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

by

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SUMMARY

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

The Sheet area contains a wide variety of igneous, sedimentary, and metamorphic rocks. The oldest known rocks are medium-grade regional metamorphics (Running River Metamorphics, Argentine Metamorphics) which are mapped as Precambrian. In places the Precambrian rocks are overlain with a strong unconformity by thick Silurian and Lower Devonian sequences of sediments and minor volcanics (Kangaroo Hills Formation, Tribute Hills Sandstone, Greensvale Formation, and Kirk River Beds). A large batholith, the Ravenswood Granodiorite, which occupies the southern central part of the Sheet area, is believed to be Silurian, but is known to intrude only the Precambrian rocks and the Kirk River Beds. In the Lower Devonian the region became stabilised as part of a craton; continental sediments, with some early marine intercalations (in places richly fossiliferous), were then laid down in a series of probably disconnected intracratonic basins whose subsidence may have been largely controlled by faults. These sediments, which are Middle Devonian to Lower Carboniferous, comprise the Fanning River Group, Dotswood Formation, Myrtlevale Formation, Lollypop Formation, Hardwick Formation, Game Hill Beds, Star Beds, Piccadilly Formation, and Clarke River Formation. A period of non-deposition, caused by slight uplift, warping, and probably granite intrusion (Oweenee Granite), occurred in the Middle Carboniferous. Then followed a prolonged period of acid and intermediate vulcanicity and granite emplacement extending from the Middle Carboniferous to the Permian. Volcanic units with abundant associated sediments laid down in these periods comprise the Sybil Group, Ellenvale Beds, St. James Volcanics, Percy Creek Volcanics, Tareela Volcanics, Insolvency Gully Formation, and a number of unnamed units.

Remnants of possible Mesozoic sediments are preserved in the Leichhardt Range (Collopy Formation).

The Cainozoic geological record consists of superficial sediments (Campaspe Beds, Sellheim Formation, Lassie Creek Gravels, and unnamed units), and extensive flows of olivine plateau basalts (Nulla and Toomba Basalts); the Toomba Basalt is probably Recent. Lateritic profiles are widely developed on certain of the older units, as well as on superficial sediments and on some of the older basalt flows. Lake deposits associated with the Toomba Basalt commonly contain diatomaceous earth. Thick accumulations of silt and sand deposited in the flood-plains of major streams are commonly deeply incised.

At present the most important economic mineral is limestone, which is quarried at Calcium for cement manufacture. Of metals, the greatest production has been that of tin from the Ewan district, but this district has been a small producer in comparison with other tinfields in North Queensland. Wolfram has been produced in small quantities from Ollera Creek. Minor copper, gold, silver-lead, and iron have also been produced. K.R. Levingston, District Geologist at Charters Towers, is preparing a full account of the economic geology of the Sheet area; this will appear in the Bureau's Records Series.

INTRODUCTION

The Townsville 1:250,000 scale Sheet area is bounded by latitudes 19° and 20° south and by longitudes 145°30' and 147° east. It was mapped geologically by staff of the District Geologist's Office, Charters Towers, from 1960 to 1962, and by a joint field party from the Geological Survey of Queensland and the Commonwealth Bureau of Mineral Resources in 1963. The geological mapping programme of this party was planned as a continuing project to complete the Townsville, Hughenden, Charters Towers, Ayr, Bowen and Proserpine 1:250,000 Sheet areas (see Locality Map, Figure 1).

The Townsville 1:250,000 Sheet area is covered by planimetric maps at a scale of 4 miles to 1 inch, and partly covered by similar maps at 2 miles to 1 inch or parish maps at 40 chains to 1 inch. All these maps are available at the Department of Public Lands, Brisbane. A topographic map at 1:250,000 scale is being compiled by the Royal Australian Survey Corps.

A complete air-photo coverage is available for the Sheet area; these comprise recent (1961) photographs at an approximate scale of 1:80,000 taken by Adastra; old Royal Australian Air Force photographs at a scale of 40 chains to 1 inch flown about 1945, and recent Adastra photographs at a scale of 30 chains to 1 inch flown from 1961 to 62 are available for certain parts of the Sheet area.

Townsville, the second largest city in Queensland, is situated on the main coastal road, rail, and air links connecting Brisbane and Cairns. Westward from Townsville regular rail and air services extend to Charters Towers, Hughenden, and Mount Isa. A bitumen highway extends south-west almost to Homestead (Charters Towers Sheet area). Elsewhere there is a fair network of shire roads and station tracks. Most unsealed roads are impassable during and for a short period after wet weather. Many homesteads have airstrips suitable for light aircraft.

When surface stream flow has ceased, water can be obtained from a depth of a few feet in the sandy beds of most of the watercourses. Away from the streams water is obtained for stock or domestic purposes from bores or wells usually sunk in the alluvium bordering small creeks. Dams on small creeks or earth tanks also provide water for stock. In the coastal region about Woodstock and Giru underground water from Cainozoic deposits is used for irrigation. In the inland region irrigation is limited to areas adjacent to permanently flowing streams such as the Burdekin River.

The climate ranges from tropical-continental in the western part of the Sheet area, to tropical-coastal about the Paluma Range in the north-east. Rainfall ranges from 25 inches in the west to about 55 inches at Paluma, and most of this falls from December to March. Relative humidity is always higher on the coast than inland. At Townsville the mean monthly R.H. is 68; it rises to 73 in the four summer months. At Charters Towers the mean is 62, and it seldom rises beyond 70 in the summer months. Mean monthly maximum and minimum temperatures for Townsville are 82.2 and 68.5, and for Charters Towers 86.2 and 62.0. The difference between the maximum and minimum temperature increases westward as the modifying influence of the Pacific Ocean falls off. Frosts occur during winter months on the inland highlands, but are rare on the coastal lowlands.

