite, volcanics, sediments, and minor metamorphics 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. Besides the northern part of the Permo-Triassic Bowen Basin, which was not examined in the course of the survey, the Sheet area includes the northeastern end of the mainly Lower Carboniferous Drummond Basin. The granitoid rocks in the east comprise a large composite batholith which forms the northern end of the Connors Arch. Those parts of the southern half of the Sheet area which were studied during the survey comprise the granitoid rocks of the Connors Arch, the Lower Permian volcanics east of the Connors Arch, and the sediments of the Drummond Basin north of the Burdekin River.

The oldest rocks are the Cape River Beds, near the western edge of the Sheet area, which consist of volcanics and metamorphics. They are probably Cambrian to Ordovician in age. Small remnants of low-grade metasediments near the Burdekin River are possibly the same age. The Ravenswood Granodiorite Complex,

from which both Middle Ordovician and Upper Silurian or Lower Devonian Rb/Sr isochrons have been obtained, is a large mesozonal batholith which intrudes and has widely 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 nonconformably overlie it farther to the west. The Drummond Basin sequence lies in moderately open folds; the margin of the basin is generally faulted or obscured by younger intrusions and volcanics. The almost vertically dipping Edgecumbe Beds, in the extreme northwest of the Sheet area, are marine sediments which are equivalent to the Upper part of the Drummond Basin Succession.

The Sheet area mainly covers igneous rocks which were formed in the Upper Carboniferous and Lower Permian. Much of the northern end of the Connors Arch consists of a diorite suite which was intruded in the Upper Carboniferous and which is now generally foliated and abundantly intruded by 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 by means of cauldron subsidence; irregular dykes and masses of intrusive rhyolite and porphyry are associated with the volcanics. 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 a large but poorly dated area of adamellite and granodiorite in the north and northeast of the Sheet area was probably intruded at the same time.

Lower Permian volcanics and associated sediments, the Lizzie Creek, Mount Aberdeen, and Kurungle Volcanics, and the Carmila Beds, occur in the north, centre, and east. In the north and centre of the Sheet area, the volcanics are intermediate to basic, and 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 granodiorite and adamellite stocks, emplaced by ring fracturing in the Lower Permian, intrude early Palaeozoic granitic basement in the northwest; another ring fracture nearby, of probably 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 the Lower Cretaceous. The discovery of a Cretaceous batholith of this magnitude (1000 sq km) 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 from 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 Sheet area (1055 m), is carved from an even younger Cretaceous intrusion (115 m.y.), a high-level alkali granite and quartz syenite stock, the Mount Abbot Igneous Complex.

A single Triassic isotopic age has been obtained from the granite of Gloucester Island, but so far no other Triassic granites are known north of about Gladstone (600 km to the south), and for the present the granite of Gloucester Island and similar high-level leucocratic granites near Bowen are regarded as Lower Permian or Lower Cretaceous.

Dykes, mainly of late Palaeozoic age, but also Lower Cretaceous, are abundant in the Bowen Sheet area, especially in the Connors Arch.

The Cainozoic era is represented by a thin veneer of probably 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 faults in the eastern half of the Sheet area are northwesterly, but this control 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 have been associated with the emplacement of the Hecate Granite in the Lower Cretaceous. The Lizzie Creek Volcanics in the northern half of the Sheet area have undergone scarcely any folding, except in places along the Millaroo Fault Zone. In contrast, the Carmila Beds dip consistently at a moderate angle to the east-northeast, and the Edgecumbe Beds dip sub-vertically in the same direction.

Gold accounts for the main value of mineral production from the area covered in this Report. The gold has been produced from numerous small mines, which had short productive lives, the most important being the Dittmer mine. The gold and minor base metal mineralization in the northeast of the Sheet area appears to be related to the Lower Cretaceous Hecate Granite.

INTRODUCTION

The Bowen 1:250,000 Sheet area is near the central Queensland coast, mid-way between Brisbane and Cape York. The Sheet area is defined by latitudes 20 and 21 degrees south and longitudes 147 and 148 degrees 30 minutes east (Fig.1).

The geology of the northern half of the Sheet area was mapped in 1964-65 by a joint field party of the Commonwealth Bureau of Mineral Resources, Geology and Geophysics (BMR) and the Geological Survey of Queensland (GSQ). The mapping was part of a joint survey of the Burdekin River region, which lasted from 1963 to 1966. The geologists of the field party were A.G.L. Paine (BMR party leader), C.M. Gregory (BMR), and D.E. Clarke (GSQ). The North Bowen field party also traversed parts of the southern half of the Sheet area, which was mapped by BMR (Sedimentary Basins Section) and GSQ in 1961, as part of a regional survey of the Bowen Basin. Those parts of the southern half of the Sheet area which were studied during the survey comprise the granitoid rocks of the Connors Arch, the Lower Permian volcanics east of the Connors Arch, and the Drummond Basin sediments north of the Burdekin River. The additional information gained from these traverses is recorded in this Report, and the structural framework and geological history of the entire Sheet area are also described. During 6 weeks with the field party 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.

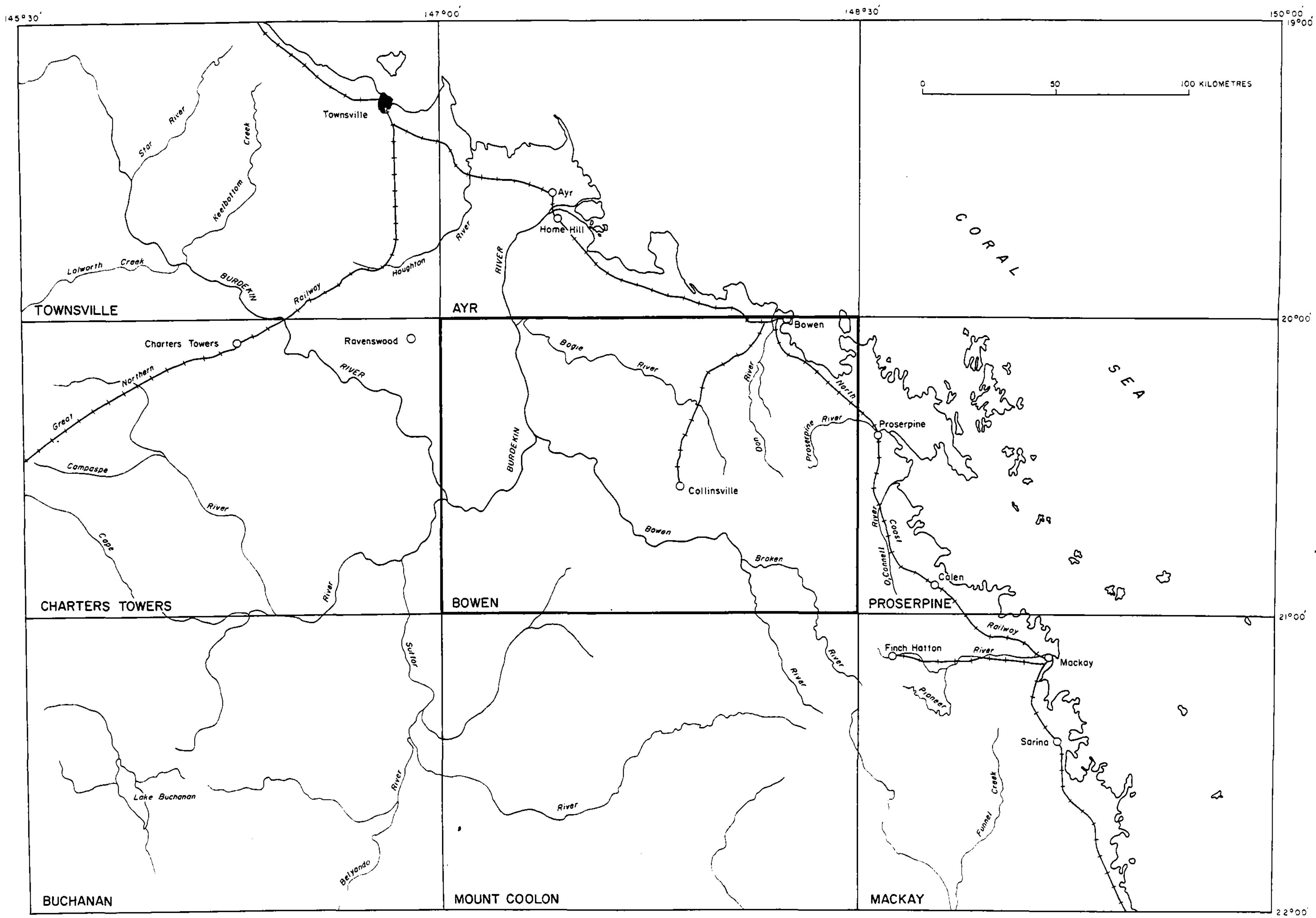
Communications and Industries

Bowen (population 5,134) is on the western shores of Edgecumbe Bay in the northeastern corner of the Sheet area. 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 smaller number of sugar farms at Kelsey Creek and Crystal Brook in the east of the Sheet area, and scattered fruit and vegetable farms in the Delta area 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 Sheet area. A branch line (also narrow gauge) runs from Bowen to Collinsville(pop. 1,884) a coal mining town 90 km. to the southwest,just within the southern half of the Sheet area.

The main coast road from Brisbane to Cairns, the Bruce Highway, passes through the northeastern corner of the Sheet area, near the North Coast Railway. Other bitumen-sealed roads connect Collinsville with Bowen, and Dalbeg with Ayr (Ayr Sheet area). Formed and maintained 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-Collinsvlle road at Mount Buckley to Pretty Bend homestead; and from Kelsey Creek to Proserpine Sheet area): roads of similar quality afford access to all other station properties. Station tracks suitable for cross-country vehicles are well distributed in the less hilly parts of the Sheet area. Sizeable parts of the southwest and southeast of the Sheet area are inaccessible by vehicle. For everyday transport the North Bowen field party used short wheelbase Land Rovers; a helicopter, a launch, and a light aircraft were chartered for short periods. Bowen is a regular port of call for airline flights between coastal towns and cities. A few of the larger cattle stations have their own airstrips.

There are no secondary industries in the area. Beef cattle raising is a major source of livelihood, 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 of the farmers have been experimenting with rice as an alternative crop; the water is obtained from surface flow in 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, and the delta has become an important supplier of fruit to southern states during the winter. Groundwater from the delta is used for irrigation. The deep water harbour at Bowen is a regular port of call for ocean-going ships plying between the Australian coast and overseas ports. The main cargo is beef, but small quantities of coal from Collinsville have been shipped for export in recent years (18,783 long tons in 1967). Most of the coal mined at Collinsville (476,810 long tons in 1969) is railed to Merinda, and thence to Mount Isa. The State Coke Works at Bowen produced 32,440 long tons of coke in 1968, and most of this was consumed by Mount Isa Mines Ltd. A solar salt works operates on tidal flats east of Bowen aerodrome, and there is a small but growing tourist industry.



To accompany Record 1970/50

Figure 1. Locality sketch and sheet area index.

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Climate
(Atlas of Australian Resources, 1952-3)

The climate is tropical. The normal maximum temperature in the area is 31^{o}-34^{o}C in January and 24^{o}C in July. Normal minima are 21^{o}-24^{o}C. in January and 10^{o}-13^{o}C in July.

On average there are fewer than 5 frosts per year. The average annual rainfall at Bowen is 1145 mm. (45 ins), but most of the northern part of the Sheet area lies between the 25 and 30-inch (630 and 760 mm.) isohyets. The driest part of the area (580 mm.) is in the southwest. The highest parts of the Clarke Range receive more than 1250 mm. of annual rainfall, and south of Mount Hector the figure exceeds 2150 mm. (Irrigation & Water Supply Commission, Qld, 1963, unpubl.). Most of the rain falls in a wet season which lasts from about November to April, but the rain is less reliably seasonal than west of the Great Dividing Range. The variability (average deviation) of rainfall in the Sheet area is between 30 and 35 percent, and the number of rain days per year ranges from 40 in the west to 80 in the east.

Surface Water

Most streams in the area dry up in the dry season, but some flow is maintained in the Burdekin River, and to a lesser extent in the Bowen River, throughout the year. 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

Cadastral maps at a scale of 4 miles to 1 inch produced by the Department of Lands, Brisbane, cover the Sheet area. A planimetric map of the Sheet area at 1:250,000 scale was produced by the Division of National Mapping, Commonwealth Department of National Development, in 1967. The technique of hill shading has been used on this map; spot heights are scarce, especially on summits, so that only an impression of relief and height above sea-level can be obtained. The Bowen Sheet area lies within the 1:1,000,000 scale ICAO map Sheet no.3234 (Clermont). Topographic (contoured) maps at 1:100,000 scale are currently being produced by the Division of National Mapping; by May 1970 the 2 easternmost Sheets (Bowen and Urannah) were available.

High quality air photographs at a nominal scale of 1:85,000 (RC9) were taken by Adastra Airways Pty Ltd in 1960 for the Commonwealth Government, and cover the whole Sheet area. The Sheet area is also covered by RAAF air photos at a scale of about 1:46,000 flown by individual 1 mile areas in 1945. Air photographs of selected 1 mile areas have been flown by Adastra at a scale of about 1:25,000 for the Department of Lands, Brisbane, as follows:

1 Mile Area	Year Flown
Scottville	1956
Bald Hill	1959
Exmoor	1959
Bowen	1960
Monte Christo	1961
Hidden Valley	1962
Mount Glenroy	1965
Glendon	1967

Photomaps (mosaics) at a nominal scale of 1 mile to 1 inch, based on the RC9 photography, are available for all 12 of the 1 mile Sheet areas. A more recent set of 6 photomaps covers the Sheet area at a nominal scale of 1:100,000. Both sets of photomaps were produced by the Division of National Mapping.

Previous and Contemporary Investigations

Probably because no economically or palaeontologically important sedimentary succession was known to occur within the northern half of the Bowen Sheet area, it was not until relatively recently that any systematic geological mapping was carried out. Jack and Maitland (Jack, 1890) produced a rudimentary geological map of the Bowen-Mackay hinterland at a scale of 12 miles to 1 inch. Until 1927, when Stanley published a description of the physiography of the Bowen district and the Cumberland Islands, the only recorded geological observations were made by officers of the Geological Survey of Queensland reporting from time to time on gold and other mineral discoveries. The first inspection report was by Jack (1879b) on the Normanby and Marengo Goldfields. Of the many subsequent reports, a dozen or so have commented on the local geology, notably Morton (1921a); the more important are: Saint-Smith (1918, Ben Lomond limestone), Morton (1921 a, 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).

Stanley's paper included many geological observations. In order to establish a basis for a study of the physiography he carried out a rapid geological reconnaissance and produced a map (his text fig. 2), which recorded for the first time the widespread occurrence of granite in the northeastern corner of the Sheet area. The area investigated by Stanley extended as far inland as lat. 20°35'S and long. 147°40'E. More than a dozen pages of his 50-page paper are devoted to the Bowen district, and the paper includes several panoramic sketches.

Most of the northern half of the Bowen Sheet area was included in a map and report by Traves (1951, unpubl.) of BMR, who carried out a systematic geological reconnaissance of the Townsville-Bowen hinterland. Traves' work was part of a comprehensive survey by CSIRO to examine the possibilities of land use for the proposed Burdekin Dam Scheme. An abbreviated version of Traves' geological report formed part of the full report by CSIRO (Christian et al., 1953). Traves' survey depended mainly on air-photo interpretation (he mapped 12,000 sq km in 7 weeks), which is of limited value in this region of complex igneous geology. Nevertheless his survey resulted in the first regional geological map of the area showing the general distribution of the major rock types.

Australian Oil and Gas Corporation Ltd (1962, unpubl.) carried out a reconnaissance aeromagnetic survey of the eastern coast of Queensland consisting of zig-zag traverses, one 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 Sheet area, and measured and described a section of fossiliferous Lower Carboniferous sediments (named Edgecumbe Beds in this report).

Specimens collected from what is now called the Thunderbolt Granite were dated isotopically by Webb et al. (1963). In 1963 a reconnaissance gravity survey of the Sheet area, using helicopters, was carried out under contract for BMR by Velocity Surveys Ltd of Canada, as part of the BMR's regional helicopter gravity programme (Darby, 1969). In 1965 a seismic refraction survey was carried out under contract for the Mines Department, to determine the position of the water table and thickness of alluvium in the Don River delta; the results of the survey were later submitted to BMR for re-interpretation (Kevi et al., 1968, unpubl.).

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 dated 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. (1969), Wyatt (1968).
Charters Towers: Wyatt et al. (1970), Clarke & Paine (1970).
Buchanan: Olgers (1969a, unpubl., 1969b).
Mount Coolon: Malone et al. (1964), Malone (1969).
Mackay: Jensen et al. (1966), Jensen (1965).
Proserpine: Clarke et al. (1968, unpubl., and in press), Paine (in press).
Ayr: Paine et al. (1969), Gregory (1969).
Bowen (S. half): Malone et al. (1966).
Ravenswood 1-Mile (Charters Towers 1:250,000): Clarke (1969,

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, helicopter pilot for Helicopter Utilities Pty Ltd, for his skill and courage during helicopter operations in the Clarke Range.

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 Danger, Mr J. Gordon of Mount Pleasant Station, and Mr A. Williams of Normanby Range Holding.

Some information contained in the Report by Malone et al.(1966) on the geology of the southern half of the Sheet area has been incorporated in the sections of this Report which describe the structure and geological history of the whole of the Bowen Sheet area.

Petrography, etc.

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, then of BMR, described the petrography of several specimens from in and around the town of Bowen.

The scheme of rock nomenclature followed by Hatch et al.(1961) has been used throughout the Report, except that the name tonalite is used for granodiorites in which potash feldspar amounts to less than 10 percent of the total feldspar. In phanerocrystalline rocks a modal quartz content of more than 10 percent is used to define acid types. Plagioclase with an anorthite content of more than 50 percent is used as the dividing line between gabbro, dolerite and basalt on the one hand and diorite, microdiorite and andesite on the other.

Most of the petrographic descriptions are based on rapid examinations made for the purpose of establishing 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 $^{87}Rb\ \lambda = 1.47 \times 10^{-11} yr^{-1}$.

Physiography (Fig. 2)

The major divide in the northern half of the Bowen Sheet area is the northeastern watershed of the Bogie River, separating the drainage basin of the Burdekin River from those of the shorter coastal streams to the northeast. The Burdekin, which is one of the largest rivers in Australia, flows into the Coral Sea, amid a large delta, near Ayr (Fig. 1). Its bed ranges between 500 m and 1000 m in width over the seaward 100 km of its course. The Bowen and Bogie Rivers are the largest tributaries of the Burdekin River in the Sheet area. The two largest northeasterly coastal streams are the Don River and the Prosperine River, both of which have substantial discharges, owing to the heavy seasonal rainfall in the ranges west of Proserpine. Although the Don River is only 80 km long, its bed is as much as 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. Relief is greatest at Mount Abbot (1055 m), which rises about 1000 m above outwash plains near the northern edge of the area, and at Mount Aberdeen (890 m), 20 km to the southeast. These are the highest of several isolated mountains in the northeast which rise steeply from at or near sea level, and include Mount Mackenzie (619 m), Mount Pring (420 m), Mount Roundback (760 m; NW of Mount Pring; summit just N 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 lat. 20°15'S the mountains form more continuous ranges. The highest and most rugged of the ranges separates the topographic basin occupied by the headwaters of the Proserpine River from the plains at the eastern edge of the Sheet area, and includes Mount McGuire (738 m) and Mount Quandong (792 m). Between the Proserpine

River and long. 147°45'E the altitude and relief are less, 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 Leichhardt Range is the deeply dissected eastern edge of a mountainous plateau which gradually loses height to the west. Much of the plateau is between 400 and 500 m above sea level, and elevations approach 600 m in a few places. Relief along the eastern edge of the range is about 300-400 m.

East from the Burdekin River to about long. 147°45'E there are uplands and low ranges separating plains.

Plains, most of which are co-extensive with the coastal plain, occur along the Burdekin and Bogie Rivers, in the northeastern part of the area, and south of the western part of the Clarke Range. The coastal plain and its inland extensions (e.g. Burdekin River plain) are depositional features. These plains are being eroded and reduced in size owing to a 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 are erosional, having developed on the easily weathered Lower Permian basalt.

An important physiographic feature of the northern half of the Sheet area is the watershed between the westerly-flowing Bogie River, and the shorter coastal streams which flow north and east. The watershed passes through Mount Abbot and trends southeast to the south of Mount Aberdeen, meeting lat. 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 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 interrelationships of different drainage basins at various stages of evolution. The only valid rules appear to be that the most rugged country is generally formed from leucocratic granites, and that dykes commonly form ridges in the areas of intermediate to basic plutonic rocks. In the Leichhardt Range geology and topography are more closely related than elsewhere, and it has been possible to photo-interpret several major features with confidence.

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

Figures 5, 6, 7, 8, 9, 24, and 25 give general impressions of the physiography and geomorphology of the northeastern part of the Bowen Sheet area, and Figures 3 and 4 relate the topography to the geology of a selected quadrangle of the Sheet area, in the headwaters of the Andromache, Proserpine and Don Rivers.

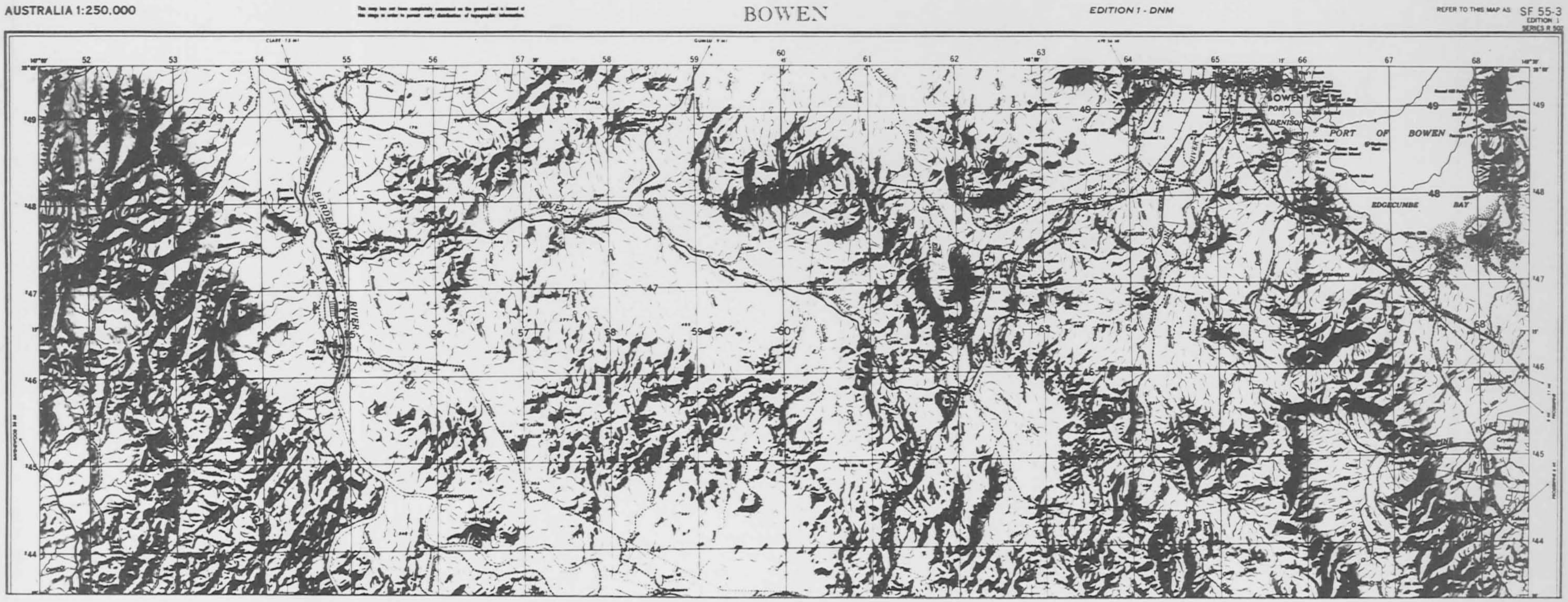
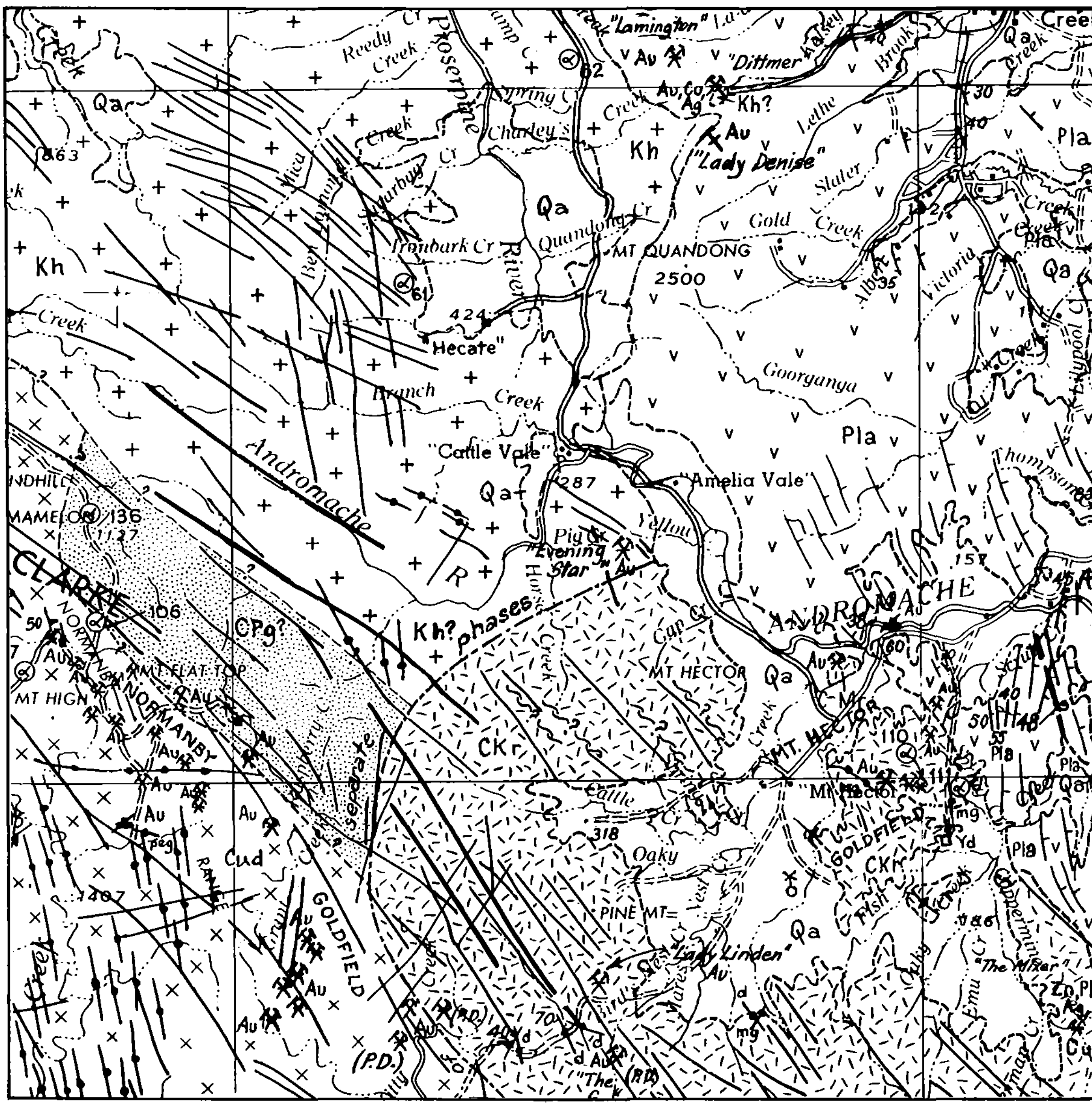


Fig. 2 Physiography (photo-reduction of the northern half of the Division of National Mapping's 1:250,000 planimetic map of the Bowen Sheet area, showing hill-shading. Reproduced by courtesy of the Director, Division of National Mapping.)

ENLARGEMENT OF PART OF BOWEN 1:250,000 GEOLOGICAL MAP COVERED BY FIGURE 3



Qa	*Alluvium*
Kh	*Adamellite, granodiorite*
Pla	*Mainly acid to intermediate pyroclastics*
CPg	*Adamellite*
Cud	*Diorite, quartz diorite, gabbro, tonalite*
CKr	*Undivided plutonic rocks*

For nomenclature, age, and relationships see text and 1:250,000 map

0 4 8 KILOMETRES

To accompany Record 1970/50 *F55/A3/16.*

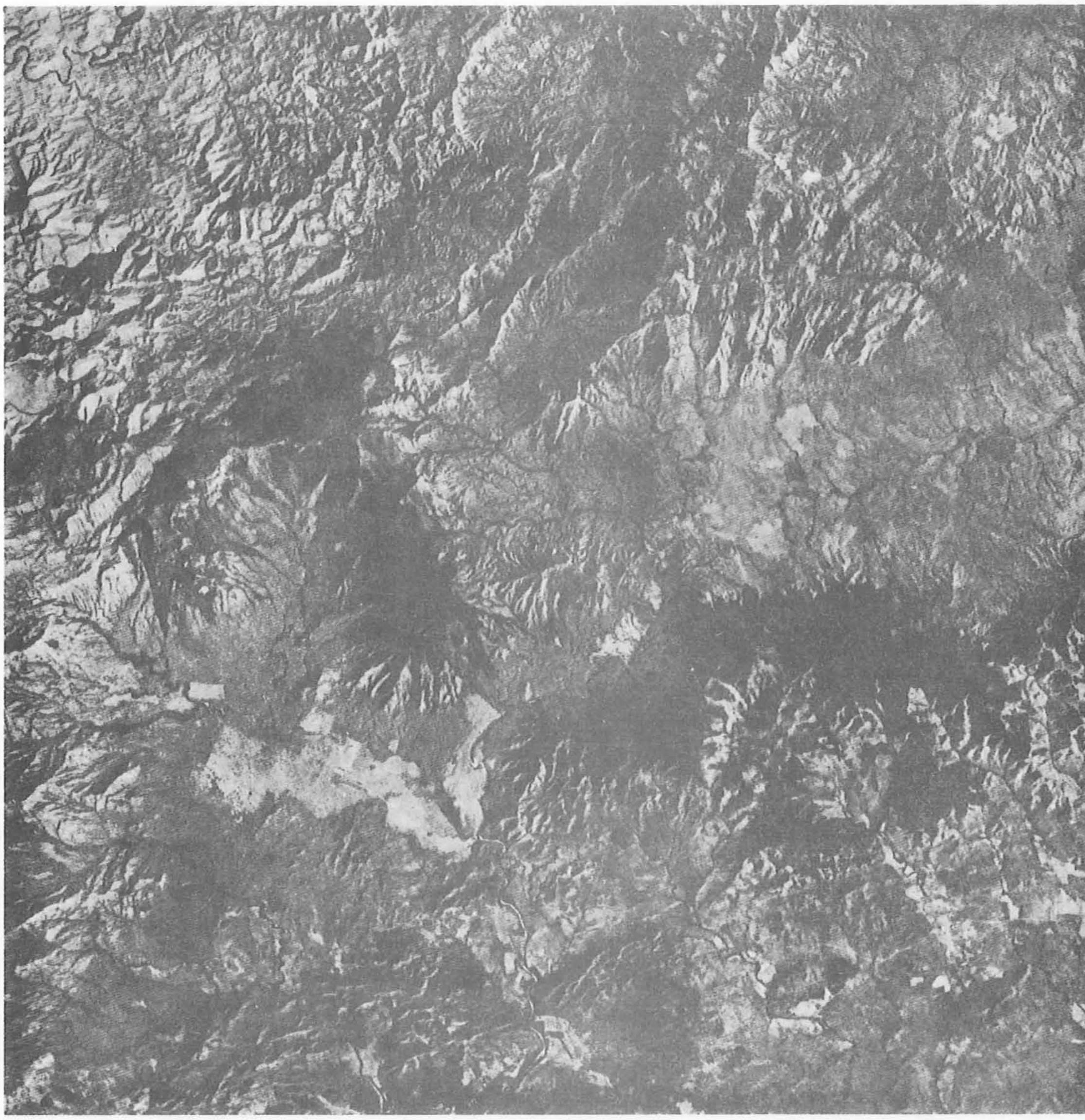


Fig. 3. Vertical air photo mosaic of part of the Clarke Range and the headwaters of the Andromache, Proserpine and Don Rivers. Same area and scale as Figure 4. This is some of the most rugged country in the Bowen Sheet area; a maximum relief in the area covered by the photo mosaic is about 850 m. There is limited correlation between physiography and geology (Fig. 4), necessitating generalized geological boundaries. The cleared areas are sugar farms in the northeast and grazing paddocks south and west of the Mount Quandong Range.

Fig. 5 View northeast from Roma Peak (660 m) to Mount Challenger (516 m, 1. centre)and nearby unnamed mountains. The sharp ridge of Gloucester Island (566 m), which is 45 km from Roma Peak, is directly behind the summit of Mount Challenger. Neg.GA.1161

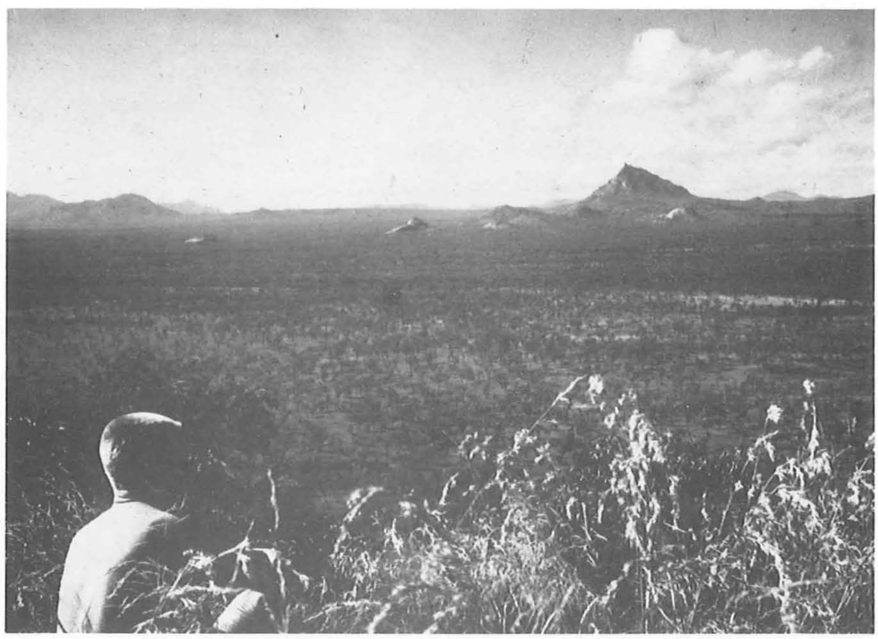


Fig. 6: View southeast from Mount Marengo (265 m, 35 km SW of Bowen) to Roma Peak (660 m, 13 km distant). Large whalebacks of Lower Cretaceous adamellite (Hecate Granite) are visible in the middle distance. Bald Rock (Fig. 26) and Sixpenny Hill are the whalebacks farthest to the right and left. Neg. GA.1156

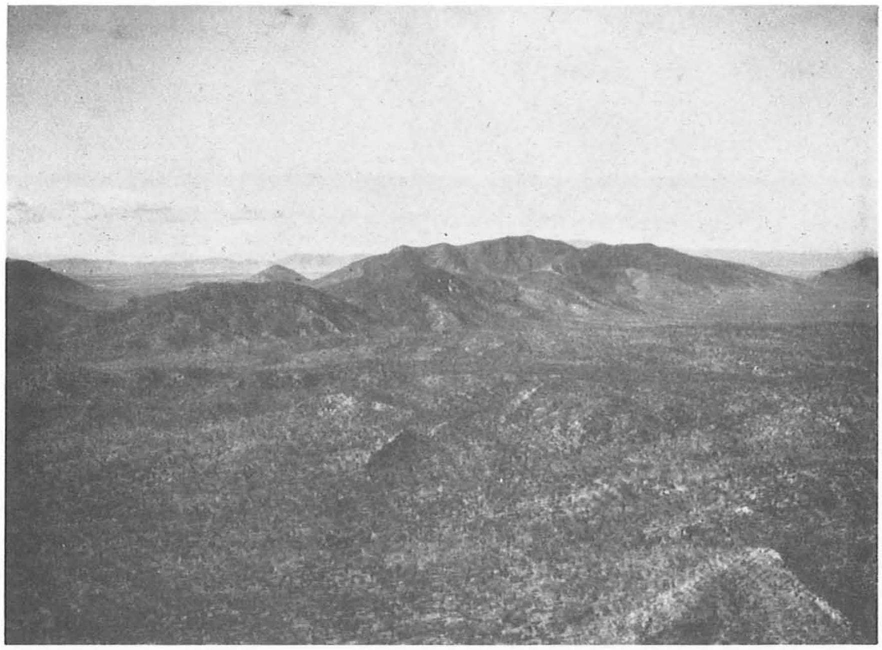


Fig. 7: View east-northeast from Roma Peak (660 m) to Mount McGuire (738 m), 16 km distant. Neg.GA.1147

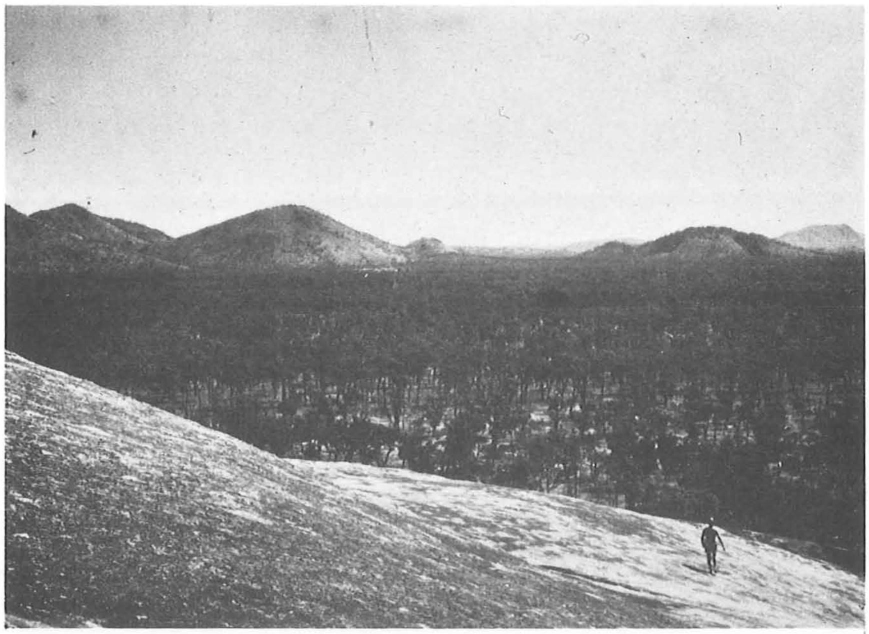


Fig. 8: View west from Sixpenny Hill, a Lower Cretaceous adamellite whaleback, to the Tree Brothers (375 m) on the left and Mount Marengo (265 m) on the right. Neg. GA.1162

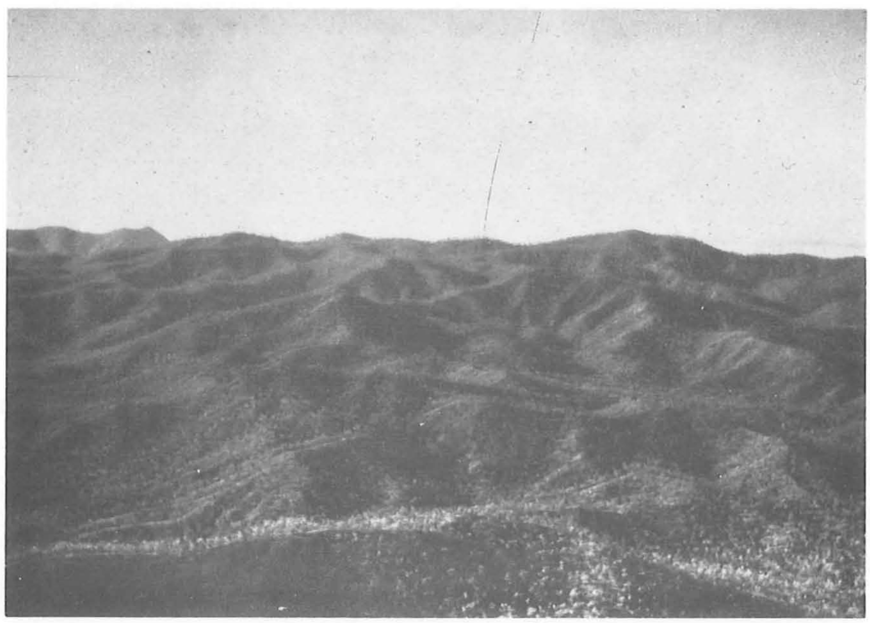


Fig. 9: Physiography of part of the Upper Carboniferous diorite suite (Cud), western slopes of Clarke Range, between Normanby Goldfield and Pretty Bend homestead. View north from helicopter. Neg.GA.1165.

