Commonwealth of Australia

State of Queensland

REPORT No. 127

Geology of the Townsville 1:250,000 Sheet Area, Queensland

BY

D. H. Wyatt, Geological Survey of Queensland
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Minister for National Development
1970

Piccadilly and Clarke River Formations, began in the upper Middle Devonian. The succession consists of both continental and epicontinental marine sediments, some of which contain rich faunas. A period of non-deposition, caused by slight uplift, warping, and granite intrusion (Oweenee Granite) occurred in the late Lower Carboniferous. This was followed by intermittent acid vulcanicity, sedimentation, and granite intrusion, extending from the late Middle Carboniferous to the Carboniferous/-Permian boundary. The volcanics and sediments of this cycle constitute the Sybil Group, Ellenvale Beds, the St James, Percy Creek, and Tareela Volcanics, the Insolvency Gully Formation, and several unnamed units.

A further cycle of volcanics and granite, which included the third late Palaeozoic epoch of granite intrusion, followed with little interlude in the Lower Permian.

At least two cycles of Cainozoic sedimentation and deep weathering are recognized, in the early Tertiary and in the late Pliocene to Pleistocene (unnamed units, Campaspe Beds, Sellheim Formation, Lassies Creek Gravels). There are extensive flows of late Pliocene to Pleistocene olivine basalt (Nulla Basalt), and a basalt flow which may be Recent in age (Toomba Basalt). The lacustrine deposits associated with the Toomba Basalt commonly contain diatomaceous earth. The thick accumulations of silt and sand in the flood-plains of major streams are commonly deeply incised.

The most important economic deposit is the limestone quarried at Calcium for the manufacture of cement. Appreciable amounts of tin have been mined in the Ewan district, but production has been small in comparison with other tinfields in north Queensland. Some wolfram has been mined at Ollera Creek, and a little copper, gold, silver-lead, and iron ore have also been produced.

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COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

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GEOLOGY OF THE TOWNSVILLE 1:250,000 SHEET AREA, QUEENSLAND

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GEOLOGY OF THE TOWNSVILLE 1:250,000 SHEET AREA
QUEENSLAND

SUMMARY

The Townsville 1:250,000 Sheet area was mapped between 1960 and 1963 by the Geological Survey of Queensland and the Commonwealth Bureau of Mineral Resources.

The area contains a wide variety of igneous, sedimentary, and metamorphic rocks. The results of isotopic dating, which mainly became available after the geological map was printed, have materially contributed to knowledge of the geological history. The oldest rocks are medium-grade regional metamorphics (Running River Metamorphics and Argentine Metamorphics) which are Precambrian or early Palaeozoic. Two rock units in the south are believed to be of Cambrian or early Ordovician age. A large batholith, the Ravenswood Granodiorite Complex, was intruded mainly in the Middle Ordovician. A thick sequence of Silurian to possibly early Devonian sediments and minor volcanics (Kangaroo Hills Formation, Tribute Hills Sandstone, Greenvale Formation, and Ewan Beds) was laid down in the Kangaroo Hills Trough in the northwest. A second intrusive episode of the Ravenswood Granodiorite Complex was accompanied or shortly succeeded by the post-tectonic Lolworth Igneous Complex, inliers of which are thought to occur at the southern edge of the area. These intrusions were associated with a major orogeny in the Lower Devonian, in which the region became established as part of the Australian craton.

The next sedimentary cycle, comprising the Fanning River Group, the Dotswood, Myrtlevale, Lollypop, and Hardwick Formations, the Game Hill and Star Beds, and the Piccadilly and Clarke River Formations, began in the upper Middle Devonian. The succession consists of both continental and epicontinental marine sediments, some of which contain rich faunas. A period of non-deposition, caused by slight uplift, warping, and granite intrusion (Oweenee Granite and unnamed granite) occurred in the late Lower Carboniferous. This was followed by intermittent acid vulcanicity, sedimentation, and granite intrusion, extending from the late Middle Carboniferous to the Carboniferous/Permian boundary. The volcanics and sediments of this cycle constitute the Sybil Group, Ellenvale Beds, the St James, Percy Creek, and Tareela Volcanics, the Insolvency Gully Formation, and several unnamed units.

INTRODUCTION

The Townsville 1:250,000 Sheet area is bounded by latitudes 19^{o}S. and 20^{o}S. and by longitudes $145^{o}30'$E. and 147^{o}E. The area was mapped by geologists of the District Geologists's Office, Charters Towers, in 1960-62, and by a joint field party from the Geological Survey of Queensland (GSQ) and the Commonwealth Bureau of Mineral Resources (BMR) in 1963. The preliminary results of this survey were presented in an unpublished BMR Record (Record No. 1965/159) under the same title and authorship as this Report. The mapping was part of a survey of the Townsville, Hughenden, Charters Towers, Ayr, Bowen, and Proserpine 1:250,000 Sheet areas (see Fig. 1).

The area is covered by planimetric maps at a scale of 4 miles to 1 inch, and partly by maps at 2 miles to 1 inch and parish maps at 40 chains to 1 inch. All the maps are available at the Department of Public Lands, Brisbane. Contoured topographic maps at 1:100,000 scale, some at 1:50,000, and one at 1:250,000 scale were published by the Royal Australian Survey Corps in 1965 and 1966.

The air-photographs available during the survey include vertical photographs at a scale of about 1:85,000 taken by Adastra in 1961, and Royal Australian Air Force vertical photographs at a scale of 40 chains to 1 inch flown about 1945; vertical photographs at a scale of 30 chains to 1 inch, flown by Adastra in 1961-62, cover parts of the area.

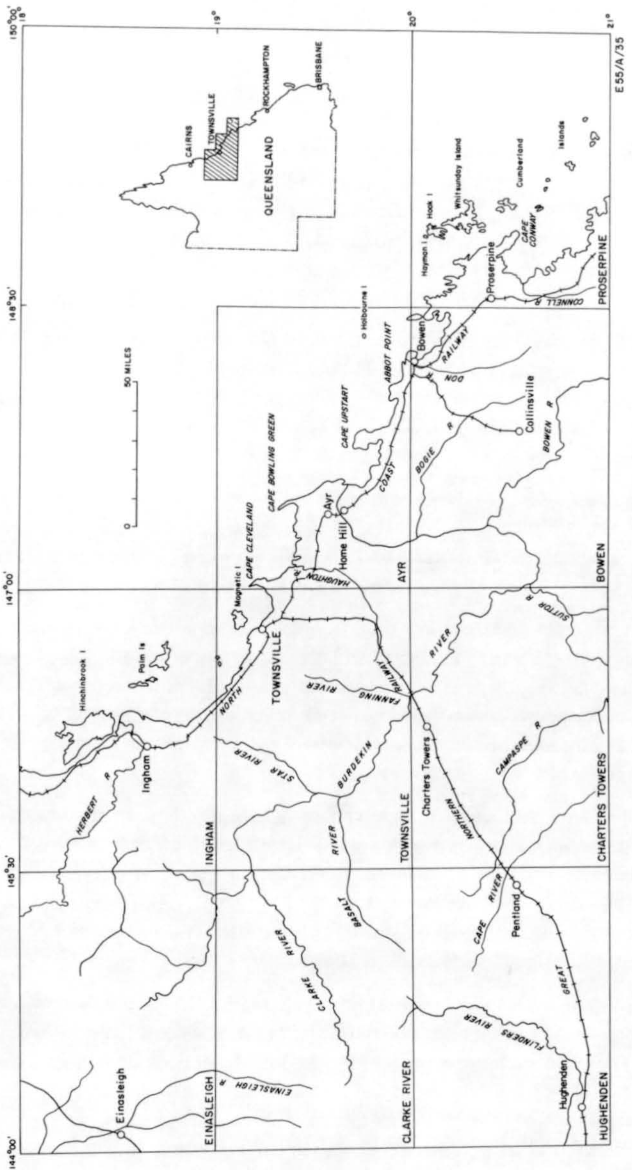
Townsville, the second largest city in Queensland (population about 64,000), is situated on the main coastal road, railway, and air route between Brisbane and Cairns. Westward from Townsville regular rail and air services extend to Charters Towers, Hughenden, and Mount Isa. Elsewhere there is a network of unsealed shire roads and station tracks, most of which are impassable during and immediately after wet weather. Many homesteads have air-strips suitable for light aircraft.

When surface flow has ceased, water can be obtained from the sandy beds of most of the watercourses. Away from the streams, water for stock and domestic purposes is obtained from bores or wells in the alluvium bordering small creeks. Dams and earth tanks also provide water for stock. At Woodstock and Major Creek groundwater from Cainozoic sediments is used for irrigation. Inland, irrigation is restricted to areas adjacent to perennial streams such as the Burdekin River.

The climate ranges from tropical-continental in the west to tropical-coastal about the Paluma Range in the northeast. The rainfall, most of which falls between December and March, ranges from 25 inches in the west to about 55 inches at Paluma. Relative humidity is always higher on the coast than inland. At Townsville the mean monthly relative humidity is 68 percent; it rises to 73 percent in the four summer months. At Charters Towers the mean is 62 percent and it seldom rises beyond 70 percent in the summer months. Mean monthly maximum and minimum temperatures for Townsville are 82.2^{o} F and 68.5^{o}F, and for Charters Towers 86.2^{o} F and 62.0^{o} F. The difference between the maximum and minimum temperatures increases westward as the moderating influence of the Pacific Ocean falls off. Frosts occur during winter months on the inland highlands, but are rare in the coastal lowlands.

Vegetation on the Paluma Range, where the rainfall exceeds 40 inches, consists of tropical rain forest, but this rapidly gives way to open *Eucalyptus* forest and woodland on the coastal plains and west of the coastal ranges. The dominant grass is bunch spear (*Heteropogon contortus*), but areas of blue grass and kangaroo grass are common.

The main industry is beef-cattle raising, and there are two large meatworks, at Alligator Creek and Ross River. Copper from Mount Isa is refined at Stuart, and shipped from Townsville, which is the main port in north Queensland. Townsville also provides an outlet for beef and sugar from the Burdekin River delta. There is a cement works at Stuart.



1. Locality map.

At Major Creek and elsewhere on the coastal plain, vegetables and fruit are produced for the Townsville market.

Isotopic Dating

A programme of isotopic dating has been carried out on the igneous and metamorphic rocks by A.W. Webb (BMR) at the Department of Geophysics and Geochemistry, Australian National University (see Appendix).

In this Report the order of treatment or allotted time span of some of the Palaeozoic rock units is different from that shown on the 1:250,000 geological map. This is because the map went to press before most of the isotopic dating results were obtained. Parts of this Report therefore update the corresponding portions of the regional geology as presented on the 1:250,000 geological map, and as summarized in the Explanatory Notes (Wyatt, 1968) which accompany the map. The differences are explained under the relevant rock units in the main text of this Report.

The geological time scale of Harland et al. (1964, pp. 260-2) is used in this Report.

Acknowledgments

We wish to acknowledge petrographic work by Miss B.R. Houston (GSQ) and F. de Keyser (BMR), and are grateful to Dr P.J. Stephenson of the Geology Department, Townsville University College, for help and advice on the geology of the Townsville district.

Previous Investigations

Leichhardt (1847, pp. 209-26) passed through the area on his journey from Moreton Bay to Port Essington in 1844-45, and Daintree (1870) described parts of the area. Jack (1879a,b) established the relationship between the granite in the Charters Towers area and the limestone around the Fanning River and Burdekin Downs, and described his Star and Dotswood Beds. These sequences, which have been variously called the Star Beds, Star Series, and Star Group, were to become type sections for the Upper Devonian and Lower Carboniferous in north Queensland. In 1960, the Geological Survey of Queensland began systematic mapping of the type areas, because of the difficulties which have arisen as a result of the general use of the name 'Star'.

The only detailed reports dealt with mining centres, and knowledge of the regional geology was based on a few published reports on widely spaced reconnaissance traverses, and numerous unpublished observations made by State and other geologists. Of the published works the more important, apart from those already cited, are by Jack & Etheridge (1892), Maclaren (1900), Reid (1917), and Saint-Smith (1922).

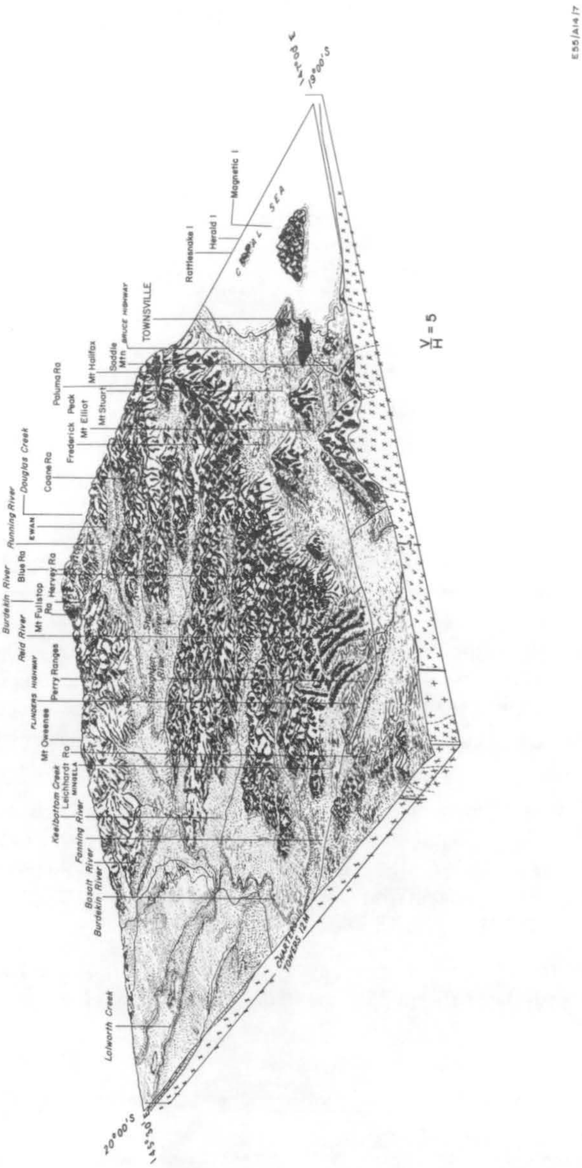
At the start of the 1963 joint survey, about three-quarters of the Townsville 1:250,000 Sheet area had already been mapped by the Geological Survey of Queensland between 1960 and 1962.

Physiography

The main topographic divisions are the coastal lowland and inland highland (Fig. 2). The lowland consists of plains, from a few miles to 30 miles wide, which extend from the coast to the foot of the nearby ranges. The plains gradually increase in elevation from sea level at the coast, where they commonly merge into tidal flats, to as much as 300 feet above sea level at the foot of the mountains, where they merge with talus and piedmont deposits.

Rising out of this plain are a number of residual hills, mountains, and ranges, such as Castle Hill (in Townsville), Mount Stuart, Mount Elliot, and others. The highest, Mount Elliot, rises abruptly from the plain to about 4000 feet above sea level.

Most of the streams in the coastal area rise on the eastern slopes of the Paluma, Hervey, or Leichhardt Ranges, and flow directly to the coast. The Reid River is an exception; it rises on the western slope of the Hervey Range and flows south parallel to the range before cutting through to join the Haughton River, which flows directly to the coast. Most of the coastal streams are deeply incised in their upper reaches, but have well developed meanders in their lower reaches, particularly where they cross tidal flats.



2. Physiographic block diagram

The inland highland is a much more complex physiographic unit. Essentially the area is a dissected peneplain, although at the time of peneplanation the general relief may not have been uniformly low, as the word peneplain usually implies. For example, the present Perry Ranges and Coane Range may have been prominent topographic features even during the period of peneplanation.

The degree of dissection varies considerably according to the underlying rocks and the intensity of faulting or fracturing. Thus, in the southwest where poorly consolidated sandstone predominates, the country is flat, and is traversed by incised streams with rather linear and parallel courses. In the central area north of Charters Towers, where granodiorite predominates, the topography can best be described as 'rugged-in-miniature', and stream courses tend to be dendritic. In the Paluma, Hervey, and Leichhardt Ranges highly faulted and fractured granite and acid volcanics predominate. Here the topography is rugged, and the streams, which are deeply entrenched along fault lines, tend to have a trellised pattern.

In the southwest, basalt forms low tablelands slightly higher than the nearby dissected peneplain.

The major streams of the inland highland are the Burdekin River and its tributaries - Douglas Creek, Running River, Star River, Basalt River, Keelbottom Creek, Lolworth Creek, and Fanning River. Few of the tributaries maintain a strong flow after the wet season, but Lolworth Creek is fed by perennial springs in the Cainozoic basalt west of Toomba homestead.

PRECAMBRIAN OR EARLY PALAEOZOIC

The stratigraphy of the Townsville Sheet area is summarized in Table 1. The oldest strata are the Running River Metamorphics and Argentine Metamorphics.

Running River Metamorphics (p€r)
(new name)

The metamorphic rocks in the valley of Running River are here named the Running River Metamorphics. They extend downstream from Ewan for at least 2 miles, and possibly as far as the Burdekin River, where they are concealed by thick Quaternary soil and alluvium. Northeast of Ewan, the formation extends into the Ingham Sheet area.

The Running River Metamorphics comprise amphibolite, mica schist, and quartzite. The amphibolite consists mainly of hornblende and plagioclase with some sphene, epidote, and a little quartz. The mafic and felsic constituents are commonly finely banded, but small patches of coarse banded hornblendite and anorthosite occur, the banding usually dying out in a central zone of basic pegmatite. A little mica schist and quartzite are associated with the amphibolite. The schist becomes dominant west of Ewan, and quartzite to the north. The mica schist in the lower reaches of Butterfly Gully, three-quarters of a mile west of Mount Brown, is associated with muscovite pegmatite which may have been formed by segregation during regional metamorphism. The quartzites which form the high divide between Bean Creek and Running River are commonly flow-folded.

The foliation trends between 020° and 060° and dips steeply northwest or southeast. In the amphibolite the foliation is folded, and the fold axes plunge northeast at 30° to 50°. The main trends in the mica schists and quartzites are northeasterly, but there are marked deviations in the intensely faulted Butterfly Gully and Bonnybrook Creek areas.

Two small bodies of hornblende-biotite granodiorite occur in the Running River Metamorphics, one in Williams Creek near the Ewan racecourse and the other near Mount Moss. They may be related to the Ravenswood Granodiorite Complex, but their relationship to the metamorphic rocks is unknown.

The Running River Metamorphics are unconformably overlain by the Ewan Beds. The unconformity can be seen west of Mount Brown, where quartz-mica schist is unconformably overlain by micaceous sandstone and limestone, and to the southeast, where the schists are overlain by quartzose conglomerate.

The formation is intruded by the Oweenee Granite north and south of Running River valley. The small outcrop of granite near where the Gregory Highway crosses Williams Creek, and the pegmatite about 3 miles to the northeast, may be related to the late granitic phases of the Ravenswood Granodiorite Complex or to the Oweenee Granite. The Running River Metamorphics are also intruded by numerous acid to intermediate dykes trending northwest. The dykes were apparently intruded along faults which divide the area into thin slices.

TABLE 1 : PRE-MIDDLE DEVONIAN STRATIGRAPHY AND INTRUSIVE ROCKS

Age	Rock Unit	Lithology	Remarks
SILURIAN/ LOWER DEVONIAN	Lolworth Igneous Complex (S-Dl)	Deeply lateritized porphyritic 'granite'	Rb/Sr isotopic age of 401 m.y. from Charters Towers and Hughenden Sheet areas. Overlain by Cainozoic sediments. Small areas near Fern Springs homestead. Gold ('Big Hit' mine just S of Sheet area)
	Kangaroo Hills Formation (S-Dk)	Quartz sandstone, shale, lenses of greywacke and conglomerate	Possibly overlies Tribute Hills Sandstone. Unconformable beneath Clarke River Formation and Sybil Group. Thin beds of quartz arenite and shale, arenite generally cross-bedded. White et al. (1959b); White & Wyatt (1960)
	Tribute Hills Sandstone (S-Dt)	Quartz sandstone, siltstone	Possibly equivalent to Pelican Range Formation. If so, older than Kangaroo Hills Formation. 3500-5000 ft thick. White et al. (1959b); White & Wyatt (1960)
	Greenvale Formation (Sg)	Siltstone, greywacke, subgreywacke, silty quartz sandstone, feldspathic sandstone, conglomerate	Thickness unknown owing to tight folding. White et al. (1959b); White & Wyatt (1960)
	Ewan Beds (Pze)	Greywacke, lithic and quartzose conglomerate, sandstone, siltstone, limestone, andesitic and rhyolitic volcanics	Unconformable on Running River Metamorphics. Intruded by Oweenee Granite and unnamed granite (Cg); tin and copper mineralization. Thickness 5000-10,000 ft. Very much fractured. Poorly preserved corals. Jack (1892); Saint-Smith (1922); Reid (1931); Bush (1960); Wyatt (1963)
M. ORDOVICIAN AND U. SILURIAN OR L. DEVONIAN	Ravenswood Granodiorite Complex (S-Dr, S-Da)	Granodiorite, granite, aplite, pegmatite, adamellite, diorite, gabbro	Originally named Ravenswood Granodiorite (see text). Rb/Sr dating shows that most of batholith was emplaced in M. Ordovician (454 ± 30 m.y.), remainder in U. Silurian or L. Devonian (394 ± 30 m.y.). Intrudes Argentine Metamorphics, Charters Towers Metamorphics, and Kirk River Beds. Strongly foliated in places. Jack (1879a); Reid (1917); Wyatt (1961, 1962, 1963)

CAMBRIAN-ORDOVICIAN	Kirk River Beds (Pzk)	Micaceous shale, siltstone, lithic and feldspathic sandstone, arkose	Intruded by and faulted against Ravenswood Granodiorite Complex. At least 12,000 ft thick. Slumping. Convolute bedding in arenites. Gold associated with Ravenswood Granodiorite Complex at Bunkers Hill
	Charters Towers Metamorphics (Pzf)	Mica schist, quartz-plagioclase-biotite gneiss	Roof pendants in Ravenswood Granodiorite Complex. Small gold deposits near Charters Towers. Jack (1879a); Reid (1917); Wyatt (1963)
PRECAMBRIAN OR EARLY PALAEOZOIC	Argentine Metamorphics (p€a)	Mica schist, quartzite, quartz schist, garnetiferous mica schist and quartzite, actinolite schist, marble, amphibolite, gneiss, migmatite; some garnetiferous granite and pegmatite; minor serpentinite	Intruded by Ravenswood Granodiorite Complex. Unconformable beneath Givetian-Tournaisian sequences. Silver at Argentine; gold in Ponto area. Jack (1879a); Wyatt (1963)
	Running River Metamorphics (p€r)	Mica schist, quartzite, amphibolite	Unconformable on Ewan Beds. Intruded by Oweenee Granite and unnamed granite (Cg); tin mineralization. Bush (1960); Wyatt (1963)

The amphibolite is similar to the amphibolite in the Argentine Metamorphics in the Six Mile Creek area north of Argentine. The mica schist and quartzite are also similar to parts of the Argentine Metamorphics, and the two formations are probably at least partly equivalent.

Argentine Metamorphics (p€a)
(new name)

The name Argentine Metamorphics is proposed for the metamorphic rocks extending from lower Speed Creek westward to Stockyard Creek and north to the Star River. The name is derived from the Parish of Argentine, County of Wilkie Gray. The formation comprises mica schist, garnetiferous mica schist, quartzite, quartz schist, garnetiferous quartzite, hematite-quartz schist, actinolite schist, amphibolite, quartz-feldspar-mica gneiss, and migmatite.

Jack (1886a) roughly delineated an area of 'slates, schists and gneisses of undetermined age' between lower Speed Creek and the head of the Star River, which he grouped with those at Charters Towers as a matter of convenience. The metamorphics at Charters Towers occur as small roof pendants in the Ravenswood Granodiorite Complex, and are not readily comparable with those in the area described above. The Geological Map of Queensland (1953) shows the area as 'undifferentiated Lower Palaeozoic'.

In the White Springs area, mica schist and quartzite predominate over actinolite schist and amphibolite, but at Crooked Creek along strike to the northeast only garnetiferous mica schist and thin quartz schist have been observed. The trend then swings east-southeast to the Towns Creek area, where actinolite and calcite-amphibole schists predominate. Farther southeast, around Flohrs Dam (mis-spelt on the map as Plohrs Dam), the metamorphics are intruded by granite and pegmatite and most of the rocks have been converted to migmatite and gneiss, but small outcrops of actinolite schist are still visible.

South of Flohrs Dam, a low range of hills extends to the southeast, and culminates in three prominent peaks called The Three Sisters. The high country is composed of quartzite and quartz-mica schist. To the south, around Boundary Creek, actinolite schist reappears in association with thin beds of recrystallized limestone. The quartzite and quartz-mica schist appear to form a syncline infolded within the actinolite schists, and are therefore the younger.

East of Flohrs Dam, between the upper reaches of Wheelbarrow Creek and the headwaters of Cattle Creek, mica schist predominates, but some amphibolite and quartz-hematite schist are also present. Farther north, around Six Mile Creek and Keirys Dam, hornblende schist and gneiss are predominant, but serpentinite, mica schist, and quartz-mica schist are also present.

North of a line between Flohrs and Keirys Dams the metamorphics have been intimately intruded by granite and pegmatite and converted into migmatite. Similar rocks recur around the North Branch of the Little Star River.

The mica schists between the North Branch of the Little Star River and the head of the Star River are similar to those in the Argentine/Wheelbarrow Creek area. To the east of the schists, immediately west of the Paluma Range, there are gneisses similar to those north of Flohrs Dam.

Three small bodies of white garnetiferous muscovite granite, too small to map separately, have been included in the Argentine Metamorphics. The first crops out over an area of a few acres about 300 yards east of the Star homestead/Basin Yard track, about 13 miles north-northeast of Star homestead. The second, which includes some pegmatite, crops out beside the road about 6 miles northeast of Lassies Creek homestead. The third is faulted against Devonian red beds about a mile northeast of Valprẽ homestead.

The trend of the Argentine Metamorphics ranges from north-northeast in the White Springs area to west-northwest around The Three Sisters. The trends around the old Argentine mining centre are variable, but in the Speed Creek area the trend is generally east-west.

In places, the Argentine Metamorphics are similar to the Running River Metamorphics. When the geological map was printed it was thought that the Argentine and Running River Metamorphics were probably Precambrian, because of their relatively high metamorphic grade and because the Running River Metamorphics are overlain with strong angular unconformity by the Ewan Beds, which contain Silurian fossils. At that stage no Ordovician or Cambrian rocks were known to occur in the region. However isotopic dates which have recently come to hand show that the Mount Windsor Volcanics (Charters Towers Sheet area) are probably Upper Cambrian and that the Ravenswood Granodiorite Complex is mainly Middle Ordovician. Thus it is now possible that the Argentine and Running River Metamorphics are Cambrian or Ordovician rather than Precambrian. A possible correlation of the Argentine Metamorphics with the Precambrian in the Luck Creek area in the Einasleigh Sheet area is given in Table 2.

TABLE 2 : POSSIBLE CORRELATION OF ARGENTINE METAMORPHICS WITH METAMORPHICS IN EINASLEIGH SHEET AREA

	Einasleigh Sheet Area		Townsville Sheet Area	
	Formation	Lithology	Main Outcrop Area of Argentine Metamorphics	Lithology
PROTEROZOIC (?)	Paddys Cr Fm	Quartz phyllite, quartzite	Back Cr	Quartzite, quartz schist
PROTEROZOIC (?)	Lucky Cr Fm	Calcareous greywacke, actinolite schist, quartz-chlorite-epidote schist, thin impure marble	Boundary Cr	Actinolite schist, thin recrystallized limestone
		Metamorphic Break		
ARCHAEAN (?)	Halls Reward Metamorphics	Migmatite, quartz-mica schist, garnet-mica schist, quartzite	Dinner Cr, Star homestead, White Springs	Migmatite SW and SE of Star homestead. Metamorphics in White Springs area
ARCHAEAN (?)	Stenhouse Cr Amphibolite	Thinly banded amphibolite, rare impure marble	Keirys Dam, Six Mile Cr, White Springs	Amphibolite, serpentinite

CAMBRIAN-ORDOVICIAN

Charters Towers Metamorphics (Pzf)
(name amended)

North and west of Charters Towers there are a number of isolated roof pendants of metamorphic rocks in the Ravenswood Granodiorite Complex. They were mentioned by Jack (1879a) and briefly described by Reid (1917). Bryan (1926) called them the Charters Towers Series, and assigned them to the Precambrian. The name is revised here to Charters Towers Metamorphics.

In the Townsville Sheet area, the small area of banded quartz-plagioclase-biotite gneiss near the head of Three Mile Creek, 7 miles northeast of Burdekin Downs homestead, and the mica schist and biotite-quartz-plagioclase gneiss south of Big Sandy (Hann) Creek are probably a northerly extension of the roof pendants near Charters Towers, and have therefore been assigned to the Charters Towers Metamorphics.

Recent mapping has shown that the Charters Towers Metamorphics at Charters Towers are more likely to be related to the Cape River Beds in the Hughenden and Charters Towers Sheet areas (Paine et al., 1965, unpubl., and in prep; Wyatt et al., 1967, unpubl., and in prep.) than to the Running River and Argentine Metamorphics. A provisional Rb/Sr whole-rock isochron of 510 $\pm$ 100 m.y. (Upper Cambrian) has been obtained from volcanics in the Cape River Beds in the Bowen Sheet area (Paine et al., in prep.). The Charters Towers Metamorphics are probably the same age as the Cape River Beds, and these two units and the Kirk River Beds are regarded broadly as Cambro-Ordovician in age.

Kirk River Beds (Pzk)
(new name)

The unfossiliferous sediments at the head of the Kirk River, which cover a triangular area of about 16 square miles west and south of Bunkers Hill mine, are here named the Kirk River Beds. The name is derived from the Kirk River, a tributary of the Burdekin River.

The beds are poorly exposed and no type section has been designated. The best outcrops are in numerous small creeks and gullies at the head of the Kirk River south of Bunkers Hill. The Kirk River Beds consist of micaceous shale, siltstone, lithic and feldspathic sandstone, and arkose. The beds range from grey-green to brownish green. The sediments are well bedded, with individual beds from 6 inches to 3 feet thick. Much of the siltstone is current-bedded, and slump and convolute bedding structures are present in the impure arenites. Most of the micaceous shale is fissile.

The Kirk River Beds are surrounded by the Ravenswood Granodiorite Complex with intrusive or faulted contacts, and the base and top of the sequence are not exposed. The beds dip consistently to the southwest at about 40^{o}, and are at least 12,000 feet thick. In the north, they are intruded by a late granitic phase of the Ravenswood Granodiorite Complex, as described by Reid (1926) at Bunkers Hill, near Ravenswood. In the southwest, the beds are intruded by the same granites, and some of them have been metamorphosed to anthophyllite-cordierite-mica hornfels and quartz-mica hornfels. Only the finer-grained sediments have been recrystallized; the coarser sediments are unaffected, except for the development of sericite and epidote in the matrix. The southwestern boundary is faulted in places. In the east, the beds are intruded by a late Palaeozoic composite granitic body (C-Pg).