Vegetation on those parts of the Paluma Range where rainfall exceeds 40 inches consists of tropical rain forest, but this rapidly gives way to Eucalyptus open 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 of the area is beef cattle grazing, 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 major port of North Queensland. Townsville also provides an outlet for beef and for sugar from the Burdekin River delta. There is an important cement works at Stuart. At Major's Creek and elsewhere on the coastal plain, vegetables and fruit are produced primarily for the Townsville market.

ACKNOWLEDGMENTS

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We 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

The first geological observations in the region were by Leichhardt during his overland expedition from Moreton Bay to Port Essington during 1844-5 (1847, pp. 209-226), but the first geological studies were made by Daintree (1869) when he reported on the Cape River diggings. Not until ten years later was more work done in the Townsville hinterland when Jack (1879a, 1879b) established the relationship between the granite of the Charters Towers area and the limestones of 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 to North Queensland. It was because of difficulties arising out of this too general use of the name "Star" that the Geological Survey of Queensland began systematic mapping of the type areas in 1960.

In general the only detailed reports relate to mining centres, and the regional geological picture was dependent on a few published reports of 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 and Etheridge (1892), Maclaren (1900), Reid (1917), and Saint-Smith (1922).

The adjoining Ingham 1:250,000 Sheet area and the remainder of the Hughenden 1:250,000 Sheet area were mapped concurrently with the present work by other joint B.M.R. - G.S.Q. field parties. The Clarke River 1:250,000 Sheet area and the southern half of the Bowen 1:250,000 Sheet area were mapped by B.M.R. - G.S.Q. parties in 1958 and 1961, respectively.

At the commencement of the 1963 joint survey geological mapping of the Townsville 1:250,000 Sheet area was about three-quarters completed, this work having been done by the Geological Survey of Queensland between 1960 and 1962. Those areas already completed included the Continong, Hillgrove, Dotswood, and Ben Lomond 1-mile Sheet areas, major parts of the Southwick, Dalrymple, and Ewan 1-mile Sheet areas, and minor parts of the Rollingstone, Magnetic, Manton, and Mingela 1-mile Sheet areas. These areas cover mainly the outcrop of the Devonian and Carboniferous sequences, but also include several areas of late Palaeozoic granite and large areas of Cainozoic sediments and basalts.

PHYSIOGRAPHY

Topographically the area is divisible into two parts - the coastal lowland and the inland highland. The lowland consists of plains, from a few miles to 30 miles wide, which extend from the coast to the foot of the coastal ranges. These 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 adjacent talus and piedmont deposits.

Rising out of this plain are a number of residual hills, mountains, and ranges such as Castle Hill, Mount Stuart, Mount Elliott, Muntalunga Range, etc. The highest of these, Mount Elliott, rises abruptly above the plain to about 4,000 feet.

Most of the streams in the coastal area rise on the eastern fall of the Paluma, Hervey, or Leichhardt Ranges, and flow directly to the coast. One exception is the Reid River which rises on the western fall of the Hervey Range, and flows south parallel to the range before cutting through and joining with 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.

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 as uniformly low as the word peneplain usually implies. For example, the present Perry Ranges and Coane Range may have been quite high features even during the period of peneplanation.

The degree of dissection of the peneplain varies considerably according to the underlying rock type and the intensity of faulting or fracturing. Thus, in the south-west of the Sheet area, where the dominant rock type is poorly consolidated sandstone, the country is flat, and is traversed by incised streams with rather linear and parallel courses. In the central area about Charters Towers, where the dominant rock type is granodiorite, the topography can best be described as "rugged-in-miniature", and stream courses tend to be dentritic. In the Paluma, Hervey, and Leichhardt Ranges, the dominant rock types are granite and acid volcanics, which are highly faulted and fractured. Here the topography is rugged, the streams are deeply entrenched along fault lines, and their courses tend to be trellised.

In the south-west part of the Sheet area, basalt forms low tablelands slightly higher than the nearby dissected peneplain.

The major stream of the inland highland is the Burdekin River. All other important water courses in the area - Douglas Creek, Running River, Star River, Basalt River, Keelbottom Creek, Lolworth Creek, and Fanning River - flow into the Burdekin. Although most of these tributaries drain substantial areas, rarely do they maintain a strong flow after the wet season. Lolworth Creek is an exception; it is a perennial stream fed by springs from the Cainozoic basalt west of Toomba Homestead.

STRATIGRAPHY

The stratigraphy of the Townsville 1:250,000 Sheet area is summarized in Table 1. (Enclosure)

PRECAMBRIAN

The oldest strata of the area are considered to be Precambrian. They have been mapped in several localities, but as it has not been possible to correlate between these localities, the strata are described as separate formations. All these presumed Precambrian rocks are metamorphics. They comprise the Running River Metamorphics and the Argentine Metamorphics.

Running River Metamorphics (p€r)

Typically developed in the valley of Running River is a sequence of metamorphics here named the Running River Metamorphics.

They occupy about 60 square miles of the Townsville 1:250,000 Sheet area. They are known to extend downstream from Ewan for at least 2 miles, and they possibly extend as far as the Burdekin River, but in this region thick Quaternary soil and alluvia mask the underlying rocks. North of Ewan the formation extends to the divide between Bean Creek and Running River, and to the north-east it extends beyond the sheet area on to the Ingham 1:250,000 Sheet area.