CAMBRIAN TO ORDOVICIAN

Cape River Beds

The oldest rocks in the Sheet area are volcanics and sediments which have been intruded and metamorphosed by the underlying Ravenswood Granodiorite Complex, and now form part of the western slopes of the Leichhardt Range. They are mapped as part of the Cape River Beds, which include the Mount Windsor Volcanics. The Cape River Beds were defined and described from the Hughenden and Charters Towers Sheet areas (Paine et al., in press; Wyatt, et al., 1970). The Mount Windsor Volcanics were defined as part of the Cape River Beds (Wyatt et al., 1970), and have broadly the same relationship to the Cape River Beds as a member has to a formation. The Cape River Beds have so far proved to be unfossiliferous, but provisional analyses suggest an Upper Cambrian isotopic age for the Mount Windsor Volcanics.

Distribution and topography

Areas of recognizable volcanics are mapped as Mount Windsor Volcanics. The volcanics crop out over an area of 300 sq. km. south-east of Rangeview homestead, and occupy a smaller area in the headwaters of Landers Creek. They form steep, closely dissected hills whose summits are of roughly coincident height (400 to 500 m. above sea level near Landers Creek, 300 to 400 m. near Rangeview).

Roof pendants of metamorphics, which may have been derived from volcanics, occur in the Ravenswood Granodiorite Complex at the western border of the Sheet area. These are mapped as undivided Cape River Beds. They form very low rises above the general level of the Ravenswood Granodiorite Complex, at about 250 to 300 m. above sea level.

Lithology

Mount Windsor Volcanics. Fine-grained porphyritic rhyolite is the main rock-type of the Mount Windsor Volcanics. Rhyodacite and rhyolite breccia are locally important, and dacite and andesite have been observed in the sequence. The volcanics grade into gneiss and schist near the Ravenswood Granodiorite Complex. Fine-grained laminated quartzite, argillite, and coarse arkose, representative of the Cape River Beds in the Charters Towers Sheet area, occur at Stuart Pocket, 10 km. north-

northeast of Glenroy homestead. They have not been found elsewhere, and the proportion of sediments in the Mount Windsor Volcanics is probably small.

In the headwaters of Six Mile Creek the Mount Windsor Volcanics are mostly siliceous pale grey to brown rhyolite, generally porphyritic in quartz and locally also in feldspar. In places the rhyolite is fragmented, and contorted flow-banding is visible on some weathered surfaces. Pyrite, commonly disseminated in small euhedral crystals, and rarely as small aggregates or thin joint-coatings, is almost universally present, but is not abundant. Volcanic breccia (with a high proportion of fragments, some of which are granitic) and dark blue-black dacite(?) are subordinate.

The roof of the Ravenswood Granodiorite Complex is believed to dip gently eastwards, and for up to 3.5 km. east from the outcrop of the contact the rhyolite is cleaved, and biotite is developed along cleavage planes. Similar rocks occur in Glenroy Creek 3 to 6 km. northeast of Mount Glenroy, though here some of the metamorphism may have been caused by the Late Palaeozoic(?) granodiorite (CPg) immediately to the north. Original volcanic textures are preserved in many rocks, although masked by strong shearing in places. However, in most rocks immediately next to the contact with the Ravenswood Granodiorite Complex the groundmass has a completely granoblastic texture. Relict quartz and alkali feldspar phenocrysts are present in the less metamorphosed rhyolites. The fractured, sheared, and recrystallized quartz phenocrysts of the more highly sheared rocks are represented by lenticular zones of quartz grains coarser than the groundmass. Abundant biotite, and minor muscovite and sericite are developed in metamorphosed rhyolites. Rare hornblende phenocrysts have been converted to aggregates of fine biotite flakes. Recrystallization of the more strongly sheared rhyoltes has produced strongly foliated gneissic rocks.

Metamorphosed rhyodacites and dacites also tend to be granoblastic and blastoporphyritic; volcanic textures are preserved in some specimens. A specimen of rhyodacite from near the contact consists of 30 percent plagioclase, 20 percent quartz, 20 percent hornblende, 20 percent potash feldspar, 5 percent biotite, and 5 percent iron oxide. The texture is granoblastic, but a few relict phenocrysts of quartz,

TABLE 1 - CAMBRIAN TO LOWER CARBONIFEROUS STRATIGRAPHY AND IGNEOUS INTRUSIONS

Record 1970/50

Period or Epoch	Rock Unit (Map Symbol)	Lithology	Topography	Remarks
LOWER CARBONIFEROUS	Clg	Adamellite, minor granodiorite, tonalite, diorite. Numerous roof pendants.	Plains and low rises; scattered tors.	Mesozonal batholith. Intrudes Ukalunda Beds and Mount Wyatt Beds. Unconformably overlain by Bulgonunna Volcanics and Suttor Formation.
	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. Middle to Upper Tournaisian. Thickness at least 4,700 m (including Proserpine Sheet area).
	Star of Hope Formation (Cls)	Lapilli tuff, welded tuff, tuffaceous sandstone, volcanolithic sandstone, sandstone with quartz pebbles, conglomerate		Overlaps Mt Hall Formation onto Scartwater Formation. Unconformably overlain by Bulgonunna Volcanics, Suttor Formation, 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 sandstones	Wide soil-covered flats and areas of long strike ridges. Relief reaches 75 m just N. of Burdekin Falls.	Interfingers with top of Scartwater Formation. Overlapped by Star of Hope Formation. 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 (Clo)	Fine feldspathic sandstone, interbeds of calcarenite, algal limestone, olive mudstone, lithic tuff.		Disconformably overlies St Anns Formation and volcanics (DCv). Overlain by and interfingers with Mt Hall Formation. Unconformably overlain by Bulgonunna Volcanics. Intruded by Mount Wickham Rhyolite at Mt McConnell, rhyolite and porphyry (Cur) and dolerite (CPi). Plant fossils. Thickness about 300 m.
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		Unconformably overlies Ukalunda Beds; disconformably overlain by Scartwater Formation. Unconformably overlain by Bulgonunna Volcanics. Intruded by granodiorite (CPg), dolerite (CPi). porphyry (Cur), and basalt (Tb). Plant fossils. Basal part of unit deposited in paralic environment; upper part may be terrestrial.
	DCv	Acid to intermediate volcanics and associated sediments	Plains with some hills and ridges	Unconformable on Mt Windsor Volcanics; faulted against Ravenswood Granodiorite Complex; disconformably overlain by Scartwater Formation; unconformably overlain by Bulgonunna Volcanics, intruded by adamellite (CPg), rhyolite and porphyry (Cur), and dolerite (CPi) probably equivalent to Mt Wyatt Formation and St Anns Formation. Probably terrestrial. About 600 m thick.
	Connors Volcanics (DCo)	Andesite, rhyolite, and dacite lavas, aglomerate, volcanic breccia	Mainly high rugged hills and ridges	Intruded by diorite suite (Cud) and Urannah Igneous Complex; unconformably overlain by Lizzie Creek Volcanics.
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 Volcanics and Suttor Formation. Intruded by adamellite (Clg). Marine and plant fossils. Partly marine environment. At least 1,500 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 Formation, St Anns Formation, Bulgonunna Volcanics, Suttor Formation; intruded and metamorphosed by adamellite batholith (Clg) intruded by porphyry (Cur). Marine environment, probably moderately deep water. Fossils (Couvinian). Thickness unknown, but at least 1200 m.

Middle Ordovician and Upper Silurian or Lower 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 phase (ODr). Batholith intrudes Cape River Beds and is nonconformably overlain by volcanics (Cuv); intruded by adamellite and granodiorite stocks (CPg, Plg) and batholith (Cug), and by ring dykes (Plr).
		ODr	Granodiorite, adamellite, minor quartz diorite, diorite, meladiorite, trondhjemite, granite	Gently undulating country	
Cambrian to Ordovician?		Cape River Beds (€Oo)	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 Volcanics and unnamed volcanics (DCv). Thickness unknown but probably great. Age not well established.
		Mount Windsor Volcanics (€Ow)	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.

plagioclase, and potash feldspar are present. The more highly altered dacites and rhyodacites appear melanocratic in hand specimen, some of them resembling amphibolites.

A slight metamorphic sheen is evident on freshly broken surfaces of many of the less altered volcanics for up to 3.5 km. from the contact. Farther away from the contact most rocks, at least in hand specimen, appear little altered.

Eight kilometres northwest of Glenroy homestead, near the headwaters of Boundary Creek, it is possible to trace a gradation from only slightly metamorphosed porphyritic rhyolite to biotite gneiss, leaving little doubt that most of the metamorphics west of Stones Creek were derived from volcanics. Brownish-yellow, sheared and severely recrystallized rhyolite, porphyritic in quartz, grades into leucocratic muscovite-biotite-microcline-quartz granofels in which no relict phenocrysts remain; finally the gronofels grades into strongly foliated biotite-feldspar-quartz gneiss.

The northern area of Mount Windsor Volcanics is an extension of strongly jointed, but generally not metamorphosed, acid volcanics which crop out 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. Fine-grained biotite-quartz-feldspar-mica schist and gneiss, muscovite-biotite-feldspar-quartz granofels, and amphibolite are the chief rock-types in the roof pendants. The granofels is almost certainly a metamorphosed acid volcanic rock, and the schist, gneiss and amphibolite may also have been derived from volcanics.

North of Rangeview homestead the unit includes 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, which intrude the metamorphics and include xenoliths of the gneiss and amphibolite country rocks, have themselves been metamorphosed to foliated biotite-albite-quartz-potash feldspar granofels. It seems therefore that there were two periods of metamorphism, with intervening dyke emplacement. The larger roof pendants are intruded by many post-metamorphic dykes of granite, felsite, pegmatite, microdiorite, and acid and intermediate porphyry. Most of the dykes are concordant with the east-northeast foliation of the metamorphics.

Structure and Thickness

Generally it is not possible to see primary attitudes in the main block of volcanics and therefore information on structures and thickness is largely lacking. The volcanics are characteristically very strongly jointed, and are cut by northeast-trending faults, along some of which the volcanics have been severely mylonitized. A strong southeast pattern of photo trends between Stones and Glenroy Creeks corresponds with the direction of cleavage and foliation observed in the field, but in most cases it is difficult to decide whether ill defined trends on the air photographs indicate bedding, cleavage, or simply a fracture pattern. Well defined northeasterly trends show on air photographs in the roof pendants. This direction is parallel to the few measured foliation directions. The trends are accentuated by numerous concordant dykes.

Age and Relationships

The Cape River Beds have so far proved to be unfossiliferous. Preliminary Rb/Sr whole-rock analyses (A.W. Webb, pers. comm.) on unmetamorphosed acid volcanics collected in Six Mile Creek have yielded an isochron of 510 ± 100 m.y.** (Upper Cambrian). If confirmed, this would be the first dated occurrence of Cambrian rocks in the Tasman Geosynclinal Zone in Queensland, but confirmation of the date awaits the collection of more material.

The Cape River Beds are intruded by the largely 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

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

to their contact with Upper Carboniferous granite (Cug).

Unnamed Metasediments (Pzu)

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

South of Expedition Pass Creek green-brown and blue-grey micaceous siltstone is both faulted against and intruded by red leucocratic biotite granite (ODa). This granite resembles the late acid phase of the Ravenswood Granodiorite Complex, and is mapped with that unit, although there is no proof of its age in this area. Fine-grained quartz-cordierite-biotite-muscovite hornfelses crop out between the road and the river; they are strongly sheared, brecciated, and intruded by thick flow-banded felsite dykes. Quartz breccia zones occur in hornfelsed siltstone. A few prospecting pits have been sunk on faults, but no trace of mineralization is now visible. 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 alignment of interstitial sericite flakes.

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

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 from the Ayr Sheet area (Paine et al., 1969).

MIDDLE ORDOVICIAN AND UPPER SILURIAN OR LOWER DEVONIAN

Ravenswood Granodiorite Complex

The oldest granitic rocks northwest of the Burdekin River are continuous with the Ravenswood Granodiorite Complex, a large early Palaeozoic batholith which underlies the northeast quarter of the Charters Towers Sheet area. They are mapped with the complex, although at present there is no proof of age in the Bowen Sheet area.

The Ravenswood Granodiorite Complex is defined and described by Wyatt et al. (1969), and Wyatt et al. (1970). In the Charters Towers Sheet area the complex consists mainly of granodiorite, but sub-units of diorite and gabbro and a late acid phase of granite and adamellite were distinguished. In the Bowen Sheet area only the late acid phase (ODa) is mapped separately, because no gabbro has been found, and diorite is of minor extent. In contrast with the batholith as a whole, in the Bowen Sheet area the late acid phase covers a larger area than the main granodiorite phase (ODr). In 1966 Clarke (1969, unpubl.) mapped the Ravenswood 1-mile Sheet area, and distinguished several more phases.

Distribution and Topography

The main granodiorite phase forms undulating country of low relief with a fairly close drainage pattern. It crops out in a meridional strip some 25 km. long by 5 to 10 km. wide, and 200 to 250 m. above sea level, extending from Rangeview homestead to the Burdekin River, and occupies about 25 sq. km. in the northwest corner of the Sheet area, where it is only 100 to 150 m. above sea level. Several small outcrops are mapped in the Burdekin River near Millaroo. Diorite forming a pocket among hills of Mount Windsor Volcanics at the western edge of the Sheet area is mapped as part of the complex, but critical age-relationships are lacking, and classification as either early or late Palaeozoic is arbitrary.

The late acid phase gives rise to rugged hills and forms much of the Leichhardt Range.

Lithology

Main granodiorite phase (ODr). A variety of rock types occurs south of Rangeview homestead: hornblende-biotite granodiorite and adamellite, biotite-hornblende adamellite, and minor quartz-diorite, diorite, and granite were found. Northwest of the homestead the main rock type is a melanocratic hornblende-biotite granodiorite, which varies from fine to medium-grained, and grades to biotite-hornblende diorite. The granodiorite here is intruded by thick dykes of aplitic granite which are related to the nearby late acid phase.

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

The pocket south of the headwaters of Landers Creek is formed from hornblende meladiorite and grey biotite-hornblende diorite. The diorite is cut by thin aplitic dykes. Banded meladiorite and micro-diorite dykes, probably related to the mass, intrude the surrounding Mount Windsor Volcanics.

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

The granite which forms most of the Leichhardt Range north of Rangeview homestead where it is intruded by younger granite (Cug, Plg), and nonconformably overlain by Upper Carboniferous volcanics (Cuv), is mapped with some certainty as part of the Ravenswood Granodiorite. However, in the lower country between the Leichhardt Range and the Burdekin the relationships are not clear, and the boundary between the Ravenswood Granodiorite (ODa) and the Upper Carboniferous granite (Cug) is very uncertain.

Around Marlborough Pocket the main rock type is grey-white biotite adamellite, grading in places to granodiorite. Coarse biotite granite which grades in places to porphyritic microgranite is overlain by the volcanics which form McGregors Bonnet (Cuv). The granite is strongly fractured, and quartz veins (which appear to have been prospected) fill northeast-trending faults. Aplitic microgranite is abundant as dykes and irregular masses in the alkali granite and adamellite which form the rugged hills southwest of McGregors Bonnet. Near the head of Landers Creek coarse porphyritic biotite granite intrudes the Mount Windsor Volcanics. The contacts are sharp and not sheared. Altered leucocratic biotite granite or adamellite, with pegmatite and siliceous phases, forms the country rock at the eastern contact of the Landers Creek stock (Plg).

Between the Leichhardt Range and the Burdekin River the granite is generally deeply weathered, and the few low hills are separated by large areas of no outcrop.

Red leucocratic biotite granite forms hills immediately north of Oaky Creek in the headwaters of Expedition Pass Creek. It is medium-grained, 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 phase of the complex dips gently east beneath the Mount Windsor Volcanics. The main granodiorite phase was intruded syntectonically, causing dynamic and thermal metamorphism of the country rocks. Large roof pendants are preserved and erosion has nowhere penetrated far below the roof of the intrusion.

Rocks of the late acid phase intrude the main granodiorite. Contacts are sharp and associated shearing and foliation are slight compared with those caused by the main granodiorite phase. It is probable that the acid phase is largely post-tectonic. The acid phase is cut by numerous northeast-trending faults.

Age and Relationships

The Ravenswood Granodiorite Complex in the Bowen Sheet area intrudes the Cape River Beds and is nonconformably overlain by volcanics which are probably Upper Carboniferous (Cuv). In the Townsville Sheet area the granodiorite is overlain nonconformably by upper Middle Devonian sediments (Wyatt et al., 1969). No isotopic age determinations have been carried out on specimens from the Bowen Sheet area, but

Rb/Sr whole rock analyses carried out on 17 specimens from the Charters Towers and Townsville Sheet areas show that most of the granodiorites of the complex were emplaced about 455 m.y. ago (Middle Ordovician), and that a second intrusive epoch occurred 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 sequence of volcanics and sediments of the Drummond Basin north of the Burdekin River was only briefly examined by Malone and party in 1961 (Malone et al., 1966), but was 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 in 1966-67 Olgers and others (Olgers, 1969, unpubl.) made a regional study of the Drummond Basin, and were able to trace separate formations through into the Bowen Sheet area from their type areas to the southwest. The succession in the Bowen Sheet area is now subdivided into the Mount Wyatt Formation, St. Anns Formation, Unnamed Volcanics (DCv), Scartwater Formation, Mount Hall Formation, and Star of Hope Formation.

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 made south of the Burdekin River, around Cockatoo Creek, but they were confined to north of latitude 20°45'S.

The Drummond Basin succession is a mainly freshwater sequence which was deposited upon a basement formed from the Ravenswood Granodiorite Complex and Cape River Beds in the north, and 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, and occupies the northwestern limb of a southwest plunging synclinorium.

The formations have a mature topography consisting of wide soil-covered flats and areas of long strike ridges. Relief reaches 75 m just 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 andesitic breccia, agglomerate, coarse tuff, and tuffaceous sandstone. These are overlain by more than 1500 m of dark red deeply weathered sediments and pyroclastics, which form a broad soil-covered flat north of Mount Graham. Fine tuff, mud-ball tuff, coarse feldspathic tuffaceous sandstone, andesitic breccia, agglomerate, tuffaceous siltstone and mudstone, conglomerate, and rare algal and inorganic argillaceous limestone make up this section. Thin lenses of grey algal limestone occur 5 km north-northwest of Mount McConnell, and again 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, forms prominent strike ridges. Acid welded tuff, devitrified felsitic tuff, rhyolite breccia, rhyolite, andesite, feldspathic sandstone, tuffaceous siltstone, and conglomerate comprise this section.

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

Structure and Thickness

The sequence in this area forms the northwestern limb of a southwest-plunging synclinorium. The axis probably coincides with the tight synclinal axis 8 km southeast of Mount McConnell. The present northern margin of the basin is faulted in places, accounting for the steep marginal dips.

Olgers (1969, unpubl.) has estimated a thickness of about 2500 m for this part of the Drummond Basin succession.

Age and Relationships

Only poorly preserved indeterminate plant fragments have been found. However, Lower Carboniferous plant fossils occur in the Drummond Basin in the Charters Towers and Bowen Sheet areas (Wyatt et al., 1970; Malone et al., 1966).
Protolepidodendron (Upper Devonian) has been collected from 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). Consequently it is possible that parts of the unfossiliferous basal sequence in the Bowen Sheet area may be as old as Upper Devonian. For a more detailed discussion of the age of the succession, the reader is referred to Olgers (1969, unpubl.).

The Drummond Basin sequence unconformably overlies the Mount Windsor Volcanics and is intruded by granite, granophyre, microgranite, diorite, porphyry, and rhyolite bodies which are of Upper Carboniferous or Lower Permian age, and by the volcanic plug (Mount Wickham Rhyolite) which forms 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 the sediments have been mainly derived from the products of contemporaneous vulcanism, but pebbles of schist, gneiss, and quartzite in the conglomerates indicate that the Cape River Beds contributed some detritus.

LOWER CARBONIFEROUS

Edgecumbe Beds

The Edgecumbe Beds are mainly marine sediments of Lower Carboniferous age which are exposed over a limited area southeast of Edgecumbe Bay. The name Edgecumbe Beds is introduced by Clarke et al. (1968, unpubl. and in press). The stratigraphic relationships of the Edgecumbe Beds are largely obscured by superficial Cainozoic deposits.

Limestone in the unit was described from Ben Lomond by Saint-Smith (1918) and by Stanley (1927). The first systematic description is by Brown (1963, unpubl.) who measured and described 1272.5 m of section in Ten Mile Creek, above its junction with the Gregory River. This constitutes the type section. The name is derived from Edgecumbe Bay.

Brown referred the sediments to the Campwyn Beds (Jensen, et al., 1966; Clarke et al., 1968, unpubl., and in press) principally because of the similarity in age. However, we consider that the two sequences cannot be directly correlated.

Outcrops of the Edgecumbe Beds in interfluvial areas is generally absent because they have been thoroughly eroded, but the sediments are very well exposed in Ten Mile Creek, which has cut through the veneer of Cainozoic sediments. A few resistant beds form scattered outcrops in interfluves. East of Ben Lomond the unit forms low, soil-covered hills.

Lithology

Shale, greywacke, limestone, feldspathic sandstone, siltstone, clayey sandstone, and pebble conglomerate are the rock types in decreasing order of abundance in the type section. The shale and fine siltstone have a slight sheen, and incipient recrystallization is indicated in thin sections by the development of platy chloritic and micaceous minerals. Consequently the finer sediments could be called argillites. Labile detrital material in the arenites is largely of volcanic origin.

Some of the light brown shales and siltstones are richly fossiliferous, containing bryozoa, brachiopods, gastropods, trilobites, pelecypods, plants, and tracks of worms and other animals (Brown, 1963, unpubl.).

The limestones vary from thin-bedded, highly fossiliferous, fragmental rocks to thick-bedded, unfossiliferous, oolitic types. Sandy and crystalline varieties also occur. Thick oolitic limestones are best exposed at the junction of Ten Mile Creek and the Gregory River; from here limestone extends along strike as discontinuous outcrops north-northwest to Ben Lomond. 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 are the only fossils which have been observed in the roof-pendant.

East of the Gregory River volcanic detritus becomes increasingly abundant in the sediments. The greywackes give way to pyroclastics and flows just east of the margin of the Sheet area. The volcanics to the northwest are andesite, coarse tuff, breccia, and agglomerate which overlie limestone on the northeast side of Ben Lomond.

Thickness

Brown estimated the total exposed thickness of the unit, including that part occurring in the Proserpine Sheet area, at 4700 m This figure does not represent the original total thickness, for neither the base nor the top of the unit are exposed.

Structure

The Edgecumbe Beds strike consistently north-northwest and dip either vertically or very steeply to the east-northeast. Rare cross-bedding proves that the sediments young to the east-northeast. This has been confirmed by palaeontological determinations on fossil collections obtained at four places in the sequence (McKellar in Brown).

The shales and siltstones are cleaved at a low angle to the bedding. The cleavage is not related to any obvious fold structure, and there is no repetition of the sequence. Exposure of the Edgecumbe Beds is so limited that it is not possible to recognize their overall structure.

Outcropping to the west of the Edgecumbe Beds, in the Longford Creek area, are the Lower Permian Carmila Beds which dip at moderate angles to the east-northeast. The structure and the difference in age between the two units show that the contact must be a fault, but it is obscured by a 10 km wide belt of Tertiary sediments. The contact is inferred to be a major strike fault or system of faults with major upthrow to the northeast. Such faults may be extensions of the O'Connell Fault or Foxdale Fault Zone in the Proserpine Sheet area (Clarke et al., 1968, unpubl. and in press).

Age and Relationships

Four fossil collections were made by Brown from his measured section along Ten Mile Creek. The fossils present in the lower two of these sections were determined by R.G. McKellar (in Brown) 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 in the Bowen Sheet area. They are also intruded 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

The sediments were deposited mainly in a shallow marine environment. The entry of unfossiliferous limestone and the increasing abundance of volcanics towards the top of the sequence suggest that the marine environment did not persist.

UPPER CARBONIFEROUS

Diorite, etc. (Cud)

In the northeast of the Bowen Sheet area it has been possible to map approximate boundaries between the acid plutonic rocks (Hecate Granite, Thunderbolt Granite, and unnamed granite (CPg)) and an older suite consisting of diorite and associated rock types (Cud). The acid rocks are mainly Lower Permian and Lower Cretaceous, but include some late Upper Carboniferous phases, whereas Rb/Sr isotopic determinations suggest that the diorite suite is probably entirely Upper Carboniferous. In the southeast of the Sheet area, owing to the relative inaccessibility, it has not been possible to distinguish between the two suites, and they are mapped together under the name Urannah Igneous Complex.

Good access is available to most of the northern half of the outcrop area of the diorite suite. In the south, vehicular travel is restricted in the more mountainous parts, but primary access is provided

TABLE 2. UPPER CARBONIFEROUS TO PERMIAN STRATIGRAPHY AND IGNEOUS INTRUSIONS

		Rock Unit (Map Symbol)	Lithology	Topography	Remarks
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.	Soil covered plains and rises, some strike ridges. Rugged hills where hornfelsed.	Conformably overlain by Rewan Formation; conformable on Blenheim Sub-group. Lacustrine, fluvial, and paludal environments. 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 Creek.	Conformable on Gebbie Sub-group or on Collinsville Coal Measures. Moderately deep to shallow water; transgressive marine phase. Abundant marine fossils. About 450 m in W. of basin, 800 m 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-group, conformably overlain by Blenheim Sub-group. Moderately shallow marine environment, 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-group. Deltaic to paludal environment, 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, sandy limestone.	Long low strike ridges and soil-covered plains.	Possibly unconformable on Lizzie Creek Volcanics. Conformably overlain by Gebbie Sub-group. Moderately deep water marine environment. 550 m thick.
LOWER PERMIAN		Thunderbolt Granite (Plg)	Adamellite, minor microadamellite; aplitic microgranite dykes.	Rugged plateau, flanked by low-lying country in the north and uneven hills and slopes on the south.	Mesozonal batholith. Intrudes Upper Carboniferous diorite suite (Cud), by which it is surrounded. Intruded by Hecate Granite in N., 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 sub-volcanic stocks emplaced by ring-fracturing. Intrude Ravenswood Granodiorite Complex, Upper Carboniferous volcanics (Cuv), Mount Windsor Volcanics, and Upper Carboniferous diorite suite (Cud).
		Plr	Porphyritic rhyolite and microtrondhjemite.	Steep ridges and peaks.	Ring dykes and possible cone sheets. intrude Upper Carboniferous Volcanics (Cuv), Ravenswood Granodiorite Complex, Upper Carboniferous granite (Cug), and Lower Permian granite (Plg).
		Mount Aberdeen Volcanics (Pld)	Andesite, dacite, rhyolite, dacite welded tuff, lithic-crystal tuff, crystal tuff, agglomerate.	Rugged crags at Mount Aberdeen and Mount 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 a relief approaching 400 m.	Apparently both nonconformable on and intruded by late Palaeozoic granite (CPg). Faulted against and intruded by Mount 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 rainforest; low strike ridges.	Intruded by Hecate Granite; down-faulted against Edgecumbe Beds. Rare plant fossils. Probably same age as Lizzie Creek Volcanics. Probably at least 7,500 m thick.
		Lizzie Creek Volcanics (Plz)	Basalt, andesite, agglomerate, lithic and tuffaceous sediments, minor acid volcanics.	Gentle rises and black soil plains in north, with some hilly country near Mount Wickham Rhyolite. Some low strike ridges to west and east of Bowen Basin. High hilly country in east.	Nonconformably overlies granite (Cug, CPg). Faulted against and nonconformable on diorite suite (Cud) and Connors Volcanics. Unconformable on Bulgonunna Volcanics. Possibly unconformably overlain by Tiverton and Gebbie Sub-groups. Intruded by and unconformably overlain by Mount Wickham Rhyolite. Marine fossils at top in Mount Coolon Sheet area. Up to 6000 m thick.

Table 2
1970/50

	Rock Unit (Map Symbol)	Lithology	Topography	Remarks
UPPER CARBONIFEROUS OR LOWER PERMIAN	CPg	Adamellite, granodiorite, granite, minor quartz diorite, granophyre, microgranite, microtrondhjemite.	Mainly low-lying undulating country.	Batholiths and stocks of more than one age. Intrude Ravenswood Granodiorite Complex, Mount Windsor Volcanics, unnamed volcanics (DCv), Star of Hope Formation, diorite suite (Cud), Carmila Beds. Intruded by granite (PKg), Mount Wickham Rhyolite, Hecate Granite, and Mount Abbot Igneous Complex. Faulted against adamellite (Cug). Nonconformably overlain by Lizzie Creek Volcanics and Mount Aberdeen Volcanics.
	CPi	Pyroxene diorite, meladiorite, minor olivine diorite, gabbro, pyroxene monzonite.	Low rises of black soil with rare outcrops.	Small intrusions, locally concordant. Intrude Drummond Basin succession and Mount Windsor Volcanics. Intruded by granodiorite (CPg).
UPPER CARBONIFEROUS	Cug	Adamellite, granite, granodiorite, minor marginal granophyre and porphyry.	Faults divide a rugged broken plateau to the west (Leichhardt Ra.) from gently undulating to uneven country in Burdekin and Bowen valleys and in SE.	Large batholith. Intrudes Bulgonunna Volcanics, unnamed volcanics (Cuv) Mount Windsor Volcanics, Ravenswood Granodiorite Complex, and Scartwater Formation. Intruded by adamellite (Plg). Nonconformably overlain by Lizzie Creek Volcanics. Intruded by and nonconformably overlain by Mount Wickham Rhyolite. Probably comagmatic with Bulgonunna Volcanics.
	Cur	Rhyolite and porphyry	Low sparsely vegetated hills and ridges.	Irregular intrusive masses and dykes. Intrude Drummond Basin sequence, Mount Windsor Volcanics, and Ukalunda Beds. Intrusive phase of Bulgonunna Volcanics and unnamed volcanics (Cuv).
	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 Mount Windsor Volcanics, unnamed volcanics (DCv), Scartwater Formation, Star of Hope Formation, St Anns Formation, Ukalunda Beds, Mount Wyatt Formation, granite (Clg). Intruded by adamellite (Cug). Unconformably overlain by Lizzie Creek Volcanics, Collinsville Coal measures, Suttor Formation.
	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 Volcanics.
	Cud	Diorite, quartz diorite, Tonalite, gabbro, granodiorite. Rare adamellite, norite, monzonite, granite.	Hills and rises in northeast. 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 Volcanics. Faulted against and nonconformably overlain by Lizzie Creek Volcanics.

by the road from Binbee to the old Normanby Goldfield and Sutherland homestead.

Topography

A great variety of topographic forms is recognizable. This is mainly due to the different stages of maturity of the particular stream systems, rather than to differences in rock type. In general the relief and altitude increase to the south.

Northeast of a line between Roma Peak and Mount Abbot there are mainly low hills and rises, with some gently undulating areas of black soil. High, north-northwest-trending ridges are developed between the Bogie River and Collinsville. The most rugged country occurs along Grant Creek, northwest and west of Fairfield hut, and in the Humbug Creek area north of Mount Roundback. Here the relief is up to 350 m. There are numerous elevations of between 600 and 700 m, and one peak is 820 m

Much of the country in the southern part of the unit consists of parallel north-northwest-trending ridges, formed by dykes, especially in the drainage basins of Emu and East Creeks. Ridges are extensively developed in that area, not because of the presence of more dykes, but because the drainage systems have evolved to a critical stage in which, although dissection is considerable, the network is still dense, and relief no more than about 150 m. South of the latitude of Crompton Creek the relative absence of dyke ridges is probably due to the higher relief and wider valleys, so that the characteristic erosion of dykes and plutonic rocks is obscured. The ill-defined plateau which surrounds Parada homestead is a local remnant of a former erosion cycle during which planation advanced far enough to obliterate any geomorphological contrast between the diorite and the dykes; this latent contrast is now being brought to light by the current cycle of erosion, as the more deeply incised creeks encroach upon the plateau.

In general the diorite suite gives rise to smoother slopes (Fig.9) than the younger acid intrusions, and the drainage pattern is more regular and more widely spaced. An example of this is the contrast provided by the Lower Permian adamellite stock west of Crompton Creek, and the surrounding hills of diorite.

Lithology

The diorite suite includes subordinate quartz diorite, tonalite, gabbro and granodiorite. Rare adamellite norite, monzonite and granite also occur. Apart from composition there are two other important characteristics in which the diorite suite differs from the younger acid intrusions: the diorites are almost universally intruded by dykes, and they are generally foliated. These two features are consistent with the age relations observed in the field and determined by isotopic dating.

The lithology of the diorite suite is described under 3 headings: 'northeastern roof pendants', 'northwestern area' and 'main area'. The northeastern roof pendants comprise outcrops northeast of a line between Mount Abbot and the village of Kelsey Creek. The northwestern area is west and northwest of the Thunderbolt Granite, and south as far as Almoola siding. The main area denotes the remainder of the rock unit.

Among the 'northeastern roof pendants' diorite and gabbro form the country rock of the Mount Pring magnesite deposit, 17 km west-southwest of Bowen. The rocks at the deposit itself have been sheared and severely altered by movements on a high-angle reverse fault, and now consist of an irregular network of tremolite crystals in a groundmass of sericite, clinozoisite, and minor chlorite and opaque minerals. Banded fine and coarse hornblende gabbro forms ridges near the mine, 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 altered and intruded by muscovite granite dykes and quartz veins.

Banded diorite and gabbro, sheared in places, form the southwestern spur of Mount Cavana at the southern end of the Bodes Range. One specimen is a highly altered olivine gabbro containing corona textures (2081*). Similar banded diorite and gabbro form low hills

*To relate rock specimen numbers quoted in this Report to B.M.R. registered numbers it is necessary to add the prefix 6515.

between Mount Cavana and the Don River. Some of the gabbro is very coarse, containing feldspars up to 2 cm across and poikilitic amphibole crystals up to 3 cm long. Here and to the north the gabbro and diorite are intruded by adamellite, granite and pegmatite dykes (CPg). Diorite between Grasstree Creek and the northwestern 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 flow-banded spherulitic felsite dyke.