No fossils have been found in the Kirk River Beds. They are not comparable with either the Running River or Argentine Metamorphics, and the lack of regional metamorphism and fracturing suggests that they are younger. They are intruded by the Ravenswood Granodiorite Complex, which is mainly Middle Ordovician. They are regarded as broadly the same age as the Cape River Beds and Charters Towers Metamorphics, that is, Cambro-Ordovician.

MIDDLE ORDOVICIAN AND UPPER SILURIAN OR LOWER DEVONIAN

Ravenswood Granodiorite Complex (S-Dr, S-Da)
(amended name)

Background, and Discussion of Age

A large batholith consisting mainly of granodiorite occupies 700 square miles in the southeast of the Townsville Sheet area, and 2000 square miles in the Charters Towers Sheet area.

The batholith was defined and named Ravenswood Granodiorite by Wyatt et al.(1965, unpubl.) and the name was published by Wyatt in 1968. Wyatt et al. recognized a broad two-fold subdivision, an initial granodiorite phase and a later granite (or acid) phase. At that stage the only isotopic dates available were three K/Ar mineral ages of 420, 420, and 440 m.y. (Lower Silurian), which had been obtained from two specimens of granodiorite in the Townsville Sheet area. A general Silurian-Devonian age was proposed, because the acid phase had not been dated, and because K/Ar mineral ages at or near the Silurian-Devonian boundary had been obtained from other granites in the region. This age was also published on the 1:250,000 geological map (included with this Report), because the Explanatory Notes went to press before any further results became available.

In 1966, during the course of 1-mile mapping of part of the Charters Towers Sheet area, Clarke (in prep.) recognized 8 distinct subunits of the batholith, and it was decided to revise the name to Ravenswood Granodiorite Complex.

In 1967-68 specimens collected by Clarke, together with others collected from both Sheet areas during the earlier regional mapping, were dated by the Rb/Sr whole-rock method (Webb, 1969), which, in this region of repeated granite intrusion, has proved more reliable than the K/Ar method as an indicator of absolute age (Webb & McDougall, 1968; Webb, 1969). Two distinct isochrons were obtained, at 454 $\pm$ 30 m.y. (Middle Ordovician) and 394 $\pm$ 30 m.y. (Upper Silurian or Lower Devonian). Specimens collected from both the granodiorites and the more acid rocks lie on both isochrons, thereby proving that the interim twofold subdivision of Wyatt et al. (1965, unpubl.) and Wyatt (1968), which had been derived only from field work, was unsatisfactory. It now seems probable that each of the two intrusive epochs consisted of a granodiorite phase (or phases), followed by a later acid phase (or phases). There are no simple field criteria for distinguishing between the products of the two intrusive episodes. More detailed mapping and further isotopic dating will be required to identify them. The problem might be solved geochemically by trace element analyses; Webb (1969) has already noted a marked difference in the initial $^{87}Sr/^{86}Sr$ ratios of the two groups.

To sum up, our present knowledge indicates that the Ravenswood Granodiorite Complex is mainly Middle Ordovician, but contains unmapped masses which were emplaced in the uppermost Silurian or early Devonian. In the Townsville Sheet area the extent of these younger masses is unknown (one specimen from the Sheet area lies on the younger isochron, a diorite from 5 miles S.E. of Mingela), and the complex is mapped empirically as a main granodiorite 'phase' and a subsidiary acid 'phase'. Wherever contacts have been seen, the more acid rocks are later than the granodiorites.

All rock types of the Ravenswood Granodiorite Complex are strongly foliated in places, the granodiorites somewhat more so than the leucocratic rocks. Small bodies of granodiorite intrusive into the Running River Metamorphics near Ewan are regarded as part of the complex. The country rock of the old Newhaven mine on Hann Creek is a slightly foliated biotite granodiorite typical of the complex; this is too small to map, but if correctly identified, it is the most westerly known occurrence of the complex in the southern part of the Townsville Sheet area.

Parts of the Ravenswood Granodiorite Complex in the Charters Towers Sheet area have been described by Jack (1879a, 1885), Rands (1891), Reid (1917), and Maclaren (1900).

The granodiorite forms low-lying gently undulating country, but the acid intrusions are more resistant to erosion and form hills.

Description

Hornblende and biotite occur in variable proportions in the granodiorite. In places the granodiorite contains numerous xenoliths of diorite 'which almost certainly represent a more basic phase of the magma which crystallized at depth' (Houston, 1961, unpubl.). Where xenoliths are abundant, the contaminated granodiorite grades into a quartz diorite containing more basic plagioclase, little if any potash feldspar, and abundant hornblende similar to that in the xenoliths (Houston, 1961, unpubl.). Small areas of more basic rocks are present in places, for example the spessartite lamprophyre at Macrossan (Houston, 1962, unpubl.), and 1 mile north of Cockatoo Well, Dotswood Holding, where hornblendite occurs with diorite (Houston, 1961, unpubl.). A feature of the Ravenswood Granodiorite Complex north-east of Dotswood homestead is the presence of pools of quartz which are closely related to the foliation of the rock (Houston, 1961, unpubl.). The pools consist of (i) interlocking mosaics of roughly equigranular anhedra, probably due to the inversion of high-temperature quartz or in some instances to recrystallization; and interlocking mosaics of elongated anhedra which probably resulted, at least partly, from recrystallization of crystals granulated by shearing; or (ii) strain mosaics resulting from foliation processes.

The leucocratic rocks of the late acid phase are generally composed of quartz, pink to red potash feldspar, and a little biotite, which is generally chloritized. The texture is extremely variable and ranges from granitic to pegmatitic, graphic, or aplitic. South and east of Mingela the granites are composed of quartz, microcline, oligoclase, and biotite. Irregular patches of microgranite occur in the granites.

The foliation in the Ravenswood Granodiorite Complex was probably developed, at least partly, during emplacement, but in places it is related to post-crystallization shearing. The intensity of primary foliation varies greatly over short distances. It is probably more strongly developed near the contacts where it is invariably parallel with the schistosity of the metamorphics. Inside the massif, on the other hand, the foliation is weak or absent, for example at the crossing of the East Fanning River north of Fanning River homestead, and at the Broughton Crossing south of Charters Towers. Foliation formed by shearing after crystallization may be seen in the Alex Hill Shear Zone east of Mingela and 3 miles south of Mingela, where both the granodiorite and the late leucocratic granite have been foliated. In the coarser rocks the quartz grains have been rolled out and flattened into thin lenticular mosaics. The granodiorite north of Dotswood has also been sheared, but here the shearing is possibly related to the intrusion of numerous northeasterly microdiorite dykes, many of which are also sheared. Numerous actinolite-epidote-quartz stringers have been developed in the microdiorite and granodiorite. The origin of the stringers is uncertain, but they probably represent a late hydrothermal phase of the dykes which are possibly contemporaneous with the shearing. The age of the shearing and of the microdiorite dykes is probably Upper Carboniferous or Permian, because similar dykes occur in an offshoot of the Upper Carboniferous Pall Mall Adamellite.

The more basic rocks of the complex are not foliated, and may therefore have been emplaced after relaxation of the stress which caused the foliation in the granodiorite.

The Ravenswood Granodiorite Complex intrudes the Argentine Metamorphics and the Charters Towers Metamorphics; leucocratic granites of the complex intrude the Kirk River Beds. The complex is overlain nonconformably by the Fanning River Group (Givetian).

SILURIAN/LOWER DEVONIAN

Greenvale Formation (S-Dg?)

A sequence of grey siltstone, greywacke, subgreywacke, greywacke conglomerate, and silty quartz and feldspathic sandstones extends southwest from the head of Marshs Creek along the valleys of Black Gin and Tribute Creeks. Part of the sequence resembles the Greenvale Formation (White, 1962, 1965), and part the Kangaroo Hills Formation. The beds have a northeasterly regional trend, but are deflected to the southeast next to the Sybil Graben. They are steeply dipping to vertical and generally dip to the northwest.

The sediments are generally well bedded, but the beds vary considerably in thickness. The beds of shale and siltstone are commonly about 2 to 3 inches thick, but the coarser sediments, which form lenticular bodies, contain beds up to several feet thick. Current-bedding is common in the finer sediments.

The formation appears to be conformably overlain by the Tribute Hills Sandstone. To the east, it is faulted against the Sybil Group, and to the south it is intruded by the Oweenee Granite.

The formation is unfossiliferous. It is shown on the Clarke River Sheet (White, 1962) as the Kangaroo Hills Formation (see below).

Tribute Hills Sandstone (S-Dt)

The Tribute Hills in the Black Gin Creek area, 20 miles west of Ewan, are formed from a continuation of the unit in the Clarke River Sheet area which was described by White et al. (1959b, unpubl.) as the Tribute Hills Formation, and later by White & Wyatt (1960) and White (1962, 1965) as the Tribute Hills Sandstone. In the Townsville Sheet area, the formation consists of steeply dipping or vertical quartz sandstone and siltstone similar to those in the type area farther west. Its thickness ranges from 3500 to 5000 feet.

East of Tribute Dam, the formation is truncated by the western fault of the Sybil Graben. The silicified quartz sandstone and quartzite forming the high country southwest of the confluence of Little Oaky and Oaky Creeks probably represent the continuation of the sandstone east of the graben.

The Tribute Hills Sandstone appears to be unconformably overlain by the Kangaroo Hills Formation in the Clarke River Sheet area (see below).

Kangaroo Hills Formation (S-Dk)

The Kangaroo Hills Formation crops out in the northwest, but is more extensively developed in the adjoining Ingham, Einasleigh, and Clarke River Sheet areas. The formation has been described by Maitland (1891), White et al. (1959a, unpubl.), White & Wyatt (1960), White (1962, 1965), and de Keyser et al. (1965).

The formation consists of thin-bedded quartz arenite and grey shale with lenses of greywacke and conglomerate. The quartz arenite usually shows small-scale current-bedding. The lithology is similar to that in the Einasleigh and Clarke River Sheet areas.

The formation has a general east-west trend in the Tomahawk Creek area, but farther south, near the confluence of Black Gin Creek and the Burdekin River, the trend is northeast. The beds form part of the eastern limb of a synclinorium, most of which lies within the Clarke River and Einasleigh Sheet areas. Numerous minor folds, most of which plunge vertically, have been observed in the synclinorium.

In the Blue Range, the Kangaroo Hills Formation is unconformably overlain by the Clarke River Formation, and in Tomahawk Creek by the Sybil Group. In the Douglas Creek area it is both intruded by and faulted against late Palaeozoic granite.

In the Clarke River Sheet area the Kangaroo Hills Formation is conformably overlain by the Perry Creek Formation. The Tribute Hills Sandstone is very similar to the Pelican Range Formation, and the beds to the south of the Tribute Hills Sandstone resemble the Greenvale Formation. The various units can probably be correlated as follows:

Black Gin Creek/Perry Creek Area	Greenvale/Perry Creek Area
Perry Creek Formation	Perry Creek Formation
Kangaroo Hills Formation	Kangaroo Hills Formation
Unconformity	Unconformity
Tribute Hills Sandstone	Pelican Range Formation
Strata south of Tribute Hills Sandstone	Greenvale Formation

The sequence in the Black Gin Creek/Perry Creek area corresponds to the succession established by White (1962, 1965) in the Greenvale/Perry Creek area. The beds south of the Tribute Hills Sandstone are therefore shown on the map as Greenvale Formation(?) rather than as Kangaroo Hills Formation, as in the adjoining Clarke River Sheet area.

Ewan Beds (Pze)
(new name)

The sediments and volcanics to the northwest of Ewan, in the catchment area of lower Oaky Creek and its tributary Bean Creek, are here designated the Ewan Beds. The limestones were described by Jack (1892). Saint-Smith (1922) has described the sequence in lower Oaky Creek, which he regarded as equivalent to his Kangaroo Hills series. Reid (1931) assigned the beds to his metalliferous series, which he regarded as Lower Silurian. Bush (1960) described the metamorphics of Ewan, but did not differentiate between the high-grade metamorphic rocks which are now called the Running River Metamorphics and the unmetamorphosed sediments and volcanics or low-grade metamorphics of the Ewan Beds. He regarded them as equivalent to the Kangaroo Hills Formation.

Structurally, the Ewan Beds appear to be a continuation of the Siluro-Devonian beds (including the Kangaroo Hills Formation) which crop out about 16 miles to the southwest on the opposite side of the Sybil Graben. The Ewan Beds, however, contain a sequence of volcanics which are not known in the Siluro-Devonian strata to the southwest, and are also much more faulted, intruded by dykes, and locally sheared than the Siluro-Devonian strata. They have therefore been mapped as a separate rock unit.

The Ewan Beds comprise greywacke and subordinate lithic and quartzose conglomerate, lithic to quartzose sandstone, siltstone, limestone, and andesitic to rhyolitic volcanics. Though deformed, the beds trend northeast and the regional dip appears to be northwesterly.

The basal quartzose conglomerate and feldspathic sandstone are overlain by lenticular beds of recrystallized limestone. The limestones are well developed between Mount Moss and the Ewan-Shrimp track, and around Mount Brown. The limestones are overlain by light to dark green, indurated, and strongly cleaved andesitic flows and tuffs, greywacke, and fine pebble conglomerate and chert. Some weakly banded acid volcanics are present, but it is not certain whether they are intrusive or interbedded in the sequence. Saint-Smith (1922) considered that the spherulitic rhyolite in the lower Oaky Creek area is interbedded with quartzite and clay slate. The quartzite, sheared siltstone, and greywacke conglomerate around the Sardine and Mount Theckla mines possibly represent a higher part of the sequence.

The fossils from the limestone, which include Halysites, Propora, Tryplasma, Favosites, and Heliolites (Dorothy Hill, pers. comm.), suggest a Silurian age. Halysites has been recorded in limestone in the Perry Creek Formation, which crops out 22 miles west-southwest of Ewan in the Clarke River Sheet area. But the Perry Creek Formation probably rests conformably on the Kangaroo Hills Formation (White & Wyatt, 1960), which is many thousands of feet thick. The limestones in the Ewan Beds crop out only a short distance above the unconformity with the Running River Metamorphics, and if the Ewan limestones are equivalent to those in the Perry Creek Formation, then an enormous thickness of older Siluro-Devonian strata is missing in the Ewan area. It is unlikely that the beds have thinned out in the Ewan area.

It is possible that the Ewan limestones are equivalent to the Carriers Well Limestone Member in the Wairuna Formation south of Halls Reward mine in the Clarke River Sheet area. The Carriers Well Limestone Member is of Lower Silurian age, and rests unconformably on the Precambrian. It is overlain by the Everetts Creek Volcanic Member, which may be equivalent to the andesitic volcanics, tuffs, and greywackes in the Ewan area, but no positive correlation can be made at present.

The northern and southern boundaries of the Ewan Beds are intruded by Carboniferous granite. To the east, they rest unconformably on the Running River Metamorphics, and to the west they are faulted against the Sybil Group.

Lolworth Igneous Complex (S-D1)

The Lolworth Igneous Complex in the northeastern part of the Hughenden Sheet area is defined by Paine et al. (1965, unpubl., and in prep.), and in the northwestern part of the Charters Towers Sheet area by Wyatt et al. (1967, unpubl., and in press). It is a large post-tectonic batholith which consists of banded garnetiferous muscovite granite and adamellite with a pegmatitic to aplitic texture (mainly in the Charters Towers area) and massive muscovite-biotite adamellite or granodiorite (Hughenden Sheet area).

In the Townsville Sheet area the complex is thought to be represented by small inliers of granitic rocks which crop out on the southern boundary of the Townsville Sheet area near Fern Springs homestead. These outcrops were not examined, but strongly weathered and lateritized granitic rocks were visited in the Charters Towers Sheet area only a few miles to the south. They contain feldspar phenocrysts up to 5 cm long, and have been assigned to the Lolworth Igneous Complex, which contains similar porphyritic rocks.

The Lolworth Igneous Complex intrudes the Ravenswood Granodiorite Complex in the Charters Towers and Hughenden Sheet areas. Isotopic dating of the complex in the Hughenden and Charters Towers Sheet areas has yielded an isochron of 401 $\pm$ 7 m.y. by the Rb/Sr method, and an average age of 395 m.y. by the K/Ar method. The complex was evidently intruded at the same time as the younger component of the Ravenswood Granodiorite Complex (i.e., at about the Silurian-Devonian boundary).

Close of the Early Palaeozoic

In the Burdekin River region, which in this context means the Clarke River, Townsville, Hughenden, Charters Towers, Ayr, Bowen, and Proserpine Sheet areas, a major orogeny took place between the Upper Silurian and the upper Middle Devonian. An Upper Silurian coralline fauna in the Perry Creek Formation (Clarke River Sheet area) was involved in the movement, and a coralline fauna in the Fanning River Group of Givetian age was not affected. The movement was accompanied by the widespread emplacement of granites, which have been named Lolworth Igneous Complex, Dumbano Granite (Hughenden and Clarke River Sheet areas), and Ravenswood Granodiorite Complex (younger component only). The orogeny is used by the authors as a convenient dividing line between the 'early' and 'late' Palaeozoic rocks of this part of Queensland. The late Palaeozoic stratigraphy and intrusive rocks of the Townsville Sheet area are summarized in Table 3.

TABLE 3 : LATE PALAEOZOIC STRATIGRAPHY AND INTRUSIVE ROCKS

	Rock Unit	Lithology	Remarks
LOWER PERMIAN	(d), (f)	Dolerite, microdiorite and felsite dykes	Intrude Permo-Carboniferous sedimentary-volcanic sequence (C-Pv). Some dykes intrude youngest granites (P-Mg). Probably includes two groups of basic to intermediate dykes separated by felsite dykes and granite (P-Mg). Maitland (1892).
	(P-Mg)	Chiefly biotite granite and adamellite. Minor quartz monzonite, quartz syenite, hornblende-quartz gabbro, microgranite	Mapped as Permian-Mesozoic before isotopic dates available. Intrude Permo-Carboniferous sequence. Epizonal stocks. K/Ar ages 265-270 m.y. (L. Permian). Maitland (1892).
UPPER CARBONIFEROUS TO LOWER PERMIAN	(C-Pv)	Intermediate and acid flows and pyroclastics; rare conglomerate, sandstone, shale, siltstone, coal	Stratigraphic relationship with Carboniferous sequence (Cuv, etç.) unknown. Probably several thousand ft thick. Thin seams of coal in Stuart/Antill Plains area. Intruded by L. Permian granites (P-Mg). Jack (1892); Maitland (1892); Dunstan (1905).
	(an)	Andesite dykes	Radiate from Mt Kitty O'Shea. Intrude Frasnian-Tournaisian sediments. Probably related to diorite (C-Pb).
	(C-Pg) (C-Pb)	Granite, adamellite, granodiorite, diorite	K/Ar isotopic ages from 277 to 282 m.y. Intrude Carboniferous and Devonian sequences. Less acid types (C-Pb) probably earlier. Includes granite at Magnetic Island (mapped 'P-Mg').
	Pall Mall Adamellite (C-Pa)	Pink and grey coarse porphyritic biotite adamellite	Intrudes Tournaisian and older formations. K/Ar isotopic age of 285 m.y. (Wyatt, 1962).
	(C-Pp)	Acid porphyry, grading to microgranite	Intrude Devonian sediments, U. Carboniferous volcanics (Ct, Cs, Cuv), and Argentine Metamorphics. Probably related to Palaeozoic granites.
	(C-Pi)	Dolerite, microdiorite	Intrude Devonian to U. Carboniferous sequences. Intruded by late Palaeozoic granite (C-Pg). Irregular bodies and dykes.
	(f), (an)	Quartz-feldspar porphyry, andesite	Dykes intruding Oweenee Granite parallel to Sybil Graben. Possibly related to intrusive rhyolite (C-Ph).
	(C-Ph)	Light-coloured rhyolite; minor dacitic intrusive breccia	Isolated plugs and sills. Intrude Ravenswood Granodiorite Complex, Devono-Carboniferous sequence, and Oweenee Granite. Gold at Mt Success.

LATE PALAEOZOIC	(Pzu)	Mica schist, hornfels, gneiss, quartzite, metamorphosed siltstone, sandstone, arkose, and limestone	Some areas probably equivalent to Devonian and Carboniferous units. Mainly contact metamorphics. Jack (1886b, 1892).
UPPER CARBONIFEROUS	(Cuv)	Dark rhyolite and dacite; volcanic breccia and agglomerate	Intruded by Oweenee Granite and other late Palaeozoic granites (C-Pg, C-Pb). May include high-level intrusives. Probably U. Carboniferous.
	(Cuy)	Rhyolite and andesite flows and associated pyroclastics	Probably U. Carboniferous. Thickness unknown.
	Tareela Volcanics (Ct)	Andesite and rhyolite flows and associated pyroclastics; minor sediments	Unconformable(?) on Star Beds. 10,000 ft thick. Wyatt (1963).
	Insolvency Gully Formation (Ci)	Subgreywacke, feldspathic sandstone, siltstone, mudstone, conglomerate, chert	Faulted against St James Volcanics and Game Hill Beds. Intruded by granite(C-Pg) and granodiorite (C-Pb). 3500 ft thick. Plant fossils, animal tracks. Wyatt (1963); McKellar (1963b).
	St James Volcanics (Cs)	Andesite flows and associated pyroclastics, subgreywacke, rhyolite flows and associated pyroclastics	Unconformable(?) on Game Hill Beds. Faulted against Insolvency Gully Formation. Intruded by porphyry (C-Pp). Possibly equivalent to Tareela Volcanics. 3000-3500 ft thick. Wyatt (1963).
	Marshs Creek Beds (Cm)	Conglomerate, subgreywacke, siltstone, feldspathic sandstone, quartz sandstone, shale, tuffaceous and siliceous mudstones, limestone, arkose	Conformable on Hells Gate Rhyolite. Unconformable beneath lateritized Tertiary sediments. At least 4000 ft thick. Fish and plant fossils. Wyatt (1963).
	Hells Gate Rhyolite (Ch)	Rhyolite flows and associated pyroclastics, minor tuffaceous sediments	Unconformable on Clarke River Formation and Siluro-Devonian sequences. Faulted against Oweenee Granite. Thickness variable, max. 3000 ft. Saint-Smith (1922); Bush (1959); Wyatt (1963).
	Ellenvale Beds (Ce)	Rhyolitic flows and pyroclastics; subgreywacke, feldspathic sandstone, conglomerate, shale, mudstone	Possibly conformable on unnamed Carboniferous sediments and volcanics(C). Faulted against Ravenswood Granodiorite Complex and Fanning River Group. Intruded by granite(C-Pg) and porphyry(C-Pp). Probably about 10,000 ft thick. Plant fossils. Wyatt (1963).

	Rock Unit	Lithology	Remarks
	(C)	Shale, chert, limestone, sub-greywacke, conglomerate; andesite flows and associated pyroclastics; minor rhyolite and sandstone	Conformable on Percy Creek Volcanics. Conformable(?) beneath Ellenvale Beds. About 3300 ft of sediments and 800 ft of volcanics. Plant fossils. Wyatt (1961).
	Percy Creek Volcanics (Cp)	Andesitic flows and pyroclastics	Unconformable on Devono-Carboniferous sequence. Conformable beneath unnamed Carboniferous sediments and volcanics(C). About 600 ft thick. Wyatt (1961).
	(Cg)	Coarse pink granite, minor porphyritic microgranite	At Townsville, non-conformable beneath Permo-Carboniferous sequence (C-Pv); intrusive contact with older rocks not known. Intrudes Siluro-Devonian sequences near Ewan, where it is probably late L. Carboniferous. Tin deposits NE of Ewan. Maitland (1892).
CARBONIFEROUS	Oweenee Granite	Pink porphyritic granite and microgranite	Rb/Sr isochron of 330 m.y., but intrudes U. Carboniferous Volcanics (Cuv, Cuy) in NE, so may include some uppermost Carboniferous to L. Permian granite. Intrudes Siluro-Devonian sequences near Ewan, Running River Metamorphics, Devonian and L. Carboniferous sequences. Faulted against Sybil Group. Tin deposits S. and E of Ewan; tin-copper at Macaulay Cr. and Mt Oweenee area. Minor wolfram, bismuth, silver, zinc. White et al. (1959b).
M. DEVONIAN TO L. CARBONIFEROUS	(D-C)	Sandstone, shale, conglomerate, limestone	Six separate poorly exposed areas. In places, probably equivalent to Fanning River Group, Dotswood Formation, Star Beds, Clarke River Formation.
LOWER CARBONIFEROUS (TOURNAISIAN)	Clarke River Formation (Cc)	Sandstone, shale, limestone, conglomerate	Equivalent in part to Piccadilly Formation. Unconformable on Kangaroo Hills Formation. Intruded by Oweenee Granite and possibly by diorite (C-Pb). Thickness probably several thousand ft. Marine and plant fossils. White (1959b); Wyatt & White (1960).
	Piccadilly Formation (Ca)	Arkose, feldspathic sandstone, quartz-pebble conglomerate	Conformable on Hardwick Formation. 1200 - 1700 ft thick. Wyatt (1963).

U. DEVONIAN TO L. CARBONIFEROUS	Game Hill Beds (D-Cg)	Feldspathic and quartzose arenites, shale, mudstone, limestone, conglomerate, subgreywacke	Probably equivalent to Star Beds. Unconformable on Argentine Metamorphics. Unconformable or disconformable beneath St James Volcanics. Intruded by porphyry (C-Pp). About 2500 ft thick. Abundant marine fossils and plants. Wyatt (1963).
	Star Beds (D-Cs)	Calcareous sandstone, shale, siltstone, limestone, arkose, subgreywacke, conglomerate	Unconformable between Argentine Metamorphics and Tareela Volcanics. Intruded by Oweenee Granite and porphyry (C-Pp). About 2300-2700 ft thick. Abundant marine fossils and plants. Copper in Reedy Bed Cr area probably related to Oweenee Granite. Jack (1879a); Wyatt (1963).
	Hardwick Formation (D-Ch)	Feldspathic sandstone, arkose, subgreywacke, shale, limestone, siltstone	Conformable between Lollypop Formation and Piccadilly Formation. Intruded by Pall Mall Adamellite. Equivalent to parts of Star and Game Hill Beds and Clarke River Formation. Wyatt (1963).
	Lollypop Formation (D-Cl)	Feldspathic sandstone, conglomerate	Conformable between Myrtlevale Beds and Hardwick Formation. Intruded by Pall Mall Adamellite. At least 1500 ft thick. No fossils observed. Wyatt (1961, 1963).
UPPER DEVONIAN (FAMENNIAN)	Myrtlevale Beds (Cum)	Feldspathic sandstone, siltstone, shale, rare limestone and conglomerate	Conformable between Dotswood Formation and Lollypop Formation. 900-1000 ft thick. Abundant marine fossils; rare plants. Wyatt (1961, 1962, 1963).
UPPER DEVONIAN (FRASNIAN)	Dotswood Formation (Dud)	Feldspathic sandstone, arkose, conglomerate, red shale, siltstone, tuff	Overlapping and probably disconformable on Fanning River Group. Intruded by Pall Mall Adamellite, dolerite and microdiorite (C-Pi), and dykes near Mt Kitty O'Shea. About 8000 ft thick. Continental deposits. Rare plant fossils. Gold at Far Fanning diggings; gold-copper at Great Caesar mine; gold at Piccadilly mines, copper at Mount Keelbottom. Jack (1879a); Wyatt (1961, 1962, 1963).
MIDDLE DEVONIAN (GIUETIAN)	Fanning River Group (Dmf)	Arkose, subgreywacke, coralline limestone, sandstone, shale	Nonconformable on Ravenswood Granodiorite Complex. About 1200 ft thick. Abundant marine fossils. Limestone biostromal. Limestone deposits worked in Calcium area; gold at Mt Success and Golden Valley; gold prospect near Calcium; iron near Woodstock. Jack (1879a,b); Hill (1942); Wyatt (1961, 1962, 1963).

MIDDLE DEVONIAN

Redefinition of Burdekin Basin

Sedimentation resumed in Givetian times with the deposition of marine strata. The sediments were deposited in the eastern part of Whitehouse's Burdekin Basin (the western part has since been named the Broken River Embayment by Hill, 1960) and in his Reid River Basin (Whitehouse, 1930). Sedimentary conditions in the Broken River area were essentially similar to those in the Burdekin area from Givetian to Tournaisian times, but the Broken River Embayment contains a great thickness of Silurian to possibly Lower Devonian strata ('early Palaeozoic') in the northwest which are absent in the eastern part of the Burdekin Basin. In coining the term Burdekin Basin Whitehouse referred to the Devonian as a whole, and was apparently not aware of the importance of the Lower Devonian orogeny. It is therefore proposed to redefine the Burdekin Basin as the area between Laroona, Valpré, and Burdekin Downs homesteads in the west, and Speeds Creek, Calcium, and Fanning River homestead in the east (i.e., embracing Whitehouse's Reid River Basin), in which sedimentation commenced in the Givetian (Fanning River Group), and ranged through to the Tournaisian.

Fanning River Group (Dmf)
(new name)

The sequence around Fanning River homestead is here designated the Fanning River Group. The group comprises a basal sandstone sequence followed by a coralline limestone sequence and a sandstone-shale sequence. The terms Burdekin Beds (Jack, 1886a,b), Burdekin Formation (Jack, 1892), and Burdekin Series (Dunstan, 1913; Reid, 1930) have been used mainly for the coralline limestone sequence in various parts of the Burdekin Basin. The term Burdekin Formation has therefore been restricted to the limestone section.

Wyatt (1961, unpubl.) subdivided his Fanning Group (sic) into the Golden Valley Formation (oldest), Fanning River Formation, and Cultivation Gully Formation (youngest), but in this Report, because the name Golden Valley is preoccupied, the names adopted are as follows:

	(	3. Cultivation Gully Formation
	(	
Fanning River Group	(	2. Burdekin Formation
	(	
	(	1. Big Bend Arkose (Heidecker, 1960, unpubl.).

The group has not been subdivided on the map.

Big Bend Arkose

Heidecker (1960, unpubl.) has described a sequence of arkose and conglomerate at Big Bend on the Burdekin River about 15 miles north of Charters Towers to which he applied the name Big Bend Arkose. These beds were not studied in detail during the present survey, but similar sequences at the head of Emu Apple Creek, 10 miles north-northeast of Burdekin Downs homestead, and at Golden Valley, on the western side of Mount Success, were studied more fully.

At the head of Emu Apple Creek they consist of buff medium to coarse feldspathic sandstone and subgreywacke, with interbedded calcareous beds containing abundant large gastropods, small stout branching bryozoa, and stout disphyllids. The sandstone weathers readily and is poorly exposed, but the beds appear to be about 1 foot 6 inches to 3 feet thick.