The Metamorphics consist of amphibolite, mica schist, and quartzite. The amphibolite consists essentially of hornblende and plagioclase with some sphene and epidote, and minor quartz. Fine mafic-felsic banding is common, but small patches of coarse hornblendite and anorthosite banding occur, the banding usually losing its character in the centre of these patches where basic pegmatite is developed (Photo Plate 1).

Associated with these amphibolites are minor quantities of mica schist and quartzite, and these rock types become dominant to the west and north of Ewan, respectively. The mica schists in the lower reaches of Butterfly Gully, $\frac{3}{4}$ of mile west of Mount Brown, are associated with muscovite pegmatite. This pegmatite may be the result of mineral segregation during regional metamorphism, rather than be related to some unexposed granite.

Photo Plate 1. Coarse, hornblende-plagioclase segregations in amphibolite of the Running River Metamorphics. In the bed of Falls Creek, 12 miles north-east of Ewan.

B.M.R. Neg. No.G/6823.

The quartzites which form the high country of the divide between Bean Creek and Running River are frequently flow-folded.

The stratigraphic relationship between the amphibolite, mica schist, and quartzite is unknown.

The regional trend is north-east; the foliation strikes between 020° and 060°, and dips vertically or very steeply either to the north-west or south-east. In the amphibolites the foliation is itself folded, with fold axes plunging north-east between 30° and 50°. Trends in the mica schists and quartzites appear to be essentially north-easterly, but the intense faulting in the Butterfly Gully and Bonnybrook Creek areas causes marked deviations from this direction.

In Williams Creek, near the Ewan racecourse, is a granodiorite which is very similar to parts of the Ravenswood Granodiorite. It consists of plagioclase, quartz, hornblende, and biotite, and contains fine-grained basic inclusions and inclusions or segregations of quartz-feldspar rock. The relationship of this rock to the amphibolite was not seen. A similar granodiorite occurs near Mount Moss where again its relationships with the surrounding rocks are unknown. In both instances, because of their small areal extent, they have been mapped with the Running River Metamorphics.

The Metamorphics are unconformably overlain by the Ewan Beds. This relationship is visible on the western side of Mount Brown, where quartz-mica schists are unconformably overlain by micaceous sandstone and limestone of the Ewan Beds, or south-east of Mount Brown where they are overlain by quartzose conglomerate of the Ewan Beds.

The Running River Metamorphics are intruded by the Oweenee Granite to the north and south of Running River valley. A small area of granite near the Gregory Highway crossing of Williams Creek is somewhat similar to the late granite phase of the Ravenswood Granodiorite, and an elongate body of pegmatite about 3 miles north-east of the same crossing resembles pegmatites of the same phase. However, the rocks in both places may equally well be related to the Oweenee Granite. The Metamorphics are also intruded by numerous acid to intermediate dykes trending north-west. The dykes were apparently intruded along faults which literally chopped this area into thin slices.

The amphibolite is lithologically similar to amphibolites of the Argentine Metamorphics in the Six Mile Creek area, north of Argentine. The mica schists and quartzites are also similar to parts of the Argentine Metamorphics, and it is quite probable that the two sequences are equivalent in part, at least.

Argentine Metamorphics (pGa)

On his map of 1886, R.L. Jack (1886a) roughly delineated an area of "slates, schists and gneisses of undetermined age" extending from lower Speed Creek westward to Stockyard Creek and north to the head of the Star River. Jack grouped these metamorphics with those at Charters Towers as a matter of convenience rather than of correlation. The metamorphics at Charters Towers occur as small roof pendants in the ~~Ravenswood Granodiorite~~, and they are not readily comparable with those occurring in the area described immediately above. The Geological Map of Queensland (1953) shows the area as undifferentiated Palaeozoic.

As no formal name has previously been used to describe these metamorphics, the term Argentine Metamorphics is proposed for them, the name being derived from the parish of Argentine, County of Wilkie Gray, where the formation is typically developed.

The Argentine Metamorphics consist of mica schist, garnetiferous mica schist, quartzite, quartz schist, garnetiferous quartzite, hematite-quartz schist, actinolite schist, amphibolite, quartz-feldspar-mica gneiss, and migmatite.

No subdivision of these metamorphics has been attempted, but distribution of the various rock types suggests that formational boundaries may be distinguished by more detailed mapping. Whether a stratigraphic succession could be as readily established is doubtful. The distribution of rock types is as follows:

In the White Springs area, mica schist and quartzite predominate over actinolite schist and amphibolite, but along strike to the north-east at Crooked Creek only garnetiferous mica schists and thin quartz schists have been observed. The trend then swings east-south-east to the Towns Creek area, where actinolite and calcite-amphibole schists predominate. Farther south-east to Flor's Dam the intrusion of granite and pegmatite has converted most of the rocks to migmatite and gneiss, but small outcrops of actinolite schist are still seen.

South of Flor's Dam is a low range of hills which extends south-eastwards, culminating in three prominent peaks called "The Sisters". This high country is composed of quartzites and quartz-mica schists. To the south, in the area of Boundary Creek, actinolite schists reappear, together with thin, recrystallized limestones. Present knowledge of structure suggests that the quartzites and quartz-mica schists form a syncline infolded with the actinolite schists. The quartzites and quartz-mica schists would therefore be younger than the actinolite schists.

East of Flor's Dam in the upper reaches of Wheelbarrow Creek, and extending eastwards to the headwaters of Cattle Creek, mica schists predominate, but minor amphibolites and quartz-hematite schists also occur. Farther north in the region of Six-Mile Creek and Cary's Dam hornblende schists and gneiss are the dominant types, but serpentinite and mica and quartz-mica schist also occur.