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 pierced by adamellite dykes. Mount Lee consists of meladiorite and hornblende gabbro, intruded by adamellite of the Hecate Granite. At the eastern foot of the hill the diorite and gabbro are brecciated, sheared, and intruded by numerous east-southeasterly aligned microdiorite dykes.

In the <u>northwestern area</u> the suite consists mainly of diorite, granodiorite, and numerous microdiorite dykes. Subordinate rock types include gabbro, and microgranite (as dykes). There is a strong persistent north-northwesterly regional trend, which reflects the main direction of faulting and dyke emplacement. Throughout most of the lower-lying country the rocks have been deeply weathered.

Coarse equigranular diorite is the commonest plutonic rock. In some areas microdiorite dykes form up to 70 percent of the exposures; other dykes observed are composed of gabbro, basalt, granophyre, microgranite, and pegmatite. Of the plutonic rocks granodiorite is next in abundance, and appears to grade into diorite. Granodioritic rocks, commonly severely sheared, also occur as xenoliths in the diorite. A large xenolith of hornfelsed feldspathic arenite at least 6 m long by 2 m wide, crops out in the Bogie River, near its junction with Sundown Creek. Alteration and remobilization of the primary minerals are evident in many outcrops, with the development of epidote, chlorite and calcite, commonly in small veinlets.

In the main area, examples of net-veined and xenolith-bearing contact zones occur in the bed of the Don River at the Mount Dangar crossing. The principal rock type is a massive to feebly foliated medium to coarse biotite-hornblende tonalite, grading into quartz diorite and granodiorite with variation of the quartz and potash feldspar content. The colour index ranges from 20 to 35. The ferromagnesian minerals, particularly biotite, form phenocrysts up to 1 cm.

The tonalite contains xenoliths of meladiorite, some of which are severely foliated, and in places the tonalite net-veins large outcrops of meladiorite. Some outcrops of tonalite are themselves net-veined by a late-stage pinkish grey biotite granite whose texture varies from fine grained porphyritic to aplitic and pegmatitic. These outcrops are similar in many respects to those described and illustrated by Allaart (1967) from south Greenland.

A 2 m-thick dyke of banded pegmatite and aplite occurs 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 severely sheared parallel to their margins (Figs 27 and 28).

Fine grained plagioclase-quartz-hornblende amphibolite and similar melanocratic cataclasites occur sporadically in the Mount Dangar Shear north of the Don River. Medium grained diorite (2103), porphyritic in hornblende, forms boulders 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 sub-horizontal cataclastic foliation.

One Mile Mountain is formed from what appears to be a dyke of altered medium-grained trondhjemite (2125). Small iron-stained patches containing epidote and fine-grained malachite were seen in hand specimens of the trondhjemite (minor gold-copper occurrences were worked nearby in the past).

Outcrops near the station track 3.5 km. southeast of One Mile Mountain consist of fine to medium grained biotite-hornblende quartz diorite, in which the quartz occurs as poikilitic lakes (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.8), 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, suggesting the presence of a localized basic complex. All minerals in the norite are unusually fresh; the plagioclase is clear and glassy. Jack (1879b) recorded occasional small areas of gneiss, schist, shale and greywacke in the Marengo goldfield, but none were observed in the course of 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, strikingly porphyritic in hornblende and biotite, and finally by a set of rectilinear biotite trondhjemite (?) veins (Figs 10-14). In outcrop the pipes superficially resemble xenoliths. 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. Massive quartz diorite and diorite crop out in the indented scarp which forms 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. The pegmatites are greisenous in places.

Massive medium grained biotite-hornblende quartz diorite, containing disseminations of 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 phases of gabbro, including gabbro pegmatite, are present. Flow-foliated 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.15).

Net-veining of diorite by tonalite is illustrated in an outcrop in Boundary Creek, 1.5 km. above its junction with the Don River. In addition, successive diorites intrude each other in net vein-style. The diorite and tonalite are intruded by a dyke of biotite granite-aplite, which includes xenoliths of microdiorite, and is itself intruded by a synkinematic dyke of microdiorite containing porphyritic hornblende (Figs 29-31).

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 have incipient granoblastic textures. The albite twinning in some of the plagioclase crystals is slightly bent, suggesting stress during crystallization. Hornblende (12%) is fresh; at least one large crystal is a replacement of pyroxene. Biotite (5 to 7%) is also fresh, and is strongly foliated. Sphene (1%) forms crystals up to 2 mm., but also occurs as narrow rims between biotite and opaques. 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.

Contamination of what may perhaps have been the Hecate Granite magma (here mapped empirically with the diorite suite) is well shown in

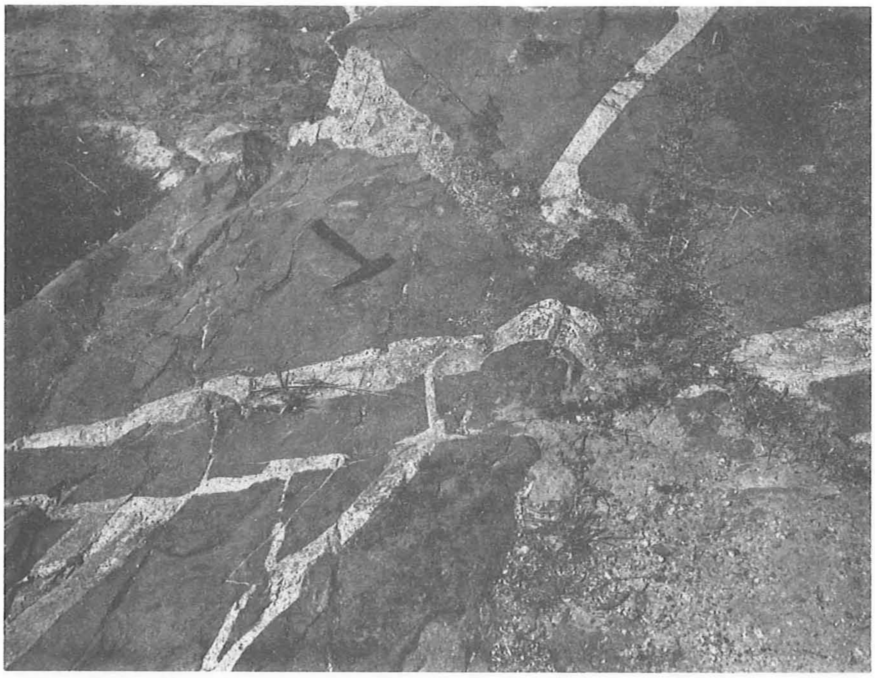


Fig. 10: Dark fine-grained diorite intruded by early irregular veins of tonalite(?), strikingly porphyritic in hornblende and biotite and containing xenoliths of diorite, and by late rectilinear veins of biotite trondhjemite(?). Ida Creek crossing, on road to Pretty Bend homestead. Same outcrop as Figs. 11 to 14. Photograph by J.E. Zawartko.

Neg.G.8559.

Fig. 11: Close-up of part of tonalite(?) vein shown in Figure 10, Ida Creek Crossing, on road to Pretty Bend homestead. Penny gives scale. The tonalite, which forms small pipes nearby in the same outcrop (Figs. 12-14), contains xenoliths of the diorite which it intrudes. Part of the outcrop has been wetted, and therefore appears darker than the rest. Neg.G.8343

Photograph by J.E. Zawartko.

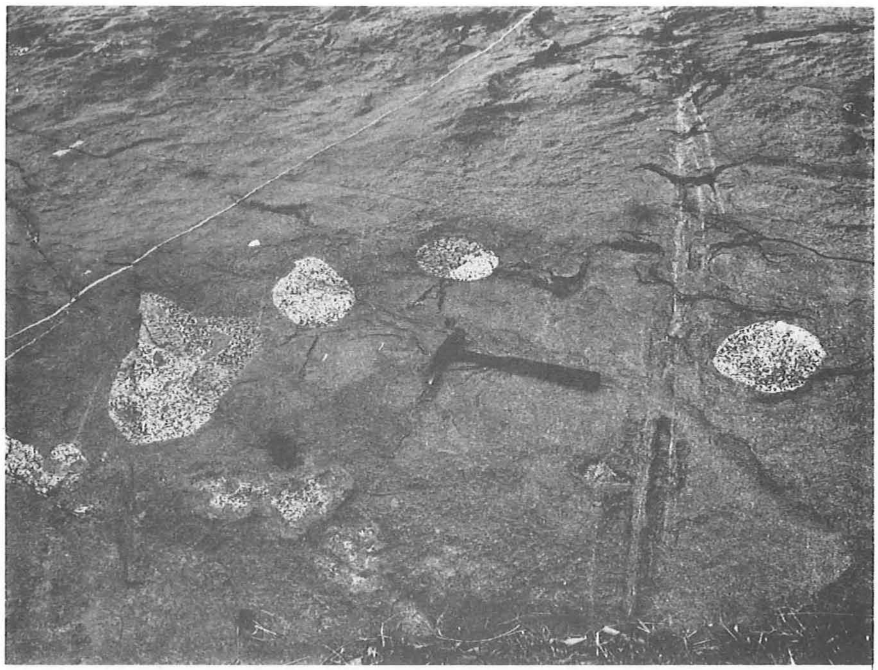


Fig. 12: Pipes of inhomogeneous tonalite(?) intruding fine-grained diorite, Ida Creek Crossing, on road to Pretty Bend homestead. Figure 10 shows another part of the same outcrop. The pipes, which contain xenoliths of fine-grained diorite, are similar in composition to the irregular veins shown in Figures 10 and 11. Photograph by J.E. Zawartko.
Neg.G.8342.

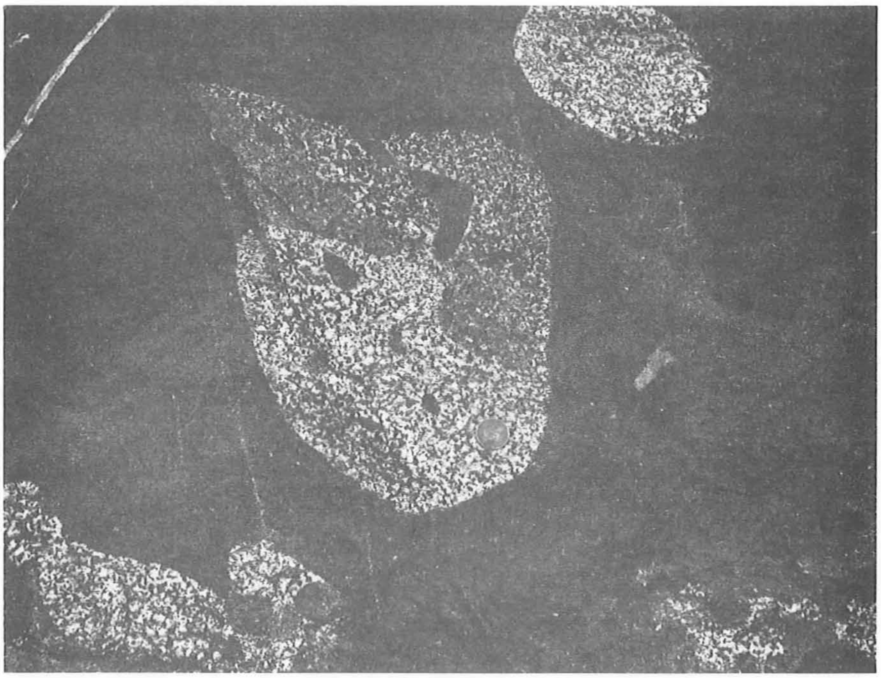
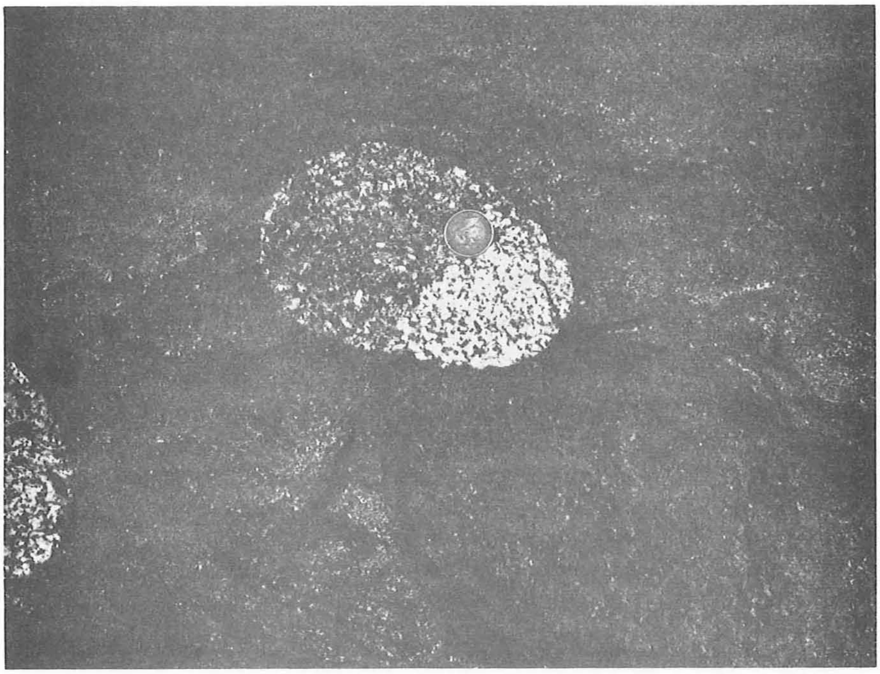


Fig. 13: Close up of intrusive tonalite(?) pipes shown in Figure 12. Penny gives scale. Neg. G.8340
Photograph by J.E.Zawartko.



Fig, 14: Close up of intrusive tonalite(?) pipe shown in Figure 12. Penny gives scale. This pipe appears to consist of two sharply demarcated components which contain different amounts of ferromagnesian minerals. Neg.GA.8341
Photograph by J.E. Zawartko.

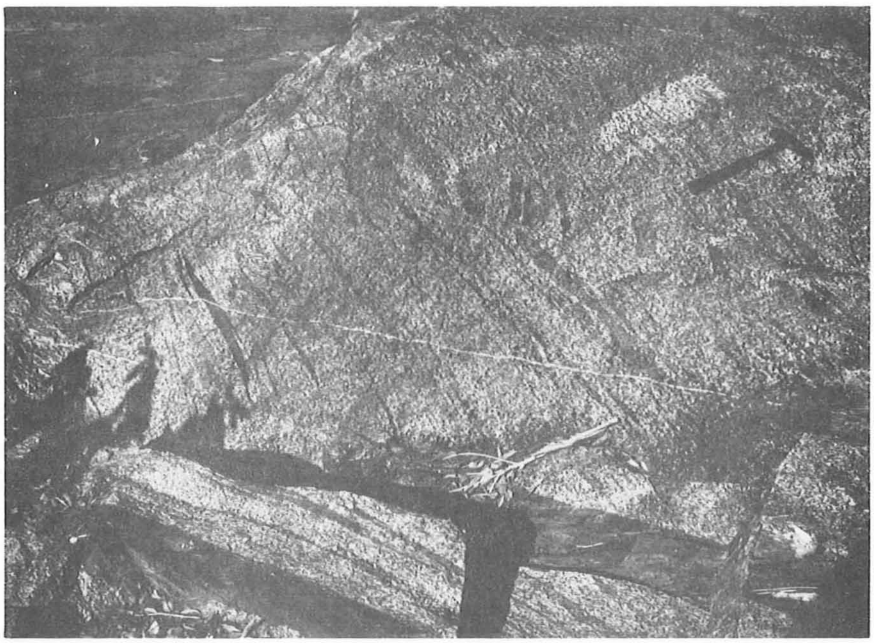


Fig. 15: Schlieren in foliated quartz diorite (Cud), in bed of creek near homestead, 12 km west-southwest of Pretty Bend homestead. The ends of some of the schlieren are bent against small faults, several of which transect the outcrop. Two thin basic or intermediate dykes cut the quartz diorite in the foreground, and a thicker one in the top left hand corner of the photograph. Neg.GA.1155.

a large outcrop in the Don River, 7 km. southeast of Pretty Bend homestead (Figs 16,17). Foliated medium grained hornblende-biotite tonalite or granodiorite contains a 3 m.-thick slice of xenolith-rich dark tonalite, 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 darker tonalite is also foliated, the foliation enclosing the xenoliths, but the xenoliths themselves are not foliated, suggesting 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), in which some of the andesine is fresh, clear and untwinned, is present in the bed of Monte Christo Creek, at its confluence with the Don River. Dark outcrops of coarse hypersthene diorite (2214) occur at the junction of Dingo and Simon Creeks. This diorite consists of andesine (55%), hypersthene (13%), microperthite (12%), clinopyroxene (8%), biotite (7%), and accessory quartz, apatite and opaques.

One kilometre north of the junction of Humbug Creek and the Don River, white powdery calcium carbonate, or 'earth lime' encloses large pieces of coarse gabbro (2208) in the bank of a small right bank tributary of the Don River. This gabbro consists of large fresh idiomorphic laths of sodic bytownite (60%) up to 1 cm. and zoned aggregates of mafic minerals. The aggregates have cores of magnetite or ilmenite and pyrite, surrounded by amphibole and minor hypersthene, and thin selvedges of granular green spinel against plagioclase. The amphibole is only weakly pleochroic and has a low birefringence. The pyrite and ilmenite or magnetite together amount to less than 1 percent.

Strongly foliated medium grained hornblende-biotite tonalite crops out in the hills between Rocky and Alick Creeks, and is intruded by sheets of aplitic microgranite, which are probably marginal offshoots of the Thunderbolt Granite. The laths of oligoclase-andesine in the tonalite are sutured and have an incipient granoblastic texture; biotite occurs in aggregates and stringers of small fresh crystals.

Diorite and quartz diorite of all grain sizes in both massive and foliated form are the country rocks at the old Normanby Goldfield. The "mullock" beside old mine shafts indicates that there are frequent intrusions of granite, adamellite, microgranite, aplite, and pegmatite in the diorites.

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 opaques and talc. The augite occurs as phenocrysts 5 to 10 mm. in diameter; the crystals have ragged edges, and are partly altered to hornblende. Olivine forms phenocrysts 2 to 7 mm. long, and occurs as inclusions in augite. In places the olivine crystals have intergrowth contacts with hypersthene, and they are commonly lined by fractures containing regularly oriented plates of dendritic ilmenite, similar to that illustrated by Hatch et al. (1961, p.394). Plagioclase forms euhedral laths about 1 mm. long, interstitial to augite and olivine; in places the plagioclase crystals include rare small euhedral crystals of green hornblende; elsewhere plagioclase itself occurs as small euhedral inclusions in augite. Hornblende forms large interstitial lakes in optical continuity; it generally occurs between the augite and olivine phenocrysts and the interstitial plagioclase. Hypersthene is closely associated with the olivine.

Structure

Structures in the diorite suite include foliation, dykes, faults, shears, and photo-interpreted lineaments.

Most of the foliation is probably due to post-crystallization cataclasis, but in some areas, for example in the Don River 7 km. southeast of Pretty Bend homestead (Figs 16 & 17), 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 strikes 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 may represent a contaminated marginal zone of the

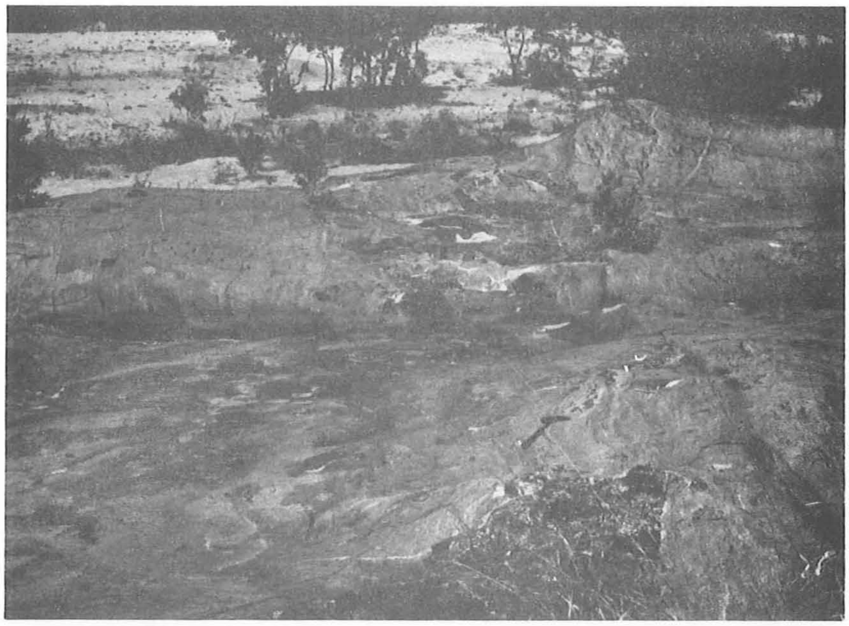


Fig. 16: Large outcrop showing contamination of tonalite (?) (Cud), in bed of Don River, 7 km southeast of Pretty Bend homestead. The strong foliation of the tonalite probably formed in the late intrusive stages, while the tonalite was still slightly plastic. A 3-metre thick slice of darker tonalite, containing large xenoliths of generally massive diorite (Fig. 17), trends away from the camera, parallel to the foliation. GA.1149.

Fig.17: Close up of margin of xenolith-bearing slice in foliated tonalite shown in Figure 16. The foliation in the slice is contorted and truncated at the margin of the slice. The xenolith-bearing slice is probably a large fragment of the contaminated marginal zone of the tonalite (against diorite) which became caught up in relatively homogeneous tonalite; while still plastic, the tonalite magma was compressed or sheared and the fragment was squeezed, worn away at the edges, and possibly partly remobilized. The relative absence of foliation in the diorite xenoliths suggests that the temperature attained during the intrusion of the tonalite was too low to overcome the rigidity of the diorite xenoliths. Neg.GA.1154.

granite, and the foliation in that area may have formed mainly during the intrusion of the Hecate Granite during the Lower Cretaceous.

The overwhelming north-northwesterly dyke trend is clearly shown on the geological map. Most of the dykes on the map have been identified by photo-interpretation, their consistent trend confirmed by field observations. The apparent absence of visible dyke trends in some areas is interpreted as being more probably due to variations in the geomorphological environment than to the actual absence of dykes. Exceptions to the regional dyke trend are evident near Humbug Creek and Boundary Creek, where west-northwesterly and northeasterly swarms have been observed or photo-interpreted. Collectively the dykes in the diorite suite represent considerable east-west crustal extension with consequent fracturing.

The faults have been mainly photo-interpreted, but a few are based on field evidence. The diorite suite is most severely faulted along and parallel to its western contact with the Lizzie Creek Volcanics and granite (CPg). This zone was an important hinge line which accommodated the differential uplift of the northern end of the Connors Arch in post-Lower Permian time, as first indicated by the age-determinations (Webb & McDougall, pp.324-5).

Marginal parts of the diorite suite have been involved in movements along major shear zones which are described elsewhere in this Report (Hecate Granite and unnamed granite (CPg)).

Age and Relationships

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

The contact with the Lizzie Creek Volcanics is partly faulted, and where it is not faulted the difference in age between the two units implies a nonconformity. The contact with the Connors Volcanics is intrusive (Malone et al., 1966). These contacts were not studied in the course of the present survey.

A sinuous dividing line, whose regularity is intended to convey its arbitrary nature, separates the diorite suite from the Urannah Igneous Complex on the map. This line is not a geological boundary; it merely indicates a zone southeast of which it has not been possible, during the current survey, to separate the intermediate to basic rocks from the rest of the plutonic rocks.

Most K/Ar mineral determinations indicate a Lower Permian age for the diorites (265 to 280 m.y.). However Rb/Sr dating of some of the diorites, and of the Urannah Igneous Complex farther south, has given an isochron of 288 ± 31 m.y. (Webb & McDougall, 1968, pp.320-4). The large plus-or-minus factor is due to low ^{87}Sr enrichment of the total rock samples. In discussing the results Webb and McDougall conclude (partly from data obtained from Sheet areas to the southeast) that the most realistic minimum estimate of the age is 305-310 m.y.

This age is in agreement with field relationships, which show that the diorite suite is substantially older than the Thunderbolt Granite.

Acid Volcanics (Cuv)

Isolated areas of acid and locally intermediate lavas and pyroclastics occupy parts of the Leichhardt Range. Many rock types are common to all occurrences; coarse blue-black dacitic welded tuff is characteristic. Rock types typical of these areas of volcanics are also common in the Upper Carboniferous Bulgonunna Volcanics, and there is little doubt that they are of the same age as, and related to, the Bulgonunna Volcanics. However their stratigraphic control is poor, and at present it is thought inadvisable to extend the name Bulgonunna Volcanics north of the area of continuous outcrop.

Distribution and Topography

Volcanics occur within the Rangeview Ring Fracture about 10 km. northeast of Rangeview homestead, and in discontinuous areas along the eastern side of the Leichhardt Range. Small areas have 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 Fracture form part of the Leichhardt Range plateau. Those along the eastern 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 pieces of rock.

Lithology

Rhyolite, porphyritic alkali rhyolite, coarse dacite welded tuff, pyritic porphyritic felsite, hornblende dacite, and saussuritized porphyritic andesite occur in the Rangeview Ring Fracture. The volcanics contain blocks of red biotite granite. Recrystallized dacite is the principal rock type in the range west of Dalbeg. The northern occurrences contain a good deal of pyroclastic material; 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 rock-types occur at the western margin of the Sheet area, northwest of Marlborough Pocket. Rhyolite and coarse andesite welded tuff predominate in the two small areas east of Millaroo Creek. The rocks at Kirknie Creek, east of the Burdekin River, are deeply weathered; they are pale pink, green, or white leucocratic rocks, and range in texture from aphyric to strongly porphyritic in quartz and feldspar.

Structure

The volcanics in the Rangeview Ring Fracture are downfaulted within it. No bedding was seen in the field, but the air photos suggest that the volcanics may be horizontal. The vertical flow banding which is visible in a few places is probably either a primary feature or 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; a prominent joint system strikes parallel to these faults. Air photos indicate that the volcanics northwest of Marlborough Pocket 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 pyroclastics also include pieces of coarse sandstone similar to sandstone (Pzu) which crops out nearby in the Ayr Sheet area. In the Rangeview Ring Fracture the volcanics seem to be intruded by Upper Carboniferous adamellite (Cug), but the relationship could not definitely be proved. West of Dalbeg the volcanics have been recrystallized by the same granite mass. East of Millaroo Creek, welded tuff is intruded by granodiorite dykes which have produced widespread hornfels zones. Some of the contact metamorphism may have been caused by small bodies of alkali microgranite (too small to map) which are associated in places with the volcanics, probably representing an intrusive phase of the igneous activity.

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

Bulgonunna Volcanics (Cub)

The area of Bulgonunna Volcanics north of the Burdekin River was mapped in 1964. Here the acid volcanics unconformably overlie the Mount Windsor Volcanics, unnamed Devono-Carboniferous volcanics (DCv), and the Scartwater Formation. They are downfaulted against the Star of Hope Formation, and are intruded by granite (Cug, CPg) in the upper reaches of Bull Creek and near the Burdekin Weir.

The Bulgonunna Volcanics are a suite of acid pyroclastic flows which were defined in the Mount Coolon Sheet area (Malone et al., 1964), and were also described (Malone et al., 1966) in the southern half of the Bowen Sheet area. The unnamed volcanics (Cuv) which crop out in geographically separate areas farther north may be broadly equivalent.

The Bulgonunna Volcanics form a belt of high hills and plateaux which support sparse vegetation. Between Bull Creek and the Burdekin Weir, plateaux are the principal land forms, with elevations of 300 to 350 m.

Lithology

Northwest of the Burdekin River there is a wide variety of rock types. East of Glenroy homestead, where the unit unconformably overlies unnamed volcanics (DCv) and the Scartwater Formation, a well bedded basal sequence of green-grey tuffaceous siltstone and sandstone, volcanic breccia and agglomerate, crystal and vitric tuff, tuffaceous mudstone, and minor andesite is overlain by thick acid to intermediate volcanic breccia, flow-banded rhyolite, and minor tuffaceous sediments.

The agglomerate and breccia are metasomatically altered and contain fragments, ranging from 0.2 mm up to boulder size, of silicified acid and intermediate 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 rhyodacitic welded tuff is down-faulted against the Star of Hope Formation. The welded tuff contains a wealth of angular rock fragments including intermediate and porphyritic acid volcanics, rhyolite, quartz porphyry, and very rare coarse biotite granite. The proportion of fragments decreases away from the contact. The welded tuff consists of anhedral crystals of andesine, hornblende, quartz, and iron ore in a groundmass of microcrystalline felsite, which shows an indistinct fluidal structure, probably representing deformed shards. Pink rhyolitic and dark grey dacitic welded crystal tuffs are exposed in Charlie Creek, 8 km northeast of Glendon homestead.

Large water-worn outcrops in the Burdekin River at the Weir consist of dacite and agglomerate intruded by dykes of dacite and microdiorite. The outcrops are strongly faulted and jointed. The dacite is a massive porphyritic or glomeroporphyritic rock containing up to 20 percent plagioclase phenocrysts and minor potash feldspar.

Quartz forms small rounded phenocrysts with few embayments. Chlorite is the only mafic mineral and accounts for up to 15 percent; it occurs mostly in the groundmass. The groundmass of the porphyritic rocks is highly siliceous, and ranges in texture from finely allotriomorphic granular to microcrystalline. Feldspar is saussuritized and epidotized in places. One specimen from a microdiorite dyke is a mass of fine-grained subhedral plagioclase, interstitial quartz, chlorite, and accessory pyrite and magnetite.

Structure and Thickness

The Bulgonunna Volcanics form a multiple blanket deposit which is gently folded and broken 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 the unit is a complex of extrusives and high level intrusives. Dips are generally low to moderate; dip reversals occur erratically throughout the area.

A prominent joint pattern is characteristic of the unit. Jointing near the Burdekin Falls was investigated by Whitehouse (1949, unpubl.) in his study of the proposed dam site.

Not enough structural information is available to enable the thickness of the unit to be estimated, but it is unlikely to be much thicker than about 1000 m., and may be considerably less.

Age and relationships

No fossils have been found in the Bulgonunna Volcanics within the area mapped. Malone et al. (1966) assigned an Upper Carboniferous age to the volcanics, because they unconformably overlie Lower Carboniferous formations and are in turn overlain unconformably by the Lower Permian Lizzie Creek Volcanics and Collinsville Coal Measures. An Rb/Sr isochron of 287 $\pm$ 12 m.y. has been obtained from the Bulgonunna Volcanics (Webb & McDougall, 1968), confirming 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 and McDougall (1968, pp. 319-20) state that if the granites and volcanics are comagmatic it is justifiable to pool the analyses of the two units. When this is done, an isochron of 289 ± 9 m.y. is produced.

Whitehouse (1949, unpubl.) reported that numerous rhyolitic porphyry dykes intrude the volcanics exposed in the Burdekin Gorge. South of the Burdekin Weir the volcanics are intruded by dark micro-diorite dykes.

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

Intrusive Rhyolite and Porphyry (Cur)

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

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

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

Intrusive pale green quartz-feldspar porphyry, epidotized feldspar porphyry, and grey quartz porphyry form a body 8 sq. km. in area 3.5 km. north of the junction of the Suttor and Burdekin Rivers. The porphyries form low sparsely vegetated hills which give a light grey photo-tone. The porphyries are faulted against the Ravenswood Granodiorite Complex in the north and are inferred to intrude the unnamed volcanics (DCv) in the south. A swarm of large cream-brown, quartz-porphyritic felsite dykes which intrudes the volcanics near the southern contact of the acid porphyry mass is probably an offshoot from that mass.

Small masses of red quartz-feldspar porphyry occur near the southwestern edge of the Sheet area. Olgers (pers. comm.) has been able to trace some of them into long arcuate dykes which were probably feeders to the Bulgonunna Volcanics.

Adamellite, etc. (Cug)

Granitic rocks which underlie part of the Burdekin River valley and form a high rugged plateau in the Leichhardt Range west of the Burdekin Weir are regarded as a northerly extension of the Upper Carboniferous batholith mapped by Malone et al. (1966), south and west of the Bowen River. Granites of 3 distinct ages exist in this general area: mainly Middle Ordovician (Ravenswood Granodiorite Complex), Upper Carboniferous, and Lower Permian. The granite which is nonconformably overlain by the Upper Carboniferous volcanics (Cuv) is probably early Palaeozoic, but it is similar to the granite which intrudes the volcanics southwest of Eight Mile Creek. The latter granite is probably only slightly younger than the volcanics, because it is intruded by ring dykes (Plr) which are thought to be the same age as the Lower Permian stock (Plg) south of Expedition Pass Creek. The northern limit of the Upper Carboniferous granite is uncertain, because it is usually not possible to distinguish it from the acid phase of the Ravenswood Granodiorite Complex.

Topography

The topography of the granite is very variable, and is controlled by faults and the degree of maturity of the drainage rather than by differences in rock type. Photo-interpretation is unreliable.

Faults extending southeast from the headwaters of Eight Mile Creek to the Burdekin Weir divide a rugged broken plateau to the west (Leichhardt Range), which has a general elevation of 350 to 450 m, from gently undulating to uneven country in the Burdekin valley. The fault scarp and much of the plateau itself are impassable to vehicles. South of about Pine Creek most of the soil has been stripped from the granite, and a pattern of ravines eroded along joints stands out boldly on air photographs.

Lithology:

Leichhardt Range. Eleven kilometres northeast of Mount Glenroy the rock is a pink to grey medium to coarse biotite adamellite. Large corroded quartz crystals are generally present, and the texture in places is graphic to pegmatitic and vughy, with development of minor amounts of muscovite. Six kilometres northeast of Mount Glenroy there is a marginal zone of pink porphyritic granophyric muscovite-biotite granite and muscovite-biotite granophyre. Numerous druses containing quartz, feldspar, and often 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 porphyritic in quartz, and feldspar-quartz porphyry. The dykes have indistinct contacts with the granite and granophyre, and may represent later 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 are the chief rock types. Both have a graphic texture. Strong shearing, brecciation, and quartz veining in the marginal parts of the granite suggest a faulted contact.

Grey medium grained biotite adamellite which contains minor hornblende and accessory red-brown sphene is the dominant rock type in the headwaters of Bull Creek, where the batholith forms an embayment in the Bulgonunna Volcanics. Near the southern contact fine grained biotite adamellite, probably occurring as dykes, forms low ridges within the main mass. The adamellite is strongly sheared and faulted where it intrudes welded dacitic tuff along its southern contact. Along the western contact it is chilled to a fine grained biotite-hornblende dellenite-porphyry, in which euhedral phenocrysts of bipyramidal quartz amount to 20 percent. Half a kilometre from the contact the rock is only moderately porphyritic; the phenocrysts range from the average groundmass grainsize of 0.05 mm. up to about 8 mm., and consist of slightly sericitized and strongly zoned plagioclase, partly kaolinized potash feldspar, bipyramidal quartz, and rare biotite and actinolitic hornblende enclosed in a groundmass of the same composition. At the contact the porphyry contains xenoliths of recognizable intermediate volcanics, but 0.5 km from the contact the inclusions are reconstituted to microdiorite. The colour index of the dellenite-porphyry appears to increase inwards from the contact; this is probably due to the increasingly complete digestion of pieces of country rock. The colour of the actinolitic hornblende ranges from pale green at the contact through deep green to brownish green 1 km. from the contact.

<u>Burdekin River Valley</u>. Hornblende-biotite granodiorite forms low hills north of Bluewater Creek, and grey biotite adamellite forms a low conical hill 1 km. south of Expedition Pass Creek. Grey leucocratic biotite microadamellite, intruded by dykes of quartz-hornblende diorite, forms the country rock on the northeastern side of the Lower Permian stock in the Leichhardt Range south of Expedition Pass Creek. Massive fresh hornblende adamellite forms a small outcrop surrounded by alluvium beside the Expedition Pass Creek where it crosses Eight Mile Creek, but between Expedition Pass Creek Track and Eight Mile Creek the bedrock is obscured by sand. East of the Burdekin River the granite is weathered and iron stained, but the prevailing rock type is a 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.

<u>Structure, Relationships and Age</u>

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, whose basal conglomerate contains pebbles of granite. Both the intrusive contacts and the nonconformity are faulted in places. In the Millaroo Fault Zone the granite and volcanics are strongly brecciated. Brecciation and minor quartz veining suggest a northeast-trending fault east of Dalbeg. Granulation and partial recrystallization of the granite have taken place along the northwest to north-south fault 3.5 km. west of the Burdekin-Bowen River confluence. 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, and assemblages of the hornblende-hornfels facies occur more than 0.5 km. from the contact. This, and the characteristic chilled marginal phases and bipyramidal quartz phenocrysts suggest that the granite was intruded at a high temperature.

The granite is probably related to the Bulgonunna Volcanics. K/Ar mineral ages (17 determinations) range between 276 and 293 m.y., and the 9 Rb/Sr whole-rock determinations define an isochron of 298 ± 25 m.y. (Webb & McDougall, 1968). No radiometric dates are available from north of the junction of the Burdekin and Bowen Rivers.

UPPER CARBONIFEROUS OR LOWER PERMIAN

Diorite, etc. (CPi)

Pyroxene diorite forms low rises of black soil with rare outcrops where it intrudes the Scartwater Formation south of the Suttor River, near its junction with the Burdekin River. A second occurrence has been photo-interpreted just north of the Suttor River.