About Pigeon Box Mill on Three Mile Creek, the lowest beds are red-brown sandy siltstone and boulder conglomerate containing boulders derived from the underlying Ravenswood Granodiorite Complex. To the northwest, near Sommerview Mill, red shale and siltstone, cream to brown feldspathic sandstone, and lithic arkose occur, but the coralline limestone of the Burdekin Formation is absent, and the upper sandstone-shale sequence is indistinguishable from the Big Bend Arkose or the lower part of the overlying Dotswood Formation.

At Golden Valley the sediments are about 50 feet thick; they comprise cobble to boulder conglomerate overlain by subgreywacke and feldspathic sandstone with occasional disphyllid corals.

In the unnamed creek on the east side of Keelbottom Creek between Turtle and Lime Creeks, the coralline limestone is underlain by impure arkose and some brown shale, and the limestone and sandstones are much more intermixed than in the Fanning River or Burdekin Downs areas.

North of Laroona homestead feldspathic sediments have been noted below the limestone, but they are generally obscured by rhyolite porphyry dykes.

At Reid Gap, about 50 feet of arkose and feldspathic sandstone rest nonconformably on the biotite granodiorite (Ravenswood Granodiorite Complex) to the south of the lime quarry. Similar beds, up to 100 feet thick, crop out at the base of the group about 3 miles east-southeast of Reid Gap. Behind the main quarry at Calcium the basal beds consist of coarse white quartz conglomerate, and on the strike ridge east of Reid Gap they consist of thin quartz conglomerate. On the hill southeast of Calcium quarry the sequence consists of about 40 feet of contact-metamorphosed quartz sandstone, calcareous sandstone, and silty feldspathic sandstone.

The Big Bend Arkose is generally between 50 and 100 feet thick, but in the Emu Apple Creek area it exceeds 200 feet, and at Big Bend Heidecker gives a thickness of 250 feet for his type section and 300 feet elsewhere. The Big Bend Arkose is probably thicker in the southwestern part of the basin, but its distribution is erratic, and in places the Burdekin Formation rests directly on granitic basement.

The Big Bend Arkose is overlain by and interfingers with the Burdekin Formation.

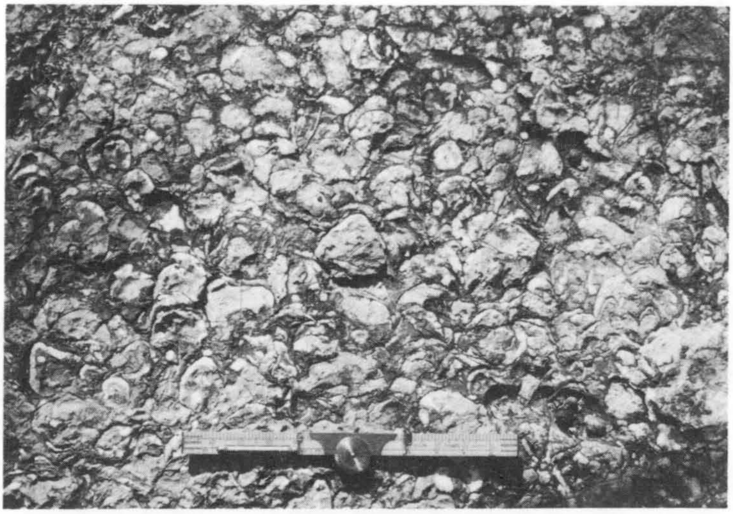
Burdekin Formation

The Burdekin Formation is well developed in the Fanning River north of Fanning River homestead. The name is derived from Burdekin Downs homestead, where Jack (1879a) first described the limestone, but his later descriptions refer to the Fanning River area, where the sequence is much better exposed.

The formation comprises about 600 feet of calcareous shale, calcilutite, fossiliferous limestone, and coral, bryozoan, and shell coquinas. A few interbeds of calcareous feldspathic sandstone and shale occur at the base, and calcareous sandstone and shale at the top.

The sequence is well bedded; the beds average 4 to 6 inches thick, but range up to 6 feet. The coral and other organic remains have commonly been slightly reworked, but it is unlikely that the material has been transported any appreciable distance, and this is confirmed by the preservation of some stromatoporoid nigger-heads in situ.

The limestones at Burdekin Downs, Valprē/Miles Lake area, and Laroona are similar to those in the Fanning River. At Calcium, however, the formation has been altered by thermal metamorphism and intense faulting. The beds of argillaceous or sandy limestone at the base and top of the calcareous sequence have been converted into calc-silicate hornfels (GSQ 15190), anthophyllite-cordierite hornfels (GSQ 15191), and wollastonite-garnet



3. Coquina of large Stringocephalus shells in the Burdekin Formation, Fanning River Group, 2.7 miles northeast of Reid River railway siding, 34 miles south of Townsville.

4. Polymictic pebble to cobble conglomerate, Dotswood Formation, 1.2 miles south-southeast of Calcium railway siding, 28 miles south of Townsville.

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In the Reid Gap area, McKellar (1964, unpubl.) has determined Nuculidea sp., Edmondia sp., Tentaculites sp., Warrenella sp., Atrypa cf. desquamata Sow., Calceola sandelina Linn., Aulopora sp., Cypricardella sp., Chonetes sp., Kayserella sp., Ptychodesma sp., and Neoactinodonta amygdalina Heidecker.

The Cultivation Gully Formation is usually overlain by conglomerate which has been mapped as the base of the Dotswood Formation. The Cultivation Gully Formation is 550 feet thick in the type area, which is probably the maximum thickness in the Fanning River/ Burdekin Downs/Laroona area. In the Calcium/Reid Gap area the thickness may be as much as 2000 to 2800 feet, but the detailed structure of the area is uncertain.

UPPER DEVONIAN

Dotswood Formation (Dud)
(amended name)

The sequence of arkose, shale, sandstone, and conglomerate overlying the Fanning River Group was named the Dotswood Beds by Jack (1879a). The beds are characterized by the presence of redbeds. The name is here revised to Dotswood Formation.

Jack based his description of the Dotswood Beds on the area immediately north of Dotswood homestead, but the formation is best developed between Fanning River homestead and Moodys Dam, where it is exposed in many creeks and gullies. The Fanning River/Dotswood road is designated as the type section.

In the type section, the lower part of the formation consists of 1475 feet of coarse buff feldspathic sandstone and subgreywacke with minor conglomerate and tuff. The middle section consists of 3600 feet of red shale, siltstone, and sandstone, with minor quartz sandstone, lithic conglomerate, and arkose, and the upper section of about 3000 feet arkose, feldspathic sandstone, and lithic conglomerate, with subordinate shale and siltstone.

Beyond the type area the thickness of the sections varies according to facies changes related to the distance from the source area, but that of the formation as a whole remains about the same. The formation appears to be continental in origin, and to have formed a broad piedmont deposit.

The basal conglomerate is widespread. North of Fanning River homestead, the conglomerate resting on the Fanning River Group consists of fragments of grey cherty mudstone set in a white argillaceous sandy matrix which is probably tuffaceous in places. The conglomerate and associated sandstone contain numerous fragments of fossil plants. It was probably from a similar white sandstone that Jack (1879b) collected Dicranophyllum australicum, now regarded as Protolepidodendron. In the small creek flowing into Keelbottom Creek between Lime and Turtle Creeks northeast of Dotswood homestead, the base of the formation is represented by a well rounded quartz-pebble conglomerate. The conglomerate with phenoclasts of granite and limestone in the Deadmans Gully area near Calcium probably represents the base of the Dotswood Formation (Fig. 4). The presence of limestone boulders indicates a period of erosion of the underlying Fanning River Group. A sudden change to continental conditions is indicated by the plant-bearing tuffaceous sediments near Fanning River homestead; the quartz-pebble conglomerate northeast of Dotswood homestead also points to a period of non-subsidence during which the labile materials were removed. There is no angular unconformity between the Fanning River Group and the Dotswood Formation, but the basal conglomerate signifies a disconformity.

Near the head of Ten Mile Creek, 12 miles north of Burdekin Downs homestead, the Fanning River Group apparently thins out, and the Dotswood Formation rests nonconformably on the Ravenswood Granodiorite Complex. Similarly, northwest of Mount Jack, the Fanning River Group is absent, and the Dotswood Formation rests unconformably on the Argentine Metamorphics.

The Dotswood Formation is generally well bedded, particularly the thin-bedded fine red sandstone and shale of the middle section. The conglomerate and sandstone in the upper section are not so well bedded, and the conglomerate is commonly cross-bedded and unsorted.

Interbeds of tuff occur in the lower feldspathic sandstone sequence. The tuff crops out in a low ridge to the west of Fanning River homestead. It is pale green and up to 30 feet thick.

The lithic conglomerates in the middle and upper sections are composed mainly of acid volcanic porphyries.

The abundance of feldspar in the other beds suggests that they were derived from a granitic terrain. In the redbed sequence in the middle section the grains are not well rounded.

The formation is poorly fossiliferous. The fossils have been recorded in the redbeds in the middle and upper sections. Protolepidodendron occurs in the basal conglomerate and sandstone north of Fanning River homestead, and Leptophloeum australe in tuffaceous sediment 4 1/4 miles to the south. McKellar (1963a) has determined ? Protolepidodendropsis sp., cf. Protopteridium sp., Sublepidodendron sp., and Stigmaria sp. from the Dotswood Formation 2 miles southeast of Valpré homestead. McKellar suggests that the flora is Upper Devonian.

The Dotswood Formation is overlain by the Myrtlevale Beds, possibly with some regional overlap.

Myrtlevale Beds (Dum)
(new name)

The marine sequence between Myrtlevale Hut and Moodys Dam is here designated the Myrtlevale Beds. The beds form narrow belts of low ground which can generally be readily identified on the air-photographs. They contain a prominent Cyrtospirifer fauna, and are a valuable marker horizon in the Devono-Carboniferous sequence.

The Myrtlevale Beds consist of a lower sandstone sequence which underlies and interfingers with a siltstone-shale sequence. The basal clastics consist mainly of coarse feldspathic sandstone grading into subgreywacke; in places, a thin basal quartzose conglomerate is present. Pebbly sandstone also occurs, but the pebbles invariably consist of quartz, quartzite, chert, and jasper, unlike the labile porphyry and granite pebbles in the underlying Dotswood Formation. The sandstone in this part of the sequence tends to be coarsely bedded and cross-laminated. The only fossils recorded are lepidodendroid plants, including Leptophloeum australe.

In the middle part of the formation, where the upper and lower sequences interfinger, cherty quartz sandstone appears, and the sediments become finer and contain a lower proportion of labile constituents. Lamellibranchs and Leptophloeum australe are found in the same beds. In the upper finer-grained section, khaki siltstone is plentiful, and the sandstone becomes thinner-bedded and ripple-marked; thin Cyrtospirifer coquinas are interbedded with siltstone and shale, which rapidly become more common upwards. Rare thin beds of limestone with solitary corals are present in the shale sequence. Calcareous and sandy Cyrtospirifer coquinas reappear near the top of the section. The lithology of the Myrtlevale Beds indicates that they were laid down in a shallow transgressive sea.

In the type area, the Myrtlevale Beds are 1050 feet thick, but the average thickness in the basin is probably about 900 feet. The succession has not been studied in detail outside the type area, but the unit can be recognized by its faunal assemblage and its stratigraphic position above the redbed sequence of the Dotswood Formation. All sections observed consist of a coarse and relatively unfossiliferous lower sequence overlain by a finer and richly fossiliferous upper sequence.

McKellar (1962c, unpubl.) has assigned a Famennian age to the beds. The fossils include : Cyrtospirifer sinensis var. australis, Spirifer sp., Mucrospirifer kennedyensis, Athyris sp., Yunnanella sp. Camarotoechia cf. lucida, Schizophoria cf. pierrensis, Spinulicosta sp., Chonetes sp. a, Chonetes sp. b, Chonetes sp.c, Chonetes sp.d, Chonetes sp., Chonetes cf. macropatus, Tenticospirifer cf. grandis, Tenticospirifer sp., Chonetipustula sp., Emanuella sp., Gurichella sp., Schuchertella sp., Thomasaria sp., ?Avonia sp., Cleiothyridina sp., Pernopecten sp., Aviculopecten sp., Crenipecten sp., cf. Cypricardinia sp., cf. Mytilus sp., cf. Pteria sp., Edmondia sp., Actinopteria sp., Modiomorpha sp., Leiorhynchus sp., Sanguinolites sp., Grammysia sp., cf. Loxonema sp., Straparollus sp., Sepulospira sp., Bellerophon sp., Pseudozygopleura sp., cf. Spyoceras sp., cf. Orthoceras sp., Clasochonus sp., and Leptophloeum australe.

The Myrtlevale Beds overlie the Dotswood Formation, probably with slight overlap, and are conformably overlain by the Lollypop Formation. The formation is probably equivalent to the lower parts of the Game Hill and Star Beds.

UPPER DEVONIAN/LOWER CARBONIFEROUS

Lollypop Formation (D-Cl)
(new name)

The sequence of feldspathic sandstone and conglomerate in Pintpot Creek, northwest of Lollypop Dam, was named the Lollypop Formation by Wyatt (1962, unpubl.). In the Myrtlevale/Dotswood/Percy Creek area, a similar sequence has been mapped by Wyatt (1961, 1962, unpubl.); although the beds are not continuous with the outcrops in the type area, their lithology and stratigraphic position between known fossiliferous formations clearly indicate that they are equivalent to the Lollypop Formation.

The Lollypop Formation consists mainly of feldspathic sandstone and minor conglomerate, although conglomerate is abundant east of Pelican Dam. Conglomerate occurs throughout the sequence, but is rather more abundant in the middle. The sandstone is fairly well bedded, and the beds are generally 2 to 4 feet thick. Large-scale cross-bedding is present in places, especially southeast of Pelican Dam.

Much of the sandstone is silicified at the surface. The Lollypop Formation is more resistant to erosion than the shales in the underlying Myrtlevale Beds and overlying Hardwick Formation, and it generally forms higher ground.

In the type area, the Lollypop Formation is about 1500 feet thick; near Pelican Dam the thickness increases to 2400 to 2700 feet, but south of Mount St Michael, near Dotswood, it is probably about 1000 feet thick.

No fossils have been found in the Lollypop Formation. The fossils in the underlying Myrtlevale beds indicate a Famennian age; those in the basal beds of the overlying Hardwick Formation indicate only a general Upper Devonian to Lower Carboniferous age, and definite Tournaisian fossils are not found until about 1000 feet above the base of the Hardwick Formation. The Tournaisian beds can be correlated with the Lower Tournaisian strata in the Star Beds, and it is possible that the lower part of the Hardwick Formation is, in part, Famennian. If this is so, then the Lollypop Formation, which conformably underlies the Hardwick Formation, is Famennian. However, it is possible that the Hardwick Formation is entirely Tournaisian, and the Lollypop Formation may extend into the lower part of that stage.

Hardwick Formation (D-Ch)
(new name)

The Hardwick Formation conformably overlies the Lollypop Formation. It was described and named by Wyatt (1963, unpubl.). The beds in Topsy Creek south of Mount St Michael and eastwards towards Percy Creek are similar in lithology to those in the type area and are regarded as equivalent to the Hardwick Formation.

The lower part of the Hardwick Formation consists of poorly sorted arkose to subgreywacke with interbedded grey shale and siltstone; the finer-grained sediments contain abundant plant remains in the upper levels. These beds are followed by a well bedded unfossiliferous limestone, from 2 to 4 feet thick, which is probably equivalent to similar limestones in the Clarke River Formation, Star Beds, and Game Hill Beds. The limestone is overlain by poorly sorted feldspathic and limonitic arenite, which is succeeded by grey-brown fossiliferous marine shale. The shale sequence contains a 4 to 6-foot bed of fossiliferous limestone, which is probably equivalent to limestones noted in the Star Beds (in the headwaters of the North Branch of the Little Star River) and in the Game Hill Beds (west of the northern tributary of Cattle Creek). The shale is followed by interbedded shale and feldspathic sandstone; the arenites are better sorted than those in the lower part of the succession, and the shale is darker in colour and unfossiliferous. The sequence at the head of Pintpot Creek is about 2700 feet thick.

In Topsy Creek, the lowest part of the formation exposed consists of shale, siltstone, and mudstone, which commonly contain abundant comminuted plant fragments. They are followed by medium to coarse feldspathic sandstone and subgreywacke, usually containing well rounded small to large quartz pebbles. Following a concealed interval equivalent to about 110 feet of strata, there is a thin bed of highly silicified conglomerate which contains rare impressions of lepidodendroid plant stems. The shale overlying the conglomerate also contains plant remains. Next follows a sequence of interbedded poorly sorted feldspathic sandstone and shale; the shale becomes darker upwards, and lepidodendroid plant remains become more abundant. These beds are overlain by poorly sorted limonitic feldspathic sandstone and pebbly sandstone. Most of the upper part of the section is not exposed, except for the topmost beds of better sorted feldspathic sandstone, which are conglomeratic in places.

Some of the basal beds and the topmost beds in the Pintpot Creek section may not be represented in the Topsy Creek section, but the highest beds exposed cannot be far below the top of the formation. The basal beds have been concealed by faulting and the topmost beds have been removed by erosion.

Marine horizons have not been recognized in the Topsy Creek section, but the marine shale found elsewhere probably occurs in the unexposed area of low relief below the topmost beds exposed. Outside the type area, marine beds similar to those in the type area crop out on the southern slopes of Mount St Michael, about 1 1/4 miles north of Topsy Creek, and the same sequence has been traced eastwards along strike for about 8 miles.

The thickness of the formation in Topsy Creek is provisionally estimated at 1000 to 1200 feet, but the true thickness is uncertain because of the presence of numerous faults and dykes. In the Mount St Michael area the estimated thickness is 1000 feet, but the top of the section is not exposed.

The upper third of the Hardwick Formation is Tournaisian and contains a rich fossil assemblage. The lower part of the formation may extend down into the Famennian, but the fossils are not diagnostic.

The fossils include Avonia kennedyensis Maxwell, Linoproductus sp., Camarotoechia sp., Schizophoria cf. resupinata Martin, Prospira sp., Crurithyris cf. urei Fleming, cf. Geisina sp., Crenipecten sp., Sanguinolites sp., Loxonema sp., Brachythyris sp., Athyris sp., Ortharychia sp., Tenticospirifer sp., Naticopsis sp., Bellerophon sp., Chonetes kennedyensis Maxwell, Gürichella eleganta Maxwell, Athyris cf. randsi Eth. fil., Aviculopecten sp., Straparollus sp., ?Spinulicosta sp., Palaeoneilo sp., Porcellia cf. pearsi Eth. fil., Edmondia sp., Mucrospirifer kennedyensis Maxwell, and Leptophloeum australe M'Coy (McKellar, 1962f, unpubl.).

The Hardwick Formation is conformably overlain by the Piccadilly Formation north of the Piccadilly mine. It is intruded by the dyke swarm radiating from Mount Kitty O'Shea, and by the Pall Mall Adamellite.

Star Beds (D-Cs)

The sediments which crop out around Horse Creek, southeast of Star homestead, and around Hellhole Creek and Corner Creek to the northwest, were named the Star Beds by Jack (1879a). In 1892, Jack & Etheridge revised the name to Star Formation. Dunstan (1913), Whitehouse (1930), Bryan & Jones (1946), David (1950), and Maxwell (1951) all used the term Star Series. Parts of the present Dotswood Formation were included. On the Geological Map of Queensland (1953), the area between Fanning River and Burdekin Downs homesteads, which includes the present Dotswood Formation and Fanning River Group, is included in the Star Group, although neither is present in the type area.

It is here proposed that the name Star Beds should be restricted to Jack's type areas until the full extent of the formation has been established.

The beds comprise a basal sequence of quartz grit and conglomerate, commonly interbedded with minor red shale and siltstone at the base. The redbeds were possibly derived from red soils from continental redbeds deposited farther south in Frasnian time. The thickness of the basal conglomerate increases from about 200 feet at the prominent hill south of Horse Creek to about 3000 feet about 2 miles north-northwest of Star homestead. As the thickness increases, so does the proportion of lithic fragments, and the subgreywacke, arenite, and conglomerate become less well sorted.

The basal sandstone and conglomerate are followed by a marine sequence of olive to khaki shale which is richly fossiliferous and contains numerous septarian nodules, particularly in the lower horizons. Thin beds of limestone and calcareous sandstone occur throughout, and gradually become more abundant upwards until, at 900 to 1100 feet above the base, calcareous sandstone and shale are found in about equal proportions. The shale is still richly fossiliferous. The sandstone-shale section is overlain by more shale with mudstone, in which marine fossils are not so abundant. The beds gradually become darker upwards, and contain abundant plant remains, particularly Leptophloeum australe.

In Horse Creek, the shales are followed by a few feet of calcareous sandstone and shale and about 12 feet of well bedded fine dark blue-grey unfossiliferous limestone or calcilutite. The limestone is widespread, and crops out at Corner Creek and northwest of Ponto Yards; similar limestones have been noted in the Game Hill Beds and Hardwick Formation, and may also be present in the Clarke River Formation. The limestone represents the highest part of the Star Beds exposed in the Horse Creek section, which is about 1300 feet thick.

At Corner Creek, the limestone is followed by shale and siltstone, calcareous sandstone, coarse feldspathic sandstone, quartz grit, and conglomerate, which is succeeded by more mudstone with limestone beds, calcareous sandstone, chert, sandstone, and olive-green shale and siltstone. The Corner Creek section is possibly 2300 to 2700 feet thick. The uppermost shales contain a prolific Tournaisian marine fauna, and most of the underlying finer-grained sediments are also fossiliferous. The fossiliferous olive-green shale and siltstone are probably equivalent to the fossiliferous beds in the Clarke River Formation at Francis Creek and the fossiliferous shales in the Hardwick Formation.

The fossiliferous shales are the highest beds exposed at Corner Creek, but they may be overlain by the chert, shale, and limestone exposed west of Dinner Creek; but if present, they are concealed by alluvium in the Corner Creek and Horse Creek sections. The fossils in these beds still indicate a Tournaisian age.

The Star Beds range from Famennian to Tournaisian. The lower 900 feet of the Horse Creek section is characterized by Spinulicosta, Sentosia, Yunnanella, and Cyrtospirifer, and the upper part by Brachythyris, Prospira, and Rhytophora. The fossils recorded from Horse Creek include Prospira cf. striatoconvoluta Benson & Dun, Schuchertella sp., Rhipidomella sp., Tenticospirifer sp., Rhytophora sp., Sulcatospirifer sp., cf. Enteletes sp., Cyrtina sp., Productellidae, Brachythyris sp., Athyris sp., Crurithyris sp., Chonetes sp., Tenticospirifer cf. grandis Maxwell, Sentosia sp., Camarotoechia cf. lucida Veevers, Spirifer sp., ?Leiorhynchus sp., Yunnanella sp., Emanuella cf. torrida Veevers, Chonetes cf. macropatus Veevers, Spinulicosta sp., Cyrtospirifer sinensis var. australis Maxwell, Mucrospirifer kennedyensis Maxwell, Schizophoria cf. pierrensis Veevers, Crenipecten sp., Aviculopecten sp., Modiomorpha sp., Bellerophon sp., Loxonema sp., Straparollus cf. australis Maxwell, Cladochonus, Leptophloeum australe M'Coy, Lepidodendron aff. veltheimianum Sternberg, and indeterminate solitary rugose corals and a fenestellid (McKellar, 1962d, unpubl.).

The Middle Tournaisian fossil assemblage at Corner Creek includes Avonia kennedyensis Maxwell, Crurithyris sp., Retzia cf. radialis Phillips, Schizophoria sp., Chonetes cf. kennedyensis Maxwell, Athyris sp., Prospira typa Maxwell, Brachythris sp., Camarotoechia sp., Schizophoria cf. resupinata Martin, Gürichella sp., Loxonema sp., Bellerophon sp., Cladochonus sp., Fenestella sp., Hollinella sp., Baylea sp., Straparollus sp., Orthoceras sp., 'Phillipsia' stanwellensis Mitchell, Crenipecten sp., Aviculopecten sp., Naticopsis sp., Sanguinolites sp., and Porcellia pearsi Eth. fil. (McKellar, 1962e, unpubl.).

In the north, for example, northwest of Ponto Yards and north and south of Basin Yards, where the Star Beds are extensively faulted and intruded by granite and porphyry, the succession is discontinuous. However, the lithology is similar to that in the Horse Creek and Star River areas, and the fossils indicate a Tournaisian age.

The Star Beds range from Famennian to Tournaisian, and are at least equivalent in part to the Myrtlevale, Lollypop, Hardwick, and Clarke River Formations. They are overlain by the Tareela Volcanics, probably disconformably, and are intruded by the Oweenee Granite and associated porphyry dykes and sills.

Game Hill Beds (D-Cg)
(new name)

The sediments to the northeast and east of Game Hill in the Argentine Mineral Field are similar to the Star Beds, with which they were correlated by Jack (1886b). However, there are sufficient differences in lithology to warrant a separate name for the present. The fossils in the Devono-Carboniferous sequences show that marine conditions began earlier near Dotswood in the south than at Blue Range in the north, and it is possible the Game Hill Beds began to be laid down before the Star Beds.

The basal part of the Game Hill Beds comprises coarse pebbly feldspathic arenite and quartz-pebble and cobble conglomerate which rest unconformably on gneissic granite, possibly belonging to the Ravenswood Granodiorite Complex, or schist of the Argentine Metamorphics. The basal beds are coarser near their base, and become less conglomeratic towards the top, where red micaceous shale is interbedded. The feldspathic arenites are overlain by quartz sandstone, grey cherty mudstone, and thin-bedded khaki shale and siltstone with brachiopods and other marine fossils and a few plant remains. These beds are succeeded by fossiliferous brown calcareous sandstone and shale with occasional cherty beds, followed by beds of conglomerate up to 18 inches thick, composed of well rounded pebbles of quartz and porphyry in a calcareous arkosic matrix. The conglomerates are overlain by fine sandstone containing Leptophloeum australe and numerous marine fossils.

Above the sandstone is a coarser feldspathic subgreywacke, followed by a well bedded grey fossiliferous limestone. The same limestone crops out in Cattle Creek a few hundred yards upstream from its confluence with Keelbottom Creek. The limestone can probably be correlated with a similar limestone in the Hardwick Formation around Mount St Michael, near Dotswood.

The limestone is overlain by tough greenish brown fine to coarse quartz sandstone which passes upwards into siliceous mudstone with plant debris, including Lepidodendron sp. The mudstone is succeeded by rhythmically bedded quartz-pebble conglomerate passing up into pebbly sandstone and impure quartz sandstone. Higher in the section the sandstone grades into poorly sorted subgreywacke and greywacke with graded bedding.

The greywackes are overlain by a probably intrusive felsite breccia (C-Ph), followed by andesites of the St James Volcanics. The whole sequence, to the base of the breccia, dips east at about 40°, with a thickness of about 2500 feet.

The Game Hill Beds have been folded into domes and basins which have been downfaulted against metamorphics. The largest dome, about 8 miles in diameter, is centred on the old Argentine silver-mining area, and the underlying metamorphics are exposed in its core. In the east the Game Hill Beds are intruded by granite or overlain by volcanics. At the head of Bog Hole Creek, the Insolvency Gully Formation may overlie the Game Hill Beds, but the detailed stratigraphy and structure are uncertain.

The Game Hill Beds range from Famennian to Tournaisian in age. Fossils recorded include Chonetes sp., Camarotoechia sp., Cyrtospirifer sp., Cyrtospirifer sinensis var. australis Maxwell, Athyris sp., Gürichella cf. kennedyensis Maxwell, Schizophoria cf. resupinata Martin, Prospira prima Maxwell, Brachythyris sp., Cleiothyridina sp., Retzia cf. radialis Phillips, ?Avonia sp., Deptagonia cf. analoga Phillips, Waagenella sp., Euphemites sp., cf. Phillipsia sp., Orthonychia sp., Naticopsis sp., Straparollus sp., Baylea sp., Stigmaria ficoides Brong., and Leptophloeum australe M'Coy (Dear, 1962, unpubl.).

The form of Cyrtospirifer sp. suggests an age older than Cyrtospirifer sinensis var. australis, and the Game Hill Beds may range from lower or middle Famennian to middle or upper Tournaisian.

LOWER CARBONIFEROUS

Sedimentation was continuous from the Middle Devonian to the late Tournaisian. The beds laid down during the Tournaisian Stage include the Clarke River Formation, the Piccadilly Formation, the upper part at least of the Hardwick Formation, and the upper parts of the Game Hill Beds and Star Beds. The Tournaisian beds and the underlying Devonian sequences were uplifted and intruded by the Oweenee Granite, and continental conditions appear to have obtained during the remainder of the Carboniferous.

Piccadilly Formation (Ca)
(new name)

The Piccadilly Formation is typically developed in the headwaters of Piccadilly Creek, three-quarters of a mile to one and a quarter miles north-northwest of Piccadilly mine. It forms strike ridges which extend west-southwest from Mount Bluey towards Morgans Dam, on Valpré Holding. These ridges form the watershed between Pintpot Creek flowing northwest to the Star River and Piccadilly Creek which flows south to Keelbottom Creek. The formation also extends 5 miles south from Morgans Dam, then southwest towards Eumara Springs homestead.

The Piccadilly Formation consists of arkose, feldspathic sandstone, and conglomerate - the latter forming the strike ridges. The conglomerate becomes more common higher in the section and is composed almost entirely of well rounded quartz or quartzite pebbles of moderate sphericity in a feldspathic sandstone matrix.

The formation is fairly well bedded and current-bedding was noted in places, especially in pebbly arenites and the finer conglomerates.

Nowhere has the top of the formation been observed, because of downfaulting against older rocks. In the type area the formation is at least 1200 feet thick, but a greater thickness, about 1700 feet, exists 2 to 3 miles farther east.

The Piccadilly Formation is lithologically similar to the conglomerate of the Clarke River Formation in the Blue Range, although it lacks the prominent jasper pebbles found in the Blue Range. Its stratigraphic position above the Tournaisian Hardwick Formation, which is equivalent to the marine horizons of Francis Creek and Blue Range, indicates that it is equivalent to the upper part of the Clarke River Formation in the Blue Range. The Piccadilly Formation can probably be correlated with the conglomerates in the Star Beds.

Clarke River Formation (Cc)

The Clarke River Formation was defined by White (1959b), and described by Wyatt & White (1960, p.178) and by White (1962, 1965). In the Townsville Sheet area it crops out in the Blue Range as an outlier of the main outcrop in the Clarke River Sheet area, where the basal sequence of sandstone, shale, and limestone rests unconformably on the Kangaroo Hills Formation, and is conformably overlain by quartz grit, sandstone, and conglomerate, commonly with conspicuous pebbles of red jasper.