North of a line between Flor's Dam and Cary's Dam the metamorphics have been intimately intruded by granite and pegmatite with the consequent development of migmatites. Similar rocks recur in the area of the north branch of the Little Star River. In these areas trends are inconsistent, and the regional pattern is not clear.

West of the north branch of the Little Star River and north to the head of the Star River is an area of mica schists which are similar to those of the Argentine-Wheelbarrow Creek area. East of these schists, immediately west of the Paluma Range, are gneisses similar to those north of Flor's Dam.

The trend of the Argentine Metamorphics varies from north-north-east in the White Springs area to west-north-west in "The Sisters" area. About the old Argentine mining centre trends are quite variable, but in the Speed Creek area they are generally east-west.

Parts of the Argentine Metamorphics are very similar to the Running River Metamorphics, and like them have been assigned to the Precambrian. Lithological comparison with the Precambrian of the Lucky Creek area (Einasleigh 1:250,000 Sheet area) suggests the following correlations:

TABLE 2

Possible correlation of presumed Precambrian Metamorphics.

	EINASLEIGH 1:250,000 Sheet area		TOWNSVILLE 1:250,000 Sheet area	
	Formation	Lithology	Main outcrop area of Argentine Metamorphics	Lithology
PROTEROZOIC ?	Paddys Ck. Fm.	Quartz phyllite and quartzite	Back Ck.	Quartzite and quartz schist
	Lucky Ck. Fm.	Calcareous greywacke, actinolite schist, quartz chlorite-epidote schist, thin impure marble	Boundary Ck.	Actinolite schist and thin recrystallized limestone
	Metamorphic break			
ARCHAEAN ?	Hall Reward Metamorphics	Migmatite, quartz mica schist, garnet-mica schist, and quartzite	Dinner Ck., Star H.S., and White Springs	Migmatite S.W. and S.E. of Star H.S., Metamorphics of White Springs area
	Stenhouse Ck. Amphibolite	Thin-banded amphibolite, rare impure marble	Cary's Dam, Six Mile Ck., White Springs	Amphibolites and serpentinites.

EARLY PALAEOZOIC

UNDIFFERENTIATED

Charters Towers Metamorphics (Pzq)

Immediately north and west of Charters Towers are a number of isolated areas of metamorphics occurring as roof-pendants in the Ravenswood Granodiorite. These rocks were first mentioned by Jack (1879a), and later described briefly by Reid (1917). Bryan (1925) called these rocks the Charters Towers Series, and assigned them to the Precambrian, but not the oldest part of the Precambrian. According to the present code of stratigraphic nomenclature the term "Series" is not applicable, and the word "Metamorphics" is proposed to replace it.

In the Townsville 1:250,000 Sheet area, small areas of metamorphics have been noted near the head of Three Mile Creek, 7 miles north-east of Burdekin Downs Homestead, where they consist of banded quartz-plagioclase-biotite gneiss, and also south from Big Sandy (Hann) Creek, where they consist of mica schist and biotite-quartz-plagioclase gneiss. These occurrences are apparently a northern extension of the roof-pendants near Charters Towers. They have therefore been assigned to the Charters Towers Metamorphics.

Recent mapping of the Charters Towers 1:250,000 Sheet area has shown that the Charters Towers Metamorphics at Charters Towers are more similar to the Cape River Beds of the Hughenden and Charters Towers Sheet areas (Paine et al. 1965, Wyatt et al., in prep.), than to the Running River and Argentine Metamorphics of Townsville Sheet area.

The Cape River Beds are tentatively regarded as early Palaeozoic rather than Precambrian, and it is therefore probable that the Charters Towers Metamorphics are also early Palaeozoic in age.

Ewan Beds (Pze)

North-west of Ewan in the catchment area of lower Oaky Creek and its tributary Bean Creek is a sequence of sediments and volcanics which are here designated the Ewan Beds. Limestones in this sequence were first described by Jack (1892). Saint-Smith (1922) described the strata of lower Oaky Creek, and regarded them as equivalent to his Kangaroo Hills series. Reid (1931) mentioned these rocks, and assigned them to his Metalliferous Series. Bush (1960) described the metamorphics of Ewan, but did not differentiate between the high-grade rocks now referred to as the Running River Metamorphics and the unmetamorphosed sediments and volcanics or low-grade metamorphics of the Ewan Beds. Bush regarded them as equivalent to the Kangaroo Hills Formation.

Structurally, the Ewan Beds appear to be a continuation of the Siluro-Devonian strata (including the Kangaroo Hills Formation) which occur some 16 miles to the south-west on the opposite side of the Sybil Graben (see section on structure). However, the Ewan Beds contain a sequence of volcanics which are not known in the Siluro-Devonian strata to the south-west. Also they are so much faulted, intruded by dykes, and locally sheared that correlation with the Siluro-Devonian strata could not be made. It is for these reasons that the new nomenclature is proposed, but with detailed mapping it is quite probably that correlation with other formations will be established, and the term may consequently be abandoned.

The Beds consist of greywacke and minor quartzose conglomerates, lithic to quartzose sandstones, siltstones, limestone, and andesitic to rhyolitic volcanics. These strata trend north-east, and, although folded and faulted, their regional dip appears to be north-west.

Basal quartzose conglomerate and feldspathic sandstone, are overlain by lenticular beds of recrystallized limestone. These limestones are well developed south-west from Mount Moss as far as the Ewan-Shrimp track, and again in the Mount Brown area.