Medium grained pyroxene diorite is the chief rock type in the mass south of the Suttor River, although gabbro and pyroxene monzonite have also been identified. Some olivine dolerite occurs as blocks in the black soil, but its relationship to the diorite is unknown. The diorite extends into the Charters Towers Sheet area.

These intrusives are only two of a group of similar masses which intrude the Drummond Basin strata, mostly in the Charters Towers Sheet area. The olivine dolerite is similar to the Tertiary olivine basalt flow 10 km. to the east, but whether the two basic rocks are related is unknown.

Biotite-hornblende meladiorite intrudes the Mount Windsor Volcanics 5 km. east-northeast of Mount Glenroy. The intrusion is bounded by an arcuate fault on its northwestern side. Dark green fibrous hornblende forms about 60 percent of the meladiorite; biotite is also abundant, and quartz (5 percent) occurs interstitially. The plagioclase is andesine-labradorite. The meladiorite is intruded by dykes of porphyritic micro-granodiorite.

For the present these intrusions are regarded as Upper Carboniferous or Lower Permian.

Adamellite, etc. (CPg)

Adamellite, granodiorite, and granite of unknown age, but probably Upper Carboniferous or Lower Permian, occupy large areas between Bowen and the Burdekin River, and form a few small stocks.

Western Part of Sheet Area

A fault-bounded area of grey medium to coarse leucocratic granodiorite forms a cuspate depression about 7 km. long, which is traversed by the upper reaches of Glenroy Creek. The granodiorite is generally equigranular, but porphyritic variants also occur. Oligoclase-andesine (50 percent), quartz (30 percent), potash feldspar (15 percent), and biotite and hornblende (together 5 percent) are the major constituents. The hornblende is dark green and equals biotite in abundance, but it is coarser than the biotite, and prismatic crystals up to 3 cm. long have been observed.

Northeast-trending dykes of saussuritized and albitized basalt, andesite, and feldspar porphyry intrude the granodiorite at the northern end of the depression, and may be associated with the Rangeview Ring Fracture. Near Glenroy Creek the granodiorite is intruded by northeast 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 which are probably associated with the southern boundary fault of the intrusion.

A roughly oval stock of strongly jointed coarse leucocratic biotite adamellite, with a marginal phase of leucocratic microadamellite on its southern side, intrudes the Mount Windsor Volcanics near the junction of Glenroy Creek and Six Mile Creek. The adamellite forms hills only slightly higher than the Mount Windsor Volcanics, but is easily distinguished on air photographs by its more widely spaced drainage pattern, and by its paler tone, which is caused by a thinner tree cover. The microadamellite contains sparse phenocrysts of quartz and potash feldspar 3 mm. in diameter; oligoclase amounts to 30 percent, quartz 40 percent, and sericitized potash feldspar 30 percent. The quartz forms anhedral aggregates which partly or wholly enclose oligoclase and potash feldspar. Small amounts of chloritized biotite and muscovite are present. Quartz veins and a few narrow greisen zones cut the microadamellite. The Mount Windsor Volcanics are metamorphosed to andalusite-alkali feldspar-biotite-quartz hornfels along the southern contact. Medium-grained porphyritic quartz diorite intrudes the Mount Windsor Volcanics in Glenroy Creek, and is faulted against the adamellite, but its areal limits are not well known. The quartz diorite contains phenocrysts of quartz and plagioclase, and is intruded by both acid and intermediate dykes.

An irregular mass of red biotite adamellite or granite crops out between Stones Creek and Boundary Creek. The adamellite intrudes the Ravenswood Granodiorite Complex, the Mount Windsor Volcanics, and unnamed volcanics (DCv), and is intruded by microdiorite dykes. The pluton includes minor phases of altered porphyritic microgranodiorite (?) of variable composition and red porphyritic microadamellite. The microgranodiorite contains rare hornblende crystals up to 1 cm. long. The microadamellite contains phenocrysts of quartz and rarer biotite and hornblende, and forms smooth slopes slightly higher than the rest of the intrusion.

Mount Graham is a small hill 100 m. high, with a central depression which was formed by the more rapid erosion of a small plug of white microtrondhjemite than the surrounding hornfelsed Star of Hope Formation. The microtrondhjemite contains rare feldspar and quartz phenocrysts. Biotite is the only ferromagnesian mineral. The texture is variable. In places closely packed blocks of biotite-hornblende microtrondhjemite up to 25 cm. long are enclosed within biotite microtrondhjemite.

An irregular mass of pinkish brown granophyre intrudes the Star of Hope Formation north of the Burdekin Falls. Plagioclase crystals in the granophyre are enclosed by granophyrically intergrown quartz and alkali feldspar. Biotite amounts to 3 percent, but is generally altered to chlorite, hematite, and epidote. Accessories include zircon and acicular apatite.

An intrusion mapped at the edge of the Sheet area southwest of the Sellheim River is a photo-interpreted extension of a mass of hornblende-biotite granodiorite, which cuts the St. Anns Formation in the Charters Towers Sheet area.

Northern Central Part of Sheet Area

Deeply weathered and altered granitic rocks which are believed to be Upper Carboniferous or Lower Permian in age occupy 500 sq. km. in the centre of the northern part of the Sheet area. In the west and south the granitic rocks are unconformably overlain by the Lizzie Creek Volcanics. In the north they are obscured by sand and soil. To the east they are intruded by the Mount Abbot Igneous Complex and overlain nonconformably by the Kurungle Volcanics. The relationship between this group of granitic rocks and the dioritic rocks (Cud) to the east is unknown; in the south the contact appears to be a fault.

The granitic rocks form low-lying gently undulating country, with a few low ranges. They are not distinctive on the air photographs. Two specimens (67 and 95, see Appendix) collected from this area have yielded Lower Permian K/Ar ages similar to those obtained from the Lizzie Creek Volcanics. This may indicate either that regional reheating of Upper Carboniferous granite occurred when the Volcanics were erupted, as was the case with the Urannah Igneous Complex and the diorite suite (Cud) (Webb and McDougall, 1968), or that isolated Lower Permian stocks remain unrecognized in a general area of Upper Carboniferous granite, and that the isotopic dating specimens were fortuitously collected from them. The first alternative is favoured.

Between Edinburgh Castle and the western slopes of Mount Abbot the dominant rock type is biotite adamellite, except for the Glen

Blazes Creek area where biotite-hornblende granodiorite, grading to biotite adamellite, forms the country rocks of 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 is the country rock both north and south of Mount Abbot. Farther east, near Finley Creek, the rock is a biotite adamellite, which in places contains rosettes of tourmaline up to 8 cm across.

Between the Bogie River and the Clarke Range granite, granodiorite, adamellite and quartz diorite have all been identified in less weathered outcrops in the larger streams. Abundant criss-crossing veinlets of calcite, in places accompanied by quartz, are a common feature of most outcrops. Dykes of microdiorite, microgranite, basalt, and aplite occur throughout, and are also deeply weathered. The only faults which can be seen on the air photographs are at Sandy Creek in the southeast, but the degree and extent of fracturing and veining suggest that many are hidden by soil cover. The deep weathering of the granite in this area is probably due to the fact that the present zone of weathering roughly coincides with the Lower Permian land surface upon which the Lizzie Creek Volcanics were extruded.

Elliot River-Bowen area

Granite in the east of the Sheet area is less altered and weathered than in the northern central part of the Sheet area. The boundary between the area of probable Palaeozoic granite and the Lower Cretaceous Hecate Granite is tentative, because the rock types of each unit are very similar. The boundary at Mount Buckley Siding is arbitrary.

Graphic biotite adamellite, in places porphyritic and fine-grained, forms basement to the Mount Aberdeen Volcanics around Mount Aberdeen, and is therefore presumed to be Palaeozoic, but its extent is not well known. Mount Mackenzie, Mount Greentop, and nearby hills are formed from coarse biotite adamellite and granite. Farther west towards the Elliot River the rock is a granodiorite, which is intruded by many thick felsite dykes, and by thinner microdiorite dykes. The western slopes of Mount Mackenzie are formed from medium grained biotite granite which in some areas is strongly foliated and recrystallized. The southern slopes of Mount Roundback (7 km NW of Mount Pring) are formed from grey medium-grained biotite adamellite. A few thin aplite dykes intrude the adamellite, and 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.

Two different granites underlie the town of Bowen and the older one is regarded as late Palaeozoic. The order of emplacement of the various igneous rocks at Bowen is : (1) volcanics (mapped with the Carmila Beds), (2) adamellite (CPg), (3) northwesterly dark dykes, (4) meridional dark dykes, (5) leucogranite (PKg), and (6) meridional microgranite dykes. The adamellite is altered. It contains phenocrysts of saussuritized zoned oligoclase, rimmed by microcline-antiperthite, which is semi-graphically intergrown with quartz in places; the mafic minerals are chlorite, epidote, opaques, and apatite. Similarly 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. A specimen (94) of hornblende-biotite adamellite collected from a bouldery hill 3.5 km southwest of the siding has yielded an Upper Carboniferous K/Ar biotite age (297-298 m.y.). At Mount Mary the adamellite is porphyritic and contains xenoliths of andesitic volcanics; on the eastern slopes a southerly trending ridge is formed from pink leucocratic microgranite which resembles the groundmass of the porphyritic adamellite. Southwest of the Port of Bowen the mapping has failed to demonstrate that any of the granite is nonconformably overlain by the Carmila Beds (Lower Permian). However the succession mapped as Carmila Beds in the area is unfossiliferous, and perhaps includes Carboniferous or older rocks.

In the northeast of the Sheet area the contacts between the granitic rocks (CPg) and the diorite and gabbro (Cud) appear to dip gently. There are many complex exposures in which the more usual biotite adamellite has been converted to biotite-hornblende adamellite or granodiorite by assimilation of basic material. In these outcrops the contaminated acid rocks are strongly flow-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 southeast trending faults in which the granite has been mylonitized and recrystallized. Gossanous quartz veins containing magnetite and pyrite occur in these faults. Quartz blows and veins cut 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, indistinguishable from the Hecate Granite (Lower Cretaceous) and at first mapped with it, crops out in a cirque-like valley in rugged country at the head of the Don River, northeast of the Normanby Goldfield. However, K/Ar biotite ages of 186/187 and 132 m.y. were obtained from specimens 106 and 136 respectively (Appendix), and the results are interpreted to mean that the granite from which the specimens were collected is late Palaeozoic, and that its minerals lost argon as a result of the intrusion of the Hecate Granite. To the southeast of here the high valley at the head of Grant Creek, west of Raspberry Creek, is underlain by massive pink biotite adamellite slightly porphyritic in potash feldspar, and containing xenoliths and schlieren of diorite which are flow-aligned in a southeasterly direction.

Shear Zones near Bowen

Several major shear zones have been mapped between Edgecumbe Bay and the Elliot River. In places shearing seems to have been a prolonged process, beginning in the dioritic country rocks (Cud) before the granite was intruded (perhaps in response to the rising granite magma), and affecting the granite both during and after cooling. Swarms of microgranite and aplite dykes, which are probably late differentiates of the granite, commonly occur within and parallel to the shear zones. In general, to avoid crowding, these dykes are not shown on the map. Many of the dykes are cataclastically foliated and recrystallized in the plane of the shear, but in others the planar structures are thought to be due to primary flow, and it is often hard to tell which of the two processes has been more important in the development of planar features. The granite no doubt continued to undergo shearing stress as it cooled and differentiated, and the later differentiates were preferentially emplaced into shears which had developed in the newly cooled granite. Similar dyke-filled shear zones occur in the Hecate

Granite. These dyke-filled shear zones are sufficiently distinctive to suggest that they may all be the same age (Lower Cretaceous), although they occur in granite which is mapped as both late Palaeozoic and Lower Cretaceous.

In the Glenore Shear, strongly sheared and recrystallized diorite (Cud) is intruded by weakly foliated biotite adamellite. Dykes of greisenized aplite, containing some pyrite mineralization, intrude the diorite parallel with the contact. The greisens consist mainly of quartz and white mica, but contain minor amounts of rutile, zircon, and topaz(?). The spurs at the northern end of the Bodes Range are formed from a swarm of sheared and greisenized aplite dykes, some of which now resemble micaceous and slightly schistose quartzites. Granite has been found on both sides of the shear, but sheared and brecciated diorite occurs between at least some of the dykes. Generally the dykes are much better exposed than their country rocks. Mount Williams, a pinnacle 12 km. south-southwest of Bowen, is formed from ferruginous and siliceous "quartzite" which is interpreted as an altered greisen. Small quantities of feldspar and white mica are present. Weathered biotite adamellite is exposed near the foot of the pinnacle. Pits and costeans have been dug in similar ferruginous "quartzite" 1.5 km. to the east-northeast, beside the Bruce Highway. Pyrite is present in the rock, although most of it is oxidized. The small pinnacle southwest of Mount Williams consists of similar ferruginous rock, which is composed of angular quartz grains and minor interstitial muscovite and pyrite. A ridge of greisenized, sheared and brecciated aplite occurs just west of the North Coast Railway, 1.5 km. west-northwest of Mount Williams. Fine-grained gneissic biotite adamellite is exposed in a small creek south of this ridge. The adamellite is porphyritic in quartz, and contains a little muscovite; it was probably coarse-grained before it was sheared and recrystallized.

LOWER PERMIAN

Lizzie Creek Volcanics

In the Bowen Sheet area the Lizzie Creek Volcanics (Malone et al., in press) are a sequence of intermediate to basic volcanics containing subordinate sediments and acid volcanics, which nonconformably overlies late Palaeozoic granite (CPg) in the centre of the Sheet area.

They were formerly named Lower Bowen Volcanics (Malone et al., 1964, 1966). North and west of Collinsville the volcanics form a relatively thin cover on granite basement, but southeast of Collinsville (Malone et al., 1966) they are a uniformly west-dipping sequence, many thousands of metres thick, which underlies the Bowen Basin succession along the eastern flank of the basin. A strip of basalt 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 Lizzie Creek Volcanics have a variable topography, characteristic of the various constituent rock types. Andesitic volcanics give rise to gently undulating terrain with some steep hills, especially where the andesites are buttressed by the Mount Wickham Rhyolite. The basalt is generally masked by black soil, outcrops being largely confined to creeks. The sediments interbedded with the basalt in the lower half of the unit form gently rolling country with a few strike ridges, but also crop out on the lower slopes of hills capped by volcanics.

Lithology

Basalt and sediments form the basal part of the unit, and are overlain by andesite and minor acid volcanics.

The basalt and sediments occur 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. Both olivine-bearing and olivine-free types occur, and some specimens contain glass in the groundmass. Some of the basalt is highly amygdaloidal or vesicular, and such rock types are commonly the most strongly altered or weathered. The amygdales (mainly zeolite) are generally about 5 mm in diameter, but range up to 25 cm.; chalcedony and agate are abundant in weathered basalt northwest of Collinsville, but most specimens are fractured. Deeply weathered basaltic tuff and agglomerate form beds up to 10 m thick. Basalt dykes intrude the sediments and the lower basalt flows and pyroclastics. None were found to intrude the andesites. Many of the dykes were evidently feeders to the flows.

Sediments in the Lizzie Creek Volcanics comprise boulder, cobble, and pebble conglomerates; lithic, feldspathic, and tuffaceous arenites; and 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 these exposures contain beds of boulder conglomerate up to 30 m thick. Boulders and cobbles form up to 90 percent of the conglomerate in the Bowen River; two-thirds of them are acid volcanics, and the rest are weathered granite, but there are occasional phenoclasts of sediments. The conglomerate at Tondarra homestead is similar, but the proportion of granite phenoclasts is higher, and there are also rare phenoclasts of gabbro and labile arenite. Thin beds of quartz pebble conglomerate, some only one layer of pebbles thick, occur throughout the sedimentary sequence. The arenites are green to brown and markedly labile; tuffaceous and lithic arenite predominate, but minor subarkose occurs too. Many outcrops are flaggy. Sorting is generally poor, and cobbles of volcanic material occur in many of the beds. The arenites are interbedded with grey-green thinly bedded siltstones, calcareous siltstone, and shale. Fragments of poorly preserved plant fossils occur in some of the finer arenites and in some of the siltstone and shale, but they are poorly preserved.

Intermediate and minor associated acid flows and pyroclastics form a structureless pile, and probably overlie the basalt and sediments. They cover large areas north of the Strathbogie-Strathalbyn road and in the Clarke Range, and appear to contain no interbedded sediments.

Structure and Thickness

Dips in the lower part of the succession are low to moderate and, except near the Millaroo Fault Zone, no well developed trends are apparent. Sudden reversals of dip, with 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. A maximum thickness of 70 to 100 m is suggested for this part of the succession.

The andesites may be at least 200 m thick. It is apparent that there has been no folding of the unit on a regional scale in the northern half of the Sheet area.

Depositional Environment and History

The sediments and basaltic volcanics and pyroclastics were probably deposited in a shallow water, near-shore, lacustrine environment. The Upper Carboniferous Bulgonunna Volcanics and granite to the southwest probably formed an upland which, together with islands and uplands of granite to the north and northeast, contributed most of the material to form the sediments. The sedimentation was a continuing process within the shallow basin, interrupted by intermittent local outpourings of basalt and pyroclastics. These were interbedded with the sediments but much of the pyroclastic material was reworked and mixed with the terrigenous material to form labile-tuffaceous sediments. The basaltic vulcanism was followed by andesitic vulcanism, apparently without any significant time break.

Relationships

The Lizzie Creek Volcanics nonconformably overlie granitic basement (Cug, CPg). In the Millaroo Fault Zone they have been downfaulted against the 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 disconformably by the Collinsville Coal Measures; they unconformably overlie and are downfaulted against the Upper Carboniferous diorite and gabbro (Cud).

Age

Noeggerathiopsis hislopi Bunb. has been identified (Mary E. White, pers. comm.) from a collection of poorly preserved plants near Mount Pollux, indicating 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).

K/Ar measurements made on plagioclase from the basalts in the northern half of the Sheet area indicate an approximate age of 270 m.y. (Webb & McDougall, 1968, p.328).

Carmila Beds (Pla)

The Carmila Beds (Jensen et al., 1966; Clarke et al., 1968 (unpubl.) and in press), are a sequence of continental volcanics and volcanolithic sediments which crops out along the eastern side of the Connors Arch (Fig.34) from Bowen 300 km. southeast to St. Lawrence. The beds occupy a north-northwesterly trending belt in the northeastern part of the Bowen Sheet area.

The Carmila Beds were named and 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 pre-Upper Carboniferous volcanics may be included in the unit near the base in places.

Topography

Where hornfelsed by the Hecate Granite along their western edge the Carmila Beds form a prominent meridional range of smooth but high hills, partly covered by rain forest. Peaks include Mount Challenger (516 m.), Mount McGuire (738 m), Mount Pluto (560 m), and Mount Quandong (792 m.). Along its western side the range ends abruptly against the Hecate Granite, which underlies the low country of the Proserpine River valley; this is because the hornfels is much more resistant to erosion than the granite. In the east the range falls away gradually in a series of long northeasterly spurs and northwesterly strike ridges. North of Longford Creek only a relatively narrow width of the beds is preserved, and 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.). They also form isolated small outcrops on North Head, in a quarry between the town and Flagstaff Hill, on a low spur at the northeastern edge of the main town area, and on the esplanade near the wharf.

Lithology

The Carmila Beds in the Bowen Sheet area consist of massive acid and intermediate lavas and pyroclastics, passing up into bedded pyroclastics and volcanolithic sediments. Neither the original base nor the original top of the beds has been observed. It appears that the base is everywhere intruded by granite, whereas the top is obscured by superficial Cainozoic sediments at the surface, and downfaulted against the Edgecumbe Beds at depth.

South of the Andromaché River, where the available evidence indicates that the Urannah Igneous Complex is intrusive into the Carmila Beds (see below), the lowest beds preserved are epidotized agglomerate, dacite crystal tuff, and volcanic breccia. The breccia is bedded in places. An outcrop of volcanic breccia just 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 just west of the Andromache River, 3.5 km. south of Amelia Vale homestead. The groundmass of the rhyolite contains abundant very fine-grained euhedral crystals of fresh biotite (average length 0.007 mm.), suggesting that the rock has been hornfelsed. Hills and rises southeast of the old battery and in the watershed between Scrub and Spring Creeks consist of massive green andesitic 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. Rock types forming the steep west-facing escarpment south of Hill Rise homestead are: altered quartz latite or andesite; rhyodacite crystal-lithic-vitric tuff; well bedded alternating medium and coarse volcanolithic greywacke; and volcanic pebble to cobble conglomerate with well rounded phenoclasts. 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 volcanics in the lower part of the sequence between the Andromache River and Eden Lassie Creek consist of massive dacite and andesite crystal tuff and agglomerate with subordinate flows. The volcanics pass up into bedded tuffaceous and labile sediments. Interbeds of more mature sediments occur in the higher parts of the section. White kaolinitic quartz sandstone crops out on 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 village of Kelsey Creek. Impure kaolinitic quartz sandstone with siltstone interbeds overlies coarse pebbly volcanolithic sediments several hundred metres northwest of a fork in the road north of Goorganga Creek; both carbonaceous siltstone and white siltstone occur, the latter bearing abundant impressions of stems, leaves, and seeds of Cordaites australis, and Cordaicarpus (White, 1966, unpubl.). Massive green lithic tuff, agglomerate, and labile sediments recur farther up-section 1 km north-west of Kelsey Creek village. The volcanics near the contact with the Hecate Granite have been partly recrystallized, and actinolite is developed in some areas. Chlorite and epidote are abundant in most rocks, but may be due to autometamorphism rather than to contact metamorphism by the Hecate Granite. The occurrence of quartz veinlets, and of pyrite, both in the quartz veins and as disseminations in the volcanics, may be related to the intrusion of the Hecate Granite.

Lithic-crystal tuff, lithic tuff, andesite, rhyolite, welded dacite crystal tuff, and tuffaceous sediments form the northern and western slopes of Mount Challenger. The sequence has been thermally metamorphosed, the sediments giving rise to spotted micaceous hornfels (2096). Microfaulting is widely developed in the finer-grained sediments. Andesite, lithic crystal tuff, welded tuff and 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. Fine-grained acid lavas, andesite, and coarse rhyolite tuff form a steep hill at the head of Jochheim Creek. Adamellite (CPg) intrudes the volcanics at the base of the hill. Diopside-hypersthene-labradorite hornfels formstors immediately west of the Bruce Highway, between Jochheim and Eden Lassie Creeks; the hornfels was probably a 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 have been hornfelsed by hornblende adamellite (CPg). Andesite, lithic tuff, and very fine-grained 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, whereas grey-white acid lithic tuff, volcanic breccia, rhyolite and andesite comprise the sequence just south of the mouth of Duck Creek. The green tuff and tuffaceous sediments are very well-bedded, but the more acid tuff and breccia are massive and probably welded. Many of the tuff beds are 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 southeast-trending fault between Mount Maria and the coast is marked by intense epidotization and minor silicification. Numerous blue-grey microdiorite dykes intrude the volcanics. Blue-black porphyritic rhyolite and rhyodacite (2059) crop out along the shore on the northeast side of Mount Bramston. The volcanics are intruded by swarms of microdiorite dykes. Both the volcanics and the dykes have been severely brecciated and locally epidotized. Similar rhyolite and rhyodacite form the western and southern slopes of Mount Bramston. Coarse lithic tuff (2060), porphyritic rhyodacite, crystal tuff, and andesite are well exposed at Adelaide Point where they are intruded by sills, 1 to 3 m thick, of spectacularly flow-banded rhyolite grading to microgranite. The cream rhyolite consists of a few quartz phenocrysts enclosed 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 form several features and outcrops in and around Bowen. Much of Stone Island consists of low outcrops of both massive and well bedded pyroclastics with subordinate lavas. At the northern point of the island the pyroclastics are altered and include massive acid to intermediate devitrified vitric and lithic tuffs, welded in places, and containing fragments of felsite, andesite, basalt and rare sandstone. A few flows of felsitic alkali rhyolite are interbedded with the tuffs. Both rock types contain scattered patches of jasper. The eastern point of the island consists generally of massive volcanic breccia, but interbeds of coarse lapilli tuff betray the structure in places. Part of the small islet of North Head is formed from volcanics, and Flagstaff Hill consists of dark aphanitic recrystallized lavas intruded by swarms of dykes. Large outcrops of porphyritic dacite, grading to quartz andesite, occur on a rocky spur at the northeastern edge of the central town area; the dacite has been intruded and recrystallized by adamellite (CPg) and several swarms of dykes. A quarry at Magazine Creek, midway between the town and Flagstaff Hill, is in an isolated residual of porphyritic quartz andesite and dykes.

Structure and Thickness

The structure of parts of the Carmila Beds, especially of the basal massive pyroclastics and flows, is usually obscure, but the upper half of the unit contains well-bedded sediments and tuffs which dip east-northeast at about 30 degrees. In spite of the well-bedded nature of most of the upper part of the succession, strike ridges are poorly developed, and then only south of the Proserpine River, so that the structure of the Beds cannot be photo-interpreted confidently. There is no evidence to suggest that the structure of the whole sequence is not just a simple east-facing homocline with an average dip of about 30 degrees. No sections have been measured in the Carmila Beds, but if an average dip of 30 degrees is assumed over the maximum observed strike width of 15 km., from Amelia Vale homestead to just west of Proserpine airport (Proserpine Sheet area), the preserved thickness is of the order of 7500 m.

Relationships and Age

Lower Permian marine fossils (Malone et al., in press) occur near the top of the Carmila Beds at several places in the St. Lawrence Sheet area, but elsewhere are absent from the beds. Plant fossils are extremely rare in the Bowen Sheet area, having been found at only one place, between Goorganga and Victoria Creeks, which is about 3600 m. above the present base of the unit. The plants, Cordaites australis and Cordaicarpus, are described by Mary E. White (1966, unpubl.) and are assigned by her to the Upper Carboniferous or Lower Permian. Noeggerathiopsis hislopi and Glossopteris (also assigned by Mrs White to the Upper Carboniferous or Lower Permian) occur in the Carmila Beds in the Proserpine Sheet area (Clarke et al., 1968 (unpubl.) and in press).

While it is quite clear that the Carmila Beds are intruded by the Hecate Granite (Lower Cretaceous), the known similarity in age between the beds and the granite adjacent to them north and south of the Hecate Granite leaves room for uncertainty about the relationship in these areas. Wherever the contact of the beds with the granite is not obviously intrusive, no evidence for a nonconformable relationship has been found. What is lacking is not so much evidence of an intrusive relationship but independent information on the separate ages of the granite and volcanics in any one area. Upper Carboniferous isotopic ages ranging from 282 to 298 m.y. have been obtained from two widely separated granite specimens (specimen 94, 3.5 km. southwest of Intaburra railway siding, and specimen 135 in the Urannah Igneous Complex at the eastern edge of the Sheet area near Pine Tree Creek). While the realm of these ages is unknown, they do suggest the existence in this area of granite older than the Carmila Beds, and it is therefore possible that further mapping could bring to light basal nonconformities in places. Alternatively the presence of these radiometric dates, combined with the absence of recognized nonconformities could indicate that volcanics of pre-Upper Carboniferous age may exist in places at the base of the Carmila Beds in a similar geological situation to that obtaining on the western side of the Urannah Igneous Complex (Lizzie Creek Volcanics and Connors Volcanics).

The fact that the Carmila Beds dip consistently away from the granite suggests that they may have been domed by the granite. It is possible therefore that the granite gained entry 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. On the other hand it is possible that the Carmila Beds homocline has a considerably relict content of primary dip off a basement granite massif which lay to the west, and which has subsequently been intruded and largely replaced by the Hecate Granite and possibly also by Lower Permian intrusions. Webb and McDougall (1968) have shown by Rb/Sr whole-rock dating that much of the granite in the Connors Arch is about 310 m.y. old (mid-Upper Carboniferous), i.e. older than the Carmila Beds.

A Lower Permian radiometric age (admittedly a minimum age) has been obtained from the Lizzie Creek Volcanics northwest of Collinsville. In the absence of more definite evidence it is assumed that the Carmila Beds are essentially the same age as the Lizzie Creek Volcanics.

<u>Kurungle Volcanics</u> (new name)

The name Kurungle Volcanics is given to a sequence of andesite and rhyolite flows and pyroclastics, which occupy a small isolated structural basin at the eastern end of Mount Abbot. The name is derived from Kurungle Holding. The type area is the upper 5 km of Finley Creek. The Kurungle Volcanics form steep hills which have a relief of up to 400 m.

Blue-grey andesite, andesite breccia, flow-banded rhyolite, agglomerate and tuff are the main rock types in the type area. The andesite varies from sparsely porphyritic to equigranular, and some is vesicular. One waterworn outcrop of agglomerate in Finley Creek consists of closely packed very well rounded pieces of andesite, up to boulder size, in a sparse matrix of andesite tuff. Flow-banded rhyolite forms prominent dipslopes in the west, between Finley Creek and Abbot Creek. Not enough structural information is available to gauge the thickness, but it is thought to amount to about 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 the quartz syenite phase of the Mount Abbot Igneous Complex, but mostly the contact is faulted. Felsite dykes, thought to be related to the younger of the two phases of the Mount Abbot Igneous Complex, also intrude the volcanics.

No fossils have been found within the Kurungle Volcanics. They are regarded as broadly equivalent in age to the Lizzie Creek Volcanics.

Mount Aberdeen Volcanics (new name)

Mount Aberdeen is 40 km. southwest of Bowen. It is a massive rugged mountain which rises abruptly from low-lying country to a height of 890 m. above sea level. The uppermost 300 m. of the mountain is formed from intermediate to acid volcanics which nonconformably overlie late Palaeozoic adamellite (CPg). Similar volcanics form crags at the summit of a mountain known locally as Mount Inbetween, 4 km. southwest of Mount Aberdeen. The volcanics are named Mount Aberdeen Volcanics. Mount Aberdeen is the type area.

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

Welded tuff on the northeastern side of Mount Aberdeen dips at 40 degrees to the southwest, but farther south andesite, agglomerate, and tuff are subhorizontal or dip gently west. Flow banding in andesite and rhyolite at the northern end of Mount Aberdeen is vertical.

The nonconformity between the volcanics and the adamellite is high on the eastern side of Mount Aberdeen, but volcanics extend all the way down the western side of the mountain, suggesting that the nonconformity dips west at a moderate angle. The attitude of the volcanics at Mount Inbetween is unknown, but they are evidently confined to the top hundred metres or so of the mountain. The thickness of the Mount Aberdeen Volcanics is possibly about 500 m.

Along the western side of Mount Aberdeen, and north of Mount Inbetween, the volcanics are intruded by biotite adamellite which 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 pyroxene has been recrystallized to green amphibole, biotite, and opaques. Some pyritic mineralization occurs along the contact.

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

No fossils have been found in the Mount Aberdeen Volcanics, nor are the ages of the surrounding granites firmly established. The volcanics are regarded for the present as Lower Permian in age, by analogy with the Lizzie Creek Volcanics.

Ring Dykes, etc. (Plr)

Acid magma intruded along arcuate fractures has formed several major dykes and numerous smaller ones in the Rangeview Ring Fracture in the Leichhardt Range. The major dykes are probably ring dykes. The smaller dykes (cone sheets?) occur in a swarm which parallels the northwestern margin of the Rangeview Ring Fracture. The Rangeview Ring Fracture and the several ring dykes and possible cone sheets probably all have a common origin, and may represent the near-surface expression of an oval granite stock like those forming Marlborough Pocket and the rugged hills south of Expedition Pass Creek. The ring dykes form steep ridges and peaks, contrasting with the adjacent rock types.

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

The thinner dykes, which may be cone sheets, consist of rhyolite which is generally spherulitic and porphyritic.

The ring dykes postdate the Upper Carboniferous volcanics (Cuv), and the swarm of cone sheets cuts the granodiorite (Plg) of Marlborough Pocket. The dykes and sheets are regarded as essentially the same age as the Lower Permian oval plutons of Marlborough Pocket and Expedition Pass Creek.

Granodiorite and Adamellite (Plg)

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

The oval stock drained by Landers and Fence Creeks in the northwest corner of the Sheet area gives rise to high massive spurs, in places mantled by scree, and intervening broad valleys, with local relief of 400 m. The stock is composed of leucocratic medium-grained pink granodiorite, in which biotite and actinolitic hornblende amount to 5 percent. Small diorite xenoliths are ubiquitous. There is little variation throughout the stock, and the contrasting geomorphology developed in different parts of the intrusion appears to be unrelated to rock type. The granodiorite intrudes the Ravenswood Granodiorite Complex in the northwest and east, and air photo interpretation suggests that it intrudes the Mount Windsor Volcanics in the southwest. No dykes were seen to intrude it, but they are abundant in the surrounding Ravenswood Granodiorite Complex.

A small boss of hornblende-biotite granodiorite intrudes volcanics (Cuv) in Millaroo Creek, 1.5 km. southeast of McGregors Bonnet. The granodiorite grades to porphyritic adamellite near the southwest margin. The adamellite contains brown biotite, green amphibole, pale green chlorite, sericite, sphene, clinozoisite, epidote, allanite, apatite, carbonates, and opaques. It includes xenoliths of volcanics and coarse biotite granite.

Two adamellite stocks occur close to each other in the headwaters of Expedition Pass Creek. Expedition Pass itself is formed from the less resistant country rock between the two stocks, which together form some of the most rugged country in the Leichhardt Range. Local relief is up to 400 m., and the high rugged country contrasts strikingly with the negative relief of the oval stock which forms Marlborough Pocket nearby (see below). Both stocks at Expedition Pass consist of medium-grained pink leucocratic biotite adamellite which, in the larger, southern stock, consists of perthite, oligoclase, and quartz with mafic-rich clusters of chlorite, biotite, apatite, zircon, and allanite. Brown-grey sparsely porphyritic medium grained hornblende-biotite granodiorite is a common rock on the lower slopes of the northern stock, and may represent a marginal phase. Both plutons consist of massive, little-altered rock types, and no dykes were seen to intrude either of them. Volcanics next to the northern stock are hornfelsed and cut by microgranite veins. A K/Ar biotite age of 270 m.y. was obtained from the southern stock. This stock has a sub-circular outline which, in the north, is sharply defined on the air photographs; it was probably emplaced into a ring fracture.

The surface of the large oval depression known locally as <u>Marlborough Pocket</u> is about 100 m. below the general level of the Leichhardt Range. The depression is formed from a granodiorite stock whose contacts are sharp and clear on the air photographs. It too was no doubt emplaced by ring fracturing. In contrast to the Landers Creek stock, whose varied topography seems to be independent of rock type, the wholly negative relief of the Marlborough Pocket stock can only be due to lithological differences between the stock itself and the granite which surrounds it (late acid phase of the Ravenswood Granodiorite Complex). In a regional sense the surface of the Marlborough stock is gently undulating, but a very close dendritic drainage pattern has developed on it, giving rise to a local relief of up to 15 m. The surrounding granite (ODa), on the other hand, is eroded into bold spurs and narrow valleys with a more deeply incised and wider spaced drainage pattern.

The Marlborough Pocket stock is medium-grained and ranges from granodiorite to adamellite. Hornblende forms narrow fibrous laths up to one centimetre long, but rarely exceeds biotite in abundance. The rock types of the stock resemble those of the surrounding country rock, except for the presence of green hornblende; this may be the clue to the remarkable contrast in susceptibility to erosion.

A small mass of leucocratic biotite microadamellite intrudes the southeastern part of the stock, forming a steep hill about 30 m. high. It contains phenocrysts of plagioclase, perthite, quartz, and biotite. Many large dykes of aplite, leucocratic microadamellite, and microgranite intrude the granodiorite nearby, and are probably related to the micro-adamellite intrusion. Rare dykes of feldspar-hornblende porphyry cut the microgranite dykes. Felsite dykes striking at about 070 degrees near the southeastern margin of the stock are probably cone sheets related to the Rangeview Ring Fracture. Thus it seems that the stock which forms Marlborough Pocket is older than the ring fracture, but the difference in age is probably not great.

An oval stock of massive pink and white biotite adamellite, contrasting with the surrounding foliated diorite and tonalite (Cud), crops out in rugged country drained by Grant Creek, 8 km. northeast of its junction with the Broken River. The stock appears to be eroding more rapidly than the surrounding more basic rocks and gives rise to more intricately dissected country. A K/Ar biotite age of 268 m.y. has been obtained from the stock.

Thunderbolt Granite (new name)

The name Thunderbolt Granite is introduced here for a Lower Permian post-tectonic adamellite batholith which covers 400 sq. km. 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 granite lies in the southern half of the Sheet area, and was included in the then Urannah Complex by Malone et al. (1966).

Distribution and Topography

The Thunderbolt Granite extends from the headwaters of Flagstone Creek in the south to just west of Mount Aberdeen in the north, a distance of about 50 km. In the north the lithology is variable, and the limit of the pluton is not well established, because it is not easily distinguished from the other granites in the area. The topography of the granite is variable, reflecting the different base-levels attained by the creek systems which drain it. A rugged plateau fragmented by ravines and fringed by cliffed spurs and re-entrants, occurs in the centre of the pluton. The plateau rises to about 300 m. above undulating country in the north and 60 to 120 m. above uneven hills and slopes in the south.

Lithology

South from Binbee, for more than 90 percent of its outcrop, the Thunderbolt Granite is a uniform pluton of massive hornblende-biotite adamellite. The quartz content ranges from 20 to 40 percent, plagioclase (oligoclase to andesine) is about 20 percent, microperthitic orthoclase (often forming large pink phenocrysts or porphyroblasts ranges from 15 to 30 percent, biotite and hornblende together amount to between 5 and 7 percent, and the accessory minerals are iron opaques, sphene, apatite, and zircon. Biotite is always more abundant than hornblende. Intermediate to basic dykes are rare, but swarms of aplitic microgranite dykes intrude the granite in places, especially around the margins, and extend out into the country rocks.