In the basal sequence, as for example, in Francis Creek, a marine Tournaisian fauna is present: it includes *Brachythyris* sp., *Camarotoechia* sp., *Productina* sp., *Athyris* sp., *Avonia* sp., *Plicochonetes* sp., *Schizophoria* sp., *Rhipidomella* sp., *Phillipsia* sp., *Syringopora* sp., *Beyrichia varicosa*, *Parallelodon* sp., *Entolium* sp., *Naticopsis* sp., *Platyschisma* sp., *Euomphalus* sp., *Warthia* sp., *Luciella* sp., *Murchisonia* sp., *Lepidodendron* sp., and indeterminate rugose corals, fenestellids, cephalopods, pelecypods, and brachiopods, including spiriferids and dielasmatids (Woods, 1960, unpubl.). The marine beds are probably equivalent to the fossiliferous marine beds in Corner Creek (Star Beds), Cattle Creek (Game Hill Beds), and parts of the Hardwick Formation.

In 1957, during the excavation of Berts Dam on Mickey Creek, Blue Range Holding, on the eastern margin of the Clarke River Sheet area, grey shales with abundant *Leptophloeum australe* were exposed. Similar shales were observed by Wyatt in 1961 in the unnamed creek southeast of Expedition Creek. The shales are similar to the plant-bearing shales in the Star Beds at Corner Creek and in the western tributaries of the North Branch of the Little Star River, and to shales in the Hardwick Formation. Further lithological correlation is provided by an unfossiliferous recrystallized limestone, apparently situated on a fault, which crops out in the unnamed creek mentioned above. This limestone can possibly be correlated with a well bedded unfossiliferous limestone overlying the plant beds in the Star Beds and Hardwick Formation. The lithology and Tournaisian faunal assemblage indicate that the basal Clarke River Beds are probably equivalent to parts of the Star Beds and Hardwick Formation. The slightly feldspathic quartz grit, sandstone, and conglomerate which conformably overlie the basal marine sequence, and which form the high country of Blue Range, can therefore be correlated with the Piccadilly Formation. *Leptophloeum australe* has been observed in the coarse clastics, which were possibly laid down in a continental environment.

The formation is moderately folded along northeast axes. A strong north-south fault (west block down) occurs near the western margin of the formation. Another fault, trending west-northwest, crosses the formation near its northern margin, and the beds show opposite dips on either side of the fault. It is possible that the boundaries of the formation in the Blue Range are controlled by faults.

The Clarke River Formation is overlain, probably unconformably, by the Sybil Group.

MIDDLE DEVONIAN TO LOWER CARBONIFEROUS

Unnamed Sediments (D-C)

On the map accompanying this Report there are six areas of sediments which are regarded as Devonian/Lower Carboniferous, but which have not been assigned to a named unit.

The southernmost area, between Keelbottom Creek and the Burdekin River, southwest of Quilps homestead, is poorly exposed owing to the thick cover of sand, soil, and pebbles derived from the overlying sheet of Tertiary laterite. The main rock type noted is red sandstone similar to that in the Dotswood Formation. Most of the area is probably occupied by a continuation of the Dotswood Formation, which crops out to the northeast around Quilps homestead and Hardwick Tank, and to the southeast around Mount Keelbottom.

Northeast of Valpré homestead, the sediments are bounded to the south and east by faults which separate them from Devono-Carboniferous rocks in which the succession has been established. The beds are no doubt continuous with the surrounding Devono-Carboniferous sequence, but are largely concealed by Cainozoic deposits.

South of Laroona homestead there is a small block of sediments which are folded into an anticline plunging east-northeast. The beds include fossiliferous limestone and sandstone which can be correlated with the Fanning River Group on lithological and palaeontological evidence. They also include fossiliferous marine sandstone and shale of Tournaisian age. The relationship of these fossiliferous beds has not been established, as they are mainly covered by soil and rubble. A great thickness of the Dotswood Formation crops out 3 miles to the southeast, but much of the Upper Devonian sequence has probably been faulted out along faults related to the Sybil Graben.

A sequence of feldspathic sandstone, shale, and conglomerate crops out 3 miles northeast of Lassies Creek homestead. Most of the beds are deeply weathered and overlain by a thin cover of laterite. They contain indeterminate lepidodendroid plant remains. The beds are overlain by tuff, tuffaceous sediments, and the Upper Carboniferous Hells Gate Rhyolite.

A narrow belt of sediments crops out 9 miles west-southwest of Lassies Creek homestead; the belt extends south from the Rio Tinto mine to Stockyard Creek. The beds are poorly exposed, but include sandstone and conglomerate. The conglomerate contains pebbles of quartz and schist, and is similar to the conglomerate in the Star Beds a few miles southeast of Basin Yards. The sediments appear to rest unconformably on amphibolite (Argentine Metamorphics) west of the Rio Tinto mine, but the structure is difficult to interpret because of the presence of faults and late Palaeozoic rhyolite dykes.

A small area of feldspathic sediments, which are probably a continuation of the Clarke River Formation on the adjoining Clarke River Sheet, crops out 7 miles northwest of Allensleigh homestead. They have been mapped by photo-interpretation. The sediments are not identical with those in the typical Clarke River Formation, and it is possible that they do not entirely belong to this formation.

Close of the Devono-Carboniferous Depositional Cycle

After the deposition of the Tournaisian sediments, the region appears to have been uplifted and slightly warped. The change from marine to continental conditions in the Clarke River, Hardwick, and Piccadilly Formations is probably related to these epeirogenic movements. The Oweenee Granite was intruded during these movements.

Uplift was followed by a short period of erosion, and then, in the late Middle to Upper Carboniferous, the volcanics were extruded and lithogenetically related sediments were laid down. The later Carboniferous rocks rest unconformably on the Tournaisian strata, but the unconformity can be only recognized on a regional scale.

The continental deposits laid down after this brief period of non-deposition comprise the Percy Creek Volcanics, St James Volcanics, Tareela Volcanics, Sybil Group, Insolvency Gully Formation, Ellenvale Beds, and unnamed volcanics and sediments in the Fanning River/Hervey Range area.

CARBONIFEROUS GRANITES

The first recognizable episode of granite emplacement in the late Palaeozoic is that of the Oweenee Granite, which intrudes the Clarke River Formation (Tournaisian) and is probably overlain nonconformably by the Sybil Group (late Middle or Upper Carboniferous). Some of the granite at Mount Stuart near Townsville is nonconformably overlain by Permo-Carboniferous rocks, and is presumed to be Carboniferous.

Oweenee Granite (Cgo) and Unnamed Granite Northwest of Running River (Cg)

The Oweenee Granite, which forms part of the Perry Ranges west of the Burdekin River, was defined by White et al. (1959b, unpubl.) in the Clarke River Sheet area. Similar granite which forms the Coane Range northeast of the Sybil Graben is also referred to the Oweenee Granite. The granite northwest of Running River is similar to the Oweenee Granite, but is left unnamed at this stage.

The Oweenee Granite is generally light pink to pinkish grey. The proportion of mafic minerals is low, and they are commonly partly or completely chloritized. The granite usually contains large feldspar phenocrysts, and quartz phenocrysts are also common in places.

The granite is strongly jointed and fractured in a northwesterly direction. The fractures become more abundant near the Sybil Graben. The Sybil Group, which occupies the graben, is faulted against the granite, and therefore it is not possible to use the absence of a metamorphic contact zone in the Sybil Group as evidence that the granite is older. In Tomahawk Creek there is a vent associated with the Hells Gate Rhyolite. The vent is filled with rhyolite and volcanic breccia containing granite fragments similar to the unnamed granite (Cg) forming the watershed between Douglas and Little Oakey Creeks. These relationships suggest that the Oweenee Granite and the unnamed granite north of Running River are older than the Sybil Group, which is probably late Middle or Upper Carboniferous. The Oweenee Granite is known to intrude the Tournaisian Clarke River Formation; it was probably intruded during the period of uplift and warping which intervened between the Tournaisian Stage and the late Middle or Upper Carboniferous.

An Rb/Sr isochron of 330 $\pm$ 7 m.y. (late Lower Carboniferous) was obtained by Webb (1969) from specimens of the Oweenee Granite and the contiguous area of granite in the Ingham Sheet area. This figure, which represents approximately an upper Visean age, is considerably greater than the K/Ar ages, which range from 275 to 300 m.y. (Richards et al., 1966; Webb, 1969). The 330-m.y. age fits in well with the field evidence in the Sybil Graben area, where it would confirm that the Oweenee Granite is older than the Sybil Group, but it creates an anomaly in the Star River/Paluma district, in that the volcanics (Cuv, Cuy) intruded by the Oweenee Granite there are thought to be the same age as the Sybil Group. More mapping is required, to find out whether the volcanics are of different ages or whether there is more than one granite.

Twelve K/Ar mineral ages, whose close grouping around an average age of about 280 m.y. is not suggestive of argon loss, have been obtained from granites in the Harvey Range/Piccadilly area (C-Pg, C-Pb, C-Pa). These granites commonly intrude the late Middle to Upper Carboniferous stratified rocks, thereby confirming a distinctly younger period of granite emplacement, close to the Carboniferous-Permian boundary.

Unnamed Granites near Townsville (Cg)

On the hillside one-third of a mile south of Stuart village Permo-Carboniferous conglomerate rests nonconformably upon a granite that does not resemble any of the early Palaeozoic granites and is presumed to be Carboniferous. Other areas of similar granite around Townsville are likewise regarded as Carboniferous, a contention which is supported by the presence of granitic phenoclasts in the Permo-Carboniferous succession elsewhere.

The granite at Stuart and the overlying conglomerate were described by Maitland (1892), who suggested a metamorphic origin for the granite because it appeared to him to grade into the conglomerate. Although the relationships are not everywhere clear, the apparent absence of contact metamorphism is taken to indicate that the conglomerate is younger. The granite is coarse, pink, and leucocratic.

The eastern part of the Muntalunga Range consists of granite, which is generally coarse and rather leucocratic; in places, it is strongly sheared. The northern spur is mainly microgranite, which contains coarse phenocrysts of albite and quartz. The relationship of the granite to the volcanics was not established; the contact between granite and rhyolite in the centre of the range is brecciated and is probably faulted. Similar coarse pink leucogranite crops out on a low rise northwest of Alligator Creek siding.

At the western end of Mount Low coarse red alaskite is in contact with volcanics, but the relationship was not established.

The northeastern shoulder of the low range southeast of the gaol at Stuart consists of coarse pink leucocratic granite with milky quartz phenocrysts. Fine leucocratic granophyre is also present.

UPPER CARBONIFEROUS

Continental sediments and volcanics were deposited and extruded after the Devonian/Lower Carboniferous succession had been uplifted and warped.

Percy Creek Volcanics (Cp)
(new name)

The andesitic lavas to the north of Fanning River homestead around Percy Creek, were named the Percy Creek Volcanics by Wyatt (1961, unpubl.). In the Percy Creek/Grasshopper Creek area they are well exposed in a syncline plunging to the east-southeast. The outcrop area in the Hervey Range is poorly accessible, and is severely faulted and intruded by granite.

The Percy Creek Volcanics include porphyritic andesite and minor agglomerate. Many of the lower flows are vesicular, but the upper flows are more dense and homogeneous. The vesicles are generally filled with zeolites, calcite, or quartzo-feldspathic material. In the neighbourhood of Percy Creek Bore, the volcanics are about 600 feet thick.

The Percy Creek Volcanics rest unconformably on the Hardwick Formation east of Mount St Michael, but southeast of Percy Creek Bore and elsewhere, the contacts with the Devonian/Lower Carboniferous sediments are faulted.

The unit is similar in lithology to andesites in the Tareela Volcanics and St James Volcanics.

Unnamed Sediments and Volcanics (C)

In the Percy Creek/Grasshopper Creek area the Percy Creek Volcanics are conformably overlain by sediments, which are succeeded by more volcanics (Wyatt, 1961, unpubl.). The same rocks occur in the Hervey Range, but the area is structurally complex and has not been mapped in detail. All the strata between the Percy Creek Volcanics and the Ellenvale Beds have been mapped as 'unnamed Carboniferous sediments and volcanics'.

The sediments crop out in a triangular area between Plumtree Yards (Fanning River Holding), Percy Creek Bore, and Mount Douglas. They comprise shale, chert, limestone, arenite, and conglomerate, with a total thickness of about 3300 feet. The beds conformably overlie the Percy Creek Volcanics and, like them, are folded in a syncline plunging east-southeast at 10° to 20°. The sequence is well exposed in the gullies on Mount Douglas, but the fossiliferous black shale and impure limestone are best exposed near Plumtree Yards, and some of the thin-bedded chert along the East Branch of the Fanning River.

North of Percy Creek Bore, the sediments include arkose, siltstone, conglomerate, and shale. The sediments are fairly well bedded, and the coarser-grained pebbly arenite is cross-bedded in places. Arkose is confined to the lower part of the section, but the arenite in the upper part is mainly feldspathic sandstone. The grainsize of the arenite ranges from fine to medium. Siltstone and shale occur mainly in the lower part of the sequence. They are brown or grey-brown, and poorly laminated. Stigmaria occurs in the brown shale. The lower beds also include black chert and a few beds of black mudstone.

Conglomerate occurs mainly in the middle of the section. It consists of rounded or subangular pebbles or small cobbles of quartz, rhyolite, and acid porphyry set in a feldspathic and lithic arenitic matrix, which suggests derivation from contemporaneous volcanics.

In the upper part of the section, mainly above the conglomerate, black shale is interbedded with feldspathic sandstone and subgreywacke. The shale is well bedded, thinly laminated, and fissile. Near Plumtree Yards, the shale is associated with beds of impure limestone and calcareous subgreywacke. The shale contains decorticated stems of large Lepidodendron veltheimianum and Ulodendron sp. (de Jersey, 1959), which indicate a Carboniferous age.

Intermediate lava flows, which are seldom more than 2 feet thick, are interbedded with the sediments above the shale at Plumtree Yards, and also farther east along the Fanning River. At Plumtree Yards they are restricted to the top 50 feet of sediments, but in the Fanning River area they are more numerous and first appear lower in the section.

This phase of vulcanicity was followed by the eruption of the rhyolite breccia which forms Mount Douglas. The rhyolite rests conformably on the underlying strata, and is seldom more than 50 feet thick. It is conformably overlain by 100 feet of sediments and subordinate volcanics. The sediments comprise shale with indeterminate plant fragments, fine to coarse micaceous and feldspathic sandstone, fine mudstone, commonly with small-scale contemporaneous slump and fault structures, and micaceous siltstone. The sediments are overlain by flow-banded rhyolite and porphyry and some pyroclastics, which are followed by coarse slightly feldspathic sandstone and quartz-pebble conglomerate.

The sediments and volcanics are succeeded by andesitic, and possibly basaltic, flows and pyroclastics which are at least 800 feet thick (Wyatt, 1961, unpubl.). They are poorly to moderately well exposed, and generally form gently undulating country covered by red-brown or dark grey soil.

North of Plumtree Yards, the andesitic volcanics represent the highest beds exposed in the syncline occupied by the Percy Creek Volcanics and overlying sediments. East of Plumtree Yards, at the head of Hellhole Gorge, the andesitic sequence is possibly represented by reworked agglomeratic material which is followed by the rhyolites at the base of the Ellenvale Beds. However, the area is faulted and the relationship of the Ellenvale Beds to the unnamed Carboniferous volcanics is uncertain.

The unnamed Carboniferous sedimentary-volcanic sequence has been intruded by microdiorite (C-Pi) at The Brothers, and granite (C-Pg) between the East and West Branches of the Fanning River.

Ellenvale Beds (Ce)
(new name)

The sequence of volcanics and lithogenetically related sediments which extends along the valley of the Reid River and its tributaries upstream of Ellenvale homestead to Reid Gorge is here named the Ellenvale Beds.

In the Reid River type section the lowest beds consist of rhyolite ash flows(?), tuff, and agglomerate, overlain by conglomerate composed of waterworn volcanic material and tuffaceous arenite. They are followed by spherulitic and flow-banded rhyolite with interbeds of rhyolite agglomerate.

The volcanic rocks are succeeded by a thick sequence of poorly sorted greywacke, subgreywacke and subgreywacke-conglomerate, khaki to grey shale, and cherty mudstone. Towards the top of the sequence the subgreywacke is better sorted and grades into lithic arkose. A thick lens of conglomerate occurs in the middle of this section; it extends eastwards from the mouth of Humpybong Creek for about 3 1/2 miles, with a maximum thickness of about 200 feet.

The sedimentary beds are overlain by an agglomeratic sequence, with minor conglomerate and lithic arkose, which forms the prominent hogback south of the Reid River, upstream from Ellenvale homestead. The conglomerate is confined to two thick interbeds, the lower 80 feet and the upper 50 feet thick; they are well exposed on the northern face of the hogback. The volcanics in the upper part of the Ellenvale Beds are not present in the equivalent Marshs Creek Beds and Insolvency Gully Formation, and the volcanic sequence in the Ellenvale Beds may have been repeated by faulting. Assuming that there is no repetition by faulting the sequence near the Reid River is about 10,000 feet thick.

Many of the finer-grained sediments contain poorly preserved plant remains. The Ellenvale Beds are considered to be Carboniferous because (i) they contain fragments of cf. Rhacopteris sp. and indeterminate equisetalean stems (McKellar, 1963b, unpubl.); (ii) they occur above known Tournaisian strata and above supposedly Carboniferous sediments with Lepidodendron veltheimianum, Ulodendron sp., and Stigmaria; (iii) they are similar in lithology to the Sybil Group; and (iv) they do not contain a Glossopteris flora.

South of Reid Gorge the Ellenvale Beds have a general east-west trend and a uniform southerly dip of 35^{o} to 40^{o}. North-northeast of the gorge the dip apparently flattens out suddenly, and farther east, the beds are faulted against Devonian strata. South of the Reid River they are faulted against the Ravenswood Granodiorite Complex and the Fanning River Group. East of Ellenvale homestead the Ellenvale Beds are covered by alluvium, and to the east of the Great Northern Railway the beds generally appear to dip to the north. The beds are faulted against the Devonian north of Plant Hill, and are probably faulted against the Ravenswood Granodiorite Complex south of Horse Camp Hill.

Horse Camp Hill consists of grey flow-banded rhyolite, rhyolitic breccia, and rhyolite with abundant rounded phenocrysts of quartz or feldspar.

About 2 miles east-southeast of Reid River railway station, there is a low hill composed of green and reddish brown tuff and agglomerate dipping north at 65^{o}. Still farther north, in the bed of the Reid River, weathered fragmental volcanic rocks, mainly agglomerate, crop out. The agglomerate is generally purplish brown, and contains subangular to well rounded fragments of andesite and rhyolite. The fragments are partly waterworn and partly sorted.

A mile northeast of Reid River road bridge the lowest beds include fine-grained andesite, with pinkish white plagioclase phenocrysts, and acid and intermediate pyroclastics, which are overlain by flow-banded rhyolite. The highest beds east of the railway crop out just north of Webbs Hill; they include micaceous siltstone and shale which probably contain a high proportion of fine-grained volcanic material. The sediments are intensely fractured, probably due to their proximity to the faults separating them from the Devonian strata to the north.

The Ellenvale Beds have been intruded by late Palaeozoic microgranite(C-Pg) (e.g., the Mount Ellenvale/Brown Mountain mass), and by a Tertiary(?) sill of olivine basalt near the southern end of Reid Gorge.

The succession in the Ellenvale Beds is similar to that in the Sybil Group, although the sediments in the Sybil Group tend to be better sorted and contain a greater proportion of granitic material. The sediments of the Ellenvale Beds are similar to those in the Insolvency Gully Formation.

Sybil Group
(new name)

The Sybil Group (Wyatt, 1963, unpubl.) is a sequence of lithogenetically related volcanics and sediments which covers an area of about 170 square miles of the Parish of Sybil in the County of O'Connell. The group has been subdivided into a volcanic sequence (Hells Gate Rhyolite), overlain by a sedimentary unit (Marshs Creek Beds).

Hells Gate Rhyolite (Ch)
(new name)

The rocks which are here named the Hells Gate Rhyolite were described by Saint-Smith (1922), who regarded them as part of his 'upper Devonian (now Siluro-Devonian) Kangaroo Hills series'. Bush (1959, unpubl.) described the rhyolite at Hells Gate, and the geological map of the Kangaroo Hills area (Tweedale & Bush, 1959, unpubl.) shows some of its distribution. Wyatt (1959, unpubl.) correlated the rhyolite at the head of Marble Gully, a tributary of Marshs Creek, with the rhyolite at Hells Gate, and suggested that both rest conformably on the Clarke River Formation, but later (1963, unpubl.) he concluded that the Hells Gate rhyolite rests unconformably on the Clarke River Formation.

The Hells Gate Rhyolite is well exposed at Hells Gate - a rocky narrows on the Burdekin River. The volcanic sequence comprises fluidal and spherulitic rhyolite with minor rhyolite agglomerate, tuffaceous agglomerate, and tuffaceous sandstone. The thickness is difficult to measure because of the presence of numerous local piles of lava, but is believed to amount to 3000 feet in places.

Rhyolite is predominant; it is generally cream to green and is usually flow-banded. Spherulites are common, and range up to 20 mm and more in diameter. The rhyolites are similar to those in the Tareela Volcanics and at the base of the Ellenvale Beds.

The Hells Gate Rhyolite overlies the Kangaroo Hills, Tribute Hills, and Greenvale Formations with marked angular unconformity, and the Clarke River Formation with a slight unconformity. It is overlain conformably by the Marshs Creek Beds. The Hells Gate Rhyolite is downfaulted against the Oweenee Granite southwest of Marshs Creek. The vent breccia in the Tomahawk Creek area contains granite fragments similar to the leucocratic granite (Cg) east of Douglas Creek, against which parts of the Sybil Group are also faulted.

The Hells Gate Rhyolite is Carboniferous, as it lies above the Tournaisian Clarke River Formation and below the Carboniferous Marshs Creek Beds.

Marshs Creek Beds (Cm)
(new name)

The sequence of sediments cropping out over much of the catchment of Marshs Creek is here named the Marshs Creek Beds. They include a lower sequence of conglomerate, subgreywacke, red siltstone and sandy limestone, feldspathic sandstone, and cherty tuffaceous mudstone, which is well exposed in Marshs Creek. The upper sequence comprises subgreywacke and pebble and cobble conglomerates, interbedded with dark grey to black commonly carbonaceous shale, siliceous mudstone, siltstone, and minor arkose and quartz grit. The beds are well exposed in Long Gully, and are at least 4000 feet thick.

The sediments are well bedded. In the lower part of the sequence the beds are mostly thin, but in the upper part, particularly in the coarser clastics, individual beds may be several feet thick. Cyclic sedimentation is a characteristic feature of the upper beds; each cycle begins with conglomerate, followed by pebbly subgreywacke arenite, and finally dark shale. Large-scale current-bedding is present in the coarser clastics.

The Marshs Creek Beds are probably late Middle or Upper Carboniferous. The fossils include the palaeoniscid fish cf. Cryphiolepis sp. and cf. Elonichthys sp. (Woods, 1963, unpubl.), cf. Rhacopteris sp. (McKellar, 1963b, unpubl.), and indeterminate equisetalean stems. The Lepidodendron veltheimianum flora found in the Clarke River Formation, and Glossopteris, are absent.

The presence of both fish and plant remains suggests a freshwater or estuarine environment. The presence of carbonaceous shale and coaly plant remains also indicates a freshwater environment.

The Marshs Creek Beds rest conformably on the Hells Gate Rhyolite, and the lower part of the sequence is composed of material derived directly from the underlying volcanic terrain. The arenites in the upper part of the succession contain a higher proportion of material derived from granite and other older rocks.

East of the Burdekin River, the Marshs Creek Beds are faulted against the Oweenee Granite. The sediments are steeply inclined next to the fault and there is no evidence of contact metamorphism.

Other formations of comparable age and lithology are the Insolvency Gully Formation and the Ellenvale Beds.

St James Volcanics (Cs)
(new name)

The St James Volcanics contain interbedded sediments and are similar to the Carboniferous volcanic and sedimentary sequences north of Fanning River homestead, which crop out in the northern tributaries of Cattle Creek in the northwestern corner of the Parish of St James. Part of the sequence has been described by Wyatt (1963, unpubl.) under the provisional name Ben Lomond Volcanics.

The St James Volcanics comprise a basal sequence of andesitic volcanics overlain by brown or greenish grey, coarse-grained, poorly sorted arenites, ranging from greywacke to subgreywacke. The arenites were formed mainly by erosion of the andesitic volcanics. The sediments are overlain by rhyolite agglomerate and spherulitic rhyolite flows which grade upwards into rhyolite welded tuff(?), tuff, and more flows.

The St James Volcanics have been folded into a syncline plunging northeast at about 20°. The formation is probably 3000 to 3500 feet thick.

To the west, the contact of the St James Volcanics with the Tournaisian sediments of the Game Hill Beds is obscured by an intrusive felsite breccia (C-Ph), but by analogy with other areas, the volcanics probably rest unconformably on the Game Hill Beds. The formation is intruded along its eastern and southern margins by rhyolite porphyry (C-Pp). To the north, it is faulted against the Insolvency Gully Formation.

The rhyolites are similar to those in the basal part of the Ellenvale Beds and in the Tareela Volcanics; the sediments are similar to those (C) which underlie the rhyolites in the Ellenvale Beds at the head of Hellhole Gorge.

The St James Volcanics are assigned to the Carboniferous because of their stratigraphic position above the Game Hill Beds, and because of their similarity to beds (C) of known age to the north and northeast of Fanning River homestead. They may once have been continuous with the Tareela Volcanics.

Insolvency Gully Formation (Ci)
(new name)

The sequence of subgreywacke and subgreywacke-conglomerate, feldspathic sandstone, dark grey mudstone, siltstone, and chert cropping out in the catchment area of Bog Hole Creek (known locally as Insolvency Gully) is here named the Insolvency Gully Formation (see also Wyatt, 1963, unpubl.). The beds were included in the Star Group on the Geological Map of Queensland (1953).

The beds are generally poorly sorted; the feldspathic sandstone usually contains fragments of volcanic rock or shale or both, and grades into subgreywacke. The conglomerate and coarser arenite are more common near the base of the section, but also occur at higher levels. Dark grey shale occurs throughout the section.

The lower part of the sequence is usually well bedded; in places the arenite shows festoon cross-laminations and the shale is well laminated. In the upper part, the mudstone and siltstone commonly form massive structureless beds up to 4 feet thick, and some of the shale is slightly calcareous. Turbidity structures have been noted in some of the fine arenites associated with the shales in the upper part of the sequence. Ripple marks are present in a few of the finer-grained arenites. Large ripples, with a wave-length of about 9 inches and an amplitude of 0.5 to 1 inch, occur in a medium-grained subgreywacke in Keelbottom Creek.

Cyclic sedimentation prevailed during deposition, and the coarse clastics are repeatedly followed by dark shale. The thickness of the cyclic units ranges from a few feet to several tens of feet, and the proportion of coarse to fine clastics varies considerably.

The beds contain plant remains which include *Calamites* sp. (McKellar, 1963b, unpubl.). Some of the shales contain well preserved tracks which were possibly made by an annelid worm. The presence of *Calamites* sp. and the resemblance to parts of the Ellenvale Beds indicate a Carboniferous age for the Insolvency Gully Formation.

The sediments appear to have been deposited rapidly, close to the source area. The presence of ripple marks and cross-laminations indicates that currents were active, and the abundance of plant remains in the dark shale suggests rapid burial in a reducing environment. The cyclic sedimentation suggests unstable tectonic conditions and the formation was probably deposited in a fairly rapidly, but intermittently, subsiding basin in which the rate of sedimentation kept pace with the rate of subsidence.

Other late Middle or Upper Carboniferous formations in the region rest conformably on the St James Volcanics, but there is a marked discordance in strike between the Insolvency Gully Formation and the St James Volcanics. The former generally trends east-west and dips uniformly north at about 30°, whereas the latter are folded into a syncline plunging northeast.

The absence of St James Volcanics in the Ben Lomond West area is probably due to faulting.

The Insolvency Gully Formation is intruded by late Palaeozoic granite (C-Pg) east of Keelbottom Creek, and by the granodiorite (C-Pb) of Ben Lomond West.

Tareela Volcanics (Ct)
(new name)

The volcanic rocks which extend over much of the Parish of Tareela are here named the Tareela Volcanics (see also Wyatt, 1963, unpubl.).

The lower part of the formation consists of andesite lavas and pyroclastics, which are conformably overlain by a sequence of rhyolite lavas and pyroclastics. Both andesites and rhyolites are well exposed in the limbs of a syncline west of the Little Star River, and the andesites in the core of a broad gentle anticline southeast of the Little Star River.

The andesites are commonly flow-banded and columnar jointed, particularly in their upper levels. Subordinate pyroclastics are present in places. In the area between the Little Star River and Stony Bore on Star Holding, the andesites are commonly amygdaloidal and strongly epidotized like those in the lower part of the Percy Creek Volcanics. About 6500 feet of andesite is exposed in the western limb of the syncline west of the Little Star River.

The acid volcanics include rhyolite flows, which are commonly spherulitic or fragmental, and pyroclastics which range from fine tuffs to coarse agglomerate. The acid volcanics are 3000 to 4000 feet thick; they are predominantly green or cream, and are similar to the Hells Gate Rhyolite and the rhyolite at the base of the Ellenvale Beds.

The Tareela Volcanics overlie the Star Beds, probably disconformably. They are also faulted against the Star Beds in many places, for example, between the Great and Little Star Rivers north of Star homestead, and west of the North Branch of the Little Star River.

No sediments similar to those in the Sybil Group or the Ellenvale Beds occur above the Tareela Volcanics.

Unnamed Acid Volcanics (Cuv)

The upland area extending from Stony Bore on Star Holding to Thornton Gap in the east and to Bog Hole Creek in the south is composed mainly of rhyolite flows and pyroclastics and minor andesite. The attitude of the volcanics south of Taylors Bore suggests that they overlie the basal andesites and trachytes of the Tareela Volcanics, and they may be equivalent to the upper rhyolitic sequence in this formation. The volcanics appear to be nearly horizontal or gently undulating, and are well exposed in gorges in Keelbottom Creek and its tributaries. The volcanics have been intruded by granite, adamellite, and granodiorite in the Mingoom, Thornton Gap, and Bog Hollow areas. They are possibly equivalent to the Tareela Volcanics, but they have not been mapped in detail.

Volcanics also crop out between the Little Star River and the coastal scarp between Saltwater Creek and Sleeper Log Creek. They form the high inaccessible country in the centre of the Paluma Range, and in the north they are largely covered by rain forest. Along the East Branch of Keelbottom Creek east of Taylors Bore, the volcanics are apparently continuous with the volcanics described above.

In the North Branch of the Little Star River the flow-banded rhyolites dip east at about 55^{o}, and overlie pink late Palaeozoic granite; in the South Branch the same rhyolites dip north at about 50^{o}. Photo-interpretation indicates that they continue to the east, and that the dip gradually swings to the northwest, which suggests that they may be part of a basin-shaped structure. Numerous northwesterly lineaments cross the structure.