The limestones are overlain by a generally light to dark green sequence of indurated and strongly cleaved, andesitic flows and tuffs, greywacke, and small pebble conglomerates and chert. Some acid volcanics appear in this part of the sequence, but banding is very vague, and it is not certain whether they are intrusive or interbedded in the sequence. Saint-Smith (1922) considered spherulitic rhylite in the lower Oaky Creek area to be interbedded with the quartzites and clay slates of that area. Farther westward and possibly higher up the section, in the area of the Sardine and Mount Theckla mines are quartzite, sheared siltstone, and greywacke conglomerate.

Fossils have so far been obtained only from the limestones. They include Halysites, Propora, Tryplasma, Favosites, and Heliolites (Hill, unpubl.) which suggest a Silurian age. Halysites has been recorded from limestones of the Perry Creek Formation, the nearest development of which occurs some 22 miles to the west-south-west of Ewan in the Clarke River Sheet area. On the other hand, the Perry Creek Formation is thought to conformably overlie the Kangaroo Hills Formation (White and Wyatt, 1960), which is many thousands of feet thick. The limestones of the Ewan Beds are only a short distance above the unconformity with the Precambrian, so that, if the Ewan limestones and those of the Perry Creek Formation are equivalent, then an enormous thickness of older Siluro-Devonian strata is missing from the Ewan area. It is not likely that these strata have merely thinned out in the Ewan area.

An alternative correlation of the Ewan limestones is with the Carriers Well Limestone Member of the Wairuna Formation south of Hall's Reward mine in the Clarke River 1:250,000 Sheet area. This limestone is of Lower Silurian age, and unconformably overlies the Precambrian. The Carriers Well Limestone Member is overlain by the Everetts Creek Volcanic Member which may correlate with the andesitic volcanics, tuffs, and greywackes of the Ewan area. It is not likely that the Ewan Beds can be positively correlated with formations from other areas until more details of the structure of the area and the stratigraphy of the Beds are known.

The Ewan Beds are intruded along their northern and southern margins by late Palaeozoic granites. To the east they unconformably overlie the Running River Metamorphics, and to the west they are faulted against the Sybil Group.

<u>Kirk River Beds (Pzk)</u>

At the headwaters of the Kirk River is a sequence of sediments covering a roughly triangular area of about 16 square miles extending west and south from Bunker's Hill Mine. Although present knowledge is insufficient to name these sediments formally, they are here designated as the Kirk River Beds after the Kirk River, a tributary of the Burdekin River which rises near Bunker's Hill in the Leichhardt Range.

Outcrop in the area is not good, and no particular section can be designated as The best developments so far observed are in the numerous small creeks and gullies forming the headwaters of the Kirk River south of Bunker's Hill. The Beds consist of micaceous shales, lithic feldspathic sandstones or arkoses, and siltstones. Colour ranges from grey-green to brownish green. Bedding is well developed, and the thickness of individual beds ranges from 6 inches to 3 feet. Many of the siltstones are current-bedded, and slump and convolute bedding structures occur in the dirty arenites. Most of the micaceous shales are readily fissile.

The Kirk River Beds are completely surrounded by granite, the contact in places being intrusive, in others, faulted, so that the base and top of the sequence are not known. Within the outcrop area the Beds dip consistently to the south-west at an average angle of 40°, and are about 12,000 feet thick. Along their northern margin they are intruded by granites (of the late granite phase of the Ravenswood Granodiorite) as originally described by Reid (1926) at Bunker's Hill, near Ravenswood. Along the south-western margin the beds are intruded by the same granites and some of them have been metamorphosed to anthophyllite-cordierite-mica hornfels and quartz-mica hornfels (G.S.Q. 15197 and 15198). Only the finer-grained sediments have been recrystallized, the coarser sediments being unaffected except for the development of sericite and epidote in the matrix (G.S.Q. 15201). The south-western boundary is faulted in places. Along their eastern margin the beds are intruded by a composite granitic body of late Palaeozoic age.

No fossils have been recorded from the Kirk River Beds. They are not comparable with any of the supposed Precambrian strata of the region, and their lack of metamorphism and fracturing suggests that they are much younger. They are intruded by the Ravenswood Granodiorite (probably Silurian). There are no dated formations of comparable aspect in the near vicinity whereby an age may be inferred. The nearest similar lithology is in the Kangaroo Hills Formation which is Siluro-Devonian.

SILURIAN - LOWER DEVONIAN

Greenvale Formation (S-Dg)

Extending south-west from the head of Marsh's Creek in the valleys of Black Gin Creek and Tribute Creek is a sequence of grey siltstone, greywacke and sub-greywacke, greywacke conglomerate, and silty quartz and feldspathic sandstones. The sequence is somewhat similar to the Greenvale Formation, but parts are similar to the Kangaroo Hills Formation.

These strata have a north-easterly regional trend, but are deflected to a south-easterly trend adjacent to the Sybil Graben. The beds are steeply dipping or vertical, the regional dip apparently being to the north-west.

Bedding is normally well developed, but the beds are quite variable in thickness. In the shales and siltstone they are of the order of 2-3 inches, but the coarser clastics, which form lenticular bodies, contain beds several feet thick. Current bedding is common in the finer clastics.

The strata appear to be conformably overlain by the Tribute Hills Sandstone. To the east they are faulted against the Sybil Group, and to the south they are intruded by the Oweenee Granite.

These strata have so far proved to be unfossiliferous. They are shown on the Clarke River 1:250,000 Sheet (White et al., 1962) as Kangaroo Hills Formation. The relationships of these strata are discussed more fully below.