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

An isolated outcrop of granite gneiss (Figs 18-20) protrudes from the sandy bed of the Bogie River, 500 m. downstream from Binbee. The gneiss contains augen of quartz and feldspar up to 8 cm. long. The foliation of the gneiss has been intricately folded, and the folds have been repeatedly dislocated along small subparallel shear planes. Unfortunately the outcrop is isolated, but it is thought that, since the gneiss occurs near the contact of the Thunderbolt Granite, and as metamorphic rocks are unknown in the region, it may represent part of the granite that was repeatedly squeezed against the wall rock and intermittently remobilized, during the intrusion of the batholith.

Figs. 18, 19, 20: Granitic augen gneiss (Thunderbolt Granite), isolated outcrop in bed of Bogie River, 500 m downstream from Binbee. The gneiss is possibly a marginal (and probably contaminated) part of the Thunderbolt Granite magma which was repeatedly squeezed against the wall rock and intermittently remobilized, during the intrusion of the batholith. The scale is graduated in inches. Negs. G.8356, G.8358, G.8361.

Figure 19: Neg. G.8358.

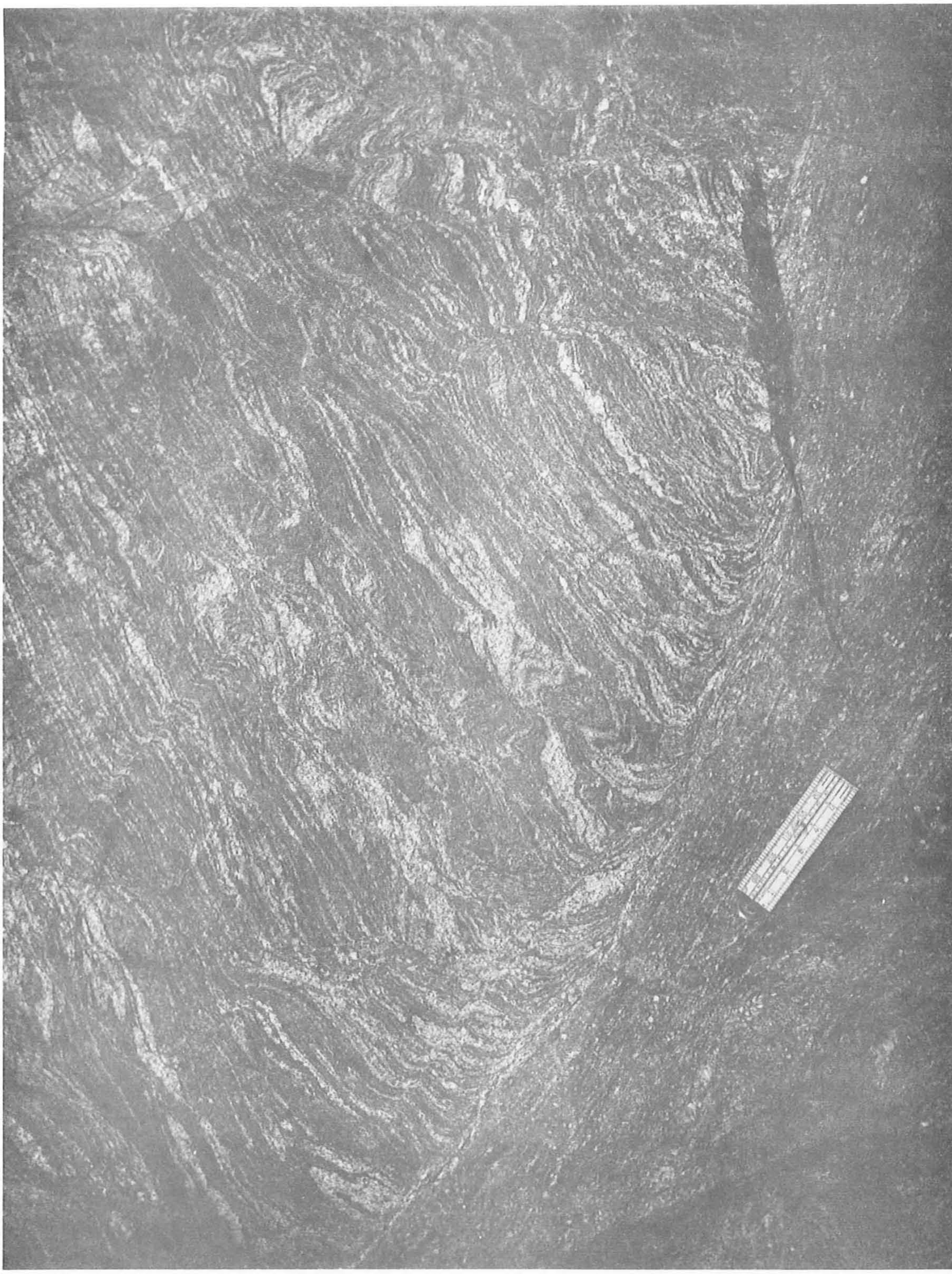


Figure 20: Neg. G.8361.

Structure

In the south the contact of the Thunderbolt Granite appears to dip steeply. It is faulted in places. Along the Bogie River, for a few kilometres upstream from Binbee, the contact dips relatively gently northeast, as indicated by the mapped roof pendant (Cud) and cupola.

Numerous lineaments, some of which may be faults, are apparent in the central rugged area. The main direction is northwest, but some strike northeast. Lineaments or faults may exist in the area of more subdued topography, but the streams may not be deeply enough incised to reveal them.

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

Relationships and Age

The Thunderbolt Granite intrudes the Upper Carboniferous quartz diorite suite (Cud) by which it is surrounded. It is younger, too, than most of the dykes which intrude the diorites, for the dykes are truncated at the granite contact. The relationship between the Thunderbolt Granite and the Mount Aberdeen Volcanics was not established. In the north the Thunderbolt Granite is intruded by the Hecate Granite, and in the southeast it is intruded by a small boss of altered granodiorite (PKs).

The mean K/Ar age on biotite is 265 $\pm$ 1.3 m.y., and this is supported by two Rb/Sr (biotite) measurements (Webb & McDougall, 1968, p.325).

Mineralization

The southern limit of outcrop of the Thunderbolt Granite is interpreted to lie just south of an old silver mine (probably the "Flagstone", Cameron, 1902), which is visible from the Binbee-Normanby road, 4 km east of Parada homestead. The lode lies next to an altered microdiorite dyke which intrudes the fine-grained marginal phase of the granite.

UPPER PERMIAN OR LOWER TRIASSIC

Mount Wickham Rhyolite (new name)

The Mount Wickham Rhyolite is a group of rhyolite flows, plugs and dykes which intrude and overlie the Lizzie Creek Volcanics between the Bowen and Bogie Rivers in the centre of the Sheet area. An isotopic age of 230 m.y. has been obtained from the rhyolite. The type area is Mount Herbert, a prominent steep hill formed from a plug, 40 km. northwest of Collinsville. The elongate outcrop area of acid volcanics between Glenmore Creek and the Bowen River was mapped by Malone et al. (1966) as Tertiary ("Brawl Creek block"), but in view of the isotopic dates which have become available from the Mount Wickham/Clarke Range area, it is now mapped with the Mount Wickham Rhyolite. Mount Glenroy and Mount McConnell, near the western edge of the Sheet area, are also included; so also is an area of dyke-like intrusives between Sandalwood Creek and the Millaroo Fault Zone.

Topography

The rhyolite, especially the intrusive phases, generally forms steep hills, many of which are isolated. The hills rise a hundred metres or so above the undulating country of Lizzie Creek Volcanics and basement granite (CPg). Many of the hills, for example Mount Herbert (about 420 m.), have cliffs for the uppermost 30 m. or so. Mount Wickham (530 m.) rises about 450 m. above the Bowen River to the south. Edinburgh Castle is about 525 m. above sea level, and about 350 m. above the surrounding country. Mount McConnell (450 m.) is a massive circular plug which rises 300 m. from the surrounding country, forming a notable landmark among the low ridges and slopes of the Scartwater Formation. Mount Glenroy (530 m.) is a pinnacle 150 m. higher than the summit level of the surrounding hills.

Lithology

The rhyolite is typically porphyritic in feldspar and quartz, the phenocrysts ranging up to about 3 cm. The rhyolite generally has an aphanitic groundmass, but in some outcrops it grades to microgranite. Quartz phenocrysts are abundant at Mount Wickham, where

TABLE 3 - LATE PALAEOZOIC TO CAINOZOIC STRATIGRAPHY AND IGNEOUS INTRUSIONS

Period or Epoch	Rock Unit	Lithology	Topography	Remarks
QUATERNARY	Qm	Coastal mud, minor evaporites.	Flat	Superficial, merges with stream alluvium. Estuarine and littoral mud flats and pans.
	Qr	Sand in beach ridges and coastal dunes.	Low linear ridges	Superficial. Ancient and present strand-line 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 River. Groundwater.
	Qs	Colluvial and residula soil, sand, and rubble.	Gently undulating	Maximum 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. A few dicotyledonous plants. 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 Formation.
LOWER CRETACEOUS	Mount Abbot Igneous Complex (Ka$_2$)	Alkali granite	Steep rugged mountains (1055 m)	Sub-volcanic 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, Mount Aberdeen Volcanics. Responsible for gold mineralization in east of Sheet area.
	Hecate Granite (Kh)	Granodiorite and adamellite; late stage leucocratic phases.	Mainly rolling low-lying country; 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. Intrudes Lizzie Creek Volcanics and Bowen Basin sediments.
TRIASSIC	Clematis Sandstone (Rc)	Cross-bedded sublabile and quartzose sandstone, pebbly	Steep-sided tablelands and mesas	Conformable on Rewan Formation. Fluvial. 300-350 m thick.
	Rewan Formation (Rr)	Red mudstone, green labile and sublabile sandstone, siltstone.	Mainly soil-covered plains and rises. Some strike ridges. Locally rugged where hornfelsed	Conformable on Blackwater Group. Predominantly fluvial. 1000 m thick.
Lower Permian or Lower Cretaceous	PKg	Leucogranite, microgranite, minor adamellite, microadamellite, diorite	Rugged mountains, hills, and islands	Epizonal stocks. Intrude Upper Carboniferous diorite suite (Cud), Upper Carboniferous or Lower Permian granitic rocks (CPg) Carmila Beds.
	PKs	Altered granodiorite	Prominent conical hill	Boss. Intrudes Thunderbolt Granite near its contact with Upper Carboniferous diorite suite (Cud). Pervasive sericite and carbonate alteration.
Upper Carboniferous, Lower Permian, and Lower 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 south-easterly continuation of Upper Carboniferous, Lower Permian, and Lower Cretaceous batholiths to N. Intrudes Connors Volcanics; some phases may intrude Carmila Beds.
Upper Permian or Lower Triassic	Mount Wickham Rhyolite (PRr)	Mainly flow-banded porphyritic rhyolite, rhyolite breccia, subordinate trachyte, dacite, obsidian, agglomerate	Steep hills and ranges. Cliffs.	Plugs and flows. Intrude and unconformably overlie Lizzie Creek Volcanics, Upper Carboniferous granite (Cug), Mt Windsor Volcanics, and Scartwater Formation. Thickness 30 to 200 m.

they are commonly 1 cm. or more in diameter. The rhyolite is generally flow-banded, often prominently. In most outcrops the banding is contorted and dips steeply. Rhyolite breccia often accompanies flow-banded rhyolite. Besides flows and plugs, large dykes of rhyolite crop out in many areas, for example Mount Wickham, Mount Herbert, and Edinburgh Castle. Table Mountain is capped by a flow which dips gently northeast, and the southern scarp of the mountain is probably a feeder dyke.

The acid volcanics at the southern end of the Millaroo Fault Zone include trachyte, rhyolite, dacite, obsidian and agglomerate, and are described by Malone et al. (1966).

Mount McConnell is formed from grey and white flow-banded aphanitic rhyolite and porphyritic rhyolite. The summit consists of rhyolite breccia. Porphyritic felsite dykes associated with the plug intrude the Scartwater Formation near the base of the mountain. The sediments next to the contact are indurated.

Mount Glenroy was inspected only from a helicopter. The rock at the summit is dark grey, and closely jointed.

Relationships

In most areas neither the intrinsic nor the relative structural attitudes of the Mount Wickham Rhyolite and the Lizzie Creek Volcanics are apparent, but where the two units occur together the rhyolite plugs of the Mount Wickham Rhyolite intrude the Lizzie Creek Volcanics, and the rhyolite flows overlie the Lizzie Creek Volcanics, probably disconformably. Malone et al. (1966) record dolerite dykes up to 4 m. thick intruding the rhyolite in the Brawl Creek area. The maximum thickness of the flows in the Clarke Range is about 30 m., although Malone et al. (1966) record a thickness of 200 m. or more in the Brawl Creek area.

Age

Rubidium/strontium whole rock analyses of specimens collected from scattered outcrops of the rhyolite (Webb & McDougall, 1968, pp. 328-9) have indicated an age of 230 $\pm$ 15 m.y., which is close to the Permian-Triassic boundary.

UPPER CARBONIFEROUS, LOWER PERMIAN, AND LOWER CRETACEOUS

Urannah Igneous Complex

In their Report on the geology of the southern half of the Sheet area Malone et al. (1966) gave the name Urannah Complex to the large composite batholith which lies east of the Bowen Basin. In the present Report the name is amended to Urannah Igneous Complex, because metamorphic rocks are now known to be absent. In addition, the name is confined to that part of the batholith in which it has not been possible during the present survey to map separate phases. Accordingly the name Urannah Igneous Complex now refers to the acid, intermediate and basic plutonic rocks in the southeastern corner of the Sheet area. The northern limit of rocks described under this heading is a sinuous arbitrary line on the map. This line is not a geological boundary; its purpose is merely to demarcate approximately the area of undivided plutonic rocks (Urannah Igneous Complex) from the northern and better known part of the batholith.

Topography

Except for a minor area of low-lying country around the Mount Hector goldfield in the northeast, the Urannah Igneous Complex forms rugged country.

The relief in places is estimated at more than 800 m. Southeast of Urannah homestead some peaks exceed 900 m. above sea level; Mount Hector is 890 m., and a peak north of the headwaters of Amelia Creek is 990 m. above sea level. A maximum elevation of 1280 m. is reached at Mount Dalrymple (Fig.21), a few kilometres southeast of the Sheet area.

The landscape of the complex is in a state of late youth or early maturity; valley downcutting is at a maximum, and 90 percent of the land surface consists of steep slopes. The spacing and structural control of streams vary a great deal throughout the complex, owing to the presence of contrasting plutonic phases which differ in their structure and susceptibility to erosion. In places dykes form prominent ridges but, except between Ernest Creek and Long Creek, no

Fig. 21: Urannah Igneous Complex. Aerial view from a point just south of the southeastern corner of the Sheet area, looking east up Massey Gorge (400 m deep), towards Mount Dalrymple (1280 m) in the Mackay Sheet area. Neg. GA.1160

sizeable areas of close parallel dyke ridges are apparent, as in the diorite suite (Cud) to the north.

Travel by vehicle in the Urannah Igneous Complex is virtually restricted to the roads shown on the map, of which only the road from Eungella (Mackay Sheet area) to Urannah homestead is suitable for regular use by conventional vehicles. Most observations were made in the more accessible parts of the complex in the northeast. South of Mount Crompton, observations were confined to a few helicopter landings in Urannah Creek. Large outcrops are abundant in many of the streams draining the western slopes of the Clarke Range (Fig.22), but outcrops are rare in a small area of rain forest which extends into the Sheet area east of Mount Crompton (Fig.23).

Lithology

Debris of severely sheared and mylonitized granite and less acid rocks forms outwash fans south and southwest of Mount Hector. Some of the rock types are blastomylonites reminiscent of the shear zones southwest of Bowen (see Hecate Granite and unnamed granite CPg); the prominent northwesterly lineaments in the mountains west of Mount Hector probably represent similar shear zones. Sheared, greisenous, iron-stained aplite forms part of the debris.

Weathered biotite microgranite and granite form low knobbly rises and small hills east and southeast of Mount Hector homestead. Outcrop is poor in the Mount Hector goldfield, and mine dumps provide the best clue to the geology. The host rock of the mineralization (at the Gumoller mine) is evidently a white hornblende-biotite trondhjemite. The trondhjemite is intruded by microdiorite dykes porphyritic in hornblende and by grey microtrondhjemite (?) dykes which contain plagioclase and biotite phenocrysts. Flaggy, closely jointed pink aplitic microgranite, silicified and slightly iron-stained, forms small hills 2 to 4 km. southeast of Mount Hector homestead, and greisenous and locally gossanous microgranite crops out on a small hill at the foot of the Clarke Range, 5 km. southeast of the homestead.

Between Pine Mountain and Fairfield hut tonalite and adamellite, commonly net-veining diorite, are the principal rock types.

Weakly brecciated chloritized granite or adamellite occurs near the contact with the Carmila Beds between the Mixer mine and Palm Tree Creek. South of Palm Treek Creek the granite is massive and unaltered. The granite or adamellite 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 (isotopic dating sample locality 113), there are outcrops of fresh massive medium to coarse uralitized quartz-augite-biotite diorite (2210).

In Urannah Creek the general rock type is a weakly foliated biotite adamellite or granodiorite, locally hornblende-bearing, and in places intruding quartz diorite. A small proportion of the creek debris consists of quartz-feldspar porphyry.

Structure

Many strong northwesterly ridge and valley lineaments are visible on air photographs of the Urannah Igneous Complex, especially in the northeast. The debris of sheared and mylonitized rocks near Mount Hector indicates that at least some of the lineaments there represent shear zones. Ridge lineaments caused by dykes are predominant between Mount Crompton and the southern edge of the Sheet area.

Weak vertical foliation occurs in Urannah Creek and Dick Creek; the strike of the foliation is easterly in the east, but swings to southeast near Urannah homestead.

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, although no intrusive relationship was seen, it is

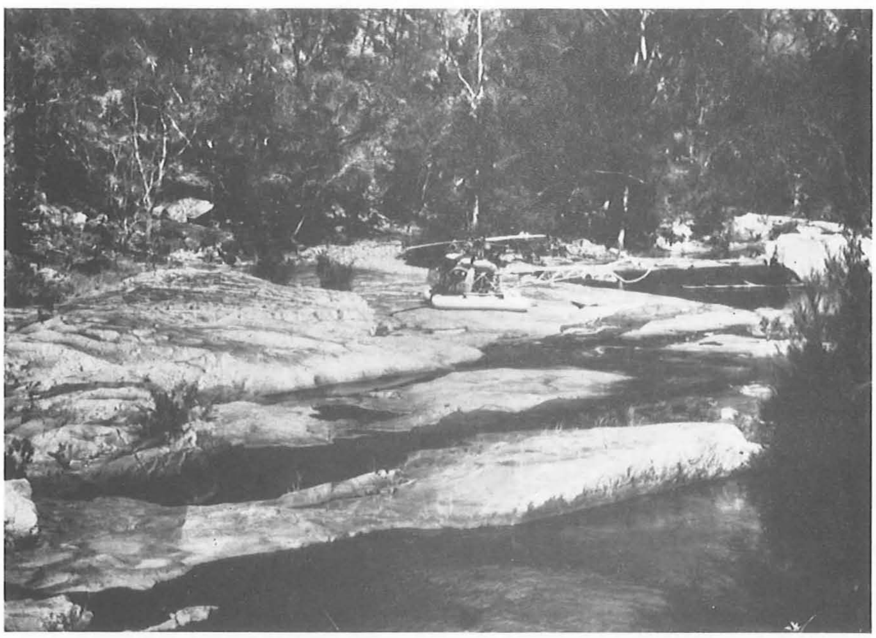


Fig. 22: Urannah Igneous Complex, bed of Massey Creek (Mount Coolon Sheet area), 11 km southeast of Urannah homestead. An irregular dolerite or microdiorite dyke strikes parallel with the stream, beneath the tail rotor of the helicopter.
Neg.GA.1152

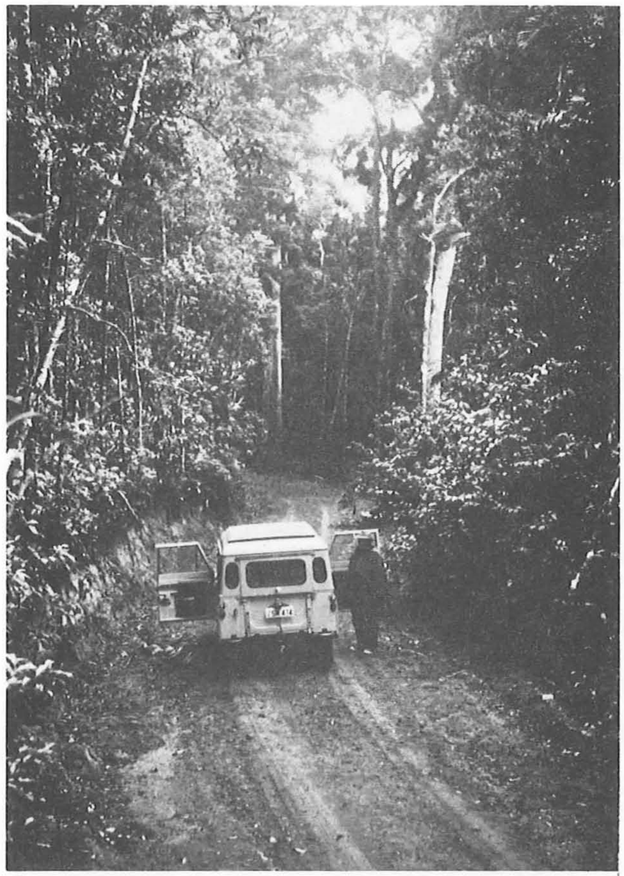


Fig. 23: Urannah Igneous Complex. An example of rain forest which extends into the east of the Sheet area east of Mount Crompton. Neg.GA.1153.

considered that at least some phases may be intrusive into the Carmila Beds, owing to the local presence of microgranite near the contact. The gold mineralization in the Mount Hector goldfield straddles the contact, but this cannot be taken as proving that the complex intrudes the Carmila Beds in this area, as the mineralization is closely associated with microdiorite dykes, and may be related to them rather than to the granite.

Age determination specimens collected from the Urannah Igneous Complex are listed in the Appendix. Webb and McDougall (1968, pp. 320-4) consider that a realistic minimum estimate of the age of most of the complex is 305-310 m.y. (U. Carboniferous). However Lower Permian and Lower Cretaceous intrusions may be present, as they are farther to the north and southeast.

LOWER PERMIAN OR LOWER CRETACEOUS

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 circular in plan, and is about a kilometre in diameter. It forms a prominent conical hill (548 m, which rises 150 m above its neighbours. The slopes of the hill are mantled by large tors. The country immediately surrounding the boss is broken and in places deeply dissected, but the granodiorite is accessible by vehicle from the Binbee-Normanby road.

In hand specimen the rock is a medium-grained to inequigranular, speckled pink and grey muscovite granite, but in thin section it appears to be a granodiorite in which biotite has been largely replaced by muscovite and chlorite, and the feldspars extensively sericitized. There are substantial amounts of calcite and siderite. Rare rectangular grains of hematite may be pseudomorphs after pyrite.

The boss was examined only at one place on its western margin, but the specimen collected may well be representative of the whole boss because photo-interpretation suggests a simple cylindrical plug-like body. At the sample site the alteration is pervasive and is not related to weathering.

The boss intrudes the Thunderbolt Granite near its contact with diorite and gabbro (Cud). Several strong lineaments, almost certainly faults, are visible on air photographs in the surrounding country. One passes through the centre of the boss itself, suggesting that emplacement was controlled by faults, which were later rejuvenated. It is conceivable that the boss is an outlying cupola of the Lower Cretaceous Hecate Granite, which has been the source of the minor gold-copper mineralization in the eastern half of the Sheet area.

Granite (PKg)

The category Lower Permian or Lower Cretaceous is used for undated granite stocks in the northeast of the Sheet area which, on the basis of field relationships, are the youngest plutonic rocks in their immediate environs. The granites are mostly leucocratic, and show a tendency to occur as subcircular masses, suggesting that they are high-level intrusions. Only very rarely are they intruded by dark dykes.

Mount Pring is an uneven rocky hill whose southern face rises steeply to 420 m. above sea level from the alluvial plain of Euri Creek. Most of Mount Pring is formed from a stock of granite which can be easily distinguished on air photographs from the diorite and gabbro which it intrudes. The stock is roughly semicircular in plan in the Bowen Sheet area, but forms irregular outcrops to the north in the Ayr Sheet area, where it has been only partly unroofed. The stock was only briefly examined, but along its western side it is a pale pink-brown leucocratic fine grained biotite granite which in places contains quartzofeldspathic druses up to 8 cm. in diameter. The druses are rimmed by zones of granite containing a higher percentage of biotite than the rock as a whole. A prominent ridge of shear-foliated leucocratic granodiorite (CPg) occurs along most of the western side of the mass. Northwest of the railway the rock is a massive fresh pink-brown leucocratic biotite microgranite, coarsely porphyritic in iron-stained quartz and feldspar. Two swarms of aplite, felsite, and microgranite dykes intrude the diorite and gabbro north and south of Mount Pring, and are evidently related to the granite.

North Head is a rocky islet, surmounted by a lighthouse, between Flagstaff Hill and Stone Island. It consists largely of pink and brown fine to medium grained biotite leucogranite. The leucogranite intrudes volcanics (Carmila Beds) and two separate swarms of dark dykes (Fig.33), and is probably part of the mass which forms Mount Mother Beddick and Cape Edgecumbe, 5 km. to the north in the Ayr Sheet area. The leucogranite is intruded by irregular but generally north-striking microgranite dykes.

Extensive outcrops of strongly jointed sparsely porphyritic leucocratic microgranite occur at the southern end of Kings Beach, and dykes of similar microgranite (grading to spherulitic rhyolite) intrude the Carmila Beds abundantly on Flagstaff Hill. The microgranite is probably a marginal variant of the leucogranite at Edgecumbe Heights.

Gloucester Island rises steeply from the sea on all sides and the highest point of its central sawtooth ridge is about 566 m. above sea level. A scrub covered bajada of scree slopes runs down to the sea on the western side of the island. Coastal outcrops suggest that the island is essentially made up 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. One kilometre north of here the older of two rock types is a massive blue-grey medium grained biotite-hornblende diorite, which contains veins and patches of diorite pegmatite. Rare pyrite aggregates up to 3 cm. in diameter occur in the diorite pegmatite. Leucocratic granite veins, some of which contain small pyrite crystals, cut across the diorite and the pegmatite. A specimen of leucogranite from here has yielded a K/Ar biotite age of 216 m.y. (Middle or Upper Triassic - discussed below).

The existence of a bajada along the western side of Gloucester Island but not on the east suggests that the western contact of the leucogranite with a more easily eroded rock (diorite?) probably dips steeply, and subcrops below the bajada a short distance to the west of the central ridge of the island.

The rugged granite range (399m.) between Sinclair Bay and Cape Gloucester is formed from leucogranite similar to the granite of

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 southeastern shores of Edgecumbe Bay, is formed from a small stock which intrudes the Edgecumbe Beds. The stock is circular in cross section and is about 2.5 km. in diameter. The stock was examined only at its northeast margin where it is a grey and pink porphyritic microadamellite. Biotite is the main ferromagnesian mineral, though small amounts of pale green amphibole are present too. The microadamellite contains many small resorbed xenoliths, and it probably represents the chilled and contaminated marginal phase of the stock. Hornfelsed limestone of the Edgecumbe Beds forms a roof pendant near sea level on the northern side of Ben Lomond (Saint-Smith, 1918; Connah, 1953b).

Age and Structural Setting

The age and structural setting of these granites in relation to the other granites in the Sheet area, especially the Hecate Granite, is obscure but intriguing. Although the potassium and argon analyses of the specimen from Gloucester Island have been carefully checked (A.W. Webb, pers. comm.), and there is every reason to believe that the data are meaningful, it is an isolated result, and in the absence of other age determinations from nearby granites, one hesitates to regard these granites as of proven Triassic age. Granites of this age appear to be confined so far to southeastern Queensland, south of about Gladstone (Webb & McDougall, 1968), which is over 600 km. southeast of Bowen. Nevertheless the age obtained is unlikely to be greater than the real age, and therefore the granites east of the Port of Bowen are probably no younger than Triassic. The fact that these apparently epizonal granites, which are Triassic or older, now occupy the same level of the crust as the nearby, but probably deeper level, Hecate Granite, is an apparent paradox which can perhaps be resolved by postulating major fault movements between the two areas of granite. Such a zone of faulting does in fact exist south of Edgecumbe Bay, as a probable northwesterly continuation of the major faults which gave rise to the Hillsborough Basin in the Tertiary or late Cretaceous in the Proserpine Sheet area (Clarke et al., 1968 (unpubl.) and in press). But the sense of movement required to resolve the apparent granite depth problem (i.e. northeast block down) is the opposite to that required to explain the present-day justaposition of the Edgecumbe Beds and the Carmila Beds.

LOWER CRETACEOUS

Minor Intrusives (Ki)

Lower Cretaceous laccoliths and sills intrude the Bowen Basin sequence and have been described briefly by Malone et al. (1966). A stock which intrudes the Lizzie Creek Volcanics north of Mount Poole, and which was photo-interpreted by Malone et al. (1966) as an intermediate or basic phase of the Urannah Complex, was visited by helicopter during the present survey and a specimen collected from it has yielded a Lower Cretaceous age (123 m.y., specimen 127, Appendix).

The stock underlies a deep pocket surrounded by hills of hornfelsed volcanics and sediments. Massive fresh medium-to-coarse hornblende-biotite granodiorite or adamellite forms low tors at the specimen locality. Here the soil on the floor of the pocket is generally granitic, but it is extensively mantled by debris of hornfelses containing tremolite-actinolite-chiastolite assemblages. These are probably remnants of colluvial deposits derived from the surrounding hills, but alternatively they could be in situ lag deposits, surviving from the volcanics immediately above the roof of the intrusion, and thereby suggesting that the present level of erosion coincides roughly with the roof of the intrusion.

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

Hecate Granite (new name)

The name Hecate Granite is given to a Lower Cretaceous batholith of granodiorite and adamellite in the northeastern part of the Sheet area, which 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 lat. 20 deg. 24'25"S, long. 148 deg. 10'30"E.

The Hecate Granite is exposed over about 1000 sq. km. but probably underlies a greater area. It is of economic importance, in that it is largely surrounded by many occurrences of gold and minor base metal mineralization.

Most of the Hecate Granite is unaltered, unfoliated, sparsely jointed, and devoid of dark dykes, and it so strongly resembles the Thunderbolt Granite that at first they were believed to be the same rock unit. Isotopic dating has since shown, however, that one is Lower Cretaceous and the other Lower Permian.

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), so that it generally forms rolling low-lying country, (Figs 3, 5, 6, 7 and middle distance of Fig.25) although there are frequent exceptions. The physiography of the granite is variable and indistinctive, and, except in the east where the batholith is flanked by a range of hornfelsed volcanics (Fig.3), the boundary is hard to photointerpret. The morphology of particular areas is controlled by the state of maturity of the streams rather than by variations in rock type.

The most prominent physical feature of the Hecate Granite is Roma Peak, a spectacular isolated rocky pyramid 40 km. south of Bowen, rising to 660 m. above sea level (Figs 6, 24, 25). Roma Peak is formed from a resistant boss of aplitic microgranite, and its northeastern face rises almost sheer for 300 m. Besides Roma Peak, other late leucocratic phases of the granite tend to form distinct hills,especially

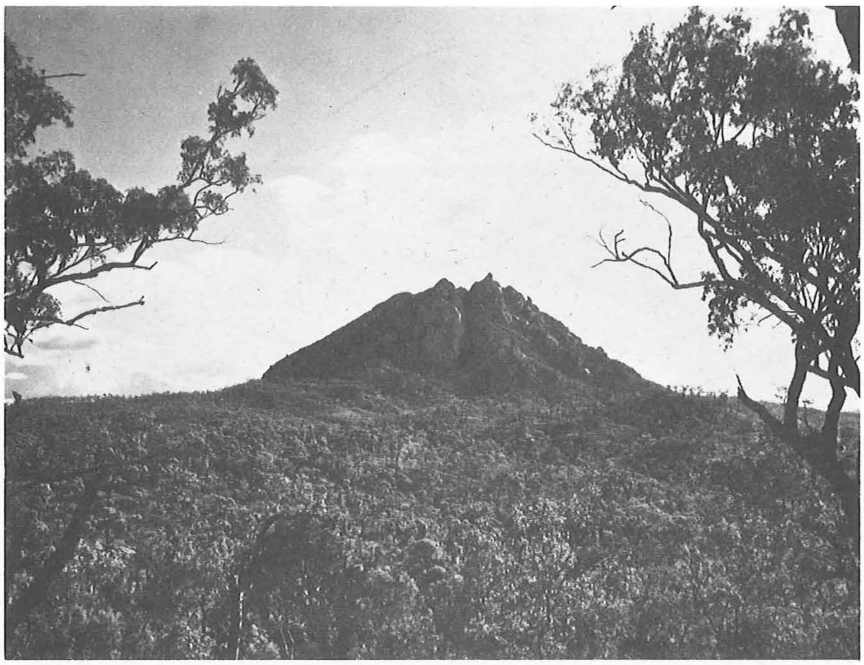


Fig. 24: Roma Peak (660 m), 37 km south of Bowen, from the east. Roma Peak is a resistant boss of aplitic microgranite, one of the late leucocratic phases of the Hecate Granite (Lower Cretaceous), which forms the surrounding lower-lying country. Neg.G.8353. Photograph by J.E. Zawartko.

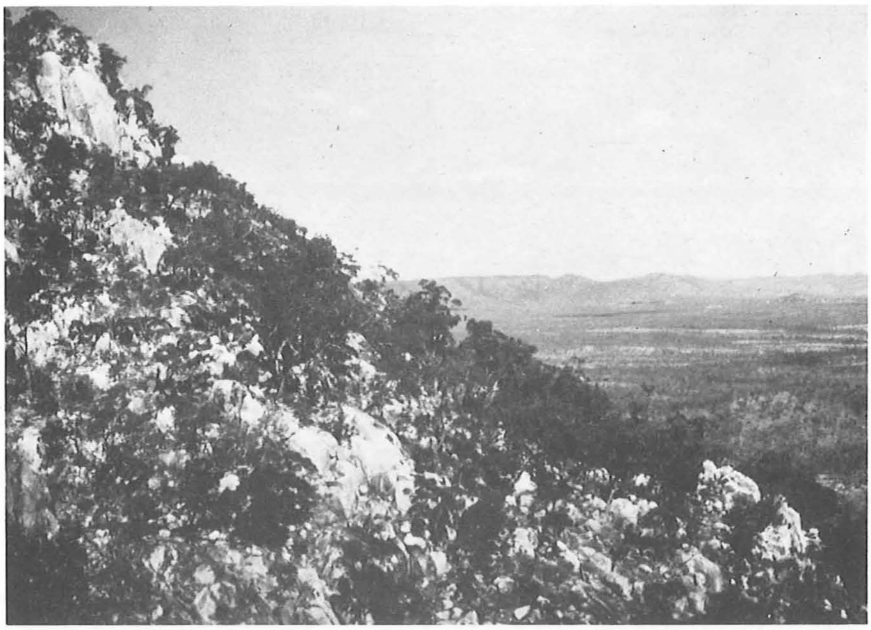


Fig. 25: View south up valley of Don River from Roma Peak. In the foreground is the southwest shoulder of Roma Peak (Lower Cretaceous massive aplitic microgranite). Undulating low-lying country in the middle distance is developed on the Hecate Granite (Lower Cretaceous). The hills in the distance are formed mainly from Upper Carboniferous dioritic rocks (Cud). Neg. GA.1164.

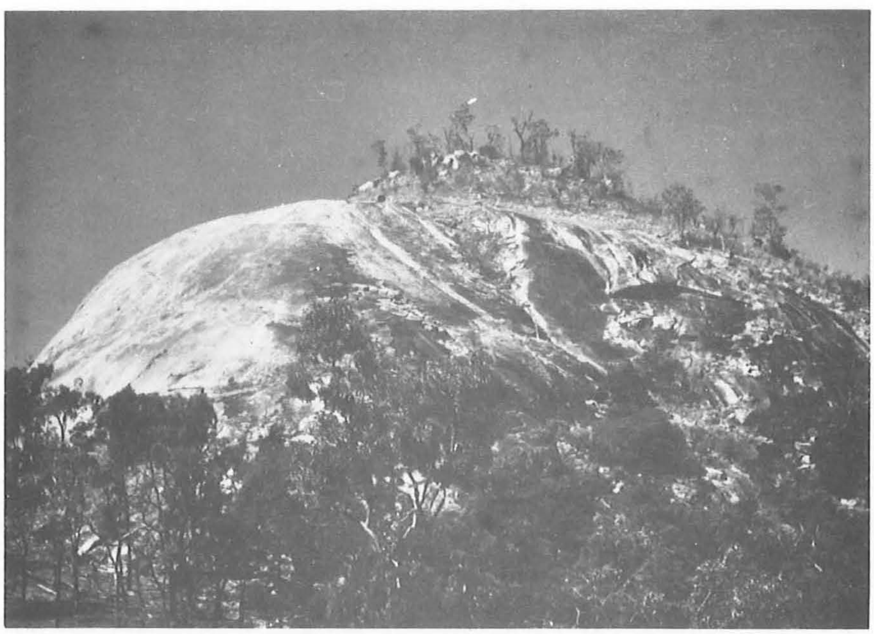


Fig. 26: Bald Rock, a large whaleback of Lower Cretaceous Hecate Granite, 3.5 km west-northwest of Roma Peak. Neg.GA.1148.