An east-west ridge of sheared spherulitic rhyolite forms Mount Douglas on the coast, north of the mouth of Saltwater Creek. The indistinct banding, as indicated by the size and distribution of the spherulites, suggests that the rhyolite is gently folded.

Unnamed Dark Grey Volcanics (Cuy)

Dark blue-grey volcanics, ranging from dacite to rhyolite, crop out at Frederick Peak and at numerous points in the Paluma Range. They commonly contain numerous fragments of similar composition to the matrix, which suggests that they are pyroclastic flows, although some of them may be high-level intrusions.

The dark volcanics form rugged hills which are covered with thick vegetation, and are restricted to a belt extending from north of the head of the Star River in the northwest to Frederick Peak in the southeast.

At Frederick Peak, southwest of Townsville, they consist of dacite to rhyolite porphyries composed of phenocrysts of glassy quartz and white feldspar set in a dark blue-grey groundmass, which also contains numerous fragments of similar composition to the enclosing rock. The proportions of phenocrysts and rock fragments are extremely variable, and many of the crystals are broken. The long axes of crystals and rock fragments are commonly parallel, but the structure is too variable to be mapped.

Mount Margaret is composed of dark blue-grey to black volcanics similar to those at Frederick Peak. They contain abundant rock fragments and phenocrysts of white feldspar, and sporadic phenocrysts of quartz. The quartz crystals are strained and embayed, and the feldspar laths are roughly aligned. Disseminations and small stringers of pyrite are also present. The rocks are probably pyroclastic flows.

Thin stringers of quartz, trending 105^{o}, occur on the southern flanks of Mount Margaret. The veins are crossed by a later set of joints trending 160^{o}.

At Mount Black similar acid volcanics have been noted. They probably consist of lava flows and pyroclastics, including welded tuffs. The rare flow banding trends at 140^{o} to 170^{o}, and dips nearly vertically. The volcanics are intruded by fine-grained basic dykes, and probably by microgranite dykes (loose blocks only).

Porphyritic and xenolith-bearing volcanics similar to those at Frederick Peak occur north and northwest of Thornton Gap. In these the quartz phenocrysts have been resorbed, and the groundmass, about 50 percent of the rock, consists of very fine-grained altered turbid material in which shard-like shapes can occasionally be recognized. The xenoliths consist of angular to rounded fragments of amygdaloidal acid volcanics. At one locality, southeast of Patterson Gorge, the long axes of the phenocrysts and xenoliths trend 005^{o} and dip vertically.

East of Godwins Peak, where Saltwater Creek emerges from the Paluma Range, a pink porphyritic microgranite is overlain by blue-grey porphyritic rhyolite. The rare banding in the rhyolite trends east-west.

Similar volcanics crop out around Blue Gum and Smith Creeks, tributaries of the Great Star River. They are mainly blue-grey acid rocks which contain variable amounts of quartz and feldspar phenocrysts and fragments of acid volcanic rock. The attitude of the volcanics is uncertain, but they are probably flat-lying. They are continuous with the volcanics in Little Crystal Creek, north of the Paluma road, which are intruded by pink epidotized granite (C-Pg).

The volcanics on Magnetic Island (mapped as 'C-Pv' without the benefit of isotopic dates) also probably belong in this informal rock unit (Cuy) - see page 51.

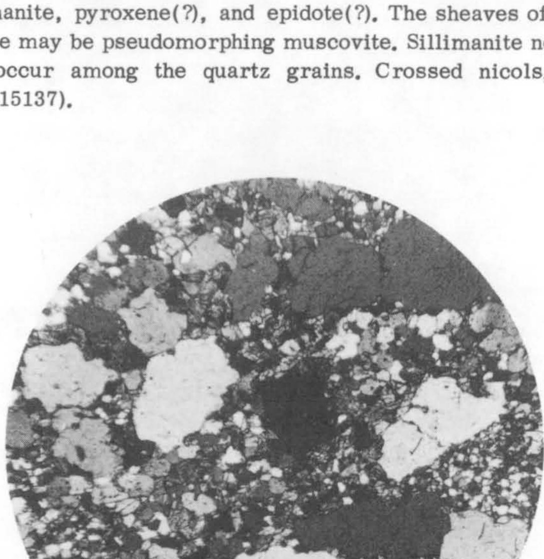
UNDIVIDED LATE PALAEOZOIC

Metamorphics (Pzu)

Contact metamorphic rocks crop out discontinuously along the foot of the coastal scarp between Mount Flagstone and Black River. They are thought to be mainly Devonian and Carboniferous in age.

Two miles northeast of Thornton Gap there is a low ridge of banded white quartzite and dark grey metamorphosed sandstone and arkose.

5. **Sillimanite gneiss (Pzu)**, near Alice River, 1.5 miles south of Mount Margaret. The rock consists of quartz, biotite, plagioclase, sillimanite, pyroxene(?), and epidote(?). The sheaves of sillimanite may be pseudomorphing muscovite. Sillimanite needles also occur among the quartz grains. Crossed nicols, X 45 (GSQ 15137).



6. Metamorphosed tuffaceous sandstone (Pzu), near Alice River, 1.5 miles south of Mount Margaret. The irregular elongate aggregates of quartz, with long axes subparallel, are set in a granular matrix of hornblende, quartz, plagioclase, sphene, and iron oxides. Crossed nicols, X 45. (GSQ 15142).

The outcrops of banded and foliated biotite schist three-quarters of a mile southeast of Thornton Gap are too small to map separately from the enclosing late Palaeozoic granodiorite and adamellite. The foliation trends 040° and dips vertically.

Metamorphosed quartzose arenite and finer-grained rocks crop out at the head of the Alice River, west and northwest of Frederick Peak (Figs 5, 6). The rocks are strongly schistose in places, but elsewhere sedimentary structures, such as cross-laminations, are preserved. Biotite is generally present, and sillimanite and coarse garnet have been developed in places.

The metamorphic rocks in the Spring Creek/Mount Flagstone district are mainly arenites, but fine-grained and calcareous beds also occur. Southwest of Mount Flagstone, in the foothills of the coastal scarp at the head of Cattle Creek, there is a lens of hematite in a metamorphosed limestone which has been converted into a tremolite-zoisite-calcite-garnet-diopside(?) skarn. The grade of metamorphism of the limestone decreases rapidly up the scarp to the west. Most of the metamorphosed arenites at the northern end of Mount Flagstone are fine to medium-grained, and consist of quartz, white feldspar, and biotite which commonly lies along vertical planes trending north. To the south, the proportion of quartz and feldspar porphyroblasts increases, pink rocks are more abundant, and aplite and pegmatite veins are more common. Near the centre of Mount Flagstone, pink porphyroblastic rocks (mapped here with the granite) predominate, and there are minor occurrences of sugary textured quartzite. Similar foliated and leucocratic rocks crop out on the eastern and southern margins of Mount Flagstone. On the saddle linking Mount Flagstone with the coastal range, and farther south to the head of Lansdowne Creek, metamorphosed sandstone, siltstone, and acid volcanic rocks crop out.

The rocks near Mount Flagstone are probably part of the Fanning River Group which has been sheared and contact metamorphosed. The occurrences at Frederick Peak and Thornton Gap may be Devonian and Carboniferous sediments sheared and foliated in a fault zone along the coastal scarp.

However, not all the metamorphics were sediments. For example, on the southern side of the valley where Lansdowne Creek emerges from the Hervey Range there is a foliated xenolithic rock composed of labradorite 'phenocrysts' (15%) set in a groundmass of quartzo-feldspathic material (75%), diopside, epidote, sphene (5%), and opaque minerals (5%). The rock is gneissic, and appears to have been derived by partial recrystallization of an igneous rock (Houston, 1964, GSQ 15215).

Jack (1886b, 1892) mentions 'greywackes, slates, etc.' cropping out unconformably below the Devonian sequence in the Reid Gap area. The mica schist to the west of Black Mount, and the metamorphosed arkose 4 miles southeast of Reid Gap, can probably be correlated with the rocks in the Reid Gap area.

Jack (1879a) recorded granite and gneiss below the sandstone bluffs (Collopy Formation) south of Haughton Valley. The present survey indicates that the so-called gneisses are part of the Ravenswood Granodiorite Complex deformed in the Alex Hill Shear Zone. The mylonite and phyllonite farther east near Four Mile Creek are possibly of similar origin, but Morton (1931) has recorded mica schist and quartzite on the western spurs of Black Mountain (C-Pg), so that some of the cataclasites may have been derived from rocks other than the Ravenswood Granodiorite Complex.

Still farther east, at Horse Camp Hill, there are minor schists similar to those at Black Mount near Calcium.

UPPER CARBONIFEROUS TO LOWER PERMIAN

Intrusive Rhyolite (C-Ph)

Isolated hills of rhyolite and minor dacite are widely distributed in the Townsville Sheet area. These rocks are fine-grained and generally off-white to light grey-brown. Almost all are flow-banded, but only a few are porphyritic.

Many of the intrusions, such as Mount Success, 3 miles east-southeast of Marlow homestead, and the intrusion 5 miles northwest of Battery homestead, are circular plugs. Others are sheets, commonly nearly parallel to the strike of the enclosing strata, as for example Mount St Michael, and the intrusions 5 miles south of Dotswood, 4 miles west of Quilps homestead, 2 miles southeast of Star homestead, 2 1/2 miles north of Laroona homestead, and near Mount Keelbottom. The remaining occurrences shown on the map appear to be irregular or dyke-like.

Coarse pyroclastic material is associated with the flow-banded rhyolite on the northeastern side of Mount Success.

These rhyolite bodies intrude sediments ranging from Givetian to Tournaisian; at Frederick Peak the country rock is late Palaeozoic volcanics (Cuy). The bodies may be related to the Carboniferous acid volcanics, or they may possibly be Permian or younger. The intrusions northwest of Battery homestead and east-northeast of Marlow homestead are overlain by laterite which appears to belong to the main period of lateritization (probably early Tertiary).

Dyke Swarms in Oweenee Granite

Swarms of quartz-feldspar porphyry and andesite dykes occur in the Oweenee Granite parallel to the faults bounding the Sybil Graben. The dykes are generally light grey or cream. Cameron (1901) has also recorded dolerite dykes at the Macaulay Creek mines. The dykes occupy subsidiary fractures parallel to the main graben faults, and are therefore probably younger than the sediments and volcanics in the graben (late Middle or Upper Carboniferous). They are possibly related to at least some of the rhyolite plugs (C-Ph).

Dolerite and Microdiorite (C-Pi)

In the area between the head of Fryers Creek, Dotswood homestead, and the East Branch of the Fanning River there are a number of low hills and ridges of microdiorite or dolerite. Most of them are irregular, and less than 1 1/2 miles long and 1 mile wide.

The dolerites and microdiorites intrude the Ravenswood Granodiorite Complex, the Givetian-Tournaisian sequence, and the unnamed Carboniferous volcanic-sedimentary sequence (C). The diorite at the head of Fryers Creek has been included in this group of intrusives; it is intruded by late Palaeozoic granite (C-Pg).

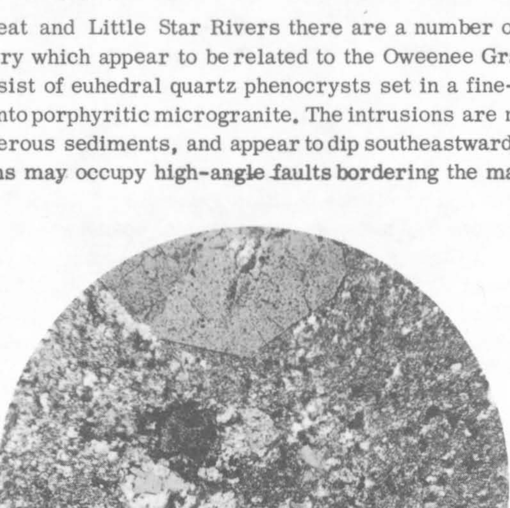
Five miles northeast of Dotswood homestead, the basic rocks are confined to the noses of three tight folds in Upper Devonian strata. They do not appear to be folded themselves, and were probably intruded into weakened zones during or after the folding of the sediments. However, the four similar bodies which crop out in the central zone of a syncline in Carboniferous volcanics and sediments north of Fanning River homestead are intimately associated with andesite flows and pyroclastics, and may have been feeders to the extrusives. These intrusives have been grouped on the map and assigned a late Palaeozoic age. Many of the basic dykes intruding the Permo-Carboniferous volcanics and granites of the coastal area may prove to be related to this group of intrusions.

Quartz and Quartz-Feldspar Porphyries and Microgranite (C-Pp)

Quartz and quartz-feldspar porphyries and microgranite are closely associated with many of the late Palaeozoic granites, particularly between Ben Lomond and Granite Creek, 17 miles north and northeast of Dotswood homestead; between the Little Star and Great Star Rivers; and east and northeast of Mount Halifax.

A fine-grained cream to pinkish brown quartz porphyry crops out around Ben Lomond East. It is generally massive, and forms steep conspicuous hills culminating in Ben Lomond East. Flow banding is present on the southern margin about Cattle Creek. In the south and west, the porphyry intrudes Upper Devonian/Lower Carboniferous sediments and Upper Carboniferous volcanics, and to the north it appears to be faulted against the Insolvency Gully Formation. To the east, it is in contact with a late Palaeozoic adamellite (C-Pg) into which it may be intrusive. East of Ben Lomond East, across Keelbottom Creek, there is another hill of greyish quartz or quartz-feldspar porphyry with a slightly coarser groundmass. The rock appears to be a fine-grained equivalent of the granitic rocks immediately to the north. A similar porphyry crops out just east of Granite Creek.

Between the Great and Little Star Rivers there are a number of irregular and sill-like bodies of porphyry which appear to be related to the Oweenee Granite to the west and northwest. They consist of euhedral quartz phenocrysts set in a fine-grained matrix, and many of them grade into porphyritic microgranite. The intrusions are not conformable with the Devono-Carboniferous sediments, and appear to dip southeastwards at a steeper angle. Some of the intrusions may occupy high-angle faults bordering the margin of the Oweenee Granite.



7. Porphyritic microgranite (C-Pp), 3 miles southwest of Rollingstone, 30 miles northwest of Townsville. Quartz (top) and alkali feldspar (bottom right) occur as phenocrysts in a micrograniti groundmass. The central coarser-grained patch, which consists of quartz, altered feldspar, garnet, muscovite, green biotite, and iron oxide, is probably a xenolith. Crossed nicols, X 45. (GSQ 15110).

Porphyritic microgranites crop out northeast and east of Mount Halifax (see Fig. 7). They are composed of phenocrysts of feldspar and euhedral or broken quartz up to 3 cm long, and pseudomorphs of chlorite and sphene, possibly after hornblende, set in an intergranular groundmass of quartz and feldspar. Some of the quartz is resorbed, and the feldspar is commonly sericitized. A few phenocrysts or xenocrysts of magnetite and garnet may be present. The porphyries are associated with adamellite, which generally occupies the low ground. The area is rugged, and covered by rain forest. Most of the porphyritic microgranites have been mapped with the granite (C-Pg) of the Paluma Range.

The porphyries are probably similar in age to the associated granitic rocks, which are late Carboniferous or early Permian.

Granites (C-Pg, C-Pa, C-Pb)
(including Pall Mall Adamellite C-Pa)

The regional mapping indicated two separate epochs of granite intrusion in the Townsville Sheet area in the late Palaeozoic, as exemplified by the Lower Carboniferous Oweenee Granite in the northwest, and by the granites near Townsville which intrude Glossopteris-bearing strata. The granites forming a northwesterly belt in the Hervey and Paluma Ranges intrude late Middle to Upper Carboniferous sediments and volcanics, and were considered to represent a possible third epoch. This threefold subdivision has been confirmed by isotopic dating. Twelve K/Ar mineral ages which group closely about an average of about 280 m.y. were obtained from granites (C-Pg, C-Pa) and granodiorites (C-Pb) in the Hervey Range/Pall Mall area, corresponding with the age of the Carboniferous-Permian boundary. This age is regarded by A.W. Webb (pers. comm.) as significantly older than the dates of 267 and 269 m.y. which were obtained from some of the younger granites of the Townsville district, just within the Ayr Sheet area (Webb in Paine et al., 1970). This distinction is supported by the occurrence in the Bowen Sheet area of co-magmatic granite and volcanics which have yielded an average age of 285 m.y. (that is, similar to the 'C-Pg' group), and yet are overlain nonconformably by Lower Permian volcanics (Webb & McDougall, 1968, p.328). The units 'C-Pg', 'C-Pa', 'C-Pb' encompass plutonic rocks, most of which are known to intrude late Palaeozoic volcanics and sediments. Most of the intrusions crop out in a northwesterly trending belt which coincides with the Paluma, Hervey, and Leichhardt Ranges.

For mapping purposes, the rocks have been subdivided into acidic ('C-Pg' : granite, adamellite, some granodiorite) and less acidic to intermediate ('C-Pb' : granodiorite, tonalite). These subdivisions are somewhat subjective, and correspond to the two types of granitic rocks which can be distinguished by photo-interpretation: acidic bodies generally give rise to rugged country, in contrast to the granodiorites, which are more easily eroded than the country rocks and tend to have negative relief. Exceptions include, for example, the adamellite which forms the low country between Pepperpot Mountain and Mount Flagstone. Some of the bodies are composite and consist of several successive intrusions.

These rocks are generally massive and little altered, and where the field relationships were unknown, this criterion has been used in an attempt to distinguish them from the early Palaeozoic granites, which are commonly foliated and altered. Individual occurrences are described below.

North of Rollingstone Creek the main rock type is a pink adamellite, whose chilled margin truncates the flow lineation in the volcanics (C-Py). The ridges in the pale pink adamellite which forms the foothills of the Paluma Range probably represent zones of hardening along faults. Successive intrusions are exposed in Ollera Creek as follows: grey porphyritic adamellite, which crops out in Ollera Gorge and contains large inclusions of gneiss; pink porphyritic granite which contains xenoliths of the porphyritic adamellite, and is intruded by thin sheets of pink porphyritic microgranite; and red epidotized granite which intrudes volcanics (C-Py) in Crystal Creek, north of the road to Mount Spec. The contacts of the intrusions generally trend northwest, parallel to the dykes, epidote veins, and faults.

The shape of the high country north and east of Tabletop homestead suggests two separate granite intrusions (both C-Pg); the granite to the east probably intrudes the granite to the north, and both intrude the granodiorite which underlies the low country west of the homestead and Thornton Gap. The drusy chloritized leucocratic granite and microgranite forming Mingoom Hill extend several miles west across Keelbottom Creek; they also intrude the granodiorite. In addition to granite and adamellite, granite porphyry crops out in the headwaters of Four Mile Creek and 3 miles south-southeast of Murrays Hut.

Pink biotite adamellite forms part of the northern foothills of Frederick Peak and the southern slopes of Wild Horse Mountain, where it is intruded by banded sheets of drusy leucogranite. Sporadic outcrops of diorite, dolerite, and microgranite, with large biotite and feldspar phenocrysts, crop out north of Granite Vale homestead, but their relationships are unknown. Both the diorite and dolerite are cut by thin veins of hornblende-plagioclase pegmatite.

Hornblende-biotite granodiorite, grading northwards into adamellite, underlies about 25 square miles in the low country north and northwest of Mount Flagstone. The granodiorite intrudes steeply dipping greywacke and sandstone (Pzu) of unknown age, and may be equivalent to the massive unfoliated part of the Ravenswood Granodiorite Complex which it resembles. At Mount Flagstone itself, the foliated quartzose metamorphics around the eastern margin grade into porphyritic granite, which forms the main hill. To the north, pink inequigranular granite, locally rich in quartz, intrudes the metamorphics and the granodiorite. The inequigranular granite forms a cliff, and appears to underlie the porphyritic Mount Flagstone granite as a flat intrusive sheet. At Pepperpot Mountain an oval mass of coarse porphyritic granodiorite appears to intrude the adamellite which underlies the low country. Inequigranular pink adamellite crops out at Settlement Pocket and Ross River Mountain; in the dissected scarp north of Settlement Pocket it is intruded by a prominent northwesterly trending ridge of coarse pink adamellite. The general northwesterly trend of the granites in this area is parallel to faults, which may to some extent have controlled their emplacement.

Black Mountain (west of Calcium) rises from a circular depression which is underlain by fine to medium-grained tonalite-granodiorite. In places the tonalite contains clinopyroxene, and is cut by felsite dykes; it intrudes the Fanning River Group.

A uniform body of pink leucocratic micrographic granite forms the high range at Brown Mountain and Mount Ellenvale. The small boss in the Limestone Hills northeast of the Reid River is a muscovite-tourmaline adamellite which is cut by acid dykes.

The oval stock of pink medium-grained adamellite forming Mount Squarepost intrudes the composite granite-granodiorite mass of Mount Sugarloaf, which in turn intrudes the Ravenswood Granodiorite Complex. The ruggedness of the country is largely due to the presence of swarms of rhyolite, andesite, and feldspar-hornblende porphyry dykes. The coarse red granite of Mount Prince Charlie is also intruded by acid and intermediate dykes.

Mount Norman is formed of a composite intrusion composed of a central fine to medium-grained grey adamellite, flanked on the east and southwest by coarse pink microperthite granite. The Black Mountain mass (south of Mount Norman) is a pink fine to medium-grained biotite-muscovite adamellite; at the mountain itself the adamellite has been greisenized, and muscovite occurs in radiating sheaves. Morton (1931) recorded gold in the greisenized granite at the western contact with the metamorphics. The composite intrusion at Bunkers Hill ranges from leucogranite to granodiorite. The granodiorite appears to have been intruded as small stocks along the eastern and southern margins of the main intrusion.

In the Townsville district numerous isolated or poorly exposed granite outcrops have been included in the unit 'C-Pg'. The coarse red biotite granite which forms Castle Hill has been extensively epidotized along northwest-trending shears, some of which have given rise to mylonite. Similar granite crops out at the eastern end of Mount Louisa. At Kissing Point a coarse pink granite occurs near a grey hornblende granodiorite crowded with basic xenoliths. The granodiorite is cut by dolerite dykes dipping south at 45^{o} and by vertical quartz veins trending northwest. North of Cocoa Creek a small hill of gneissic adamellite is intruded by the adamellite (P-Mg) of Cape Cleveland (Ayr Sheet area).

The biotite adamellite of Magnetic Island (mapped in the 'P-Mg' group) has yielded a K/Ar biotite age of 280 m.y. and therefore apparently belongs in the 'C-Pg' group.

The Pall Mall Adamellite (C-Pa), which was named by Wyatt (1962, unpubl.), is a coarse pink to grey rock which in places contains phenocrysts of oligoclase, potash feldspar, and quartz up to 3 cm long.

Intrusives at Mount Kitty O'Shea (C-Pb and dykes)

Numerous andesite dykes, radiating from a small granodiorite intrusion (C-Pb), pierce the Devono-Carboniferous sequence around Mount Kitty O'Shea northwest of Fanning River homestead.

The dykes are generally porphyritic, with a variable proportion of hornblende, augite, and plagioclase phenocrysts, ranging up to 0.75 inches long. The groundmass is fine-grained. The dykes range up to 12 feet wide, but average 4 to 6 feet, and are up to 1 1/2 miles long.

There are also oval intrusions similar in composition to the dykes. They are usually elongated parallel to the strike of the sediments, whereas the dykes are generally normal to the trend of the country rock.

Most of the dykes occur in a sector southwest of the central intrusion which forms a depression. Another swarm, about half a mile wide, trends northwest and southeast of the central intrusion along the axial region of a broad anticline in the Devono-Carboniferous sediments. A third group trends north and south. No dykes have been recorded in the northeastern quadrant.

The dykes were probably emplaced along tension fractures formed during the folding of the Devono-Carboniferous strata or during the intrusion of the granodiorite. Although the Devono-Carboniferous strata were slightly warped and uplifted at the end of the Tournaisian, the folding was probably not completed until the close of the Palaeozoic. It was probably during this later stage of folding that the granodiorite was intruded into the core of the anticline, and the dykes into tension fractures in the country rock.

Unnamed Volcanics and Sediments (C-Pv)

The intermediate volcanics which form the low hills northwest of Rocky Springs homestead are interbedded with sediments which contain Glossopteris sp. Similar volcanics form much of the hilly country around Townsville and extend southeast as far as the Haughton River (Ayr Sheet area, Paine et al., 1970).

The volcanics consist mainly of intermediate to acid pyroclastics and flows. The pyroclastics are generally coarse-grained, and many of the flows contain abundant fragments, which suggests that they are ash-flow tuffs. Fragments of granite (presumably derived from Carboniferous intrusives) are common in the pyroclastics and conglomerates. The subordinate finer-grained sediments, which crop out poorly, are feldspathic subgreywacke, shale, siltstone, and thin bands of coal. Thick dykes of flow-banded rhyolite intrude the volcanics in places, and it is possible that some of the rhyolite mapped with the volcanics is intrusive also.

Jack (in Jack & Etheridge, 1892) described Permo-Carboniferous sediments containing Glossopteris leaves in a railway cutting near Stuart Creek, and Walkom (1922) recorded Glossopteris indica(?) from a railway cutting '6 1/2 miles from Stewart's Creek, Townsville (GSQ F 1811)' and at 'Rodgers Mine, on Stewart's Creek, Townsville (GSQ F 1847)'. Dunstan

(1905) records 'coal-measure sandstones' from bores as far south as Antill Plains railway station. During the present survey sediments containing Glossopteris leaves were observed 1 1/4 miles southeast of Stuart Prison, beside the road to Rocky Springs homestead.

The volcanics are generally massive, and mappable structures are rare. Platy and linear flow structures can be measured in places, but they are of little regional significance. The dips on the rare sedimentary interbeds may indicate the general structure, as for example at the confluence of the Ross River and Five Head Creek. Some of the dips may be original. Because of the lack of mappable structures and scarcity of fossils, the main criteria for mapping these volcanics as a unit have been continuity of outcrop and, where this is lacking, similarity in lithology.

The prevalence of coarse pyroclastics and conglomerate indicates that the volcanics were derived from nearby volcanoes set among granite hills; the sediments were evidently deposited in isolated swampy valleys among the hills.

Because they contain a Glossopteris flora the volcanics are regarded as Permian, or possibly uppermost Carboniferous in age. They are regarded as broadly equivalent to the Lizzie Creek Volcanics (formerly Lower Bowen Volcanics) of the Bowen Basin (e.g., Malone et al., 1966).

Individual occurrences are described below.

The volcanics which form the northwestern tip of Magnetic Island are mapped with this unit, but the granite which intrudes them (mapped with the unit 'P-Mg') has yielded a K/Ar mineral age of 280 m.y., indicating that it belongs in the 'C-Pg' group, and therefore that the volcanics belong in the 'Cuy' group. The volcanics are dark massive acid agglomerate composed of crystals of white feldspar, quartz, and rock fragments, set in a black flinty matrix. The rock fragments are commonly similar to the matrix, but granite fragments are also present. Pyrite occurs in the matrix in places. The volcanics are also intruded by dolerite, felsite, aplite, and microdiorite dykes.

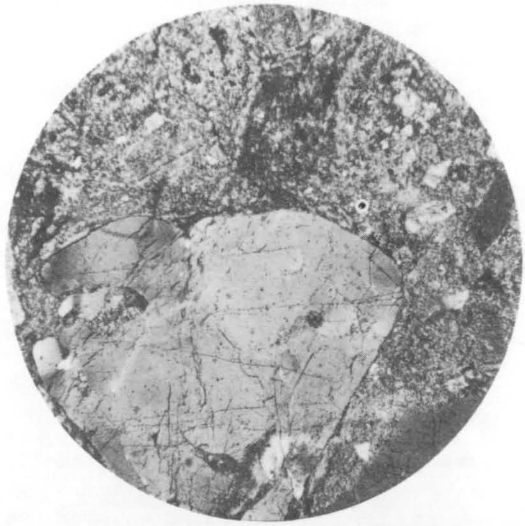
Kulburn Hill is a northwesterly trending ridge of acid flows and pyroclastics; some intermediate volcanics may also be present. The flow banding dips northeast at moderate to steep angles.

The northeastern shoulder of Frederick Peak consists of ridges of light-coloured acid to intermediate lavas and pyroclastics which have been sheared and intruded by quartz veins. They contain disseminated pyrite in places. The direction of shearing (110^{o}) is parallel to a postulated fault along the northern margin of the peak; and the volcanics appear to be faulted against the late Palaeozoic dark grey volcanics (C-Py). These light-coloured volcanics are similar to the Kulburn Hill rock.

Medium-grey porphyritic acid volcanics (Fig. 8), crop out at the eastern end of a narrow ridge which trends east-northeast from Mount Black. Along the southern edge of the ridge there is a breccia which appears to occupy a fault zone. Many of the volcanics on the ridge contain fine disseminations or aggregates of pyrite. The flow banding trends 080^{o} adjacent to the breccia zone at the eastern end of the ridge. These lighter-coloured volcanics are different from those at Mount Black (Cuy).

Grey-brown altered biotite-feldspar porphyry crops out at the western end of Mount Low, and medium to coarse quartz-feldspar porphyries crop out at the eastern end.

Pale brown medium to coarse-grained biotite trachyte and purple andesite crop out on the southeastern slopes of Mount Marlow, in Many Peaks Range. Near the top of the range, granite is associated with trachyte and rhyolite, but the relationships were not established. The trachyte and rhyolite resemble dyke rocks found elsewhere.



8. Porphyritic acid volcanic rock, Permo-Carboniferous volcanics (C-Pv), Mount Black. The embayed grain of strained quartz, with bubble trains, is set in a groundmass of fine-grained turbid feldspar and quartz. Small turbid phenocrysts of altered feldspar occur in the northern and eastern quadrants. Crossed nicols, X 45. (GSQ 15116).

Various volcanic rocks with minor conglomerates occur on and around Mount Stuart, but their relationships are not well known. The following rock types and field relationships were noted.

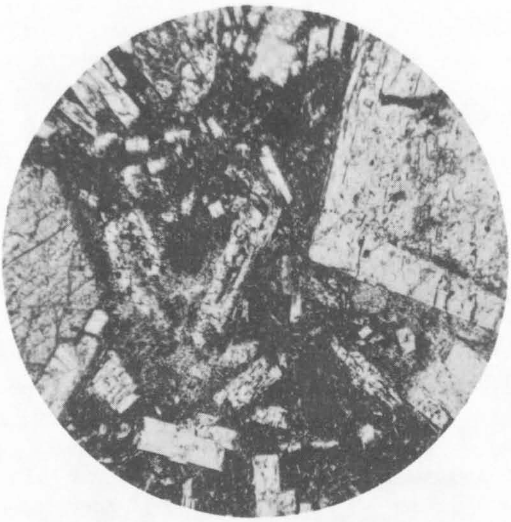
Half a mile southwest of the summit are outcrops of melanocratic fine-grained andesite or welded tuff, which appears to dip at about 10^{o} to the southeast. The outcrops are probably remnants of the roof of the Mount Stuart intrusion (P-Mg), and are too small to be mapped separately.