Tribute Hills Sandstone (S-Dt)

Forming the Tribute Hills south of the Burdekin River in the Black Gin Creek area, 20 miles west of Ewan, is a continuation of the Tribute Hills Sandstone described by White et al. (1959b) from Crooked Creek in the Clarke River 1:250,000 Sheet area as the Tribute Hills Formation, and later by White and Wyatt (1960) as the Tribute Hills Sandstone. In the Townsville 1:250,000 Sheet area the formation consists of steeply dipping or vertical quartz sandstone and siltstone similar to those of the type area at Crooked Creek.

East of Tribute Dam the formation is truncated by the western fault of the Sybil Graben. Silicified quartz sandstone and quartzite forming the high country immediately to the south-west of the junction of Little Oaky and Oaky Creeks probably represent the continuation of the sandstone on the eastern side of the graben. The formation has not been recognized farther to the north-east.

The thickness of the formation on the Townsville 1:250,000 Sheet area is between 3500 and 5000 feet.

The Tribute Hills Sandstone appears to be unconformably overlain by the Kangaroo Hills Formation on the Clarke River 1:250,000 Sheet area. However, the relationships of the Tribute Hills Sandstone are discussed more fully below.

Kangaroo Hills Formation (S-Dk)

In the north-western part of the Townsville 1:250,000 Sheet area is a continuation of the Kangaroo Hills Formation which is more extensively developed on the adjoining Ingham, Einasleigh, and Clarke River 1:250,000 Sheet areas. The formation was first described by Maitland (1891). It has been described by White et al. (1959a), and White and Wyatt (1960).

The Formation consists of thin-bedded quartz arenites and grey shales with lenses of greywacke arenite and conglomerate. The quartz arenites usually show small-scale current bedding. This type of lithology is identical with that exhibited by the Formation in the Einasleigh and Clarke River 1:250,000 Sheet areas.

The Formation has a general east-west trend in the Tomahawk Creek area, but farther south, near the junction of Black Gin Creek and the Burdekin River, the trend is north-east. These trends occur within the eastern limb of a large synclinal structure, the greater part of which occurs within the Clarke River and Einasleigh 1:250,000 Sheet areas. The structure within this syncline is not simple, as numerous minor folds, whose axes usually plunge vertically, have been observed.

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

Relationship of the Kangaroo Hills Formation, Tribute Hills Sandstone and (?) Greenvale Formation

On the Clarke River 1:250,000 Sheet area, there is evidence which suggests that the Tribute Hills Sandstone is equivalent to the Perry Creek Formation which conformably overlies the Kangaroo Hills Formation. On this evidence the Tribute Hills Sandstone is younger than the Kangaroo Hills Formation.

However, there is also evidence in the Clarke River 1:250,000 Sheet area which suggests that the Tribute Hills Sandstone is overlain, with an unconformable overlap or similar relationship, by the Kangaroo Hills Formation. On this evidence, the Tribute Hills Sandstone cannot be equivalent to the Perry Creek Formation but must be older than the Kangaroo Hills Formation.

Now the strata which lie immediately south of the Tribute Hills Sandstone appear to conformably underlie it. Thus, if the Tribute Hills Sandstone is regarded as equivalent to the Perry Creek Formation, the strata in question must be equivalent to the Kangaroo Hills Formation. But as the Kangaroo Hills Formation also lies immediately north of the Tribute Hills Sandstone it follows that the Sandstone must be folded synclinally within the Kangaroo Hills Formation. This structure is not evident from knowledge of the regional structure.

If the evidence for the apparent equivalence of the Tribute Hills Sandstone and the Perry Creek Formation is discarded, and the evidence for the apparent unconformity between the Tribute Hills Sandstone and the Kangaroo Hills Formation adopted, the relationships appear to be as follows:

Perry Creek Formation
Kangaroo Hills Formation

Unconformity

Tribute Hills Sandstone
Strata lying south of Tribute Hills Sandstone

Now the Tribute Hills Sandstone is very similar to the Pelican Range Sandstone, and the strata lying south of the Tribute Hills Sandstone are somewhat similar to the Greenvale Formation. If these lithological similarities are valid then the following relationships hold:

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

Thus the sequence in the Black Gin Creek - Perry Creek area becomes the same as that established by White (1962) in the Greenvale - Perry Creek area, and the sequence fits the regional structure better. It is for these reasons that the strata south of the Tribute Hills Sandstone have been shown on the map as possible Greenvale Formation rather than as Kangaroo Hills Formation, as in the adjoining Clarke River 1:250,000 Sheet area.

Ravenswood Granodiorite (S-Dr, S-Da)

Typically developed over much of the Ravenswood Goldfield and the southern part of the Charters Towers Gold and Mineral Field, and extending north to Piccadilly, Dotswood, and Speeds Creek, and west to the Newhaven Provisional Goldfield is an extensive area of granitic rocks which form part of an ancient batholith. The dominant rock type constituting this mass is granodiorite, and the unit is here designated the Ravenswood Granodiorite.

The granodiorite (S-Dr) in places may grade to tonalite, diorite, or even gabbro, but these types are not abundant. Both hornblende and biotite are present in the granodiorite, and their relative proportions range between quite wide limits. In some areas a strong foliation is present, but in others it is almost impossible to recognize.