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 gently undulating country, stretch in a line for 8 km. northwest from Roma Peak (Figs 6 and 26). At Mount Gibralter the granite has been buttressed by a swarm of dykes, and gives rise to broken hills and ridges. The drainage basins of the Don and Proserpine Rivers are mainly composed of gently rolling country, but the base level of the Proserpine River, which has a well defined, basin-like valley (Figs 2 and 3), is a hundred metres or so lower than that of the Don River due west of it. The meridional watershed between the two rivers occurs in broken country which forms an indented east-facing scarp in the north, but which broadens and gains height towards the south, culminating in deeply dissected mountains at the heads of the Don and Andromache Rivers. These mountains have a local relief approaching 600 m.

There is good access to most of the Hecate Granite. The Bowen-Collinsville road (sealed) crosses it in the northwest. Well maintained gravel roads run from the Bowen-Collinsville road to Pretty Bend homestead (Normanby-Upper Don River road), from the Bruce Highway near Intaburra Siding to Roma Peak homestead, and in the Proserpine and Andromache River valleys. A track which can be negotiated by cross-country vehicles runs from Roma Peak homestead to the old Normanby Goldfield, and similar tracks cross other parts of the batholith.

Lithology

A typical specimen of the Hecate Granite, collected from 3.5 km. southwest of Roma Peak, is a massive white and pink medium to coarse biotite-hornblende granodiorite, composed of zoned oligoclase-andesine (45 percent), quartz (25 percent), perthitic alkali feldspar (15 percent) hornblende (5 percent), biotite (3 to 5 percent), magnetite (1 percent) sphene (less than 1 percent), and a trace of apatite. The grain size of the plagioclase, quartz, hornblende and biotite is generally about 2 to 4 mm., but may range up to 8 mm. Most of the perthite occurs as large poikiloblasts between 2 and 3 cm. long, but some forms smaller crystals between the other minerals. Both biotite and hornblende are fresh, although rare flakes of biotite are chloritized. The biotite is pleochroic from straw yellow to deep brown, and the hornblende from yellow to blue-green. The sphene occurs in long crystals up to 2.5 mm. in length, easily visible to the naked eye. The quartz is fractured, and most grains have wavy extinction. Most outcrops in Simon Creek are fresh, massive, and unjointed, and consist of white and pink adamellite or granodiorite in which all minerals including biotite and hornblende appear unaltered.

Massive, medium to coarse biotite adamellite underlies low-lying sand-covered rises south and west of Pretty Bend homestead, but leucocratic granite and microgranite, occurring apparently as thick sheets, form rugged country farther to the south and west, including the steep peak of Monte Christo (about 500 m.). The sheets form a semi-circular swarm whose focal point is an isolated hill rising from the sandplain 1.5 km. south-southwest of Pretty Bend homestead. Diorite forms the valleys between the concentric granite sheets. An unusual inequigranular leucogranite, grading in places to microgranite and elsewhere rarely to pegmatite, forms the central hill near the homestead. The leucogranite is slightly porphyritic with yellow-brown quartz phenocrysts, and contains scattered relict xenoliths, commonly almond-shaped, and composed of biotite, quartz, feldspar, and red garnet. Biotite appears to form about 50 percent of the xenoliths. In places rare homogeneous crystals of red garnet up to 3 mm. in diameter and sieve-textured garnets up to 1.5 cm. in diameter occur in the leuco-granite outside the xenoliths. The potash feldspar (65 percent) is mainly perthitic orthoclase, but includes some microcline. Quartz (25 percent) is unstrained and only slightly fractured, and occurs in irregular grains up to 5 mm., and as small aplitic blebs in the potash feldspar. Oligoclase (10 percent) is fresh and not zoned. Biotite occurs as small fresh laths, some of which are accompanied or surrounded by muscovite. In another specimen the large quartz grains are strained and fractured, some of them having oval outlines, whereas the smaller aplitic grains are neither strained nor fractured. The larger grains are probably xenocrysts.

In the Proserpine River valley the rock types are gradational between granodiorite and adamellite, and there is little variation, although minor granite and diorite occur in places. Foliation is un-common. Quartz occasionally forms phenocrysts (which are usually highly fractured), but most rock types are equigranular. In some specimens biotite occurs in aggregates, giving the rock a speckled appearance. Small pod-like microdioritic xenoliths form 1 percent or less of most outcrops. On the valley floor the granite is deeply weathered and is largely obscured by coarse sand.

Biotite is the main ferromagnesian mineral in the northern part of the Hecate Granite, and adamellite is probably more common than granodiorite. Sixpenny Hill, a whaleback about 30 m high, is formed from massive, fresh medium-grained inequigranular adamellite, in which the biotite occurs as perfectly formed pseudohexagonal phenocrysts. The very large bare outcrops of fresh rock are almost completely devoid of joints. Several larger whalebacks occur between Sixpenny Hill and Roma Peak.

The small circular outcrop area northwest of Mount Aberdeen is a boss of biotite-hornblende adamellite which is porphyritic in plagioclase.

Mount Pleasant (about 450 m) is composed of hornblende-biotite adamellite similar to the Thunderbolt Granite, but its form suggests that it is a separate intrusion, younger than the Thunderbolt Granite. An offshoot of medium-grained hornblende granodiorite intrudes sheared diorite to the south.

Late-stage leucocratic phases are a feature of the Hecate Granite, and include leucogranite, microgranite, aplite, pegmatite, and intergradations between these rock types. Leucogranite, microgranite, and aplite are commonly associated with shear zones in the north of the granite. Some of these occurrences are described below. Aplite and pegmatite dykes are especially abundant between Roma Peak and the Proserpine River, and around Roma Peak itself. Some of the dykes in this area are 3 m thick or more, and form prominent lineaments on the air photographs; many of them dip at low angles, and in some of them pegmatite grades upwards into aplite. Feldspar crystals in the pegmatites range up to 20 cm in length. Rare tourmaline crystals were seen in a few of the dykes. Roma Peak itself is an isolated plug of pink and buff leucocratic aplitic biotite microgranite, which is much less easily eroded than the main granite. The plug is oval in cross section, and has a long diameter of just over 1 km.

Shear Zones and Associated Late Leucocratic Phases

In the north of the Hecate Granite there are several large shear zones, which are commonly associated with late leucocratic phases of the granite. The rugged country at the heads of the Don and Andromache Rivers was not visited, but several large lineaments may possibly represent similar shears. Shear zones also occur in the area of granite which is mapped as late Palaeozoic (CPg), in the north of the Sheet area, and are described under that heading. There the possibility was raised that the shear zones in the two areas of granite (mapped as late Palaeozoic and Lower Cretaceous respectively), possessing as they do so many features in common, were formed at the same time, and therefore could indicate that the granite within which they all occur is entirely Lower Cretaceous in age.

Mount Buckley (256 m.) rises 200 m. above low-lying undulating country, and has the overall shape of a huge upturned ship, with a sharp prow pointing to the southeast. It consists essentially of buff and pink leucocratic aplitic granite, sheared to varying degrees, which has been intruded along a strong shear zone, the Mount Buckley Shear. Outcrops of fine-grained gneissic granitic rocks, superficially mesocratic and believed to be blastomylonites, occur among outcrops of aplitic granite along the northeastern side of Mount Buckley and crop out in washaways in the low country for several hundred metres in a direction normal to the shear. The blastomylonites are finely banded rocks which are interpreted as the deformed equivalents of the main phase of the Hecate Granite (and in places of its country rocks of diorite and gabbro). The variably sheared aplitic granite is believed to be a late phase of the Hecate Granite. The dark colour of many of the blastomylonites is due partly to their fineness of grainsize, and partly to the presence of very fine-grained biotite. The blastomylonites and the aplitic granite grade into one another, and there is probably no fundamental difference in lineage between them. The different rock types simply represent different stages in a continuous or repetitive process of differentiation, intrusion and shearing. Similar aplitic granite and blastomylonite form an irregular hill northwest of Mount Buckley, on the other side of Five Mile Creek, and the rocks forming the two hills are described together.

The more mesocratic cataclasites show all gradations between biotite microadamellite or microgranite with an incipient granoblastic texture, and blastomylonite. The microadamellite contains 5 to 10 percent fresh biotite in small tabular crystals which average 0.15 mm. in length; the crystals are pleochroic from pale straw yellow to very deep grey-brown. There is a little fine-grained green hornblende. Crystals of sphene reach a length of 1.5 mm. Euhedral magnetite(?) crystals (0.05 to 0.1 mm.) occur scattered throughout, and there are a few small euhedral laths of tourmaline, pleochroic from colourless to deep blue. A typical blastomylonite has a grain-size of 0.03 to 0.25 mm. and consists of granoblastic quartz (70 percent), orthoclase (10 percent), microcline (5 percent), sodic plagioclase (5 percent), and small fresh laths of biotite (10 percent) occurring in separate bands. The biotite is accompanied by sphene, epidote, and clinozoisite; finely disseminated opaques and equidimensional apatite grains form inclusions in the quartz and potash feldspar. Another blastomylonite, which was possibly derived from tonalite, consists of quartz (60 percent), epidote (20 percent), actinolite (15 percent), and sodic andesine (5 percent). In some of the blastomylonites small octahedra of magnetite(?) are surrounded by bleached reaction rims.

Foliation in the Mount Buckley Shear dips vertically or steeply southwest, and is generally expressed by alternating biotite-rich and biotite-poor bands in the blastomylonites, some of which are flaggy. The foliation bends gently in places, but is essentially planar. Puckering and schistosity are absent. In places the foliation is expressed by the development of ill-defined felsic rods in a groundmass richer in biotite. The long axes of the rods are vertical, and the intermediate axes lie in the plane of the shear, indicating horizontal movement. Xenoliths of intermediate to basic rocks in the blastomylonites are deformed into rods with the same vertical orientation. That the movement was principally horizontal is borne out by the common occurrence of thin, highly convoluted quartz veins, which strike across the shear. The fold axes of the veins are vertical, and the tightness and orientation of the folding together show that the rock has undergone a considerable amount of shortening at right angles to the shear. There has been very little disruption of the folds in the quartz veins, and this, combined with the absence of puckering in the foliation, suggests that the shear movements were accommodated along a large number of very closely spaced planes, and that a significant amount of crustal shortening has occurred at right angles to the shear. The blastomylonites are commonly intruded by veins of only slightly sheared biotite adamellite which in places form complex networks.

Some natural exposures of the resistant aplitic granite which forms the hills seem devoid of ferromagnesian minerals, but freshly broken surfaces generally reveal small grains of magnetite(?) concentrated in bands in the plane of the foliation. Most exposures of the aplitic granite show a banding which is no doubt largely the expression of planar structures created by shearing during intrusion, but in places the banding is contorted, and it is impossible not to suspect that in places it represents a flow foliation which formed in the granite before it cooled. In places undeformed pegmatite veins have been intruded along the middle limbs of small vertically plunging monoclines in the banding. These veins evidently represent the terminal phase of the granite, intruded after shearing had finally ceased. Minor subsequent hydrothermal or pneumatolitic activity in the shear is indicated by the presence, in some of the rocks, of disoriented small flakes of white mica, suggesting incipient greisenization. In parts of the Mount Buckley Shear there are granite veins which show all gradations between the massive state and a foliated and incipiently boudinaged condition, and this, taken in conjunction with the related features described above, affirms that granite intrusion and shearing were largely contemporaneous.

The <u>Mount Dangar Shear</u> has features akin to those of the Mount Buckley Shear, and the two may be physically continuous, although there is a 30-degree divergence in strike between the two. The Mount Dangar Shear dips steeply west at about 65 degrees. Fine exposures of gneissic blastomylonite occur in the bed of the Don River where it crosses the shear. The proportion of orthoclase to plagioclase (oligoclase-andesine) differs widely in two specimens collected within a few metres of each other, suggesting some redistribution of constituents. In one specimen garnet forms rare small metacrysts, and opaque minerals are absent. An irregular mass of medium to coarse leucoadamellite forms the uneven hill of Mount Dangar (216 and

187 m.) and has been shattered owing to proximity to the shear. The Mount Dangar Shear between Mount Dangar and Mount Buckley forms the boundary between the Hecate Granite and the diorite and gabbro (Cud). Aplite dykes up to 3 m. thick intrude foliated and schistose amphibolite (ex-quartz diorite) in the plane of the shear; some of them have been foliated and greisenized. A large quartz blow containing blocks of greisenized adamellite also occurs in the shear.

Iron-stained ridges of foliated greisen occur in sheared quartz diorite several kilometres northwest of Mount Challenger (516 m.), and are thought to be sheared and altered aplite dykes of similar origin to those at Mount Buckley. The greisens contain abundant disseminated pyrite; some zones in the greisens have been brecciated by later movements. The Mount Challenger Shear is near the contact with the diorite and gabbro, 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 ptygmatically folded, the second associated with the breccias.

In conclusion it may be stated that, in contrast to the late Palaeozoic diorite and gabbro, in which foliation, albeit generally weak, is a regional feature, the Hecate Granite is a massive batholith in which intrusive stresses have been released along well-defined shear zones. This suggests that forcible intrusion was an important process operating during the emplacement of the granite.

Relationships and Contacts

The Hecate Granite intrudes the late Palaeozoic plutonic rocks (Urannah Igneous Complex, Thunderbolt Granite, Cud, CPg), the Carmila Beds, and the Mount Aberdeen Volcanics. The limits of the batholith are not accurately known. Photo-interpretation can be applied along the eastern contact, where the granite has intruded and hornfelsed volcanics of the Carmila Beds which have a contrasting photo pattern, and to some extent along the contact with the diorite and gabbro (Cud), which generally have a smoother pattern and darker tone than the granite. The contact with Palaeozoic granite (CPg), e.g. in the north and south, cannot be photo-interpreted, and in these areas the boundary is positioned very tentatively. Isotopic dating has shown that the massive pink and white adamellite or granodiorite (CPg) which crops out at the very head of the Don River is probably late Palaeozoic, even though it is indistinguishable from the Hecate Granite.

The contact with the Palaeozoic diorite and gabbro is commonly a complex zone of net-veining and xenolith inclusion. A good example occurs in Bluff Creek near its junction with the Don River, where foliated granodiorite (Hecate Granite) net-veins inequigranular diorite (Cud). The foliation is apparently a marginal feature, for it dies out a few metres downstream. Another net-veined contact zone crops out in hills 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 problematical: it is mapped as the western limit of massive adamellite and granodiorite characteristic of the Hecate Granite as a whole, but west of the mapped position of the contact there are wide areas of foliated tonalite and quartz diorite (e.g. in the Ida Creek Ranges, and in the Don River at the crossing north of Pretty Bend) which may be contaminated and flow-foliated marginal phases of the Hecate Granite. Net-veined outcrops containing flow-aligned blocks of diorite and gabbro in various stages of assimilation are common at the contact in the northern part of the batholith; a good example occurs in Stockyard Creek, 5 km south of Mount Lee. Shearing occurs along the contact in places, as was noted above in the Mount Dangar Shear. In Mares Nest Creek near Roma Peak homestead the margins of some of the large gabbro roof pendants in the area are sheared to gneiss and amphibolite. Migmatite may be developed, due to the introduction of thin bands of granite. Biotite-hornblende syenite and monzonite have been created by contamination of adamellite in a marginal zone west of Pine Hill, near Mount Aberdeen. Stoped blocks of microdiorite up to 2.5 m occupy half of a large outcrop in Eden Lassie Creek 6 km southwest of the Bruce Highway.

<u>Dykes</u>

In addition to dykes which are obviously consanguineous with the granite, such as aplite, pegmatite and leucocratic microgranite, dykes of different affinity have been intruded into the Hecate Granite in several areas, especially in the northwest. These include microdiorites, dolerites, quartz porphyries, dacites, and microtonalites. The most prominent swarm is at Mount Gibralter, where east-trending dykes form pronounced ridges, linked in places by less common meridional ridges. The dykes in the Hecate Granite are possibly related to the second Lower Cretaceous intrusive episode, which occurred in the Albian (Mount Abbot Igneous Complex).

Age

Nine individual K/Ar determinations on biotite and hornblende from 7 widely spaced specimens of the Hecate Granite fall within the time-span of 120 to 128 m.y., and average 125 m.y. These results prove the reality of the Hecate Granite as a Lower Cretaceous batholith of sizeable dimensions.

Mineralization

The distribution of gold and minor base metal mineralization around (but outside) the Hecate Granite leaves no doubt that the mineralization and the Hecate Granite are related. 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, none of which are presently being worked, are described in the Economic Geology Section of this Report. Minor indications of mineralization found during the course of the regional mapping are:

(1) cubes of hematite pseudomorphing pyrite up to 1 cm. across in a quartz-filled breccia in pegmatitic granite, 1 km. northeast of Pretty Bend homestead; and

(2) small clots of pyrite and chalcopyrite in fine biotite adamellite 4 km. southwest of Roma Peak; a large quartz blow, iron-stained in places, intrudes coarse adamellite 1 km. to the east-northeast of this locality, and is associated with sporadic pinking, epidotization, and sericitization of the adamellite, which in places resembles typical altered rock types from some of the mine dumps at Charters Towers;

(3) leucocratic pegmatitic granite, faintly greisenized in places, forms the northern slopes of a conical hillock 1 km. northeast of Mount Monte Christo. Some outcrops of the granite are patchily coated with scarlet ochre, and others are sulphur stained. Broken specimens of the less weathered parts of the granite reveal a small percentage of very fine-grained pyrite as crystals and very thin stringers along grain contacts;

(4) at grid reference E639800, N2443800 in the hills between Pretty Bend homestead and Boundary Creek, coarse white biotite granite (evidently occurring as thick concentric sheets intruding diorite) contains pegmatitic phases and veins which in places enclose aggregates up to 3 cm. across of hematite and limonite after pyrite

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 is not a markedly high-level intrusion, but was emplaced beneath a substantial thickness of country rock. This suggests either that this part of the crust has undergone several thousand metres of uplift since the Cretaceous, or that it was formerly the site of a high mountain range whose summits were several thousand metres above sea level.

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 ruggedly and abruptly from surrounding low-lying country. The cone sheets crop out in a semicircle around the western end of Mount Abbot, forming low ridges and hills.

The quartz syenite body is the older and larger of the two stocks, and is apparently the oldest component of the complex. Its grain-size is very variable, but it seems to be uniform in composition. Quartz generally forms about 10 percent. Alkali feldspar is intergrown with interstitial quartz and green to green-brown amphibole. The coarser phases of the quartz syenite contain druses up to 3 cm. in diameter lined with euhedral crystals of quartz and alkali feldspar and minor filiform amphibole. The alkali granite which forms the younger stock is a uniform fine-grained sparsely porphyritic leucocratic biotite granite, in which opaque minerals, sphene, green amphibole, apatite and zircon are present in accessory amounts. The cone sheets are mainly flow-banded rhyolites which are commonly porphyritic in feldspar, quartz, and biotite, but some of them are microgranites.

The stocks have well defined contacts which appear to dip subvertically. The alkali granite stock intrudes the quartz syenite stock. The cone sheets appear to be related to the alkali granite stock; some dip vertically but most are inclined at angles ranging from 20 to 70 degrees towards a focus beneath the alkali granite stock. Felsite dykes which form a swarm in the basement granite to the north of the quartz syenite stock are truncated by that stock and are therefore probably older than the cone sheets.

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

DYKES

Dyke swarms (mainly microdiorite) are almost ubiquitous, especially in the eastern half of the Sheet area.

In particular, few outcrops of the diorite suite (Cud) were mapped which do not contain dykes (e.g. Fig.32); their orientation and some indication of their abundance are shown on the geological map.

Some of the more interesting outcrops of dykes in the northern half of the Sheet area are described below.

Mount Dangar Crossing

Large outcrops of tonalite and diorite in the bed of the Don River just north of the Mount Dangar crossing are abundantly intruded by dykes (Fig.27). The outcrops are transected by a relatively major northwesterly aligned fault, northeast of which many of the dykes are strongly sheared, especially along their margins. The shearing evidently represents the relative adjustment of discrete blocks of country rock along narrow lines of weakness, which coincided with the dykes. Southwest of the fault all dykes appear to be unaffected by shearing.

Southwest of the fault several northwesterly pale grey porphyritic microgranodiorite dykes are 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 aligned microdiorite dykes have been cut by meridional microgranodiorite dykes, which in turn have been cut by a second set of easterly microdiorite dykes. A set of north-northwesterly microdiorite dykes, dipping west at 50 degrees, also intrudes the tonalite, but its relationship to the other swarms is unknown. The first set of microdiorites and the microgranodiorites are generally sheared in the plane of the dykes, mainly along the margins. The tonalite country rock is generally massive, and it is clear that the shearing movements were essentially confined to the fractures filled by the dykes. However in one instance (Fig. 28), the plane of maximum intensity of shearing passes from the margin of a microgranodiorite dyke at a low angle into the tonalite, and over a distance of several metres, lies several centimetres outside the dyke. This suggests that the shearing may have mainly occurred after the dykes had cooled. Weak renewed movements along former shearing directions is illustrated by minor brecciation of a late unsheared microdiorite dyke where it cuts an earlier sheared microgranodiorite.

In thin section the sheared dykes north of the Mount Dangar crossing are seen to be blastomylonites. The microgranodiorite

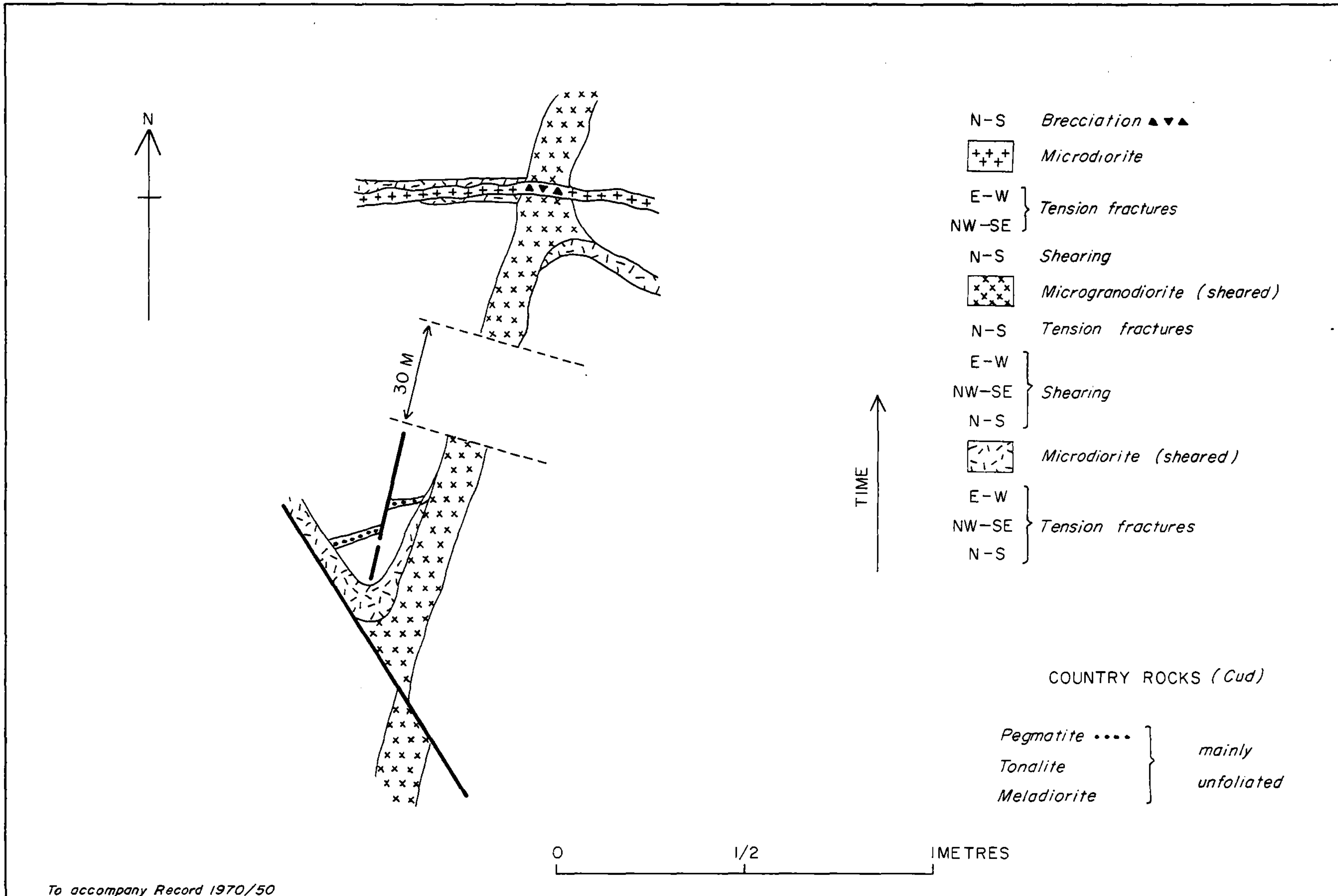


Fig.27 Sketch showing history of dyke emplacement and associated shearing, in bed of Don River, just north of Mount Dangar crossing. Some of the fracture directions listed do not occur in the outcrops sketched above.

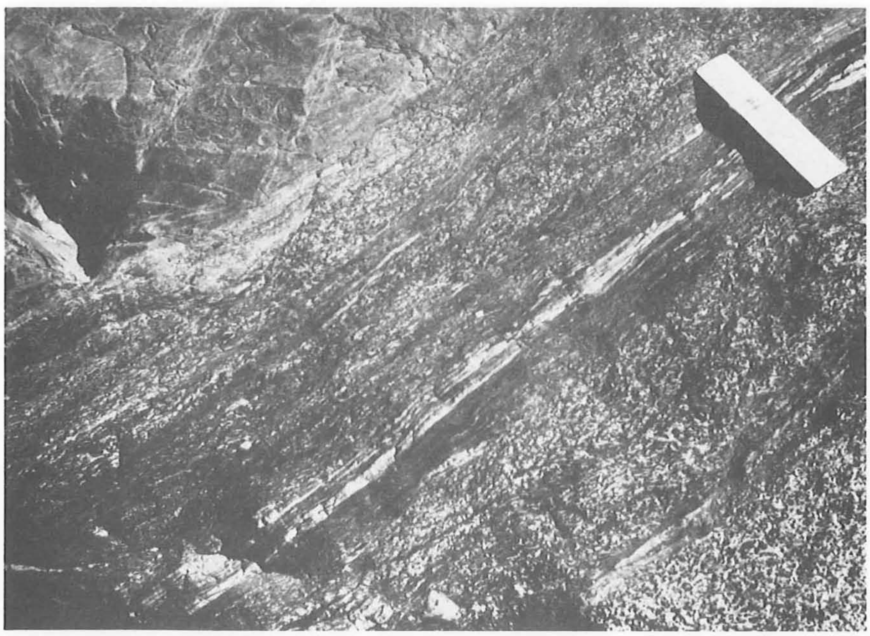


Fig. 28: Mylonite zone in tonalite (Cud), bed of Don River, upstream from Mount Danger crossing. Part of a sheared micro-granodiorite dyke is visible in the top left hand corner of the photograph. The scale is 6 inches (15cm) long. Neg.GA.1157

(2116) has a general grain size of 0.02 to 0.07 mm. Quartz is abundant, amounting to 60 percent. Augen of recrystallized quartz grains probably represent former quartz phenocrysts. The feldspars are orthoclase (25%) and andesine-labradorite (15%). Biotite (10%) occurs as rare aligned aggregates and as small fresh sub-parallel laths throughout the groundmass. The microdiorite (2117) has a similar grainsize and differs from the microgranodiorite chiefly in the scarcity of quartz and the presence of 15 percent hornblende, defining, together with biotite, a pronounced foliation.

<u>Boundary Creek</u>

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 29, 30, 31). The granite-aplite contains ovoid xenoliths of dark microdioritic rock, which are net-veined by the granite aplite. It appears either that the granite-aplite dyke was intruded into a fracture previously occupied by a microdiorite dyke, or that a granite-aplite liquid and a microdiorite liquid, which failed to mix, were admitted simultaneously into the same fracture.

<u>Bowen Town District</u>

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)

A description of these dykes is given by Paine et al. (1969). Figure 33 of this Report is a sketch of the relationship at North Head.

Mount Gibraltar

Apparently localized swarms of east-westerly and subordinate meridional dykes intrude the Hecate Granite around Mount Gibralter (295 m). The swarms include spherulitic alkali rhyolites, leucocratic alkali microgranites, porphyritic microtonalites, porphyritic micro-granodiorites, and porphyritic fine-grained diorites.

Age of the Dykes

In the Lizzie Creek volcanics the dykes appear to have been feeders to the flows, in that basic dykes only intrude the basalts, and andesite dykes only intrude the basalts and overlying andesites. 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 Brawl Creek area.

Many of the ubiquitous microdiorite and other dykes intruding the diorite suite (Cud) northeast of the Bowen Basin are probably mainly pre-Thunderbolt Granite in age, because they appear to be largely absent from the Thunderbolt Granite. It seems reasonable to regard some if not most of them as feeders to the Lizzie Creek Volcanics and possibly also the Carmila Beds. The probability that some of them are distinctly younger than the Thunderbolt Granite is indicated by the presence of a few swarms of intermediate to basic dykes in the Thunderbolt Granite itself near Scrub Top Mountain, and is suggested by a K/Ar hornblende age of 255 m.y. obtained from a microdiorite dyke (specimen 107, Appendix) near Mount High, in the Normanby Goldfield. On the other hand, the relative absence of dark dykes in the Thunderbolt Granite may be due as much to the probably much greater abundance of fractures in the diorite suite as to the difference in age between the diorite suite and the Thunderbolt Granite.

The presence of a varied assemblage of dykes in the Hecate Granite at Mount Gibraltar proves that emplacement of some of the dykes took place at least as recently as Lower Cretaceous time. Swarms

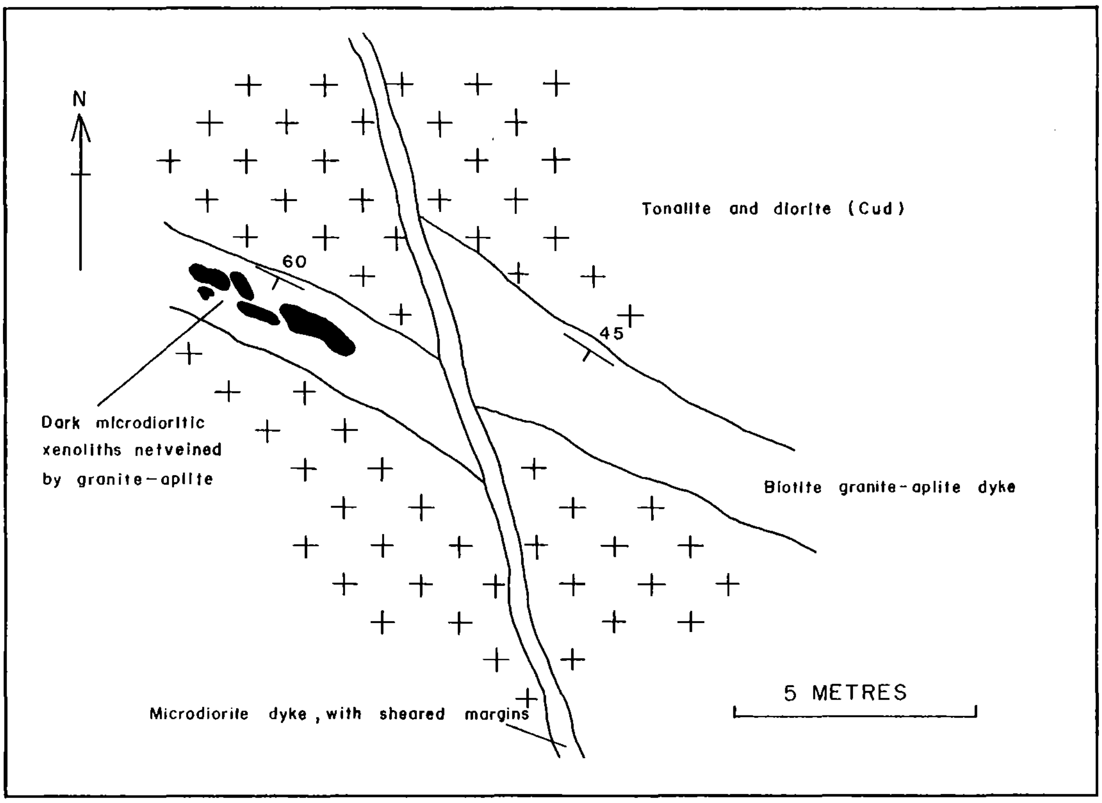


Fig.29 Dykes in bed of Boundary Creek, 1·5 km upstream from its junction with the Don River

Figures 30, 31 are photographs of part of this outcrop.

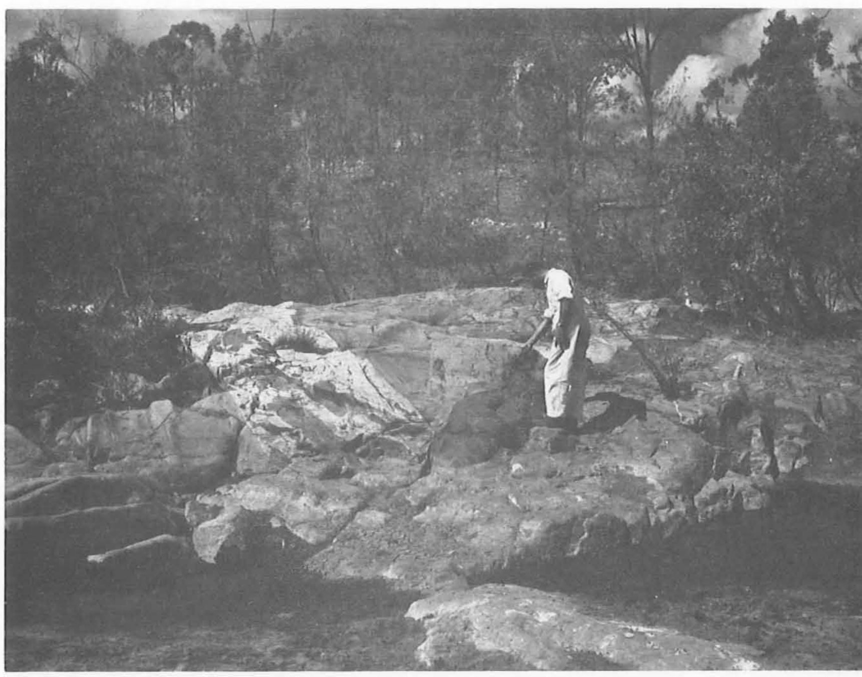


Fig. 30: Microdiorite amd granite-aplite dykes intruding tonalite and diorite (Cud), in bed of Boundary Creek, 1.5 km upstream from its junction with the Don River. Figure 29 is a sketch of this outcrop. Photograph by J.E. Zawartko.
Neg. GA.8350

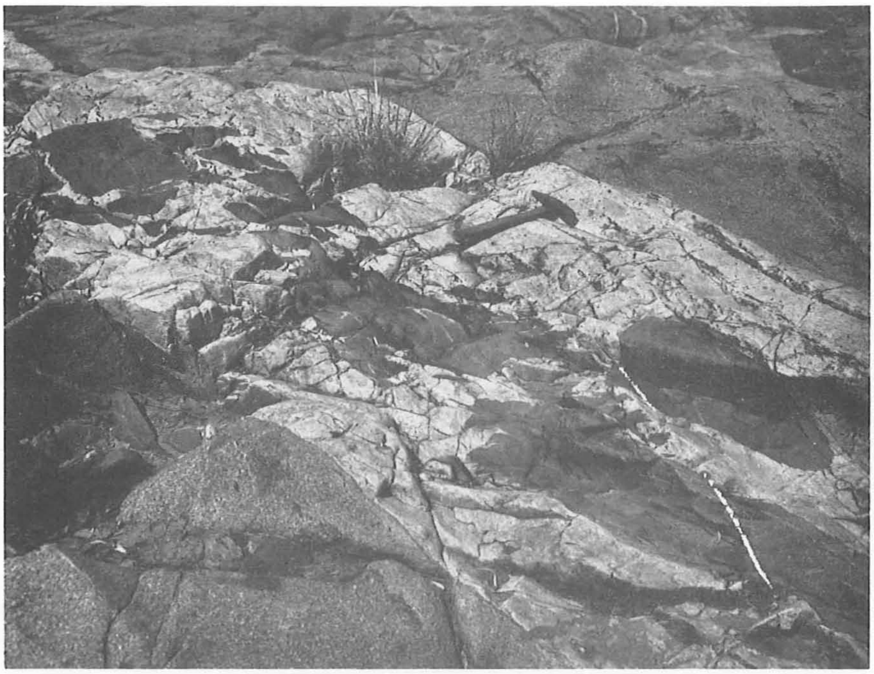


Fig. 31: Close-up of granite-aplite dyke in Figures 29 and 30. The ovoid xenoliths of dark microdioritic rock are confined to the granite aplite dyke, and are net-veined by the granite-aplite. Photograph by J.E. Zawartko. Neg.G8351.

Fig. 32: Basic to intermediate dykes intruding foliated quartz diorite (Cud), in bed of creek near homestead, 12 km west-southwest of Pretty Bend homestead. Figure 15 was photographed nearby. Neg. GA.1159.