Coarse massive green volcanic breccia, agglomerate, and mudball tuff crop out beside the road 2 1/2 miles southeast of the summit. Flow-banded rhyolite, welded tuff, and trachyandesite occur in the headwaters of Hell Hole Creek, on the western side of Mount Stuart. Dense dark blue-green tuff, massive creamy rhyolite with large spheruloids, pink rhyolite, and weathered quartz-veined agglomerate crop out 1 1/2 miles southeast of Aplins Weir.

At the confluence of Five Head Creek and the Ross River conglomerate dips steeply to the northeast. It consists of phenoclasts of granite, rhyolite, dark porphyritic volcanics, and coarse quartz-feldspar porphyry set in a friable matrix of green subgreywacke. The conglomerate contains rare lenses of green subgreywacke with grains of quartz, feldspar, biotite, and quartzite. The conglomerate is intruded by keratophyre sills, and red quartz microsyenite crops out in the bed of the river a few yards to the west.

Tuff and conglomerate with granitic and volcanic phenoclasts are exposed in a railway cutting half a mile south of Stuart. Maitland (1892) recorded conglomerate and tuff at Stuart railway station, and sandstone, shale, conglomerate, and impure coal in a railway cutting nearby. On the hillslopes one-third of a mile south of Stuart, conglomerate occurs among outcrops of granite, and is believed to be younger than the granite (Cg), although the relationships are uncertain.

Trachyte and andesite crop out in the hills south of Stuart Gaol; poorly preserved Glossopteris leaves occur in shaly interbeds; Maitland (1892) records volcanics interbedded with sandstone, blue-black shale, and impure coal.



9. Augite andesite, Permo-Carboniferous volcanics (C-Pv), southwest of the Bruce Highway, half a mile south of Julago railway siding. The euhedral augite, iron oxides, and plagioclase phenocrysts are set in a turbid fine-grained groundmass. Large zoned plagioclase crystals enclose anhedral grains of augite (northeast quadrant). In the intersertal groundmass granules of opaque minerals and semiopaque ferromagnesian material occur between tiny laths of feldspar. Plane polarized light, X 45. (BMR 15695).

Northwest-trending lineaments can be seen on the air-photographs of the hills southwest of Whites Creek, where augite andesite (Fig. 9) and microdiorite are the main rock types. The lineaments may indicate a dyke swarm, but no intrusive contacts were seen. Tuff, pyritiferous agglomerate, and rhyolite are also present, and most of the rocks are severely epidotized. Pale buff porphyritic acid volcanics and minor andesites form the centre and western end of the Muntalunga Range; augite andesite crops out in the eastern foothills.

Woodstock Hill is composed of massive augite andesite containing numerous phenocrysts and abundant oligoclase in the groundmass. The steep hill immediately south of Woodstock Hill consists of rhyolite and augite andesite.

The summit ridge of the Sisters Mountains consists of massive rhyolite breccia and white kaolinized flow-banded rhyolite crowded with spheruloids up to 6 inches in diameter.

The massive epidotized volcanic breccia in the upper reaches of Alligator Creek is intruded by thick dykes of rhyolite and thin dykes of dolerite. The acid dykes are probably related to the nearly granites which intrude the volcanics. Other rock types cropping out on the lower slopes north and south of the creek include sanidine porphyry, welded tuff, epidotized hornblende andesite, spherulitic dacite or rhyolite, and volcanic breccia with granite fragments.

Volcanic breccia with quartzite fragments, and recrystallized rhyolite crop out at Spur End.

LOWER PERMIAN

Granites (P-Mg)

In the Townsville-Woodstock area several granites intrude the Permo-Carboniferous volcanic-sedimentary sequence (C-Pv). The massive granites form rugged mountains such as Mount Elliot, Saddle Mountain, and Mount Stuart. The granite of Magnetic Island now appears to belong to the 'C-Pg' group.

K/Ar biotite ages of 267 and 269 m.y. have been obtained from the granites at Mount Elliot and Cape Cleveland respectively, just within the Ayr Sheet area; they indicate that this group of granites is Lower Permian, and is unlikely to contain any Mesozoic intrusions.

Mount Elliot is the highest peak in a rugged precipitous range which rises over 4000 feet above sea level. The granite forms an elliptical stock, 12 miles long and 9 miles wide, with well defined curvilinear margins, which are well exposed. The centre of the stock has been deeply eroded by the headwaters of Major Creek.

Only the margin of the stock was examined. The main rock type is a pink coarse porphyritic granite which contains large deep pink potash feldspar phenocrysts averaging 1 cm long. The granite varies little in composition and texture around the margin of the stock. The groundmass consists of coarse zoned plagioclase ranging from andesine to albite, partly chloritized biotite, green hornblende, and minor magnetite, apatite, zircon, epidote, and allanite. Dr P.J. Stephenson (pers. comm.) has found a zone of xenoliths in Major Creek, just south of the centre of the stock, and indications of a similar zone to the north of the centre, which suggest that the stock may have a concentric structure.

Microgranite crops out in a narrow zone at the contact, and also as a sheet-like body intruding volcanic breccia in the northeastern foothills. The volcanics southwest of Mount Elliot have been recrystallized.

Saddle Mountain is a stock about 4 miles across, immediately northeast of the Mount Elliot stock. The summit, which rises to 2800 feet above sea level, lies just east of the Sheet area.

Only the margins of the stock were examined: the main components include pink medium-grained leucogranite with granophyric intergrowths, red drusy leucocratic micro-adamellite with fine micrographic intergrowths and a little chloritized biotite, and micro-granite locally developed at the contact. Boulders of medium-grained hornblende-quartz gabbro were found 1 1/2 miles southeast of Hidden Vale homestead in a small creek which rises in the centre of the stock. The gabbro consists of labradorite, hornblende, pyroxene, (commonly enclosed in hornblende), minor potash feldspar associated with quartz, and a little epidote, magnetite, sphene, and apatite. Small boulders of gabbro also occur near the southeastern flank of Saddle Mountain in the Ayr Sheet area. The gabbro boulders are cut by thin pegmatite veins, which suggests that they are older than the granite.

The adamellite of Magnetic Island is medium to coarse-grained and leucocratic, and contains a few phenocrysts of feldspar. A little partly chloritized biotite, iron oxides, and zircon are also present. At Huntingfield Bay irregular patches of pegmatite occur in the adamellite and also in the agglomerate at the contact. Both adamellite and agglomerate are cut by thin aplite veins. The sporadic druses in the adamellite are filled with quartz, albite, and epidote (P.J. Stephenson, pers. comm.), and pegmatite. Rare rounded xenoliths of medium-grained granodiorite(?) are enclosed in the adamellite.

The centre of Mount Stuart consists of a stock ranging from hornblende-quartz monzonite to leucogranite. The stock intrudes Permo-Carboniferous volcanics, and possibly intrudes the adjacent granite to the west and north.

A net-veined complex (Fig. 10), crops out at the summit. It consists of closely packed rounded xenoliths of fine grey-brown microgranite, fine hornblende-quartz syenite, and hornblende-quartz monzonite, embedded in a matrix of medium-grained micrographic adamellite. The xenoliths contain both brown-green and blue-green hornblende and acicular crystals of actinolitic amphibole; they also contain magnetite, epidote, sphene, and chlorite. The adamellite matrix consists of phenocrysts of plagioclase set in a groundmass of quartz, feldspar, hornblende, and a little magnetite, epidote, sphene, and chlorite. The margins of the xenoliths have been partly resorbed and recrystallized, or perhaps chilled. The complex is permeated by irregular veins and ill defined patches of pink medium-grained hornblende granite, which in places intrudes the adamellite. The entire complex is traversed by a sparse network of epidotized aplite veins. Rare disseminated pyrite and chalcopyrite are present in some of the rocks.

A coarser-grained massive adamellite or quartz monzonite crops out half a mile southeast of the summit (Fig. 11), and a coarse red granite occurs near the eastern margin of the central stock on a ridge 1 1/2 miles southeast of the summit.

Other rock types regarded as part of the central Mount Stuart stock include: coarse pink micrographic leucogranite in Sachs Creek, 2 1/2 miles south-southeast of the summit; red leucocratic quartz microsyenite in a creek bed 2 1/2 miles south of the summit; coarse pink to grey micrographic hornblende adamellite or quartz monzonite with prominent laths of hornblende and plagioclase in a creek bed 2 1/2 miles south-southwest of the summit; and medium-grained pink to buff micrographic leucogranite with hornblende and biotite, or with abundant acicular hornblende crystals, on the ridges flanking the western side of the mountain.

Red porphyritic quartz microsyenite similar to the Mount Stuart central stock crops out in the bed of the Ross River near its junction with Five Head Creek.

Microgranite crops out in a northwesterly belt in the southwestern foothills of Mount Stuart (P.J. Stephenson, pers. comm.); this probably also intrudes the Permo-Carboniferous volcanics.

Maitland (1892) regarded Mount Stuart as a volcanic vent or neck, but the textures of the main rock types suggest the intrusions were somewhat deeper-seated. The dark aphanitic volcanic rocks, dipping at 10° to the south-southeast near a small dam half a mile southwest of the summit, probably represent part of the roof rocks: the intrusion breccia at the summit also suggests close proximity to the roof.

The northern and northeastern margins of the stock are very sharp, and are probably faulted. The rest of the boundary, as mapped, is based on a single reconnaissance traverse and on photo-interpretation.

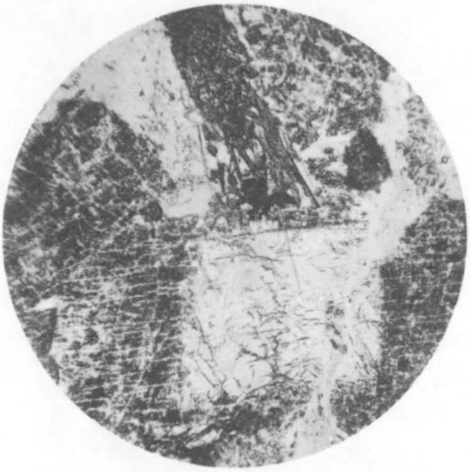
Boulders of medium to coarse pink hornblende adamellite or quartz monzonite, with large laths of hornblende and plagioclase, giving rise to a texture very similar to that of some of the Mount Stuart rocks, occur in a creek 2 miles northeast of the summit of The Sisters Mountains. The boulders are probably derived from a small intrusion in the volcanics.

Dykes

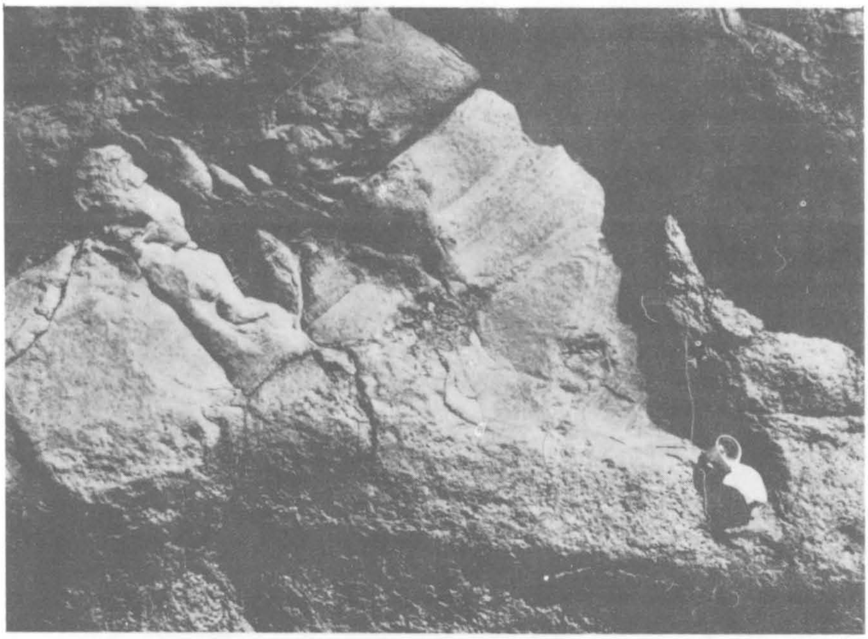
Dykes are common around Townsville. Most of them were probably intruded during the late Carboniferous and Permian, but some of them may be younger. Excellent exposures of basic and acid dykes can be seen at Huntingfield Bay on Magnetic Island.

The dykes include dark basic to intermediate intrusions and pale felsitic intrusions. The basic to intermediate dykes are widely distributed, but the felsites are only found around the granites mapped in the 'P-Mg' group.

10. Granitic net-veined complex (P-Mg), near television station on summit of Mount Stuart, 5 miles southwest of Townsville. The rock is composed of xenoliths of sparsely porphyritic mafic-rich microgranite to micromonzonite set in a matrix of strongly porphyritic and somewhat coarser micrographic hornblende adamellite. The xenoliths are closely packed, moderately rounded, and have dark recrystallized (or chilled?) rims.



11. Adamellite or quartz monzonite (P-Mg) at roadside half a mile south-southeast of the summit of Mount Stuart. The rock consists of turbid alkali feldspar, plagioclase, quartz, hornblende, chlorite, sphene, and epidote. At the top of the photograph acicular hornblende is associated with plagioclase and sphene; a needle of hornblende extends into the large zoned plagioclase crystal in the centre of the photograph. The cluster of hornblende needles is bordered on the left by quartz, and on the right by turbid alkali feldspar. Plane polarized light, X 45. (BMR 15660).



12. Adamellite intruding and truncating sinuous flow banding in a felsite dyke, Huntingfield Bay, Magnetic Island. The felsite has been recrystallized to a siliceous mosaic. (See Fig. 13).

13. A thin aplite dyke from the nearby adamellite, Huntingfield Bay, Magnetic Island. The aplite intrudes coarse agglomerate and a dolerite dyke. (A few yards northwest of Fig. 12).

At Huntingfield Bay (Figs 12, 13) a basic dyke, which intrudes the volcanics, has been cut by a later set of dark dykes. On Rattlesnake Island (Fig. 14) and Acheron Island in the Ingham Sheet area to the north two swarms of dark dykes intersect each other at right angles.

On the mainland the dark and pale dykes were rarely seen in contact, but where they do occur together, the dark dykes are invariably younger.

14. Two intersecting swarms of basic to intermediate dykes, north coast of Rattlesnake Island. The country rock is a pale grey massive porphyry (C-Pp).

Basic to Intermediate Dykes. The earlier of the two dark dykes at Huntingfield Bay is an altered dolerite which has been hornfelsed by the nearby granite. It consists of labradorite, hornblende, secondary biotite, and rare pyroxene. The later dyke is a fine-grained microdiorite consisting of a few large embayed crystals or xenocrysts of quartz set in a matrix composed of microlites of oligoclase, pale brown hornblende, and rare pyroxene.

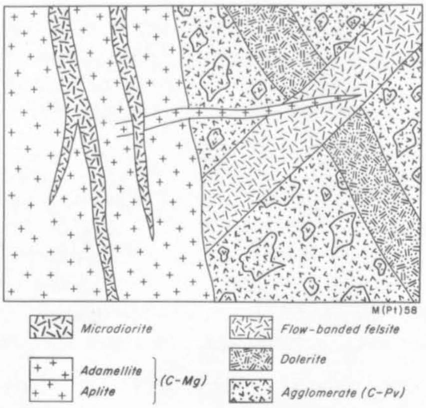
The age of the Magnetic Island granite (now dated at 280 m.y. - see p. 50) lies between those of the two dark dykes. The dykes possibly represent an earlier dolerite suite and a later microdiorite suite; but elsewhere around Townsville the composition of individual dykes ranges from dolerite through quartz dolerite and augite microdiorite to normal microdiorite. In general, dolerite is more abundant than microdiorite and commonly contains appreciable amounts of interstitial quartz, potash feldspar, and albite.

The dark dykes are commonly about 5 feet thick, but range up to 20 feet. Most of the dykes trend northwest, but some strike northeast and north.

Felsite Dykes. Pale acid felsite dykes are locally abundant. They are closely related to the Mount Elliot, Saddle Mountain, and Cape Cleveland granites (P-Mg), and an example occurs at the contact of the Magnetic Island granite. The dykes comprise leucocratic rhyolite and soda rhyolite, with or without quartz and feldspar phenocrysts. Quartz keratophyre and leucocratic microadamellite have also been recorded.

The dykes are almost invariably flow-banded. The banding may be parallel to the walls or contorted. Spherulitic texture is common, and small pyrite cubes occur locally. Epidote, calcite, and sericite are common alteration products.

The felsite dykes are usually 20 to 30 feet thick. They are well exposed in the upper part of Alligator Creek south of its confluence with Cockatoo Creek. Dolerite dykes are also abundant in this locality.



15. Relationships between volcanics, dykes, and adamellite, Magnetic Island.

Field Occurrences. The field occurrences are described briefly below.

At Huntingfield Bay, Magnetic Island, the following order of intrusion can be observed (see Fig. 15):

Microdiorite dykes (youngest)
Adamellite and aplite
Felsite dyke
Dolerite dyke
Agglomerate and volcanic breccia (oldest).

At West Point, the volcanics are intruded by dykes of dolerite and hydrothermally altered quartz-feldspar porphyry, which has a different texture to that of the typical felsites.

Some of the flow-banded rocks in the Many Peaks Range may be intrusive (see p. 51); they resemble the felsite dykes found elsewhere. The banding is subvertical, and trends from 020° to 125°. On the southern slopes, in the middle of the range, rhyolite is intruded by thin northwesterly trending dolerite dykes composed of phenocrysts of basic plagioclase, green hornblende, titanaugite, magnetite, rare quartz, and patches of chlorite and calcite.

Dark north-northeasterly dykes, 5 to 6 feet wide, intrude coarse leucogranite in the centre of the Muntalunga Range. They consist of calcic plagioclase, brown basaltic hornblende, a little clinopyroxene, and some quartz, magnetite, epidote, chlorite, and calcite. A microdiorite dyke on the northern flank of the range is intersected by thin concordant veins of hornblende aplite. Coarser porphyritic dolerite dykes intrude both the granite and volcanics in the eastern foothills across the railway line.

The augite-biotite andesite southwest of Whites Creek may be intrusive. Some boulders of altered alunite-bearing albite dolerite were also found. The rock consists of albite, clinopyroxene, chlorite, magnetite, alunite, and a little quartz.

Dykes of brown porphyritic keratophyre intrude the central stock of Mount Stuart beside the road within 2 1/2 miles of the summit. They are composed of phenocrysts of albite, partly altered to calcite and sericite, set in a hypidiomorphic groundmass of albite, potash feldspar, quartz, chlorite, and magnetite. The dykes strike 095° to 125°.

On the right bank of the Ross River at the confluence with Five Head Creek, a sill of pale brown quartz keratophyre intrudes a conglomerate dipping steeply to the east-northeast.

The sill contains phenocrysts of albite in a fine-grained hypidiomorphic groundmass of potash feldspar, quartz, albite, and fine-grained aggregates of biotite. In the bed of the Ross River near the opposite bank, multiple basic to intermediate dykes strike 130°. They are cut by aplite veins, and enclose small ovoid xenoliths which contain acicular hornblende similar to that at the summit of Mount Stuart.

The granite 2 miles southeast of the summit of Mount Stuart is intruded by dykes of dark greenish blue spherulitic albite rhyolite striking 100°, and the microgranite half a mile to the west is intruded by a dolerite dyke, 20 feet wide, which trends 120°. Pyritic coatings occur on joint surfaces in the dolerite. The walls of the dyke are jagged owing to the fracturing of the granite in several directions. The dyke is composed of calcic plagioclase, magnetite, green hornblende, titanaugite, chlorite, and rare quartz.

On the hillside south of Stuart, where conglomerate overlies granite (see p. 36), a thin rhyodacite dyke has been intruded along a small fault between the granite and the conglomerate. The dyke contains xenocrysts of quartz and phenocrysts of plagioclase set in a turbid fine-grained groundmass of potash feldspar(?), plagioclase, quartz, and devitrified glass(?). A dyke of coarser mauve-brown porphyritic rhyodacite intrudes the granite nearby. It consists of phenocrysts of potash feldspar and oligoclase in a groundmass of plagioclase, xenomorphic quartz, some chlorite, and finely disseminated iron oxide. The phenocrysts are largely altered to calcite and chlorite. Farther down the hill a 6-foot dyke of weathered dolerite striking 120° intrudes a pink aphanitic rhyolite dyke(?).

Half a mile southeast of Stuart Prison, dykes of white fluidal soda rhyolite intrude granite (Cg). The banding dips at 40° towards the west-northwest, and strikes 200°. The rhyolite contains a few small clots of albite and quartz crystals set in a medium to fine-grained hypidiomorphic groundmass of quartz and alkali feldspar. A few patches of fine sericite, usually associated with quartz, are also present.

The boulders of spherulitic flow-banded rhyolite(?) near the base of the hill to the south of Woodstock Hill are probably derived from dykes. Near the top of the hill, dolerite dykes trending northwest intrude pyroxene andesite. In places they contain pyrite in small quartz veins.

Near the western corner of the Saddle Mountain granite, a dyke of coarsely porphyritic microdiorite or dolerite, 3 feet wide, intrudes a large boulder of welded tuff. The rock is composed of hornblende, some uralite, a little quartz, and basic plagioclase (An 50+).

In upper Alligator Creek, thick flow-banded dykes of rhyolite and albite rhyolite intrude massive volcanic breccia. Most of the dykes trend north-northeast. The flow banding in the thickest dyke (which is 400 to 500 feet thick) is highly contorted throughout, but in the thinner dykes (20 to 30 feet thick) it is usually parallel to the walls and absent in the centre. A little biotite is present in the groundmass, and all the dykes are strongly epidotized. Pyrite cubes are common. A swarm of dolerite dykes, trending east-southeast and averaging 4 to 6 feet wide, intrudes the felsite dykes. The dolerites contain colourless clinopyroxene and rare potash feldspar and quartz.

At Spur End at the southwestern tip of Mount Elliot, the recrystallized volcanics are intruded by dark porphyritic rhyolite. The rhyolite contains large pink phenocrysts of anorthoclase(?) set in a dark blue aphanitic devitrified groundmass containing a few corroded flakes of partly chloritized brown biotite.

Age. A basic dyke which intrudes the volcanics (probably Upper Carboniferous) of Magnetic Island is intruded by the nearby granite, which is uppermost Carboniferous or early Permian, suggesting that there is a suite of late Carboniferous melanocratic dykes in the Townsville district.

Other melanocratic dykes intrude the Lower Permian granites.

Most of the basic dykes in the Townsville-Stuart area are tholeiitic and free of olivine and the difference in composition compared with the Cainozoic olivine basalts indicates that they represent a separate cycle of igneous activity. The dykes are commonly jointed and faulted, probably as a result of tectonic movements, such as the faulting which preceded the Cainozoic olivine basalt cycle. All that can be said at present is that most of the basic dykes in the Townsville-Stuart area are broadly related to the late Palaeozoic cycle of igneous activity.

The pale dykes are generally confined to the environs of the granites mapped in the 'P-Mg' group, from which some of them are probably offshoots.

MESOZOIC(?)

Collopy Formation (Mc)
(new name)

The sequence of Mesozoic(?) sandstone, arkose, and conglomerate at Mingela Bluff in the Leichhardt Range is here named the Collopy Formation (Table 4). The name is derived from Collopy Holding. The coarse sandstone cropping out 2 miles west of Bunkers Hill is correlated with the sandstone at Mingela Bluff. The type section is Mingela Bluff, at longitude $146^{o}42'52''$E. and latitude $19^{o}53'26''$S.

Jack (1879a, pp. 8-9) tentatively suggested that the sandstone at Mingela Bluff was younger than at least part of the Devonian sediments around Dotswood, but older than the Desert Sandstone.

At Mingela Bluff the formation consists chiefly of medium to coarse-grained micaceous sandstone, coarse quartz sandstone and feldspathic sandstone, arkose, and conglomerate. The basal beds are coarse micaceous feldspathic sandstone and subordinate well sorted quartz sandstone. Thin bands of conglomerate, composed largely of moderately well rounded milky quartz, are common. About 100 feet above the base of the section there is a 50-foot bed of conglomerate containing rounded cobbles of quartz, quartzite, quartz porphyry, microgranite, volcanics, and shale; the cobbles average about 2 inches in diameter. In the upper 200 feet, intervals of relatively thin-bedded fine micaceous feldspathic sandstone up to 50 feet thick are separated by beds of coarse sandstone. Two indeterminate fragments of plant stems were noted in the finer sandstone. Where the sandstone is micaceous, it weathers readily to form large caves and overhangs. The topmost 50 feet consists of coarser feldspathic sandstone. The estimated thickness of the sequence in the centre of the bluff is 500 feet, but it is probably slightly thicker at the eastern end of the bluff.

The beds are generally about 20 feet thick and lenticular, and cross-bedding is common; the sediments range from light brown to reddish brown in places.

At Mingela Bluff the Collopy Formation has an average dip of 10^{o} to the southeast, but 2 miles northeast of Grass Hut it is horizontal. Higher dips are found along the large easterly transcurrent fault which displaces the formation.

West of Bunkers Hill the formation consists of coarse quartz sandstone and coarse conglomeratic lithic sandstone, containing granite and volcanic phenoclasts.

The Collopy Formation rests nonconformably on the Ravenswood Granodiorite Complex. West of Bunkers Hill, the Ravenswood Granodiorite Complex is intruded by swarms of rhyolite, andesite, and microgranite dykes, which do not intrude the Collopy Formation. The base of the sandstone west of Bunkers Hill is at about the same level as the present erosional surface of the Kirk River Beds, and the Collopy Formation probably originally rested on top of the Kirk River Beds. The formation appears to be of freshwater origin.

The age of the Collopy Formation is unknown, but similar sandstones occur in the Just Range 25 miles southwest of Charters Towers, where they are regarded as an outlier of the Lower Triassic Warang Sandstone of the Galilee Basin (Wyatt et al., 1967, unpubl., and in press.).

TABLE 4 : MESOZOIC AND CAINOZOIC STRATIGRAPHY

	Rock Unit	Lithology	Remarks
QUATERNARY	(Qs)	Sand, soil	Superficial. Chiefly residual. Some transported.
	(Qa)	Sand, silt, gravel	Superficial. Alluvial and colluvial deposits. Gravel used as road ballast, concrete aggregate. Groundwater.
	(Qr)	Sand	Superficial. Coastal dunes representing old and present shorelines.
	(Ql)	Lacustrine deposits, including diatomaceous earth	Superficial. Deposited in lakes ponded by Toomba Basalt.
	Toomba Basalt (Qt)	Olivine basalt	Superficial. Youngest flow in area. Similar to Kinrara Basalt in Einasleigh Sheet area. Twidale (1956).
PLIOCENE TO PLEISTOCENE	Sellheim Formation (Cze)	Sandstone, sandy claystone, pebble conglomerate	Probably remnants of old alluvium of Burdekin and Fanning Rivers. Jack (1879a).
	Nulla Basalt (Czn)	Olivine basalt	Plateau-basalt flows. Erupted W of Bluff Downs and Southwick homesteads. Flowed E along watercourses.
	(Czb), (Czy)	Olivine basalt, commonly overlying silicified quartz sandstone and conglomerate (silcrete)	Unnamed remnants of flows NE and E of Nulla Province. Small plugs in E. Silcrete not genetically related to basalt (see text).
	Lassies Creek Gravels (Czl)	Pebbly argillaceous arkosic sandstone, minor conglomerate	Nonconformable on and derived from Oweenee Granite. Weakly mottled by iron oxides.
PLIOCENE	(Tf)	Ferricrete	On Campaspe Beds.
	Campaspe Beds (Tc)	Pebbly argillaceous sandstone, rare siltstone	Disconformable on laterite (Tl). Derived mainly from Lolworth Igneous Complex.
EARLY TERTIARY	(Tl)	Laterite	On early Tertiary sediments, parts of Nulla Basalt, Oweenee Granite, Lolworth Igneous Complex, Devono-Carboniferous sequence, Ravenswood Granodiorite Complex, and Charters Towers Metamorphics.
	Unnamed Tertiary sediments (not on map)	Sandstone, shale	Lenticular lacustrine deposits derived from and nonconformable on Ravenswood Granodiorite Complex. Lateritized. Lacustrine. Plant fossils, 50 ft thick. Morton (1945); Jack (1879a); Marks (1913).
MESOZOIC(?)	Collopy Formation (Mc)	Micaceous sandstone, arkosic in places; conglomerate, minor quartz sandstone	Nonconformable on Ravenswood Granodiorite Complex. Large-scale cross-bedding. Rare indeterminate plants. At least 500 ft thick. Jack (1879a).

CAINOZOIC

Cainozoic lacustrine and fluviatile sediments and basalt occur in the Townsville hinterland. Piedmont and fluviatile deposits form most of the coastal plain, and a narrow belt of littoral deposits is present along the coast.

Many of the continental sediments are lithologically similar, and if it were not for the occurrence of ferruginous zones in old weathering profiles, they could not be easily distinguished.

Weathering Profiles as an Aid to Subdividing the Cainozoic

Two lateritic weathering profiles have been recognized in the Townsville Sheet area. The ferruginous zone (Tl) of the older and thicker profile is a laterite according to common Australian usage, that is, a zone of red-brown rock consisting mainly of hydrated iron and aluminium oxides, passing downwards into mottled and pallid zones. It is referred to in this Report as laterite. The ferruginous zone (Tf) of the younger profile is nowhere more than 3 or 4 feet thick, and consists of a brown porous mass of intergrown nodules formed from concentric layers of iron oxides. This is referred to as ferricrete. The younger profile is developed on the Campaspe Beds and also probably on older exposed units. The Campaspe Beds disconformably overlie the older profile (e.g., at Red Falls on Lolworth Creek), and for this reason the younger profile can only be recognized with certainty where developed on the Campaspe Beds.

The main characteristics of the weathering profiles are summarized in Table 5.

TABLE 5 : CHARACTERISTICS OF THE WEATHERING PROFILES

	Older Profile	Younger Profile
Thickness	25-30 ft or more	About 5 ft, but commonly less
Colour	Generally red	Generally brown
Profile	3-6 ft laterite, grading downwards into mottled and pallid zones and altered parent rock	1-2 ft ferricrete passing rather abruptly downwards into mottled zone and parent rock
Topographic expression	Tends to form prominent mesas up to 40 ft high. Tops of mesas form part of an old peneplain	May form a low step 3-4 ft high, but frequently has no topographic expression
Remarks	Developed on numerous rock types	Recognized only on Campaspe Beds

The Cainozoic deposits can be subdivided into:

3. Sediments younger than the ferricrete, i.e., the Sellheim Formation, and the Pleistocene and Recent alluvium and colluvium.