The granodiorite in places contains numerous xenoliths of diorite which "almost certainly represent a more basic phase of the same magma which crystallized at depth" (Houston, 1961). In areas where these xenoliths are most numerous the granodiorite appears to have become contaminated to become a quartz diorite in which the plagioclase is more basic than in the granodiorite, the potash feldspar, in general appears to be absent, and hornblende, similar to that in the xenoliths, becomes abundant. (Houston, 1961).

Leucocratic granites and aplites (S-Da) form a prominent phase of the batholith representing about 5 to 10 percent of its known outcrop. They tend to form topographically higher country than the granodiorite. This leucocratic phase appears to be later than the granodiorite. It is composed of translucent quartz, pink to red potash feldspar, and minor, commonly chloritized, biotite. The texture is extremely variable in these leucocratic granites, ranging from granitic to pegmatitic, graphic, or aplitic. South and east of Mingela the granites have a typical granitic texture, and are composed of quartz, microperthite, microcline, oligoclase, and biotite. Micrograritic phases occur as irregular patches within these granites. A foliation is fairly commonly developed, but is usually not as marked as in the granodiorite. In many places the foliation can be related to post-crystallization shearing, but in others it was possibly imposed in a late stage of crystallization.

Small areas of more basic rocks occur, for example at Macrossan, where spessartite lamprophyre is developed (Houston, 1962), and one mile north of Cockatoo Well, Dotswood Holding, where hornblendite occurs with diorite (Houston, 1961). These varieties are not foliated, and were probably emplaced after relaxation of the stress which imposed the foliation on the Granodiorite.

The host rock at the abandoned Newhaven Mine is a slightly foliated biotite granodiorite; this rock type is quite typical of the Ravenswood Granodiorite.

The Ravenswood Granodiorite intrudes the "Charters Towers Series", and Argentine Metamorphics. The leucocratic granites intrude the Kirk River Beds. The Granodiorite is overlain nonconformably by the Fanning River Group.

Preliminary radioactive age-determinations of two samples of granodiorite from the Mingela/Fanning River district indicate an age of 420 million years $\pm$ 3% (Silurian). (Determinations by A.W. Webb at the Department of Geophysics, Australian National University).

In the Townsville 1:250,000 Sheet area the petrology of the Ravenswood Granodiorite has been studied mainly north-east of Dotswood Homestead. There the most characteristic feature is the presence of "pools" of quartz which are closely related to the foliation of the granodiorite. These "pools" consist of mosaics of different types (Houston, 1961):-

1. Interlocking mosaics of individual anhedra
   (a) roughly equigranular anhedra probably due in general to the inversion of high-temperature quartz or in certain instances to re-crystallization,
   (b) somewhat elongate anhedra probably the result in part at least of re-crystallization of crystals granulated in shearing.

2. Strain mosaics resulting from the foliation processes.

The foliation of the Ravenswood Granodiorite was possibly produced by the same stress that folded the "Charters Towers Series" and Argentine Metamorphics. In fact, R.L. Jack (1879a) regarded the granites of the Charters Towers area as resulting from extreme regional metamorphism of the metamorphic rocks there. However, whatever the mode of origin of the granitic magma, the possibility of the foliation being related to flow during emplacement of the magma cannot be disregarded. The intensity of foliation varies quite markedly, sometimes within short distances. Although insufficient evidence is available, present observations suggest that foliation may be strongest near contacts with the metamorphics, and weak or absent in areas well removed from any known metamorphics. Also, when a strong foliation is developed it is invariably parallel to the schistosity in the nearby metamorphics. For example, north of Charters Towers near Breddan, the foliation in both granodiorite and metamorphics generally strikes north-west. In the Main Creek area, north-north-east of Dotswood H.S., the foliation in the granodiorite strikes 060°

whereas a few miles to the north in the metamorphics, the foliation strikes between 060° and 090°. However, in areas well removed from any known metamorphics, e.g., at the crossing of the East Fanning River north of Fanning River Homestead, or at the Broughton Crossing south of Charters Towers on the Charters Towers 1:250,000 Sheet area, the foliation is almost or completely absent, at least macroscopically.

In some areas the foliation is related to severe shearing movements after crystallization. This is typically shown in the granodiorite east of Mingela where a strong fault zone extends east towards Horse Camp Hill, and again 3 miles south of Mingela where the granodiorite and late granite phase have been foliated by the same fault system. In the coarser parts of these rocks, the quartz grains are rolled out and flattened into elongate, lens-shaped mosaics.

Besides being foliated, the granodiorite north of Dotswood has also been sheared. This shearing may be related to the intrusion of numerous north-east trending microdiorite dykes many of which have themselves been sheared; abundant actinolite-epidite-chlorite stringers are developed in both the microdiorite and the granodiorite. The mode of formation of these stringers is in doubt, but they are probably attributable to a late-stage hydrothermal phase of the dykes which were possibly intruded contemporaneously with the shearing.

The age of the shearing and dyke intrusion is probably late Palaeozoic, as dykes similar dykes to those in the granodiorite occur in an offshoot of the late Palaeozoic Pall Mall Adamellite.

In the area of Dinner and Horse Creeks, respectively some 5 miles south-south-east and east-south-east of Star Homestead, granitic rocks, mainly muscovite pegmatites, occur associated with migmatite. Similar rocks occur at the head of the north branch of the Little Star River. These pegmatites appear to be genetically related to the migmatites, and occur only with rocks of the highest grade in the Argentine Metamorphics. The absence of muscovite in the pegmatitic parts of the late leucocratic granite phase also suggests that these northern pegmatites are of different origin. The results of a proposed granite sampling programme for age determination may indicate whether or not these different granites belong to a similar period of intrusion.