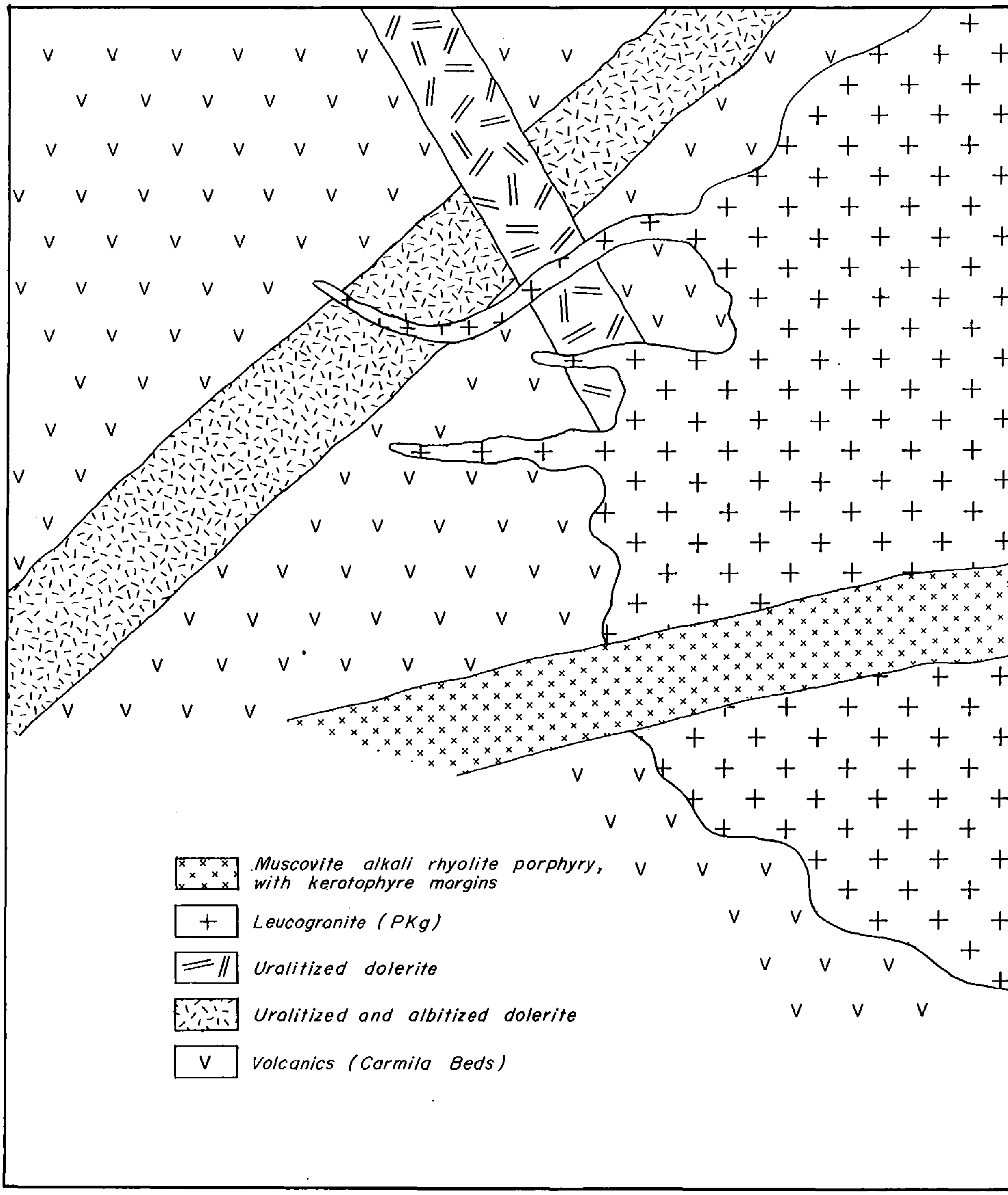


Fig.33 Diagrammatic sketch (not to scale) showing relationships of volcanics, granite, and dykes at North Head, near Bowen.

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

Sediments (To)

Flat-lying Tertiary sediments, largely masked by superficial sand and alluvium, underlie low-lying country southeast of Edgecumbe Bay. The sediments occupy the northern end of the Bowen-Proserpine Lowland (Fig.2), and are believed to be thin equivalents of the much thicker sediments of the Hillsborough Basin, a Tertiary graben in the Proserpine Sheet area. Seismic surveys have indicated a maximum thickness of about 2200 m of sediment in the graben immediately south-east of Proserpine (Clarke et al., 1968 (unpubl.) and in press), but the section 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 sediments are chiefly 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. Throughout the area the clasts in the conglomerates are mainly volcanic. The sandstone and the matrix of the conglomerates were derived from a granitic provenance probably mainly the Hecate Granite. Weakly lateritized conglomerate and sandstone are exposed along the Bruce Highway immediately southeast of Greta Creek. Ferruginous pisolites are developed on the surface of strongly mottled sandstone just north of where the Bruce Highway crosses Longford (Eden Lassie) Creek.

A local prospector has found pieces of silicified wood in Greta Creek, which have no doubt been derived from the Tertiary sediments. Palynological evidence from a well (Proserpine 1) drilled into the graben southeast of Proserpine in 1965 suggests that there the sediments are either late Tertiary or late Cretaceous in age (Evans in Clarke et al. 1968 (unpubl.) & in press). A late Tertiary age is favoured for the sediments in the Bowen Sheet area owing to their strong resemblance to other deposits of similar age in the Burdekin

River region, for example the Campaspe Beds in the Charters Towers Sheet area.

Basalt (Tb)

Remnants of a horizontal olivine basalt flow about 2 m. thick, situated 3.5 km. northeast of Mount Graham at the western edge of the Sheet area were discovered in the course of the present survey.

The basalt contains phenocrysts of plagioclase and olivine. The phenocrysts range up to 2 mm. and form 5 to 10 percent of the rock. Olivine phenocrysts are subhedral, partly embayed, and partly replaced by serpentine. Plagioclase phenocrysts are zoned from An_{68} to An_{50}. In the groundmass, the plagioclase laths are randomly oriented and measure 0.1 by 0.02 mm. Augite is colourless and forms granular to prismatic crystals 0.03 mm. across. Octahedral iron oxide and interstitial pigmented glass and pale green chlorite are also present.

The basalt is fresh and unconformably overlies the deeply weathered Star of Hope Formation. Its freshness suggests that it may be significantly younger than the probably late Oligocene basalts which intrude and overlie the sediments of the Bowen Basin.

QUATERNARY

Residual and Colluvial Sandy Soil (Qs)

Large expanses of mainly residual sandy soil mask the bedrock along the northern edge of the Sheet area. These areas contain some colluvial material too. The sand and soil-covered areas have a gently undulating surface which is higher than the flat depositional plains developed on the adjoining areas of alluvium. Some of the sand and soil is semi-consolidated, and may be as old as Tertiary. Small areas of residual sandy soil occur elsewhere in the Sheet area, but in these cases the bedrock geology is known, and has been mapped instead of the soil. The maximum thickness of the sand and soil is probably of the order of 3 m.

Alluvium (Qa)

Alluvium, characterized by flat depositional surfaces, occurs extensively along the larger streams in the area, notably the Burdekin, Don, Proserpine, and Andromache Rivers, and Euri Creek. Most of the alluviated areas are coextensive with the coastal plain, and the alluvium in these areas is evidently a product of the same cycle of degradation and aggradation as gave rise to the coastal plain. Perhaps in response to recent uplift some streams, in particular the Burdekin River, flow in well incised channels which in places have sub-vertical banks of alluvium; for example the vertical banks of the Burdekin River near Millaroo are estimated to be 25 m. high in places. Elsewhere, for example in the upper reaches of the Don and Proserpine Rivers, the alluviated areas are now erosional remnants of more continuous strips of alluvium which was laid down before the streams were rejuvenated.

Although the alluvium is probably mostly Quaternary in age, in places consolidated pebbly grit with lenses of conglomerate, slightly mottled in some layers, is exposed in the beds and banks of creeks, for example in Expedition Pass Creek, north of the cattle yard. These deposits are probably 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 in the more thickly alluviated areas along the river, and thicknesses of the same order occur in the Don River delta (Kevi et al., 1968, unpubl.).

Coastal Mud Flats (Qm)

Littoral and estuarine mud flats which are periodically inundated by high tides and floods, occupy several square kilometres of the foreshores of Edgecumbe Bay, notably at the mouths of the Gregory River and Eden Lassie Creek. The seaward portions of the flats tend to be overgrown by mangroves, whereas the landward parts contain evaporite deposits and are generally blanketed by a thin layer of salt. The salt gives a white air photo pattern, and the mangrove swamps a contrasting black one. The mud flats merge with the stream alluvium.

Coastal Sand Ridges (Qr)

Beach ridges and sand dunes fringe the shores of Edgecumbe Bay in places and similar ridges occur several kilometres inland. Beach rock, formed by calcareous cementation of rock debris, occurs between tide marks in places, notably just west of Gloucester Park tourist resort.

Outwash and Talus Deposits (Qu)

Talus tongues, now largely stabilized by vegetation, occur around Mount Roundback and along the western side of Gloucester Island. At Mount Roundback it seems that the tongues are no longer constructional features, but are being eroded, suggesting that they were formed during a different climate.

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

STRUCTURE

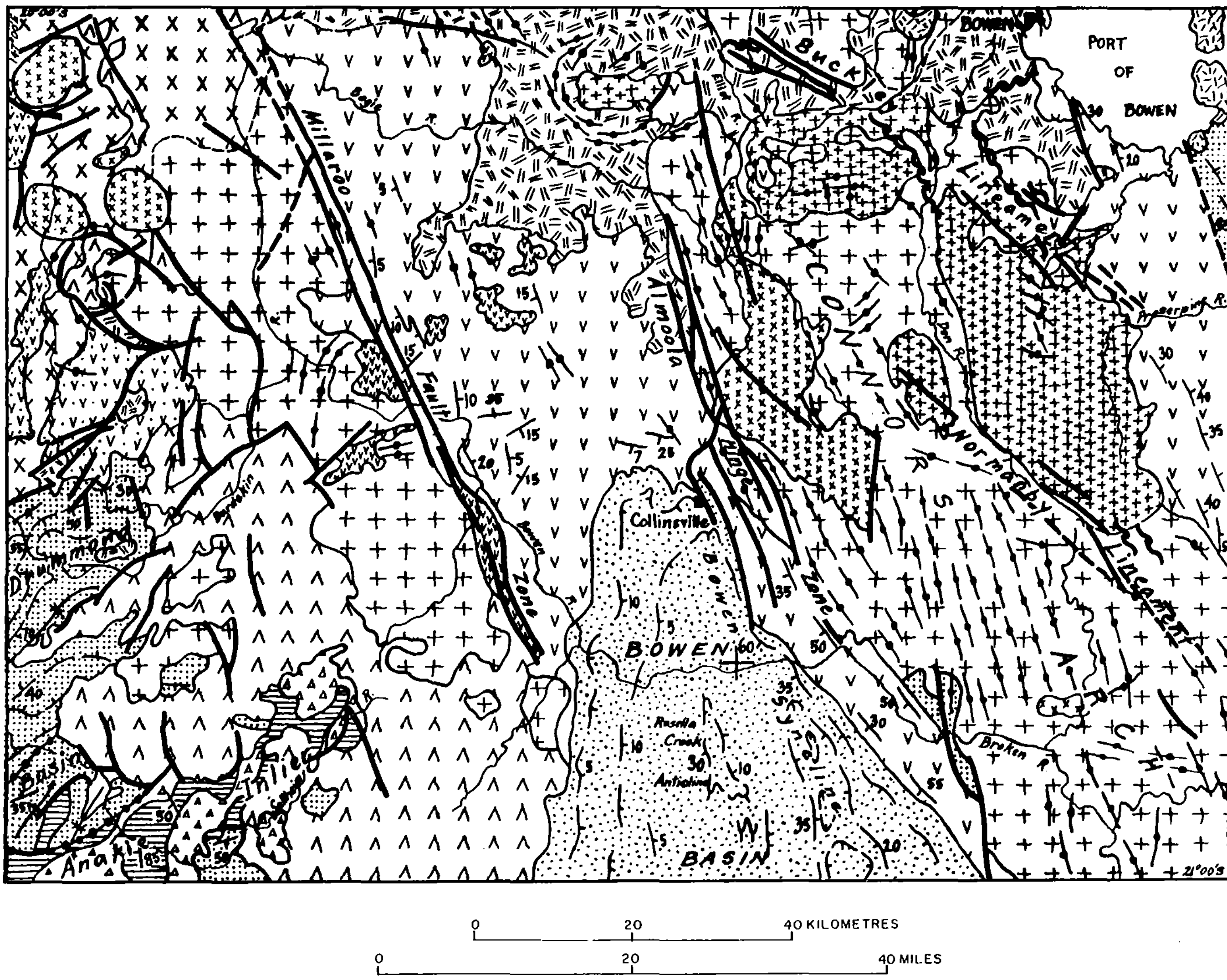
The structural framework of the Bowen Sheet area is shown in Figure 34.

The major structural elements are (1) the pre-Permian granites, volcanics, and sediments west of the Millaroo Fault Zone and Bowen Basin, (2) the thin cover of Lower Permian volcanics resting on late Palaeozoic granite in the northern centre 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

Fig. 34

STRUCTURAL FRAMEWORK



L. CRETACEOUS	Adamellite, etc.	U. CARBONIFEROUS	Adamellite, etc. (may include L. Permian and L. Cretaceous intrusions in Connors Arch)
L. PERMIAN OR L. CRETACEOUS	Granite		Acid volcanics
U. PERMIAN OR TRIASSIC	Acid volcanics	L. CARBONIFEROUS	Adamellite, etc.
PERMIAN TO TRIASSIC	Sediments	U. DEVONIAN TO L. CARBONIFEROUS	Sediments and volcanics
L. PERMIAN	Acid to basic volcanics	M. DEVONIAN	Sediments and metamorphics
	Adamellite, etc.	M. ORDOVICIAN AND U. SILURIAN OR L. DEVONIAN	Adamellite, etc.
U. CARBONIFEROUS OR L. PERMIAN	Adamellite, etc.	CAMBRIAN TO ORDOVICIAN	Acid volcanics and metamorphics

- Geological boundary
- Fault
- Shear zone
- Dyke
- 15 Generalized strike and dip of strata
- Horizontal strata
- Anticline, showing plunge
- Syncline, showing plunge

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trends of flow banding or metamorphic foliation are 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., 1970; Paine et al., in press), and no regional pattern has emerged from the reconnaissance mapping.

The locally cleaved and metamorphosed Ukalunda Beds constitute the northern end of the Anakie Inlier, which separates the Mount Wyatt Formation to the southeast from the main part of the Drummond Basin to the northwest. The Anakie Inlier trends northeast, parallel to the folds in the Drummond Basin sediments. Although steep dips occur in places in the Drummond Basin, the folding is mainly fairly open, and contrasts with a zone of tight folding in the Charters Towers and Buchanen Sheet areas. The Drummond Basin sediments in the Bowen Sheet area comprise the northern arm of the arcuate Scartwater Salient, which is thought to have been created (Olgers, 1969a) in the middle of the Carboniferous by westward movement of the northern end of the Anakie Inlier relative to the Lolworth-Ravenswood Block. The axis of maximum westward movement coincides roughly with lat. 21°20'S, which is about 35 km, south of the southern edge of the Sheet area. The type of deformation envisaged would involve longitudinal dextral extension of the fold axes in the limbs of the salient.

Little folding of the Bulgonunna Volcanics has taken place, but faulting and jointing are common. In many places the volcanics have faulted margins against the Drummond Basin sediments, and they were probably erupted largely through fractures in the basement, which foundered in large blocks. Tongues of Bulgonunna Volcanics extend to the southwest over the Drummond Basin, coinciding with synclines in the basin, suggesting that the synclines may have formed depressions at the time of extrusion of the volcanics, or alternatively that the volcanics were gently folded along the pre-existing fold axes of the underlying sediments. The unnamed volcanics in the northwest also appear to have undergone very little folding, and like the Bulgonunna Volcanics, their extrusion was probably closely related to faulting in the basement.

The post-tectonic extrusion of the Upper Carboniferous volcanics, which was closely followed by widespread granite emplacement, was the last major event in the stabilization of the western half of the Sheet area. The western half of the Sheet area is distinct from the eastern half, in that the latter underwent major tectonic movements in the Permian and Mesozoic.

The Lizzie Creek Volcanics in the north are a relatively undeformed and thin sequence resting on granite. They are essentially limited on the west by the Millaroo Fault Zone. The western part of the Bowen Basin is a shelf zone which is a structural extension of the shelf to the north. It contains a relatively thin sedimentary pile, with some disconformities, and is only gently folded. The Collinsville Coal Measures overlap the Lizzie Creek Volcanics in the western shelf zone.

In the east, 6000 to 9000 m. of volcanics and sediments were deposited in a trough zone extending east from the axis of the Bowen Syncline and overlapping the area now occupied by the Connors Arch. The trough varied in size and environment 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 basin is the steeply dipping eastern flank of the Bowen Syncline. It is outlined by the Back Creek Group, striking north-northwest, and dipping to the west-southwest at angles of 40° or more. The axis of the syncline is occupied by discontinuous outcrops of the Clematis Sandstone, and is located east of the centre of the Bowen Basin, the asymmetry being due to the greater thickness of sedimentation and stronger folding in the eastern trough of the basin. 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 area of volcanics in the northeast. To the north, owing to the dying out of the Almoola Hinge Zone, 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, simulatneously with the main folding in the Bowen Basin. Substantial further uplift probably occurred in the Lower Cretaceous, following 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 discovered in the Bowen Sheet area. The older Edgecumbe Beds occupy a homocline which has a similar strike, but which dips east much more steeply. It is necessary to postulate a major fault with upthrow to the east to explain the relative positions of the two homoclines.

Faults and Shear Zones

Two regimes of faulting are recognizable, one in the west, where there is no clearly predominant direction, and the other in the centre and east of the Sheet area where there is a strong northwest to north-northwest control. The Millaroo Fault Zone forms the boundary between the two regimes.

The faults in the west are evidently post-tectonic basement fractures of small extent. Southwest, meridional, and southeast directions occur, and there are several ring-fractures in the northwest. Two arcuate faults in the southwest are occupied by dykes which were probably feeders to the Bulgonunna Volcanics.

In the centre and east of the Sheet area there are several major faults and fault zones. The Almoola Hinge Zone has been the main locus of uplift of 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 has been high-angle reverse, east block up. The Lizzie Creek Volcanics have been 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 than this figure. At its southern end the fault dies out and passes into steeply dipping sediments. Other north-northwesterly faults affect the Collinsville Coal Measures, but although important in mining, they are not of regional significance. Most are high-angle reverse faults downthrown to the west. To the east there is a series of faults parallel to the Collinsville Fault. One forms the faulted contact 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 margin of the Sheet area meridional faults separate the Urannah Igneous Complex and the Connors Volcanics from the overlying Lizzie Creek Volcanics and Back Creek Group. The relative movement is again 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 it.

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 (geological map) developed during granite intrusion in the Lower Cretaceous, and the other shears, although apparently cutting Palaeozoic granitoid rocks, may have originated at the same time. The sense of movement on the major fault in the northeast, which is inferred to separate the Carmila Beds from the Edgecumbe Beds, is west block down, similar to the movements in the Almoola Hinge Zone.

GEOLOGICAL HISTORY

In the Cambrian and possibly Lower Ordovician a sequence of sediments and acid volcanics (Cape River Beds) was deposited in the west of the Sheet area. Small remnants of similar rock types (Ɛzu) near the Burdekin River suggest that the sequence may once have extended farther to the 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 granite batholith (Ravenswood Granodiorite Complex) with accompanying dynamo-thermal metamorphism, which converted part of the sequence to schist, gneiss, and granofels. These events led to the establishment of the Lolworth-Ravenswood Block (Wyatt et al., 1970; Paine, in prep.).

In the Lower Middle Devonian (Couvinian stage), while the Lolworth-Ravenswood Block was being uplifted and eroded, the area to the southeast of the block subsided, allowing sediments to accumulate to a considerable thickness in moderately deep water in a marine basin (Ukalunda Beds). During the Givetian and Frasnian stages of the Devonian the Ukalunda Beds were folded and uplifted, and were converted into an erosional area.

The events described above may have been represented in the centre and east of the Sheet area too, but if so all evidence has now been obliterated by younger rocks.

In the uppermost Devonian (Fammenian stage) deposition was resumed on both sides of the northeasterly-trending area of folded Middle Devonian sediments (Anakie Inlier), in fresh water conditions to the northwest (St. Anns Formation), and in a shallow marine environment to the southeast (Mount Wyatt Formation). The two environments, which together comprise the Drummond Basin, probably interfingered across the top of the inlier. Northwest of the inlier deposition persisted into the Lower Carboniferous (Scartwater, Mount Hall, and Star of Hope Formations), and sedimentation was augmented at times by eruptions of acid volcanics. At the same time a thick sequence of strata (Edgecumbe Beds) was being deposited 150 km. to the northwest, in the northeastern corner of the Sheet area; at the start the environment was marine, but after a time volcanics began to be erupted, and, a short distance to the east in the Proserpine Sheet area, they predominate to the exclusion of sediments, suggesting that the marine environment may not have persisted. 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) rose to invade the crust in the southwest. This granite has most of the characteristics of emplacement in the mesozone, and was probably responsible for the dynamo-thermal metamorphism of the Ukalunda Beds.

The isotopic dating results (Webb & McDougall, 1968, pp. 320-324) suggest that the oldest of the granitoid rocks which now form the Connors Arch in the east of the Sheet area were emplaced in the Upper Carboniferous about 310 to 305 million years ago. These rocks comprise the diorite suite (Cud) and parts of the Urannah Igneous Complex and undivided late Palaeozoic granite (CPg). Except for a remnant of volcanics (Connors Volcanics), the country rocks of these older masses have been either completely replaced by younger intrusions or covered by younger strata.

In the uppermost Carboniferous, about 290 to 285 million years ago, the crust in the southwest of the Sheet area fractured, enabling great volumes of acid magma to rise to the surface. Much of the magma was erupted as continental pyroclastic flows (Bulgonunna Volcanics and unnamed unit Cuv), but the rest failed to break through to the surface and cooled to form a large adamellite batholith (Cug). Renewed intrusion probably occurred in places in the Connors Arch and in the areas of undivided late Palaeozoic granite. The small intermediate to basic intrusions (CPi) in and around the Drummond Basin may also have been emplaced at this time. It is probably mainly granite of this age that underlies the Lizzie Creek Volcanics in the centre of the Sheet area.

A period of quiescence followed, during which the cover rocks of the Upper Carboniferous granite were partly eroded away. Then, 20 million years later, in the Lower Permian, magma once again rose to the surface. A thin sequence of basalt and andesite, with intercalated continental sediments (Lizzie Creek Volcanics), was deposited on a stable platform of granite east of the Millaroo Fault Zone and north of the Bowen Basin. In contrast to this, the area now occupied by the Connors Arch subsided, and was pierced by a multitude of volcanic vents and fissures. Several thousand metres of basalt, andesite, and sediments (also Lizzie Creek Volcanics), which are marine at the top, were laid down upon and along the southwestern edge of the Connors Arch, presaging the development of the Bowen Basin. This thick sequence is the more rapidly deposited representative of the thinner sequence on the platform to the north. In addition, thick acid to intermediate volcanics and associated sediments (Carmila Beds), were deposited in an apparently wholly continental environment in the northeast of the Sheet area. The isolated Kurungle and Mount Aberdeen Volcanics are probably also representative of this epoch of vulcanism.

Intrusion of the enormous number of dykes which are now exposed in the Connors Arch must have been accompanied by great extension of the crust in an east-west sense. Although at least some of the dykes (e.g. specimen 107, Appendix) were emplaced later in the Permian, it seems logical to regard most of them as feeders to the Lizzie Creek Volcanics and Carmila Beds, which now dip off the arch to either side. The extension may perhaps have been due to the subsidence alone, and it may not be necessary to envisage corresponding compression of adjoining areas.

At about the same time as the volcanics were being erupted, and while the area now occupied by the Connors Arch was being downwarped, ring fractures formed in the Leichhardt Range, in a late post-tectonic environment; piston-like granite stocks (Plg), oval in cross section, and in places accompanied by ring dykes (Plr), rose to high levels to replace foundering cylindrical blocks of early Palaeozoic granite. Meanwhile, in a contrasting mesozonal environment, an adamellite batholith (Thunderbolt Granite) was intruded into the deeply buried Upper Carboniferous diorites. The temperatures reached during the burial and reheating of the diorite suite and Urannah Igneous Complex at this time were high enough to expel all of the radiogenic argon gas which had accumulated in the crystal lattices of the ferromagnesian minerals since the rocks had originally cooled, so that the K/Ar radiometric 'timer' was reset to Lower Permian time.

At about the middle of the Lower Permian the volcanic eruptions subsided. After a short break in deposition, downwarping of the Bowen Basin began afresh, and sediments again began to accumulate (Tiverton Sub-group), but this time with no accompanying volcanics. The basin itself was still open to the sea. At the start the sediments collected only in the most actively downwarping zone of the basin, near its eastern edge. Deposition continued to keep pace with subsidence. Later the sedimentary area expanded to the north and west as a shallow sea (Gebbie Sub-group), around which shallow deltas and swamps developed in places, allowing thick accumulations of plant debris to form (Collinsville Coal Measures). An even more widespread marine transgression then took place (Blenheim Sub-group), but this was brought to an end a few million years after the beginning of the Upper Permian, when the shoreline retreated, and fresh water conditions prevailed throughout the remaining lifetime of the basin. The main Upper Permian sequence (Blackwater Group) was derived largely from volcanics eroded from off 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 a score or so kilometres north of the Bowen Basin, and formed volcanic plugs and flows (Mount Wickham Rhyolite) piercing and overlying the Lizzie Creek Volcanics and Upper Carboniferous granite. Ash from these eruptions drifted at times to the southeast, and settled out among the sediments that were building up 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 red beds, but it is abruptly overlain by the pebbly quartzose Clematis Sandstone. The change in sediment type was probably brought about by a slowing down in the rate of subsidence, allowing more thorough reworking of the detritus. Folding of the sediments in the Bowen Basin, although possibly initiated during sedimentation, was probably completed near the end of the Triassic. The birth of the Connors Arch in its present form, which brought to the surface granitoid rocks which had been deeply buried in the Lower Permian, was no doubt cogenetic with the folding of the sediments of the Bowen Basin. Along the western side of the arch the uplift took place along the Almoola Hinge Zone (Fig.34).

The latest major structural event was the intrusion of a large adamellite-granodiorite batholith (Hecate Granite) into the north of the Connors Arch in the Lower Cretaceous, 125 million years ago. The Hecate Granite has characteristics (e.g. thermal aureole, and pegmatites) which are not typical of a high level of emplacement. To have become exposed at the surface the granite either must have been emplaced beneath a mountain range several thousand metres high which has since been eroded away, or it must have been uplifted by an equivalent amount. Perhaps the entire northern end of the Connors Arch was further uplifted at this time, by means 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.

Small heterogeneous laccoliths and sills (Ki) were intruded into the Bowen Basin at the same time, but probably at a much higher level than the Hecate Granite. Ten million years later the high-level subvolcanic Mount Abbot Igneous Complex was emplaced into the basement of late Palaeozoic granite in the north of the Sheet area, the mechanism of intrusion being similar to that of the cylindrical Lower Permian stocks in the Leichhardt Range.

There is no further record of geological events until the Oligocene or early Miocene, when thin terrestrial sediments (Suttor Formation) and non-orogenic plateau basalts (Tb) were laid down in the south and southwest of the Sheet area. Both the basalt and the sediments were lateritized during a period of prolonged deep weathering. Later they were eroded, and only remnants now remain. A veneer of semi-consolidated and weakly lateritized outwash deposits (To) southeast of Edgecumbe Bay was probably deposited late in the Tertiary.

The most recent geological formations are alluvial and other deposits. The alluvial (Qa), residual (Qs), and outwash (Qu) deposits are undergoing dissection at present, 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. Those of the Bowen Basin (e.g. coal) and of the Sellheim-Ukalunda area (silver, etc.) are not described here, because these areas were not mapped during the present survey. Descriptions of them are given by Malone et al. (1966). A resume of the economic geology of the whole Sheet area will appear in the Explanatory Notes (Paine & Cameron, in press).

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

Some reserves of gold almost certainly still exist at Normanby, but the area is relatively inaccessible and the present economics of the field are unattractive. Substantial reserves of limestone occur in the northeast of the Sheet area. There are three small, presently uneconomic deposits 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 known to be producing in the Sheet area at present.

All of the gold mined in the eastern part of the Sheet area occurred in base metal sulphides in the primary zone, which caused treatment difficulties in the early days, and in places led to the premature abandonment of many of the mines, notably at Normanby. The area is considered to have some potential for further discovery and production of minor mesothermal gold and base metal deposits. As a whole the area must be regarded as having prima facie potential for the discovery of large low-grade copper (and possibly also molybdenum) deposits of the porphyry type; small copper prospects which should be examined with this in mind occur southeast of Mount Aberdeen and southwest of Birralee homestead.

TABLE 4

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	dumps 1,920	334.5	-	-
1950	3,906	369.82	31.82	-
1951	585.3	931.41	7.38	-
<u>Totals</u>	17,126.78	54,536.94	23,418.4	295.56

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 (1946 a, b, c, unpubl.; 1947, unpubl.), McKeown (1944, unpubl.), Morton (1921a; 1946), Munn (1950, unpubl.), Reid (1935c, 1936, 1937a, 1940), Ridgway (1935b, 1939a,b; 1940a,b; 1941 a, b, c, d; 1942, unpubl.), and Zimmerman & Branch (1961, unpubl.). In addition, petrographic reports have been written by Knight (1940a,b; 1945, unpubl.), and reports have been prepared by the Mineragraphic and Ore Dressing Sections of CSIRO (1940 a, b, c, d; 1944, 1945, 1948, 1949, 1954 all unpubl.).

The ore at the Dittmer mine was unusually rich. Total recorded production (Table 4) was about 55,000 ozs of gold; 23,000 ozs 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 has come 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 intrusive diorite, which is possibly a contaminated cupola of the Hecate Granite. The main contact with the Hecate Granite is less than one kilometre from the mine.

Production began in 1935. Morton (1946) estimated that average recovery to the end of 1944 was 5 ozs of gold, 2 ozs of silver, and 2.5 percent copper per ton. By 1947 reserves had become depleted, and in 1948 the mine closed down. The operating firm was reorganized to a public company whose aim was to mill the lower grade ore left in the mine, and the accumulated dump material. Production resumed in 1949 and continued to 1951, but the venture 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 devoid of gold mineralization (Morton, 1946; Denmead, 1946b, unpubl.). Three diorite dykes were met during development operations.

The Dittmer ore (CSIRO, 1940d, unpubl.) consists mainly of pyrite and chalcopyrite, with lesser amounts of sphalerite, galena and bournonite, and a trace of pyrrhotite. The pyrite, which is invaded and partly replaced by the base metal sulphides, has undergone differential movements within the orebody during deposition; coarse crystals of pyrite are commonly highly fractured, and are separated from each other by thin shatter zones of fractured pyrite which has been re-cemented by quartz gangue and later sulphides. Most of the chalcopyrite was introduced later than these movements and tends to be aligned parallel to the fracture planes.

Most of the gold occurs in the pyrite crystals, where it is invariably fine-grained. The gold content increases in the presence of chalcopyrite, and especially of galena and bournonite. Coarse particles of gold occur only in association with galena and bournonite. Evidently the gold was first introduced with the pyrite, but further deposition took place after the pyrite was shattered.

The "Lady Denise" prospecting area (Denmead, 1947, unpubl.) occurs in a complex zone of andesite and intrusive granite 1.5 km. south of the Dittmer No.1 shaft. The andesite forms small roof pendants in the granite, and a minor gold-bearing vein occurs along a faulted contact between andesite and granite.

Auriferous quartz veins were worked in the Happy Valley area north of Dittmer, in the Carmila Beds, between 1874 and 1909. The main producers were the Golden Fleece (260 ozs), Lamington (about 500 ozs), and Commonwealth (about 90 ozs). As at Dittmer, chalcopyrite was an important ore mineral.

Most of the ore was produced from the oxidized zone. Alluvial gold was won in the early years of the field.

The Sunrise (formerly Iron Duke) and Orient were opened up in 1934-35 (Ridgway, 1935b).

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

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

The Golden Hill mine (Ridgway, 1940a, unpubl.) was 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 a little sphalerite, besides the normal pyrite and chalcopyrite.

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

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

Normanby Goldfield (Fig.35). The Normanby Goldfield (or, more correctly, the southern part of it, for when it was proclaimed it appears to have included the Happy Valley diggings in the range west of Proserpine, and the yet-to-be-discovered Dittmer mine) was the object of a substantial but short-lived gold rush in the 1870's. 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 (1937a, unpubl.) have reported on the field, the most detailed descriptions being those of Jack (1879) and Morton (1920 & 1921a). 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 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 1880's and 1890's there were persistent inefficient attempts to treat by simple amalgamation the gold which was finely divided in the sulphides. The effectiveness of amalgamation was further reduced by the presence of copper, and minor 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 ozs of primary and 2000 ozs 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^{o} and 85^{o} to the northeast; there is a subsidiary series of easterly veins which dip north at a high angle. The veins averaged 15 to 30 cm. in width, 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. Minor secondary enrichment (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 had the deepest shaft (130 m.) but few of the other workings on the field went

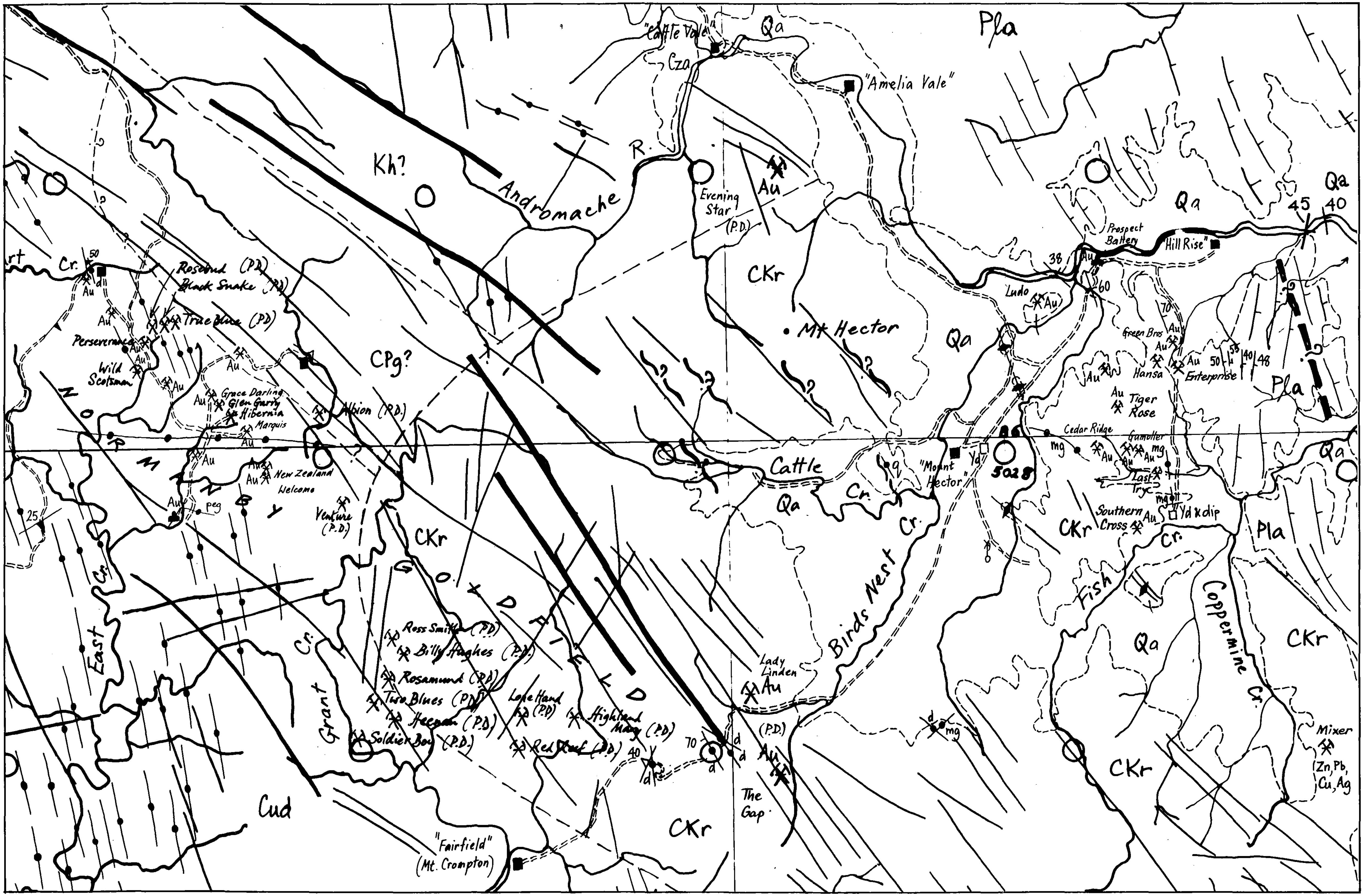

Fig. 35. Part of one of the photo-scale (1: 85,000) compilations of the Bowen Sheet area, showing mines in the Normanby Goldfield and east of Mount Hector.

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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 pale coloured pyrite.