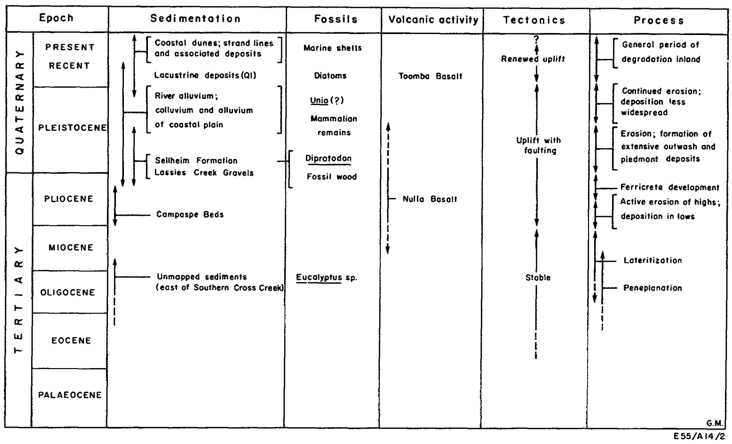
2. Sediments intermediate in age between the laterite and ferricrete, i.e., the Campaspe Beds and possibly the Lassies Creek Gravels.

1. Sediments older than the laterite, i.e., sediments typically developed in the Featherby Range, west of Charters Towers, and those which form the falls at Red Falls. (Because of the laterite cover these sediments were found to be unmappable at 1:250,000 scale in the Townsville Sheet area).

Since the field work for this Report was completed, the senior author has studied the geomorphology of the pre-Nulla Basalt land surface and has shown that silcrete is genetically associated with the laterite profile, and not with the basalts. The occurrence of basalt overlying silcrete is fortuitous, and does not indicate a genetic relationship, as was formerly thought (Wyatt et al., 1965, unpubl.). This later work has also shown that the Nulla Basalt is everywhere younger than the laterite*.

The geomorphology of the Cainozoic rock units indicates that the history of the Cainozoic era was complex. A simplified history is given in Table 6.

TABLE 6 : PROBABLE TIME-RANGES OF CAINOZOCC ROCK UNITS AND EVENTS



Unmapped Tertiary Sediments

Between Southern Cross Creek and Sandy Creek the laterite (Tl) is underlain by a sequence of horizontal sandstone and shale about 50 feet thick. The sediments form the northern end of the Featherby Range (generally known locally as Featherby Wall), which is an east-facing scarp composed of lateritized granodiorite and Tertiary sediments. The exposures along the scarp, and the geomorphological relationships elsewhere in the Townsville and adjoining Charters Towers Sheet areas, clearly indicate that these sediments were laid down in depressions in a granitic terrain.

Similar sediments at the southern end of Featherby Wall and at Little Red Bluff, both in the Charters Towers Sheet area, have been described by Morton (1945), Jack (1879a), Marks (1913), Reid (1917), and Saint-Smith (1921). Morton records dicotyledonous plant remains from Featherby Wall and Little Red Bluff.

When the geological map and Explanatory Notes went to press it was thought that the lateritization of these deposits probably occurred in the Miocene, but evidence from the Roma area (N.F. Exon, pers. comm.) shows that the deep weathering profile is older than basalts which have been dated isotopically at 23 m.y. (lower Miocene). This suggests that the laterite is pre-Miocene, and therefore that the lateritized Cainozoic sediments are even older.

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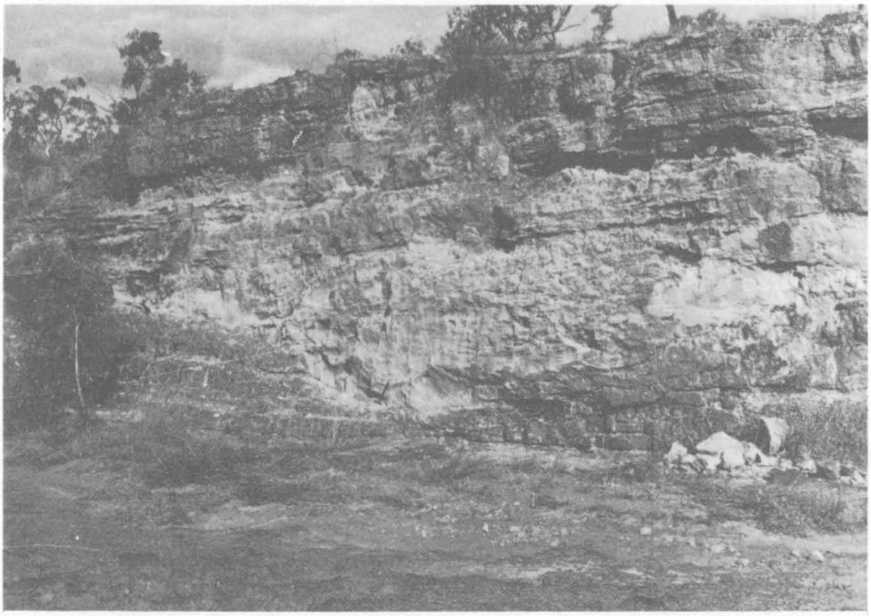
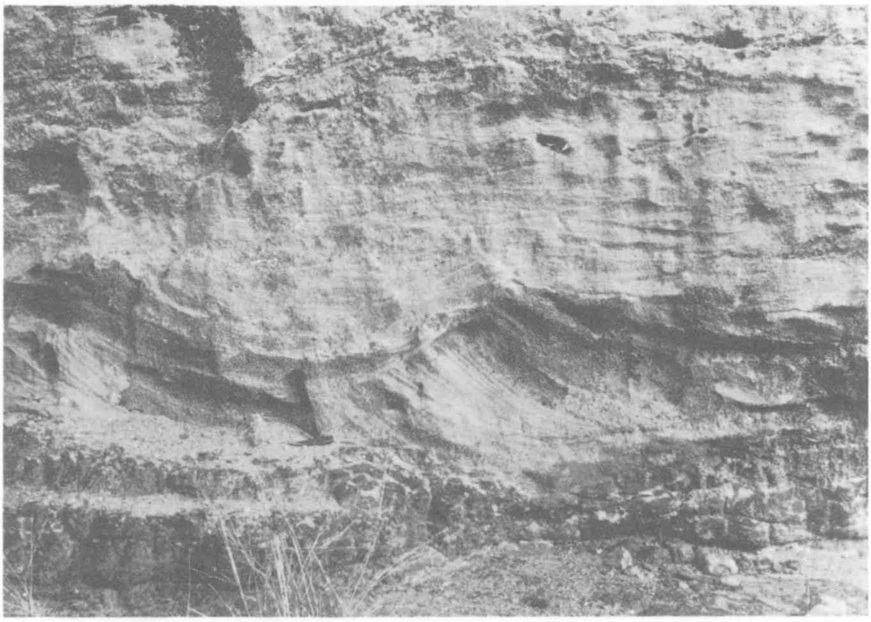
* The Nulla Basalt has been mapped as overlying the Campaspe Beds where the Homestead-Myola track crosses Hann Creek, but here the ferricrete is absent. Also, north of Allensleigh homestead there are sediments, with a ferricrete development, which are younger than the basalt, but which at the time of the survey were equated with the lateritized sediments of Featherby Wall. This suggests that either (1) the sediments under the basalt near Myola do not belong to the Campaspe Beds or (2) that there is another ferricrete younger than that developed on the Campaspe Beds.



16. About 20 feet of buff argillaceous grit of the Campaspe Beds (Pliocene) disconformably overlying early Tertiary sediments on the right bank of Lolworth Creek at Red Falls. Nearby the Campaspe Beds are capped by a thin layer of ferricrete (Tf).



17. Close-up of disconformity shown in Figure 16.

In 1967, the senior author found lateritized argillaceous sandstone, coarse quartz sandstone, and pebble conglomerate beneath the Nulla Basalt between Bluff Downs and Allensleigh homesteads. Like those in the southern part of the Sheet area, these sediments cannot be interpreted on the air-photographs. They are generally exposed only in the cliffs of laterite mesas, and even here may be obscured by talus. For these reasons it has not been possible to map them at the 1:250,000 scale.

Campaspe Beds (Tc)
(new name)

The thin Cainozoic sediments between the Cape and Campaspe Rivers in the Hughenden Sheet area were mapped as the Cape-Campaspe Series by Dunstan (1913). The present survey has shown that the beds extend over a large area in the Hughenden, Charters Towers, and Townsville Sheet areas. The name is here revised to Campaspe Beds, and Red Falls on Lolworth Creek is nominated as the type locality (Fig. 16). The Campaspe Beds give rise to sandy plains which are being dissected by streams incised 10 to 20 feet below the level of the plains.

The Campaspe Beds consist of white to pale buff argillaceous gritty sandstone, fine to medium-grained sandstone, and rare siltstone. Much of the coarser sandstone is pebbly, and small calcareous nodules occur locally in the finer beds. The sandstone consists of quartz and feldspar in a matrix of fine quartz sand, silt, or clay. White mica is commonly present, and the flakes are usually randomly oriented. The beds are generally poorly sorted and poorly bedded. The sediments are fairly well consolidated, although somewhat friable. A rare example of cross-bedding can be seen at Red Falls (Fig. 17), where foreset beds fill a scour in the underlying lateritized sediments.

In interfluvial areas the Campaspe Beds are capped by a poorly preserved layer of nodular ferricrete (Tf), which in many places has disintegrated to buckshot gravel. Where dissected by streams, the ferricrete commonly gives rise to a sharp step at the top of the breakaways bordering the streams, but in some areas it has been completely removed. A zone of weak mottling underlies the ferricrete, commonly with a rather abrupt transition. The mottled zone ranges from 2 to 5 feet thick, and passes gradually into apparently unaltered Campaspe Beds within a few feet.

The Campaspe Beds are horizontal in the Townsville Sheet area, but depositional dips of up to 15° occur close to the source areas in the Hughenden and Charters Towers Sheet areas.

At Red Falls the sequence is 15 to 20 feet thick, and the maximum thickness in the Townsville Sheet area is probably less than 30 feet.

The Campaspe Beds disconformably overlie laterite (Tl) at Red Falls. In the Charters Towers Sheet area they are overlain by the Nulla Basalt where the Homestead-Myola track crosses Hann Creek; here the ferricrete is missing, and there was probably a period of erosion before this particular basalt flow was extruded. Some exposures farther east along Hann Creek suggest that the basalt and the Campaspe Beds may abut against each other in places. The relationship of the Campaspe Beds to the Sellheim Formation is uncertain, as the contacts are obscured by sandy soil. In the Hann Creek/Gains Creek area, the Sellheim Formation is at a higher elevation than the Campaspe Beds, and is thought to be younger.

The Campaspe Beds are a piedmont deposit derived from the coarse granite of the Lolworth Range (Lolworth Igneous Complex). The lack of sorting, poor bedding, random orientation and distribution of mica flakes, and the persistence of the coarse fraction far from the source area all indicate that the beds were laid down under torrential conditions. The preservation of feldspar indicates that little chemical weathering took place in the source area, and that the material was rapidly transported and buried. The vegetation was evidently sparse, and the climate arid, but subject to sudden torrential storms.

The Campaspe Beds were laid down on the laterite covering a former peneplain, which may have been considerably undulating in places. It is likely that the basal beds were derived in places directly from the laterite. This would give rise to a high initial iron content in the sediment, which in turn would be a suitable source material for the development of the ferricrete.

The Campaspe Beds are tentatively regarded as Pliocene. They are younger than the major period of lateritization (probably pre-Miocene), but older than the Toomba Basalt, which is probably sub-Recent. They appear to be older than the Nulla Basalt, which is of late Pliocene to Pleistocene age, and are probably older than the Sellheim Formation which is about the same age as the Nulla Basalt.

Lassies Creek Gravels (Czl)
(new name)

Pebbly arkosic sandstone, grit, and minor conglomerate crop out in the headwaters of Lassies Creek. The sediments are similar to the Campaspe Beds in lithology, and may be of similar age.

The formation fills hollows and gullies in the surface of the Oweenee Granite, which was the source rock for the sediments. The thickness is variable, with a maximum of 25 feet.

The sediments are fairly well consolidated, but are generally poorly sorted, and show little evidence of transport. They are slightly mottled owing to an uneven distribution of iron oxides, but do not contain any ferricrete zone. The formation is being dissected by present-day streams where the only exposures are found. The formation has given rise to small deposits of alluvial tin derived from the Oweenee Granite.

Nulla Basalt (Czn)

The Nulla Basalt extends into the southwestern part of the Townsville Sheet area from the Clarke River Sheet area (Twidale, 1956; White, 1965). It comprises a number of olivine basalt flows which form a broad slightly domed plateau centred on Nulla Nulla homestead in the Clarke River Sheet area. Photo-interpretation suggests that there are several distinct levels in this plateau, which probably represent separate flows or groups of flows. The flows forming successively higher levels generally appear not to extend as far as the preceding flows; all are centred roughly on Nulla Nulla homestead. In the Townsville Sheet area, most of the flows have a regional easterly dip, and many of the basalts tail off into narrow flows along the larger streams that border the main outcrop area (see map). One narrow flow extends along the west bank of the Burdekin River from about 12 miles northwest of Gainsford homestead to the junction of the Anabranch and the Burdekin River. The flow south of the Basalt River possibly filled an older course of that river. Another flow occurs parallel to and north of Hann Creek.

The Nulla Basalt is deeply eroded, and most of it is covered by red or black soil strewn with boulders. Many streams, such as Allingham Creek and the Basalt River and its tributary Sandy Creek, are deeply incised, and sections of basalt up to 100 feet thick are exposed. The maximum thickness is uncertain, but it is unlikely to be more than 150 feet.

Preliminary K/Ar whole-rock dating suggests several episodes of eruption, which in some instances can be equated with regional topographic levels. Results indicate at least five episodes, which occurred 4.5, 4.0, 2.3, 1.3 and 1.1 m.y. ago (Plio-Pleistocene) (A.W. Webb, pers. comm.).

Undivided Cainozoic Basalt (Czb)

East of the Burdekin River but north of Plains Creek, near Valpré homestead, there are isolated small mesas of olivine basalt which are possibly outliers of the main field of Nulla Basalt. There are similar mesas farther northwest, south of the Burdekin River and upstream of New Moon homestead. These, however appear to belong to a separate flow, possibly of similar age, which followed the juvenile valley of the Burdekin River. This valley is now partly preserved by a number of basalt mesas which extend farther west to the lower reaches of Cleanskin and Blue Range Creeks in the Clarke River Sheet area.

Throughout the Townsville Sheet area there are isolated olivine basalt plugs, usually with no associated flows. All, except one in the lower reaches of Tomahawk Creek 12 miles west-northwest of Ewan, lie in the eastern half of the Sheet area, but west of the Paluma and Hervey Ranges.

The characteristics of these plugs are summarized in Table 7.

Sediments North and Northeast of Allensleigh Homestead (Tl)

North and northeast of Allensleigh homestead the Nulla Basalt is overlain by outwash fans from the Oweenee Granite. The fans consist of sand and gravel which contain nodular ironstone similar to the ferricrete on the Campaspe Beds. At the time of this survey the degree of leaching and iron enrichment of these sediments was thought to be comparable with that of the sediments at Featherby Wall, and they were mapped accordingly as laterite (Tl). It therefore followed that at least the northern (and possibly oldest) flows of the Nulla Basalt were older than the laterite. With the recent discovery of lateritized sediments under the Nulla Basalt near Allensleigh homestead, the correlation of the sands and gravels with the sediments at Featherby Wall is no longer tenable.

Recent work by the senior author has shown that much of the soil on the Nulla Basalt south of the Basalt River contains grains and pebbles of quartz, and more rarely fragments of granite and pebbles of ironstone. This suggests that these fan deposits once extended much farther south, where they have since been eroded away as a consequence of the rejuvenated stream activity which caused the Basalt River and Allingham Creek to cut deeply into the Nulla Basalt.

If these outwash deposits did once extend farther south, then the ancestral valley of the Basalt River was probably cut in them. This valley is now preserved by a flow which gives a K/Ar date of 1.3 m.y. These deposits therefore are older than that, but younger than 4.0 to 4.5 m.y., that is, the K/Ar age of the flow they overlie. In other words their age is late Pliocene.

Sellheim Formation (Cze)
(new name)

A thin cover of flat-lying sediments overlies the Ravenswood Granodiorite Complex in the Charters Towers Sheet area, south from Sellheim railway station to near Broughton (Jack, 1879a). The northern part of the outcrop extends into the Townsville Sheet area, and similar sediments to the north and northwest, along the Burdekin and Fanning Rivers and Hann Creek, have been included in the formation. The sediments form a low sandy capping on the underlying rocks, and support Burdekin plum, bottle tree, and low scrub.

The formation comprises sandy claystone, brown or bluff quartz sandstone, and fine pebble conglomerate with a subordinate matrix of fine sand or clay. There is usually a ferruginous quartz sandstone at or near the base. The formation is generally mottled orange-brown and cream; the mottling is due to bleaching adjacent to near-vertical tubules, up to 1 cm in diameter, filled with off-white clay. The tubules are interpreted as root cavities which were filled with clay when the wood decomposed. The nearby sandstone was probably bleached by humic acid formed during the decomposition of the wood.

The Sellheim Formation is horizontal. It is poorly bedded, but vague cross-bedding was noted in a few places. The maximum observed thickness is 10 feet.

TABLE 7 : SUMMARY OF OLIVINE BASALT INTRUSIONS

Location	Dimensions	Relief	Host Rock	Remarks
146°40'0"E; 19°54'S	14chs x 10chs	20 ft	Ravenswood Granodiorite Complex	Situated on strong east-west fault
146°40'E; 19°53'S	23chs x 16chs	10-15 ft	"	
146°38'42"E; 19°52'30"S	3chs diameter	5 ft	"	Found by detailed mapping in 1966; not shown on map
146°36'E; 19°53'32"S	7chs x 5chs	1-2 ft	"	
146°27'54"E; 19°52'52"S	24chs x 17chs	50 ft	"	On major NW-trending fault
146°24'00"E; 19°48'36"S	20chs x 15chs	40 ft	"	On same fault as above
146°23'00"E; 19°47'43"S	15chs x 7chs	10 ft	"	" " " " "
146°17'12"E; 19°46'28"S	40chs x 30chs	400 ft	Ravenswood Granodiorite Complex and Fanning River Group	Arthurs Peak. Segregations of olivine. Phenocrysts of green glassy pyroxene up to 15 mm across
146°29'27"E; 19°45'00"S	33chs x 25chs	50 ft	Ravenswood Granodiorite Complex	Surface flow structure preserved in places. Possibly remains of a double orifice
146°31'3"E; 19°43'3"S	32chs x 28chs	200 ft	"	Pyroxene similar to that at Arthurs Peak
146°14'0"E; 19°28'36"S	85chs x 25chs	20-30 ft	Pall Mall Adamellite and its contact with Argentine Metamorphics and Game Hill Beds	Blueberry Hills. Low mesa (20-30') formed by thin (4-6') basalt flow. Circular fracture patterns, 10 ft diameter, probably related to effusion points
146°12'12"E; 19°20'45"S	10chs diameter	100 ft	Argentine Metamorphics	
146° 01'12"E; 19°02'05"S	10chs x 7chs	15 ft	Oweenee Granite	
145°40'E; 19°5'8"S	15chs x 9chs	0-15 ft	Hells Gate Rhyolite (Sybil Group)	Found by detailed mapping in 1967; not shown on map
146°38'E; 19°42'S	Possibly 20 ft thick	-	Ellenvale Beds	A sill conformable with arenites of Ellenvale Beds; dips SSE at about 65°

The survival of iron oxides in the ferruginous sandstone near the base suggests that the sediments have not been subjected to lateritic weathering, and if this is so they are presumably younger than the Campaspe Beds.

The formation contains small fragments of silicified wood. The remains of Diprotodontus, reported by Jack (1879a) near Gilgunyah homestead in the Charters Towers Sheet area, were probably found in sediments belonging to the Sellheim Formation.

The formation may represent high-level deposits along the Burdekin River and its tributaries. At Sellheim, the formation is about 110 feet above the present stream bed, but in the Hann Creek area it is not so high.

The Sellheim Formation rests nonconformably on the Ravenswood Granodiorite Complex, and is probably younger than the Campaspe Beds. Its relationship to the Nulla Basalt is unknown, but it lies at a higher elevation than the basalt near the confluence of Hann Creek and the Burdekin River, and it appears that the formation may have been dissected by the Burdekin River before the river channel was filled by a flow dated at 1.1 m.y. It is tentatively regarded as Plio-Pleistocene in age.

Toomba Basalt (Qt)

Olivine basalt crops out north of Toomba homestead, and extends northeast between Lolworth and Fletcher Creeks. The basalt has a distinctive pattern on air-photographs. It was named the Toomba Basalt by Twidale (1956), who recognized it as the youngest flow in the Nulla Province. The basalt is vesicular, and ropy surfaces are preserved in places. Collapsed lava tunnels and pressure ridges are common, and the surface of the flow is extremely rough and impassable to vehicles.

The eruption centre is in the Hughenden Sheet area, 25 miles west of the southwestern corner of the Townsville Sheet area. The basalt flow tapers in width northeast from the eruption centre, and eventually forms a narrow ribbon parallel to the Burdekin River in the lower Lolworth Creek area, and near The Rocks. The Toomba Basalt is covered by scrub, but no soil has yet been formed on the flow. It dammed many of the small streams in the area, and diatomaceous earth (Ql) was deposited in many of the lakes. It has a very youthful aspect, and the lack of erosion and soil cover suggest that it is probably Recent. K/Ar dating suggests that the Toomba Basalt is no older than 100,000 years (Appendix). It is similar to the Kinrara Basalt (White, 1963, 1965) in the Einasleigh Sheet area.

Beach Deposits (Qr)

A discontinuous belt of fixed coastal dunes up to 2 miles wide borders the coastline between Cleveland Bay and the mouth of Bluewater Creek. The dunes are old strandlines, and are seldom over 10 feet above the intertidal flats.

Maitland (1892) described a beach-rock in the littoral zone on Magnetic Island. The deposits are formed of shell debris cemented by calcium carbonate, and are too small to be shown on the map. Similar deposits, now being eroded, were noted on Acheron Island just north of the Sheet area. A pumice beach, similar to that described by Maitland on Magnetic Island, was noted on the northeastern side of Cape Cleveland, just within the Ayr Sheet area (Paine et al., 1970).

Alluvium and Colluvium (Qa)

Deposits of alluvium up to 50 feet thick border many of the main streams. The thickest deposits occur along the Burdekin River and in the lower reaches of its tributaries. They consist mainly of grey silt. The deposits are well stratified, and signs of old soil profiles remain in some of the older ones. The oldest deposits along Keelbottom Creek and the Fanning River are usually mottled by iron oxides.

In the coastal lowlands there are extensive alluvial deposits which grade into colluvium near the foot of the coastal scarps. Most of the wedges of scree which form part of the colluvium have been stabilized by vegetation. Most of the deposits are being dissected by present-day streams, and the only areas of active deposition are in the deltas of the coastal streams and in the littoral zone along the coast.

The thickness of the deposits on the coastal plain is unknown. Jack (1886c) has recorded up to 109 feet of 'drift in bores in the Stuart Creek area'; he (1879a) recorded the presence of Unio and decayed mammalian remains in the deposits, and assigned a post-Tertiary age to them.

Sand and Soil (Qs)

Much of the low country between Mount Boddington and Gainsford homestead is covered by residual sand and sandy soil derived from the Ravenswood Granodiorite Complex, Sellheim Formation, Campaspe Beds, and unmapped lateritized Tertiary sediments.

Farther north, near Dotswood, there are rises covered with soil and pebbly and cobbly rubble. The sediments appear to be older than the alluvium along Keelbottom Creek. The pebbles and cobbles consist mainly of quartz or quartzite, similar to those in the Sellheim Formation, and the rubble may be the eroded residue of beds equivalent to the Sellheim Formation. The abundance of silicified wood in the pebble-cobble fraction also suggests that they were derived from the Sellheim Formation.

Other soil and pebble-covered areas occur between the Little and Great Star Rivers, and west of the Great Star River. The coarser fraction is confined mainly to the area between the two rivers above their confluence or northwest of Corner Creek, where the streams descending from the Coane Range are checked before entering the Great Star River. Farther west and southwest, most of the underlying rocks are masked by deep soil.

STRUCTURE

One of the most notable structural features in the Townsville hinterland is the well developed fault system. The faulting has affected all rocks ranging from Precambrian to Mesozoic(?), and in the Charters Towers Sheet area faulting has also affected Cainozoic strata. The progressive stabilization of the region is demonstrated by the different types of folds found, by the decrease in the degree of metamorphism of the younger rocks, and by the change in the depositional environments in which the younger beds were laid down.

The beds mapped as Precambrian or early Palaeozoic have been isoclinally folded, and the development of shear cleavage has imposed a strong vertical or near-vertical schistosity on the rocks. Flow folding and mineral segregation in places suggest dynamic metamorphism at moderate to high temperatures and pressures. Bedding is generally unrecognizable, and the order of superposition is unknown. Individual fold closures can generally not be recognized. The same is true of the Charters Towers Metamorphics, which are probably Cambrian or early Ordovician, but the Kirk River Beds, which are believed to be the same age, are not so severely folded or metamorphosed. This may be because they were intruded by the Ravenswood Granodiorite Complex at a higher crustal level.

The Siluro-Devonian sediments have been crumpled into numerous small folds, commonly with a near-vertical plunge, in which dips are moderate to steep, and bedding is still recognizable. The folds are usually similar, and fracture cleavage is well developed. The succession has apparently been folded into a broad synclinorium of which only part of the southeast limb appears in the Townsville Sheet area. Individual fold closures can be readily identified. The Siluro-Devonian sediments were apparently laid down on a rapidly subsiding seafloor. They were not metamorphosed when regionally folded in the early Devonian or late Silurian.

The Devono-Carboniferous sediments have been folded into a number of irregular basins and domes; dips are gentle to moderate, and individual fold closures are readily discernible. The axial trends of the closures are variable, but they appear to be closely related to the proximity of the underlying basement of granite and metamorphics. The Devono-Carboniferous sediments have also been faulted, particularly near the basement, where dips are generally steeper, and the folds tighter.

In the late Middle to Upper Carboniferous strata, which are confined to isolated areas bounded by faults, folding appears to be much more open.

Little is known of the structure of the Permo-Carboniferous sequence, but its general structural style appears to be similar to that of the Upper Carboniferous strata. Both the Upper Carboniferous and the Permo-Carboniferous rocks were laid down in an epicontinental environment. The development of fold structures in them was probably related to differential movements in the basement. The movements may have been Saxonic in type (de Sitter, 1956, p. 464).

The gently undulating attitude of the Collopy Formation is probably due to slight differential movement during uplift. Steeper dips occur near faults. Faulting continued throughout the Cainozoic, as indicated, for example, by the location of basalt plugs along old faults.

The Cainozoic geological history is summarized in Table 6.

Faulting has played an important role in the deformation of the late Palaeozoic rocks. Two main directions can be recognized: one trends southeast and swings to east-west near the coast, the other trends east-northeast. The displacements along the faults are well displayed in the Devono-Carboniferous sediments. Apparent horizontal displacements of up to 12 miles (e.g., Hell Hole Gorge) and apparent vertical movements of 15,000 to 20,000 feet can be inferred in places.

One of the main structures formed by the southeasterly fault system is the Sybil Graben in the Oweenee Granite, southwest of Ewan, in which the Sybil Group is preserved. The movements on the faults bounding the graben appear to have been mainly vertical. The parallel subsidiary faults outside the graben in the Oweenee Granite have been the loci of intrusion of quartz-feldspar porphyry dykes. The Sybil Group sediments have been disturbed near the bounding faults, and may be a downfaulted remnant of a once more extensive sequence.

The Alex Hill Shear Zone trends west from Horse Camp Hill to Marmy Creek. The zone ranges from 1 1/2 to 4 miles in width, and the degree of shearing is variable. Where the shear zone cuts the Ravenswood Granodiorite Complex, phyllonite, schist, and gneiss have been developed, as for example, at Alex Hill*, in the hills 3 miles farther west, and south of Mingela Bluff. The shear zone appears to be displaced or truncated by a post-Tournaisian northwesterly fault extending from Exley to Keelbottom Creek. The east-west faults displacing the Collopy Formation are probably controlled by the shear direction, and indicate that the shear was still a line of weakness, at least to Mesozoic time. Tertiary movements probably occurred along the Alex Hill Shear Zone during uplift of the coastal ranges. The shear zone is probably one of the features controlling the distribution of mineralization westward from Grass Hut to Salas siding, Fanning, and Marmy Creek.

Structures Associated with the Late Palaeozoic Granites

Some of the late Palaeozoic granites have strongly curvilinear boundaries, which suggests that they may have been intruded into ring fractures.

Both the trend of the granitic belts and the orientation of individual granitic bodies generally correspond with the major fault directions; for example, the Oweenee Granite

* Alex Hill is not shown on the map. It is the hill 896 feet above sea level 1 mile south of Emu Camp Dam.

trends northeast and the coastal range granitic belt northwest. Where preferred orientations are apparent in the separate intrusions of the coastal belt they are generally either northwest or northeast.

In the Clarke River Sheet area, the Middle Devonian limestone and Precambrian metamorphic rocks are separated by an east-northeasterly fault. The easterly projection of this fault corresponds roughly with the axial region of the Oweenee Granite, suggesting that the granite was emplaced along a major zone of weakness extending from the head of the Gregory River east-northeast towards Paluma. Although there is no evidence to suggest that the limestones of the Broken River Formation near Craigie outstation and those of the Burdekin Formation near Laroona have been displaced from each other by a strike-slip movement of 75 miles, nevertheless it is possible that some ancient and major lineament existed, along which movement has occurred, and which may have influenced the location of the Broken River Embayment and the Burdekin Basin.

ECONOMIC GEOLOGY

Mineral deposits are widely distributed in the Townsville Sheet area, but total production is relatively small. The most important are the tin deposits in the Kangaroo Hills Mineral Field, and the limestone quarried at Calcium. A full account of the economic geology is being prepared by K.R. Levingston, District Geologist at Charters Towers.

Tin

Until recently, when large-scale quarrying of limestone began at Calcium, the annual value of the tin concentrates produced exceeded that of all other minerals.

All the tin occurrences can be related to the Lower Carboniferous granites (330 m.y.). Most of the tin has been won from lodes, some of which are in the sediments and metamorphics adjacent to the granites. Smaller amounts have been obtained from the deep leads at Waverley, where stanniferous gravels occur at the base of Tertiary sandstone which overlies granite and is overlain by Tertiary(?) basalt. Only a little has been derived from Recent alluvial deposits.

The main producing area is still about Oaky Creek and Running River in the southern part of the Kangaroo Hills Mineral Field. Tin has also been produced at widely scattered localities in the Oweenee Granite southwest of the Sybil Graben.

Most of the ore shoots are small pipes or leaders in fissure lodes. At the Sardine mine, the largest producer, the orebodies are near-vertical and tabular, and consist of numerous closely spaced lenses. Production in recent years has been mainly from a pipe at the northern end of the workings. The presence of separate shoots of cassiterite and stannite-cassiterite ore suggests that there may have been two phases of tin mineralization.

Most of the ore produced is cassiterite, except at the Sardine mine, which also produces tin-copper concentrate with a high content of stannite.

Production has fluctuated considerably since the field was first worked for tin in 1883, mainly owing to changes in the price of tin, the small size and discontinuity of the orebodies, and the poor access to the field until 1937. The annual production of the field has averaged 100 tons of concentrate, but production has varied greatly from year to year.

Total production from the Kangaroo Hills Mineral Field is about 8300 tons of cassiterite concentrate and 220 tons of stannite concentrate. The field extends into the Ingham Sheet area, but most of the production has come from the southern part of the field in the Townsville Sheet area. Production from the Tinvale area is about 675 tons of concentrate, mostly from the Daintree mine.

Tungsten

Wolfram has been mined in several areas, notably in the Ollera district. The deposits occur in late Palaeozoic granite and quartz porphyry and in the adjacent Running River Metamorphics and Ewan Beds. The associated minerals include molybdenite, fluorspar, garnet, and chalcopyrite.

At Ollera the deposits occur in pipes; elsewhere they occur as pipe-like shoots or leaders associated with shears, fractures, or joints. The gangue is usually quartz or chlorite or both. Alluvial deposits have also been worked in the Ollera district.

Production has been sporadic, and figures for the late 1800's and early 1900's are incomplete. Total production since 1899 is about 526 tons of wolfram conçentrate (including bismuth sulphide and oxide). About 290 tons of this can be credited to the Ollera district, where the Belle Vue mine was the largest producer. The remaining 236 tons came from various small deposits in the Kangaroo Hills Mineral Field. Among these the Isabel, with a production of about 70 tons of concentrate, was one of the more important mines.

Copper

Copper mineralization is widespread, but most of it is associated with deposits worked primarily for other minerals, notably tin. The mineralization generally appears to be related to late Palaeozoic granites and porphyries, but the copper mineralization in the andesitic lavas of the Percy Creek Volcanics (Coppermine Creek) is of unknown origin. The most important mines worked mainly for copper include the Mount Theckla and True Blue in the Ewan Beds, the Kennedy and Great Northern* in the Star Beds, the Rio Tinto in Devono-Carboniferous sediments (D-C), and the Macaulay group in the Oweenee Granite. All the deposits, except the Great Northern, of which little is known, consist of small veins or shoots in fissure lodes. None of them was payable below the zone of oxidation and slight secondary enrichment which generally extended to a depth of 100 to 150 feet, and most of the main workings did not go below this level. Deeper workings at the Mount Theckla mine encountered chalcopyrite, but no payable primary sulphide bodies were found. Three diamond drill holes put down by the Department of Mines in 1962 at Rio Tinto also failed to locate appreciable mineralization below the near-surface copper ores.

The principal minerals in the ore mined were azurite, malachite, cuprite, and bornite, together with argentiferous galena and sphalerite. Production is unknown, but it is unlikely to have exceeded 500 tons of ore averaging about 20 percent copper.

Rare disseminated chalcopyrite was observed in a granitic net-veined complex (P-Mg) at the summit of Mount Stuart during the course of this survey.

Gold

Part of the Townsville Sheet area is included in the Charters Towers and Ravenswood Gold and Mineral Fields, but gold production has been small. The main mining centres and types of deposits are listed in Table 8.

The Grass Hut and Fanning deposits, like those of Charters Towers and Ravenswood, are associated with the Ravenswood Granodiorite Complex. In the other centres, the gold mineralization appears to be related to late Palaeozoic intrusives in Devonian sediments.

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* R.D. Jack (1879a) records the occurrence of the Great Northern mine in the Star Beds, but does not give its locality; it is believed to have been near the Kennedy mine.

TABLE 8 : SUMMARY OF GOLD MINING AREAS

Mining Centre	Mines	Country Rock	Mineralizing Agent	Type of Deposit	Associated Minerals	Main Production Years
Piccadilly	Piccadilly P.C. Piccadilly No. 1W	U. Devonian sandstone and shale (Dud)	?	Quartz reef	Pyrite	1894-1909
Far Fanning	Several mines on three main lines of lode	U. Devonian sediments(Dud) and late Palaeozoic porphyry (not shown on map)	Late Palaeozoic porphyry(?) (C-Ph)	(a) Quartz leaders in steeply dipping felsite dykes (b) Gently dipping stockworks	Pyrite, arsenopyrite, and rare chalcopyrite	1895-1908
Mount Success	Mount Success	Porphyry(C-Ph) and Fanning River Group	Late Palaeozoic porphyry of Mount Success(C-Ph)	Contact replacement	Pyrite and sphalerite	1895-1906
Golden Valley	Golden Valley P.C. Golden Valley Block " " No. 1E " " No. 1W " " No. 2W	Felsite(C-Ph) and Ravenswood Granodiorite Complex	Late Palaeozoic porphyries and felsite of Mount Success(C-Ph)	Quartz reef with felsite hangingwall and granite footwall	Pyrite and sphalerite	1898-1907 1922-1934
Grass Hut	Numerous mines on several lodes	Ravenswood Granodiorite Complex	Late acid phase of batholith	Quartz reefs in fissures(?)		1887-1895
Fanning/Salas siding	Numerous mines on several lodes	Ravenswood Granodiorite Complex	Late acid phase of batholith	(a) Quartz reefs in fissure, e.g., Rose of Allandale (b) Pipe-like body of greisenized granodiorite, e.g. Welcome	Pyrite, galena, sphalerite, argentiferous tetrahedrite, and chalcopyrite	1890-1900 Some revival 1930-1940

Gold is also known to occur at Bunkers Hill (Ravenswood Granodiorite Complex and Kirk River Beds), Horse Camp Creek (Ravenswood Granodiorite Complex), Mount Squarepost and Magnetic Island (uppermost Carboniferous granite), Mount Elliot (Lower Permian granite), Ponto (Argentine Metamorphics), and Six Mile or Argentine Extended (uppermost Carboniferous granodiorite).

Total production of gold in the Sheet area has been low, but returns separate from those for the Ravenswood and Charters Towers Fields are not available.

Silver-Lead

Silver has been worked in silver-lead deposits in limestone of the Ewan Beds at Bonnybrook Creek, 2 miles north-northwest of Ewan, and in the Argentine Metamorphics, Game Hill Beds, and late Palaeozoic granodiorite at Argentine. Silver-lead-copper deposits were worked at Stockyard Creek in 1892 (Maitland, 1893), but the location is unknown.

At Bonnybrook Creek, the deposits are contact-metamorphic lodes related to late Palaeozoic porphyry (C-Ph) intruding limestone. The Argentine deposits are fissure lodes.

About 50,000 oz of silver were produced in the Kangaroo Hills Mineral Field, and a small quantity was obtained as a by-product of gold mining in the Ravenswood and Charters Towers fields. The production of lead is negligible.

Dr P.J. Stephenson (pers. comm.) has reported the occurrence of chloritic alteration zones 1 foot wide in granitic rock near the head of Major Creek, in the Mount Elliot stock (P-Mg); the zones have cores of vein quartz which contains pyrite and minor galena.

Iron

Iron ore deposits are known at Willetts Knob, near Mount Moss north of Ewan; 3 miles northeast of Laroona homestead; and 3 miles southwest of Mount Flagstone, near Woodstock. The Willetts Knob and Woodstock occurrences are contact-metasomatic deposits associated with limestone in the Ewan Beds and Fanning River Group respectively. The iron mineralization is probably related to late Palaeozoic granites. The Laroona deposits occur in calcite-actinolite schist of the Argentine Metamorphics, and are also probably related to late Palaeozoic granite. The chief minerals are magnetite at Willetts Knob, and magnetite and hematite at Woodstock and Laroona.

Only the Woodstock deposit has been worked; total production is small and has been used in the manufacture of cement at Stuart; the output in 1967 was 1840 tons.

Limestone

Limestone deposits have been worked near Calcium and Reid River. Production is from limestone in the Fanning River Group and from 'earth lime', which has apparently been formed by weathering of the andesitic agglomerates in the Ellenvale Beds.

The limestone was burnt to make quick-lime for use in the gold-cyaniding plants at Charters Towers, and has also been used in sugar mills, for agricultural purposes, and for the manufacture of cement. After the virtual cessation of cyaniding in Charters Towers about the time of the 1914-18 war, production was erratic until the North Australian Cement Company began production in 1955. Since then output has gradually increased: in 1967 production of limestone for cement was 131,912 tons, and for burnt lime 4894 tons. Production of earth lime was 2372 tons.

Very large quantities of limestone are available in the Fanning River Group near Fanning River, Burdekin Downs, and Laroona homesteads.

Clay

Clay has been quarried in the Quaternary alluvium north of Townsville for the manufacture of bricks since about 1960. The main production is from Kurukan, where 11,035 tons was produced in 1967.

Clay-shale for the manufacture of cement is quarried at Partington, near Stuart. In 1967, production was 27,505 tons.

Aggregate and Road Metal

Numerous quarries about Townsville work the late Palaeozoic granites and volcanics for aggregate and road metal, but no production figures are available.

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APPENDIX : ISOTOPIC AGE DETERMINATIONS FROM THE TOWNSVILLE 1:250,000 SHEET AREA

By A.W. WEBB

Rock Unit or Map Symbol	Sheet Area Specimen No.	ANU Accession No.	Military Grid Reference E.	N.	Rock Type	Material Analysed	Method	Age (m.y.)	Remarks
Toomba Basalt	E 55/14/84	GA 5769	413200	2513600	Olivine basalt	Whole rock	K/Ar	$\ngtr$0.10	
" "	85	GA 5770	415900	2513600	" "	" "	"	$\ngtr$0.10	
" "	90	GA 5775	416300	2513500	" "	" "	"	$\ngtr$0.10	
Nulla Basalt	10	GA 5563	425100	2509100	" "	" "	"	1.14	) Same flow
" "	11	GA 5564	424600	2509600	" "	" "	"	1.10	)
" "	12	GA 5565	417100	2511900	" "	" "	"	2.40	
" "	13	GA 5566	400800	2522500	" "	" "	"	1.32	Underlies E55/14/14
" "	14	GA 5567	400600	2522500	" "	" "	"	1.29	Probably same flow as E/55/14/53,73, 74,75,91
" "	52	GA 5568	411600	2512500	" "	" "	"	2.27, 2.37	Same flow as E55/ 14/12
" "	53	GA 5569	402900	2518300	" "	" "	"	1.28	
" "	56	GA 5576	409900	2507300	" "	" "	"	1.29	
" "	73	GA 5756	356700	2535500	" "	" "	"	1.34	
" "	74	GA 5757	"	"	" "	" "	"	1.28	
" "	75	GA 5758	"	"	" "	" "	"	1.26	
" "	77	GA 5760	358600	2535400	" "	" "	"	1.43	
" "	78	GA 5761	353200	2541100	" "	" "	"	3.95	
" "	79	GA 5762	353500	2544200	" "	" "	"	4.11	
" "	80	GA 5763	354400	2542900	" "	" "	"	4.34	
" "	81	GA 5764	348800	2533900	" "	" "	"	1.25, 1.27	
" "	83	GA 5766	347100	2535900	" "	" "	"	4.45	
" "	91	GA 5776	414300	2513500	" "	" "	"	1.25	
P-Mg	60	GA 5732	496100	2595300	Adamellite	Biotite	K/Ar	280	
C-Pg	23	GA 5725	455400	2569900	"	"	"	277	
"	26	GA 5730	444700	2565300	Granodiorite	"	"	277	
"	"	"	"	"	"	Hornblende	"	282	
"	28	GA 5729	442600	2564700	"	Biotite	"	280	
"	39	GA 5588	431900	2616500	Granite	Whole rock	Rb/Sr	*	Lies on Oweenee Granite isochron

C-Pb	5	GA 5535	429200	2572000	Granodiorite	Biotite	K/Ar	277	
"	19	GA 5731	454300	2574700	"	"	"	284	
"	"	"	"	"	"	Hornblende	"	279	
"	24	GA 5726	450500	2569500	"	Biotite	"	290	
"	29	GA 5728	450400	2574000	"	"	"	282	
"	29	GA 5728	450400	2574000	"	"	"	290	
"	30	GA 5727	453300	2571400	"	"	"	286	
"	"	"	"	"	"	Biotite	"	284	
Pall Mall Adamellite	18	GA 5533	418900	2557700	Adamellite	"	"	283	
Oweenee Granite	7	GA 5584	419000	2602000	Granite	Whole Rock	Rb/Sr	*	
" "	15	GA 5585	351800	2580000	"	" "	"	*	
" "	16	GA 5586	353000	2578300	"	" "	"	*	
" "	17	GA 5284	384700	2584000	"	" "	"	*	
" "	"	"	"	"	"	Biotite	K/Ar	300	Argon loss from
" "	38	GA 5587	409900	2616700	"	Whole rock	Rb/Sr	*	this sample; cf.
Ravenswood Granodiorite									Rb/Sr age
Complex (S-Dr)	1	GA 5283	456500	2524100	Granodiorite	Biotite	K/Ar	420	) K/Ar ages are
" " " " "	44	GA 5274	473200	2511400	"	"	"	440	) minima; cf. Rb/Sr
" " " " "	"	"	"	"	"	Hornblende	"	420	) age
" " " " "	"	"	"	"	"	Whole rock	Rb/Sr	ø	
" " " " "	47	GA 5798	476400	2505500	Diorite	" "	"		Lies on 394±30m.y.
" " " " "	59	GA 5702	430700	2499800	Foliated adamellite	" "	"	ø	isochron with specimens from
Ravenswood Granodiorite									Charters Towers
Complex (S-Da)	46	GA 5599	475200	2507500	Granite	" "	"	ø	Sheet area
" " " " "	48	GA 5600	485700	2503700	Adamellite	" "	"	ø	
" " " " "	49	GA 5701	488500	2504200	"	" "	"	ø	

Footnotes: (1) The analytical error in individual K/Ar determinations is ± 3 percent, unless otherwise stated

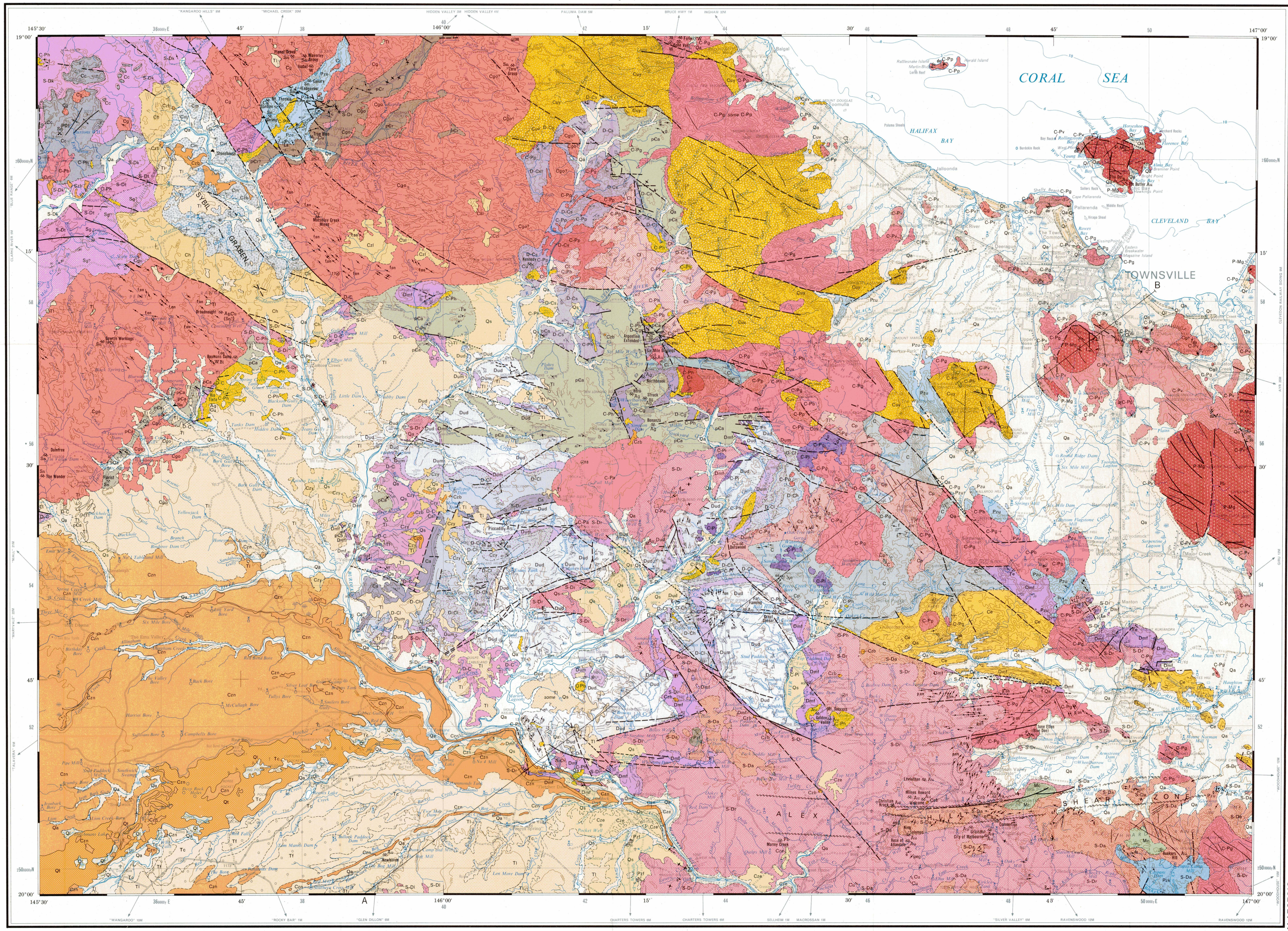
(2) Rb/Sr isochrons : * 330 ± 7 m.y.; ø 454 ± 30 m.y.

(3) Owing to an oversight, some of the isotopic dating specimen localities have not been printed on the map.

TOWNSVILLE
QUEENSLAND

AUSTRALIA 1:250,000 GEOLOGICAL SERIES

SHEET SE 55-14



Reference

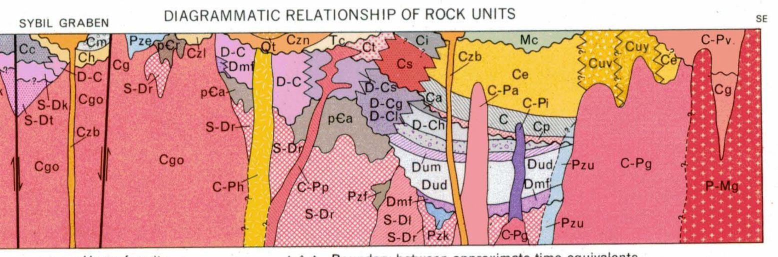
	Geological boundary
	Anticlinal axis
	Synclinal axis
	Fault
	Where location of boundaries, faults and folds is approximate, line is broken; where inferred, queried; where concealed, boundaries and folds are dotted, faults are shown by short dashes
	Relative horizontal movement on fault
	Lineament (air-photo interpretation)
	Approximate boundary of shear zone
70	Strike and dip of strata
	Horizontal strata
	Vertical strata
	Dip<15° (air-photo interpretation)
	Dip 15° — 45° (air-photo interpretation)
	Trend (air-photo interpretation)
	Joints (air-photo interpretation)
	Platy flow, inclined
	Platy flow, vertical
	Vertical cleavage
20	Strike and dip of foliation
	Vertical foliation
35	Direction and plunge of lineation
80	Strike and dip of joint
	Vertical joint
	Fossil locality, general
	Macrofossil locality
	Microfossil locality
	Plant fossil locality
72	Specimen collected for isotopic dating
	Dyke, sill or vein: a-aplite; an-andesite, do-dolerite, microdiorite, f-felsite, g-granite, microgranite, ob-olivine basalt, p-porphyry, peg-pegmatite, q-quartz

·Cu	Minor mineral occurrence	Bi	Bismuth
	Prospect	Cl	Clay
	Mine	Cu	Copper
	Abandoned mine	Fe	Iron
	Quarry	Ls	Limestone
	Alluvial workings	Mo	Molybdenum
	Battery	Pb	Lead
	Abandoned battery	Sn	Tin
Ag	Silver	W	Tungsten
Au	Gold	Zn	Zinc

	Bore
	Bore or well
	Windpump
	Dam or tank
	Dam on watercourse
WH	Waterhole
	Waterhole on stream
	Falls
	Rapids
	Lake, perennial and intermittent
	Spring
	Swamp
	Mangroves
3	Fathom line
	Rock ledge. Coral reef
	Road
	Vehicle track
	Railway line, with station and siding
	Railway line abandoned
	Telegraph line
	Power transmission line
	Built-up area
	Old township
	Building or hut
Yd	Yard
	Airport
	Landing ground
	Trigonometrical station (datum: mean sea level, Brisbane)
753′	Spot elevation in feet (datum: mean sea level, Brisbane)
(PD)	Position doubtful
1000	Topographic form lines
	Sand dune

SYBIL GRABEN

DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS



~~~ Unconformity /\/\/ Boundary between approximate time-equivalents

Reference

CAINOZOIC	QUATERNARY		Qs	Residual sand and soil
			Qa	Alluvium and colluvium
			Qr	Old coastal sand dunes and beach deposits (showing trend of dunes)
			Ql	Lacustrine deposits, diatomaceous earth
		Toomba Basalt	Qt	Olivine basalt
	PLIOCENE TO PLEISTOCENE	Sellheim Formation	Cze	Sandstone, sandy claystone, pebble conglomerate
		Nulla Basalt	Czn	Olivine basalt
				Basalt flows in old stream beds
			Czb	Olivine basalt
			Czy	Silicified quartz sandstone and conglomerate
		Lassies Creek Gravels	Czl	Pebbly, argillaceous arkosic sandstone, minor conglomerate
	TERTIARY: PLIOCENE	Campaspe Beds	Tf	Ferricrete
			Tc	Pebbly, argillaceous sandstone, rare siltstone
	TERTIARY: MIOCENE ?		Tl	Laterite
MESOZOIC?		Collopy Formation	Mc	Micaceous sandstone, arkosic in places; conglomerate, minor quartz sandstone
	PERMIAN TO MESOZOIC		P-Mg	Mainly biotite granite and adamellite; minor quartz monzonite, quartz syenite, microgranite, hornblende-quartz gabbro
LATE PALAEOZOIC	UPPER CARBONIFEROUS TO LOWER PERMIAN		C-Pv	Intermediate and acid flows and pyroclastics; rare conglomerate, sandstone, shale, siltstone, coal
			C-Pg	Granite, adamellite, minor granodiorite
			C-Pb	Granodiorite, diorite, minor adamellite; Porphyritic granodiorite
		Pall Mall Adamellite	C-Pa	Pink and grey coarse porphyritic biotite adamellite
			C-Pp	Acid porphyry grading to microgranite
			C-Pi	Dolerite, microdiorite
			C-Ph	Mainly intrusive light-coloured rhyolite; minor dacitic intrusion breccia
	UNDIFFERENTIATED		Pzu	Mica schist, hornfels, gneiss, quartzite, metamorphosed siltstone, sandstone, arkose, limestone
	UPPER CARBONIFEROUS		Cuy	Dark rhyolite and dacite; volcanic breccia and agglomerate
			Cuv	Rhyolitic and andesitic flows and pyroclastics
		Insolvency Gully Formation	Ci	Subgreywacke, feldspathic sandstone, siltstone, fossiliferous mudstone, conglomerate, chert
		Saint James Volcanics	Cs	Andesitic flows and pyroclastics, subgreywacke; rhyolitic flows and pyroclastics
		Marshs Creek Beds (Sybil Group)	Cm	Conglomerate, subgreywacke, siltstone, feldspathic sandstone, quartz sandstone, dark shale, tuffaceous and siliceous mudstones, limestone, arkose; fossiliferous
		Hells Gate Rhyolite (Sybil Group)	Ch	Rhyolitic flows and pyroclastics; minor tuffaceous sediments
		Tareela Volcanics	Ct	Andesitic and rhyolitic flows and pyroclastics; minor sediments
		Ellenvale Beds	Ce	Rhyolitic flows and pyroclastics, subgreywacke, feldspathic sandstone, conglomerate, fossiliferous shale and mudstone
			C	Fossiliferous shale, chert, limestone, subgreywacke, conglomerate, andesitic flows and pyroclastics; minor rhyolite and sandstone
		Percy Creek Volcanics	Cp	Andesitic flows and pyroclastics
		Oweenee Granite	Cg	Coarse pink granite; minor porphyritic microgranite
			Cgo	Pink porphyritic granite and microgranite
	MIDDLE DEVONIAN TO LOWER CARBONIFEROUS	Undifferentiated	D-C	Sandstone, shale, conglomerate, limestone
	LOWER CARBONIFEROUS	Clarke River Formation	Cc	Sandstone, shale, limestone, conglomerate; fossiliferous
		Piccadilly Formation	Ca	Arkose, feldspathic sandstone, quartz pebble, conglomerate
	UPPER DEVONIAN TO LOWER CARBONIFEROUS	Game Hill Beds	D-Cg	Feldspathic and quartzose arenites, shale, mudstone, limestone, conglomerate, subgreywacke; fossiliferous
		Star Beds	D-Cs	Calcareous sandstone, shale, siltstone, limestone, arkose, subgreywacke, conglomerate; fossiliferous
		Hardwick Formation	D-Ch	Feldspathic sandstone, arkose, subgreywacke, shale, limestone, siltstone; fossiliferous
		Lollypop Formation	D-Cl	Feldspathic sandstone, conglomerate
	UPPER DEVONIAN	Myrtlevale Beds	Dum	Feldspathic sandstone, siltstone, shale, rare limestone and conglomerate; fossiliferous
		Dotswood Formation	Dud	Feldspathic sandstone, arkose, conglomerate, red shale, siltstone, tuff
	MIDDLE DEVONIAN	Fanning River Group	Dmf	Arkose, subgreywacke, coralline limestone, sandstone, shale; fossiliferous
EARLY PALAEOZOIC	SILURIAN TO LOWER DEVONIAN	Lolworth Igneous Complex	S-Dl	Porphyritic granite, deeply lateritized
		Ravenswood Granodiorite	S-Dr	Granodiorite, quartz diorite, gabbro; foliated in places
			S-Da	Late "acid phase" granite, aplite, adamelite; foliated in places
		Kangaroo Hills Formation	S-Dk	Quartz sandstone, shale, lenses of greywacke and conglomerate
		Tribute Hills Sandstone	S-Dt	Quartz sandstone, siltstone
		Greenvale Formation	Sg	Siltstone, greywacke, subgreywacke, silty quartz sandstone, feldspathic sandstone, conglomerate
	UNDIFFERENTIATED	Ewan Beds	Pze	Greywacke, lithic and quartzose conglomerate and sandstone, siltstone, limestone; andesitic and rhyolitic volcanics; Fossiliferous limestone
		Kirk River Beds	Pzk	Micaceous shale, siltstone, lithic feldspathic sandstone, arkose
		Charters Towers Metamorphics	Pzf	Mica schist, quartz-plagioclase-biotite gneiss
PRECAMBRIAN?		Argentine Metamorphics	p€a	Mica schist, quartzite, quartz schist, garnetiferous mica schist and quartzite, actinolite schist, marble, amphibolite, gneiss, migmatite; some garnetiferous granite and pegmatite; Minor serpentinite
		Running River Metamorphics	p€r	Mica schist, quartzite, amphibolite

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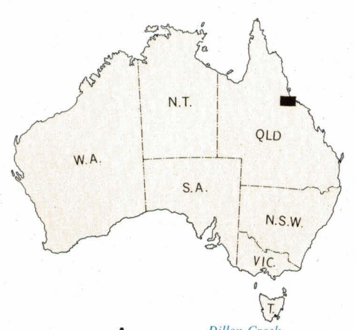
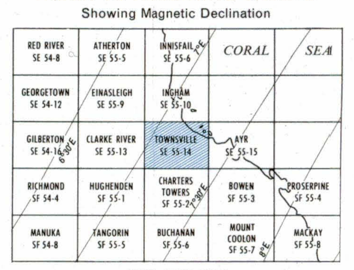


INDEX TO ADJOINING SHEETS
Showing Magnetic Declination



Scale 1:250,000

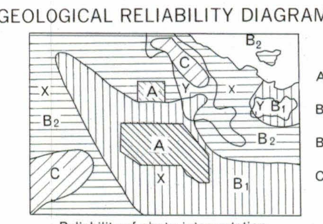
5 0 5 10 15 MILES

5 0 5 10 15 20 25 KILOMETRES

GREY NUMBERED LINES INDICATE THE 20,000 YARD TRANSVERSE MERCATOR GRID, ZONE 6 (AUSTRALIA SERIES)

Section
Quaternary sediments omitted from section
Thickness of Tertiary rocks exaggerated
Attitude of faults not known
Scale: $\frac{V}{H} = 1$

GEOLOGICAL RELIABILITY DIAGRAM



A Detailed traverses
B1 Detailed reconnaissance with air-photo interpretation
B2 Reconnaissance and air-photo interpretation
C Air-photo interpretation

Reliability of photo-interpretation
X — moderate to good
Y — poor (largely rain forest)

Geology by: D. H. Wyatt (G.S.Q.) 1960-63, D. W. Dearne (G.S.Q.) 1961-62, A. G. L. Paine, R. R. Harding (B.M.R.), D. E. Clarke (G.S.Q.) 1963
Compiled by: D. H. Wyatt, W. J. Rowland (Dept. of Mines, Brisbane), A. G. L. Paine, A. Tatarow (B.M.R.)
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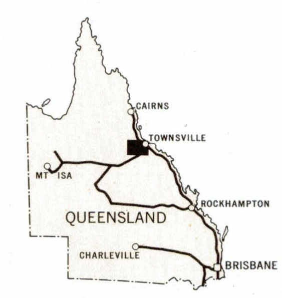

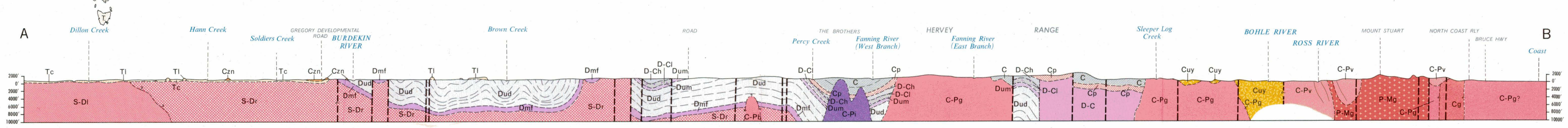

FIRST EDITION 1968

TOWNSVILLE

SHEET SE 55-14

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