Diorite is the principal host rock, but some of the veins occur in granite (Morton 1920). Both granite and diorite are intruded by abundant dykes of fine-grained diorite. The coarse diorite grades to hornblende gabbro and hornblendite, and many of the more melanocratic types contain disseminated pyrite, as also do the dykes. Morton (1921a) noted that the auriferous veins appear to be the youngest component of the complex succession of rock types. In general the main direction of emplacement of the veins is the same as that of the dykes (NW to NNW).

Mount Hector Area (Fig. 35). The Mount Hector area was the centre of considerable mining activity in the 1930's. Inspections were made by East (1946), Reid (1935b), and Ridgway (1935a,b,c). The Cedar Ridge mine, which was worked between 1932 and 1939 for a total output of 1928 fine ozs of gold from 1255 tons of ore, was the largest producer.

Most of the auriferous veins occur in the Urannah Igneous Complex near its margin, and are closely associated with andesite and microdiorite dykes. At least one of the mines (Green Bros) is recorded as occurring in silicified volcanics (Carmila Beds) near the contact. The veins often 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 thin-sectioned and is a trondhjemite- see section on 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 degrees 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 had been 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 ozs of gold from 983 tons of ore.

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

Marengo Area. The Marengo goldfield (unproclaimed) is 40 km. 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 1930's, and Reid (1935d) was hopeful that the more efficient recovery methods of the battery newly established on the field 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 outcropping secondary copper minerals usually indicated the presence of gold. The auriferous veins yielded values too low to maintain mining activity. Total production was probably less than 1000 ozs. The Ore Dressing Section of CSIRO made a report on treatment of the ore in 1939.

Eden Lassie (Longford) Creek Area. 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 Hecate Granite from the Upper Carboniferous diorite suite (Cud).

Most production has come from a southeasterly-striking vein system which trends along the faulted contact of the diorite suite and the Hecate Granite. The Golden Gusher, Crazy Cat, Anniversary and Lady Ellen are all close together on this vein system. Mineralization in the Lady Ellen occurs in a quartz vein which has filled a fault separating diorite on the hanging wall from adamellite on the footwall. Production figures for the Golden Gusher are incomplete. Reid (1935e) states that one crushing of 38 tons yielded 81 ozs of gold. In 1937 (1937b) he reported that £400 worth of gold (about 90 ozs) was won from a shaft 18 m. deep, next to the underlie shaft of the Golden

Gusher. The gold is accompanied by minor silver and copper. Reid (1937c) also inspected the Albion mine.

The geology near 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 to gneiss by severe shearing and recrystallization. Thin aplite dykes cut both diorite and adamellite. The contaminated adamellite dykes are themselves commonly slightly foliated.

The Birthday Gift mine was small, but the ore was rich and mining was profitable. Recorded production for the years 1931 to 1935 is 351 tons of ore yielding 606 ozs of gold bullion. The auriferous veins are in greisenized diorite (Morton, 1932). The development of greisen was probably associated with the synkinematic 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; in fact the contact relationships between the diorite suite and the Hecate Granite in this area are typical of the region. The quartz veins are vughy, 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 from the Lucky Strike has been negligible.

At the Elusive mine on Mount McGuire, quartz veins carrying 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 as occurring in coarse biotite granite 1.5 km. south of Bootooloo Siding.

A diorite dyke forms the hanging wall, and a silicified quartz-feldspar porphyry dyke the footwall. The reef was followed for a length of 15 m. Morton (1941, unpubl.) described copper and gold workings 2.5 km, south-southeast of Mount Gordon.

Reid (1931b, 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 15 cm, thick at its widest part, hugs a thin diorite dyke. A sample from the widest part of the vein assayed 2 ozs 4 dwt per ton. This is probably the prospect which was previously visited by Morton (1927b, unpubl.).

A mine known as Mount Poole was described by Morton (1922, unpubl.). It is located about 20 km, southeast of Collinsville, in altered volcanics and sediments (Lizzie Creek Volcanics) close to their contact with granite and diorite (Ki). The workings have a general northwesterly strike, and the auriferous veins dip to the southwest and northeast at angles between 50° and vertical. 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, which is located about 11 km, south-southeast of Collinsville. Low gold values were detected in several thin quartz veins in an area of altered shale and sandstone, which are faulted and dip steeply. The sediments are intruded by a swarm of thin diorite dykes, and granite crops out over a small area 150 m, south of the auriferous veins.

Alluvial gold has been recovered 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 a highly irregular bed-rock surface.

A group of gold prospects near the head of Millaroo Creek, known locally as Lionel Diggings, have no recorded production.

Silver and Base Metals

Copper and silver were substantial byproducts from the Dittmer gold mine at Kelsey Creek. Recorded production from Dittmer to the end of 1951 was 23,418 ozs of silver and 296 tons of copper.

Small amounts of copper, lead and zinc accompany gold in many of the mines in the east of the Sheet area, especially in the Mount Marengo field, where copper-stained outcrops were commonly 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. ESE of Emu Plains homestead), King Solomon (about 5 km. NNE of Emu Plains homestead), Arbroath (about 14 km. NNE of Emu Plains homestead), and Flagstone (about 23 km. N of Emu Plains homestead). No production figures are available for any of the mines. 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, conformable with the bedding of the Lizzie Creek Volcanics (here described by Cameron as 'clay-slate rock'). Cameron states that samples of the surface ore assayed 13.9 percent lead and 13 ozs 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 ozs of silver to the ton.

The Arbroath mine was developed on a galena-bearing quartz vein in diorite. The vein runs up to 1 m. in thickness, 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 down the dip of a heavily limonitized micro-diorite(?) dyke. The dyke dips to the northwest at 70°. The miners followed thin lenticular quartz-siderite veins which are concordant with the dyke. Quartz occurs as dog-tooth crystals growing normal to the vein; the interstices are filled by crystalline siderite. Minor chalcopyrite and galena occur in the "mullock". Cameron interpreted the wall rocks as slates and quartzites.

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 which dips to the southwest; a monoclinal fold occurs in the lode where 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. Some 43 tons of handpicked silver-lead ore were produced in the period 1924-25, assaying 9 oz 8 dwt silver per ton, a trace of gold, 10 percent lead, and 19.2 percent zinc. From 1952 to 1954 more than 30 tons of ore were produced, but it was complex, and proved hard to treat. A trial shipment of 5.4446 tons was smelted at Port Kembla, and returned 1.058 tons of copper and 110.4993 ozs of silver. Minerals identified in the ore included 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. south-southwest of Birralee homestead, which is 23 km. southwest of Collinsville. The mineralization occurs in gossanous quartz outcrops in hilly country within a small isolated area of biotite granite which is surrounded by massive acid and basic volcanics. Carbonates of copper and lead occur in the siliceous gossan; when broken, some of the harder quartz was seen to contain specks of galena, pyrite, chalcopyrite, and sphalerite. Morton observed that the lode appears to dip gently to the west, but it is insufficiently exposed to allow its thickness to be estimated. Some ore specimens were reported to have contained 5.9 percent copper, and 23 ozs of silver per ton. Ridgway reports that there were 7 shafts on the reef, which was proved over a length of at least 500 m., and he noted that the reefs are intersected by aplite intrusions.

Knight (1949, unpubl.) described 3 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 maximum grade of primary ore at 1.5 percent copper, and the possible total extent of ore at 3,000 tons per vertical foot.

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 iron-stained 'crushed' (brecciated?) granite, situated just south of a small hill known as the Pinnacle. Copper carbonates and oxides occur irregularly on joint planes in altered, sericitized, and strongly jointed fine-grained granite. Operations were carried on for 4 years, and a 5-ton parcel of ore is said to have been shipped to Mount Morgan in 1914. Although the ore was much too low grade to be profitable at the time, in the present-day context the prospect seems to be worthy of further investigation in the hope that the mineralization may be of the porphyry copper type.

Jack (1879a) observed numerous specimens of malachite, associated with zeolites, along the Bowen River between the mouth of Pelican Creek and Birralee homestead, but did not have the opportunity to pursue the occurrences to their outcrop.

Tungsten

A gently dipping pipe-like deposit of scheelite was reported by Ridgway (1947) to occur 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 between the volcanics and an Upper Carboniferous adamellite batholith (Cug).

The pipe is small and the ore low grade; after thorough sampling the deposit was abandoned.

Iron

Connah (1953a, unpubl.) examined a deposit of disseminated magnetite which occurs in the zone of contact metamorphism of 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 to recover copper from carbonate ore (Reid, 1928).

Magnetite is reported to occur as small segregations and scattered grains in a hornblende-garnet-epidote skarn, which is interbedded with quartz-mica hornfels. Connah suggests that the skarn is a metamorphosed basic sill. The skarn is no more than 30 m. thick. There are scattered small patches which contain a high percentage of magnetite, the average iron content of these being 39 percent.

This deposit evidently represents a totally uneconomic source of iron, but it is mentioned here to draw attention to a skarn-type occurrence 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, just 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 whole hill with a geiger counter, and recorded counts of between 100 and 200 per minute, which is higher than normal for igneous rocks. Bead tests failed to reveal uranium in selected samples of the granite.

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 (1953, unpubl.) inspected the deposit in more detail, and suggested that reserves are considerably less (see also Connah, 1958). The limestone is interbedded with tuffaceous sediments and pyroclastics, and all three types of rock have been hornfelsed by the adamellite intrusion (PKg) of Ben Lomond. Brooks (1953, unpubl.) described the petrography of some limestone specimens from Ben Lomond.

Farther to the south-southeast appreciable quantities of massive oolitic argillaceous limestone of the Edgecumbe Beds are exposed in Ten Mile Creek (Brown, 1963, unpubl.). Scattered limestone outcrops between Ben Lomond and the junction of Ten Mile Creek and the Gregory River suggest the presence of further substantial reserves.

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 by open cut from time to time for agricultural purposes, and is similar to deposits of earth lime near Home Hill (Connah, 1958; Paine et al., 1969).

The earth lime appears to form residual deposits which have resulted from the selective weathering of coarse diorite or gabbro. A deposit of earth lime of unknown but probably small extent was found during the regional mapping near the right bank of the Don River, 1 km. north of its junction with Humbug Creek.

Limestone of unspecified nature is 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 was described by Saint-Smith (1919b). The magnesite forms veins up to 75 cm. thick, filling the plane of a reverse fault in diorite and gabbro (Cud). Smaller veins fill tension joints on either side of the main fault. Small veinlets of chromite and asbestiform anthophyllite are present in the gabbro, which is serpentinized next to the main fault. The total recorded production of magnesite is 25 tons, and the grade was about 97% $MgCO_3$.

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 expected the extraction of uniform ochre to be difficult. Subsequent realization of this expectation prevented successful exploitation of the deposit. Gypsiferous clay underlies the ochre.

Gemstones

A vein containing amethyst was discovered in 1965 near Binbee by a road-making crew, during reconstruction of the Bowen-Collinsville road.

Chalcedony and agate are abundant in weathered basalt of the Lizzie Creek Volcanics northwest of Collinsville, but most specimens are fractured.

Facing Stone

Large whalebacks of fresh medium to coarse adamellite (Hecate Granite), lacking vertical joints, occur a few kilometres west and northwest of Roma Peak (e.g. Sixpenny Hill and Bald Rock, Figs 8 and 26). These whalebacks may contain a few widely spaced sub-horizontal exfoliation joints. The adamellite contains euhedral pseudohexagonal phenocrysts of biotite, and appears very suitable for building (facing) stone. There would be no access difficulties. Smaller whalebacks of inequigranular granite (PKg) containing fresh fine-grained biotite crystals occur beside the Bruce Highway just west of Euri Creek Siding.

Groundwater

Almost all groundwater usage in the northern half of the Sheet area is confined to the Don River delta, where shallow wells are sunk in alluvium for irrigation of vegetable and fruit crops. The sale of irrigated fruit and vegetables, especially mangoes and tomatoes, to metropolitan markets during the southern winter constitutes an important local export industry. Kevi et al. (1968, unpubl.) have interpreted a geophysical survey of the Don delta, which was designed to enable the pumping capacity of the delta to be estimated. Elsewhere the different kinds of land use in the area are generally related to the amount of local rainfall.

Areas of alluvium along the larger streams such as the Don and Proserpine Rivers should be capable of supplying adequate amounts of groundwater for foreseeable pastoral needs. Considerable quantities of water may be obtained during the dry season by sinking spears a few metres into the sandy beds of the larger watercourses. The sugar farms along the Burdekin River at Dalbeg and Millaroo are independent of groundwater, and draw their supplies from surface flow in the river, which is regulated by a weir at the edge of the Leichhardt Range.

Engineering Geology

Some geological and geophysical observations have been made from time to time during the course of feasibility studies for dam sites.

Gloe (1950 & 1951, 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 which separates the Bulgonunna Volcanics from the Star of Hope Formation. Seven diamond drill holes were put down at the main site, and several more to test the foundations of proposed embankments, which would be required to extend for 7 km. to the northwest of the main dam.

The Irrigation and Water Supply Commission, Qld (1963, unpubl.) investigated the geology of proposed dam sites on Pelican Creek and the Broken River, in an evaluation of alternative water supply schemes for the Collinsville power station. The Bureau of Mineral Resources (Mann, 1962, unpubl.) carried out geophysical studies of these dam sites.

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APPENDIX

ISOTOPIC AGE-DETERMINATIONS FROM THE BOWEN 1:250,000 SHEET AREA, by A.W. WEBB.

(Note: The analytical error in individual K/Ar determinations is ± 3 percent)

Rock unit name or map symbol	Sheet area Specimen No.	A.M.W. Accession No.	Military Grid Reference E	Military Grid Reference N	Rock Type	Material analysed	Method	Age (X 10^6 yrs)	Remarks
Mt Abbot Igneous Complex	F55/3/119	GA 5531	600600	2480200	Quartz syenite	Hornblende	K/Ar	116	Rolled block, not in situ.
Hecate Granite	61	GA 5331	665100	2434500	Adamellite	Biotite	"	123	
" "	62	GA 5330	669800	2440950	Granodiorite	"	"	125	
" "	62	GA 5330	669800	2440950	"	Hornblende	"	127	
" "	91	GA5398	641250	2444200	Adamellite	Biotite	"	128	
" "	97	GA 5529	621250	2467200	"	"	"	120	
" "	100	GA 5399	629100	2466400	"	"	"	123	
" "	117	GA 5355	644350	2458500	"	"	"	124	
" "	118	GA 5356	648000	245500	"	"	"	124	
" "	118	GA 5356	648000	245500	"	Hornblende	"	126	
Ki	33	GA 5272	636700	2373900	Gabbro	Plagioclase	"	133	
Ki	127	GA 5358	624100	2411700	Adamellite	Biotite	"	123	
Pkg	35		678950	2492900	"	"	"	216	See text
Urannah Igneous Complex	110	GA 5734	679800	2419600	"	"	"	250	Altered sample. Minimum age only.
" " "	113	GA 5346	683100	2397300	Diorite	"	"	283	
" " "	114	GA 5396	679800	2401700	Adamellite	"	"	289	
" " "	114	GA 5396	679800	2401700	"	"	Rb/Sr	309	
" " "	114	GA 5396	679800	2401700	"	Whole rock	"	*	
" " "	115	GA 5392	681100	2399000	Granodiorite	"	"	*	
" " "	115	GA 5392	681100	2399000	"	Biotite	"	314	
" " "	115	GA 5392	681100	2399000	"	"	K/Ar	289	
" " "	115	GA 5392	681100	2399000	"	Hornblende	"	294	
" " "	135	GA 5354	684500	2408500	Adamellite	Biotite	"	282	
" " "	135	GA 5354	684500	2408500	Adamellite	"	Rb/Sr	290	
" " "	135	GA 5354	684500	2408500	"	Whole rock	"	*	
Mt Wickham Rhyolite	69	GA 5520	562050	2475700	Acid volcanic	Whole rock	Rb/Sr	▲	
" " "	72	GA 5524	572700	2455600	"	"	"	▲	
" " "	74	GA 5521	565100	2448600	"	"	"	▲	
" " "	75	GA 5522	565100	2448700	"	"	"	▲	
" " "	76	GA 5523	564800	2448500	"	"	"	▲	
" " "	78	GA 5525	577200	2443700	"	"	"	▲	
" " "	143		569300	2436200	"	"	"	▲	
dyke	107	GA 5329	654000	2423100	Microdiorite	Hornblende	K/Ar	255	
Thunderbolt Granite	14	GA 473	620700	2447700	Adamellite	"	"	270	
" " "	26	GA 5252	619700	2457000	"	"	"	264	
" " "	26	GA 5252	619700	2457000	"	"	Rb/Sr	260	
" " "	27	GA 5253	614300	2446800	"	"	K/Ar	261	
" " "	38	GA 5338	629200	2437450	"	"	"	259	
" " "	86	GA 5332	615700	2458100	"	"	"	264	
" " "	86	GA 5332	615700	2458100	"	"	Rb/Sr	271	
" " "	109	GA 5380	630300	2432800	"	"	K/Ar	265	
Plg	25	GA 5251	532900	2471900	Adamellite	Biotite	K/Ar	272	
Plg	125	GA 5365	662600	2398700	Granite	"	"	268	
Lizzie Creek Volcanics	55	GA 5373	565800	2455500	Basalt	Plagioclase	K/Ar	274	Minimum age
" " "	56	GA 5374	568850	2452500	"	"	"	229	Argon loss, or related to Mt Wickham Rhyolite?
" " "	68	GA 5375	566700	2476000	"	"	"	264	Minimum age
CPg	67	GA 5530	584600	2487300	Adamellite	Biotite	"	272	
"	94	GA 5534	656100	2475100	"	"	"	297, 298	
"	95	GA 5513	609000	2490700	Granodiorite	"	"	269, 272	
"	106	GA 5347	656100	2424700	Adamellite	"	"	186, 187	Argon loss by contact metamorphism by Hecate Garnite
"	136	GA 5560	655900	2427800	"	"	"	132	Possible argon loss by contact metamorphism by Hecate Granite

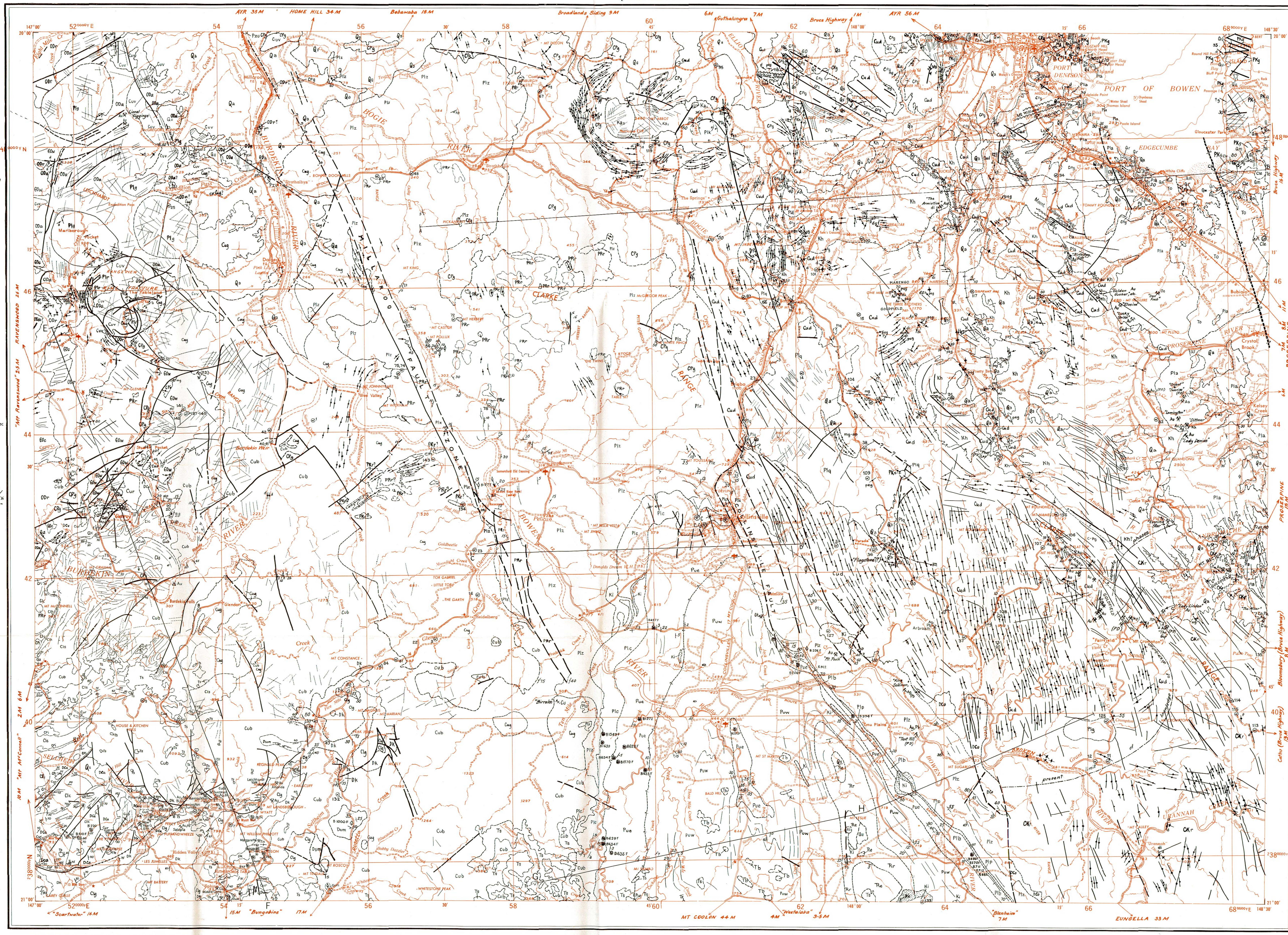
Rock unit name or map symbol	Sheet area Specimen No.	A.N.U. Accession No.	Military Grid Reference E	N	Rock Type	Material analysed	Method	Age (X 10^6 yrs.)	Remarks
Cug	1	GA 832	552700	2441800	Adamellite	Biotite	K/Ar	278	
"	1	GA 832	552700	2441800	"	Whole rock	Rb/Sr	+	
"	3	GA 729	569400	2411200	"	"	"	+	
"	3	GA 729	569400	2411200	"	Biotite	"	+	
"	3	GA 729	569400	2411200	"	"	K/Ar	283 286	
"	8	GA 831	536500	2415600	Granodiorite	"	"	276 288	
"	8	GA 831	536500	2415600	"	"	"	293 283	
"	8	GA 831	536500	2415600	"	Whole rock	Rb/Sr	+	
"	9	GA 5292	528700	2402900	"	Hornblende	K/Ar	281 283	
"	16	GA 5532	575200	2417300	Adamellite	Whole rock	Rb/Sr	+	
"	20	GA 1243	532500	2400000	Granodiorite	"	"	+	
"	20	GA 1243	532500	2400000	"	Biotite	K/Ar	280	
"	20	GA 1243	532500	2400000	"	Hornblende	"	280	
"	22	GA 5528	567200	2411300	Adamellite	Whole rock	Rb/Sr	+	
"	23	GA 5198	574900	2423500	"	Biotite	K/Ar	278 283 289	
"	23	GA 5198	574900	2423500	"	Hornblende	"	282 291	
"	42	GA 5391	546900	2440500	"	Biotite	"	282	
"	42	GA 5391	546900	2440500	"	"	Rb/Sr	+	
"	42	GA 5391	546900	2440500	"	Whole rock	"	+	
Bulgonunna Volcanics	40	GA 5514	546950	2438900	Welded tuff	Whole rock	Rb/Sr	ø	
" "	41	GA 5515	546950	2438850	Rhyolite	"	"	ø	
" "	81	GA 5517	564000	2408200	Acid volcanic	"	"	ø	
" "	84	GA 5518	561700	2407500	"	"	"	ø	
" "	131	GA 5556	538700	2394300	Rhyolite	"	"	ø	
" "	132	GA 5557	555900	2389700	Andesite	"	"	ø	
" "	134	GA 5559	573400	2429700	Toscanite	"	"	ø	
Cud	11	GA 1072	662700	2393300	Muscovite-biotite-granite	Muscovite	K/Ar	268 271 281	
"	11	GA 1072	662700	2393300	" " "	Whole rock	Rb/Sr	*	
"	12	GA 472	660900	2393300	Tonalite	Biotite	K/Ar	271 277	
"	12	GA 472	660900	2393300	"	"	Rb/Sr	284	
"	12	GA 472	660900	2393300	"	Hornblende	K/Ar	271 266	
"	13	GA 812	647500	2409300	Adamellite	Biotite		270	
	13	GA 812	647500	2409300	"	Whole rock	Rb/Sr	*	
"	15	GA 474	628400	2455900	Granodiorite	Biotite	K/Ar	271 272	
"	15	GA 474	628400	2455900	"	Hornblende	"	258 258	
"	24	GA 1162	625000	2423900	Diorite	Biotite	"	268	
"	24	GA 1162	625000	2423900	"	Hornblende	"	273	
"	36	GA 5378	630350	2423600	Tonalite	Biotite	"	268	
"	37	GA 5335	643000	2410900	Granodiorite	"	"	270	
"	37	GA 5335	643000	2410900	"	Hornblende	"	273	
"	87	GA 5336	612700	2458300	Diorite	"	"	273	
"	87	GA 5336	612700	2458300	"	Biotite	"	266	
"	101	GA 5333	622900	2462200	"	Hornblende	"	270	
"	104	GA 5328	626800	2446300	Quartz diorite	"	"	266	
"	104	GA 5328	626800	2446300	"	Biotite	"	265	
"	105	GA 5327	631150	2443750	Diorite	"	"	263	
"	105	GA 5327	631150	2443750	"	Hornblende	"	279	
"	108	GA 5379	647800	2413700	Gneissic granite	"	"	270	
Clg	7	GA 5288	540700	2385500	Granodiorite	Hornblende	K/Ar	327 330	
"	17	GA 1160	536900	2387000	"	"	"	294	
"	17	GA 1160	536900	2387000	"	Biotite	"	294	
"	18	GA 1161	532800	2387100	Adamellite	"	"	290	
Mt Windsor Volcanics	F55/3 /137	GA 5714	535400	2443000	Acid volcanic	Whole rock	Rb/Sr	x	
" "	138	GA 5715	535200	2442850	"	"	"	x	
" "	139	GA 5716	535150	2442900	"	"	"	x	
" "	140	GA 5717	535050	2442950	"	"	"	x	
" "	141	GA 5718	534700	2443050	"	"	"	x	
" "	142	GA 5719	534300	2443050	"	"	"	x	

<u>Rb/Sr Isochrons:</u> ▲ 230 ± 15 m.y. * 288 ± 31 m.y. + 286 ± 3 m.y. ø 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
Syncline
Plunge of fold axis
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
Strike and dip of strata
Prevailing dip of strata
Vertical strata
Horizontal strata
Dip <15°
Dip 15°–45°
Joint pattern
Trend lines showing plunge
(air-photo interpretation)
Lineament
Strike and dip of foliation
Unmeasured foliation
Vertical foliation
Horizontal foliation
Strike and dip of cleavage
Vertical cleavage
Strike and dip of platy flow
Vertical platy flow

Marine macrofossil locality
Plant fossil locality
Fossil wood locality
B1633F collection described in BMR Report No. 100
Isotopic dating specimen with locality number
Measured stratigraphic section
Dykes, showing dip where inclined: a-aplite, d-dolerite/microdiorite, di-diorite, f-felsite, g-granite/adamellite, gd-granodiorite, mg-microgranite/microadamellite, pg-pegmatite, pm-microdiorite porphyry, q-quartz. Absence of rock-type symbol indicates air-photo interpretation
Metamorphic aureole
Major mine
Abandoned mine — Unworked deposit
Abandoned battery — Prospect
Quarry or open cut — Abandoned alluvial workings
Minor mineral occurrence

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

o	Bore
	Windpump
T	Tank
	Dam on stream
WH	Waterhole
	Swamp
	Irrigation channel
5	Road, showing mileage between points
	Vehicle track
	Railway with station
	Telephone line
TO	Telephone exchange
PO	Post office
W/T	Dwelling with wireless transceiver
	Power transmission line
	Fence
"Glendon"	Homestead or dwelling
	Airport
	Landing ground
	Seaplane anchorage
Yd	Yard
	Trigonometrical station
	Minor horizontal control point
·932	Spot elevation, approximate
(P.D.)	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	Ka2	Alkali granite
			Ka1	Quartz syenite
		Hecate Granite	Kh1	Aplitic microgranite
			Kh	Hornblende-biotite granodiorite and adamellite, late stage leucocratic phases
			Ki	Granodiorite, diorite, rhyolite, porphyry, gabbro, microdiorite
	TRIASSIC	Clematis Sandstone	Ʀc	Cross-bedded quartzose sandstone, feldspathic in places; some pebble conglomerate
		Rewan Formation	Ʀr	Red mudstone, green labile and sublabile sandstone, siltstone, volcanic pebble conglomerate
	LOWER PERMIAN OR LOWER CRETACEOUS		PKg	Leucocratic biotite adamellite, granite, microadamellite
			PKs	Sericitized and carbonated 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	PƦr	Flow-banded porphyritic rhyolite, rhyolite breccia
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	Hornblende-biotite adamellite; aplitic microgranite dykes
			Plg	Hornblende-biotite granodiorite, biotite adamellite
			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 tuffaceous 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, minor granite, diorite, granophyre, microgranite, microtrondhjemite
			CPi	Pyroxene diorite, meladiorite, minor olivine dolerite, gabbro, pyroxene monzonite
	UPPER CARBONIFEROUS		Cug	Adamellite, granodiorite, granite, minor marginal granophyre and porphyry
			Cur	Intrusive rhyolite and quartz-feldspar porphyry
		Bulgonunna Volcanics	Cub	Rhyolite, rhyodacite, and dacite welded tuffs, acid lavas, and air-fall pyroclastics, minor andesite and tuffaceous sediments
			Cuv	Rhyolite, rhyodacite, and dacite welded tuffs, acid lavas, and air-fall pyroclastics, minor andesite
			Cud	Diorite, quartz diorite, gabbro, tonalite, granodiorite. Abundant dykes, mostly intermediate in composition
	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	St 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 and granite, minor granodiorite
			ODr	Granodiorite, adamellite, minor diorite, meladiorite, trondhjemite, granite
	CAMBRIAN-ORDOVICIAN	Cape River Beds	€Oc	Gneiss, schist, 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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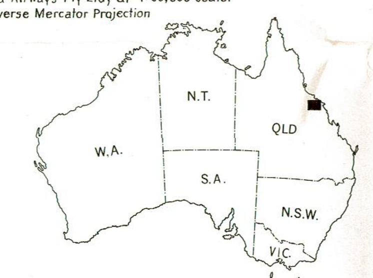
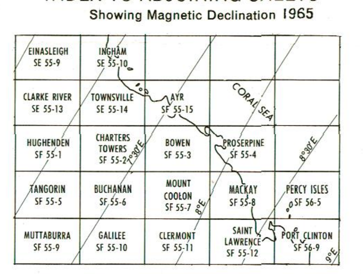


INDEX TO ADJOINING SHEETS
Showing Magnetic Declination 1965

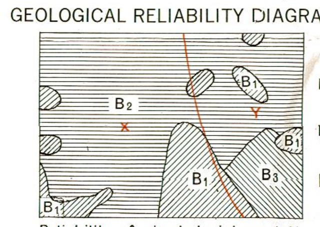


Scale 1:250,000

5 0 5 10 15 MILES

5 0 5 10 15 20 25 KILOMETRES

GEOLOGICAL RELIABILITY DIAGRAM



B1 Detailed reconnaissance mapping
B2 Reconnaissance with air-photo interpretation
B3 Some traverses, mainly air-photo interpretation

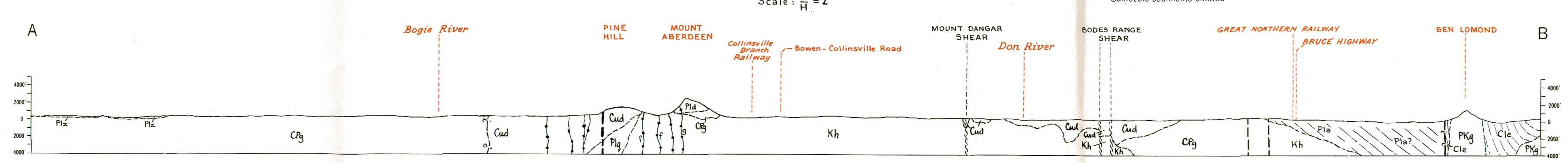
Reliability of air-photo interpretation
X Good to moderate
Y Moderate to poor

Geology 1961 and 1964–67 by C.W. Gregory, E.J. Malone, A.R. Jensen, A.&L. Paine, F. Olgers (BMR); D.E. Clarke, V.R. Forbes (GSQ). 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
Drawn by R. Swoboda, A. Salarow, F.J. Roberts (BMR)

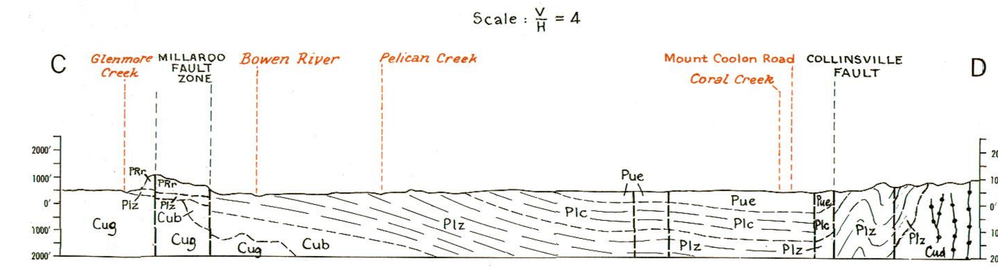
Sections

Altitude of faults not known. Folding schematic. Cainozoic sediments omitted

Scale: V/H = 2



Scale: V/H = 4



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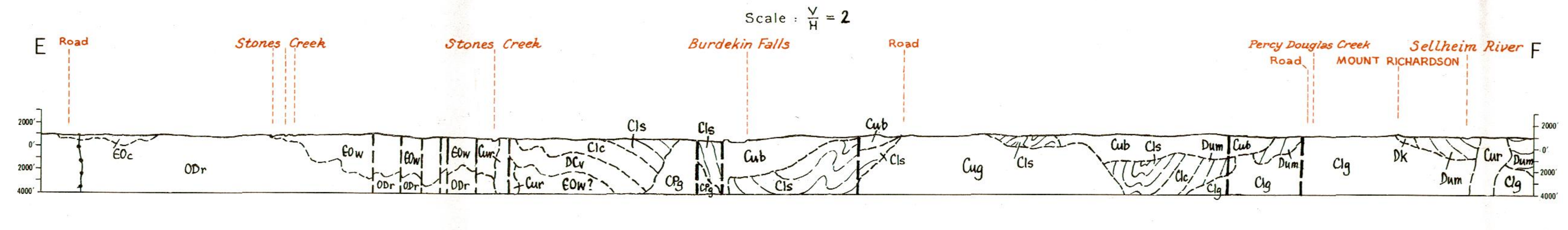

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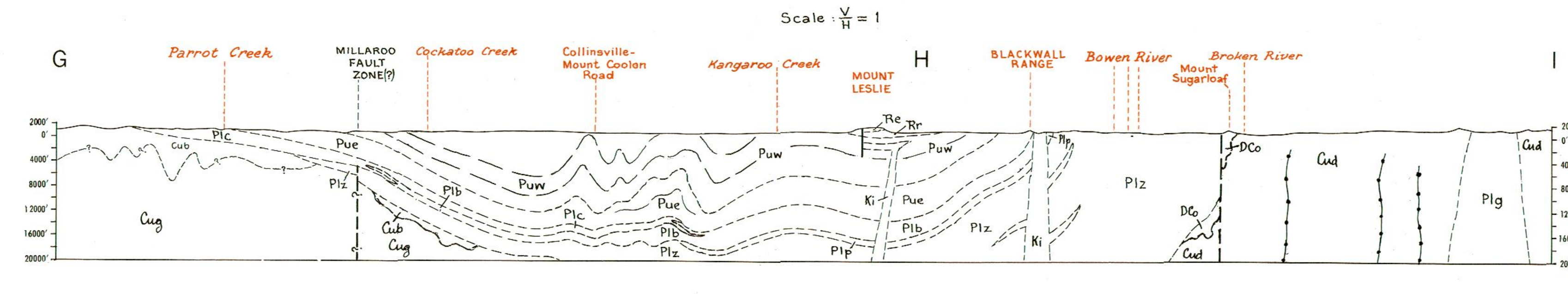
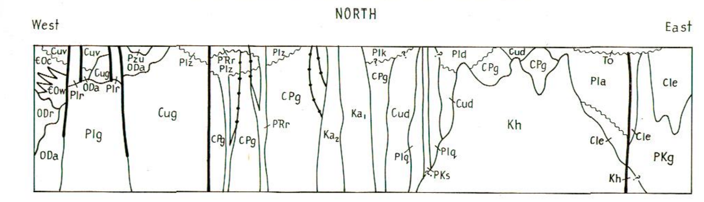
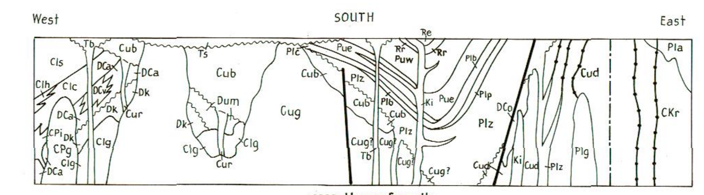


DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS

NORTH



SOUTH



Unconformity

SECOND PRELIMINARY EDITION, 1970

SUBJECT TO AMENDMENT

BOWEN

SHEET SF 55-3

Complimentary