Three occurrences of garnetiferous granite have been noted - all are non-foliated. The first and most northerly occurs about 300 yards east of the Star Homestead - Basin Yards track about 100 yards north of the block fence which is about 13 miles north-north-east of Star Homestead. Here cropping out over an area of a few acres, white muscovite granite intrudes Argentine Metamorphics. The garnet occurs as small crystals sparsely disseminated throughout the rock.

The second occurrence is on the road from Laroona Homestead to Lassie Creek Homestead, about 6 miles north-east of Lassie Creek Homestead. Here an isolated body of white, garnetiferous muscovite granite and pegmatite has been exposed by road excavations. Its extent and relationships are unknown.

The third and most southerly occurrence is about 1 mile north-east of Valley Homestead. Here a white, garnetiferous muscovite granite is faulted against red beds of the Devonian sequence.

The only other garnetiferous granites known in the area mapped during the present survey occur in the Lolworth Igneous Complex in the Charters Towers 1:250,000 Sheet area. The relationship of these isolated northern occurrences to those of the Lolworth area is unknown. If all these garnetiferous granites are of similar age, the northern occurrences must be younger than the Ravenswood Granodiorite which is intruded by the Lolworth Igneous Complex.

Lolworth Igneous Complex (S-D1)

Small areas of granitic rocks considered to belong to the Lolworth Igneous Complex have been photo-interpreted on the southern boundary of the Townsville 1:250,000 Sheet area near Fern Springs Homestead. Here these rocks occur as small inliers amongst laterite which has been dissected east of the homestead to expose the underlying rock.

Although these outcrops were not visited in the Townsville Sheet area, granitic rocks have been examined in the Charters Towers Sheet area immediately to the south, where they are strongly weathered and lateritised. Large feldspar phenocrysts up to two inches long can be recognized, and it is on account of this feature that they have been assigned to the Lolworth Igneous Complex, which also contains such coarsely porphyritic material.

The characteristics of this Complex are discussed in a report on the geology of the north-eastern part of the Hughenden 1:250,000 Sheet area (Paine et al., 1965).

A radioactive age-determination on one sample from the Lolworth Igneous Complex in the Charters Towers Sheet area has given an age of 400 million years ($\pm$ 3%) - Lower Devonian (determination by A.W. Webb at the Department of Geophysics, Australian National University, Canberra). It intrudes the Ravenswood Granodiorite (probably Silurian) in the Charters Towers and Hughenden Sheet areas.

Close of the Early Palaeozoic

The early Palaeozoic era (Cambrian to Lower Devonian) closed with a period of major orogenic folding and uplift. This is evidenced by the marked difference in tectonic style between the early and late Palaeozoic strata, and the strong angular unconformity which exists between them. This movement occurred at some time between the beginning of the Devonian and the Givetian. This age relationship is based on the evidence of a coralline fauna, indicating an Upper Silurian age, in the Perry Creek Formation (Clarke River Sheet area) which was involved in the movement, and a coralline fauna, indicating a Givetian age, in the Fanning River Group which was not involved in the movement.

The foliated nature of parts of the Ravenswood Granodiorite suggests that it was intruded during the latter stages of this orogenic period. In fact, the attitudes and fold patterns of the early Palaeozoic (and also Precambrian) strata suggest that the orogeny produced a broad anticlinorium whose core was intruded by the Ravenswood Granodiorite. If this reconstruction is correct then much of the roof of the batholith was removed prior to deposition of the Givetian strata, as a marked erosional unconformity exists between the Granodiorite and the Fanning River Group.

LATE PALAEOZOIC

MIDDLE DEVONIAN

Following a period of erosion after the Silurian to Lower Devonian orogeny, sedimentation recommenced in Givetian times with the deposition of marine strata. These sediments were deposited in part of what Whitehouse (1930) termed the Burdekin Basin. His term embraced the sedimentary basin of the Broken River area which has since been called the Broken River Embayment (Hill, 1960).

Although sedimentary conditions in the Broken River and Burdekin areas were similar from Givetian to Tournaisian times, the Broken River Embayment contains a great thickness of early Palaeozoic strata which are absent in the Burdekin area. Thus, for any discussion of the sedimentary histories of those two areas it seems advantageous to restrict Whitehouse's term to the area between Laroona Homestead, Valpre Homestead, and Burdekin Downs Homestead in the west, and Speed's Creek, Calcium, and Fanning River Homestead in the east. It is within this area that the Fanning River Group is developed.

Fanning River Group (Dmf)

Typically developed in the vicinity of Fanning River Homestead is a sequence of strata here designated the Fanning River Group. These strata were previously described by Wyatt (1961) as the Fanning Group. The Group consists of a basal sandstone sequence followed by a coralline limestone sequence followed by a sandstone/shale sequence. Although the term Burdekin Beds (Jack, 1886 a and b), Burdekin

Formation (Jack, 1892) and Burdekin Series (Dunstan, 1913; Reid, 1930) have been used for strata of this age from various parts of the Burdekin Basin, it is obvious that these terms have been applied essentially to the coralline limestone section. The term Burdekin Formation has therefore been restricted to that section. In 1961 Wyatt subdivided his Fanning Group as follows:-

Top

Cultivation Gully Formation	Fanning Group
Fanny River Formation	
Golden Valley Formation	

Bottom

However, the term Golden Valley Formation is pre-occupied in Australian stratigraphic nomenclature, and it would be desirable to retain the well established name "Burdekin" for the limestones. As Heidecker (1960) has described strata equivalent to the Golden Valley Formation from the Burdekin Downs area it is proposed to use his term "Big Bend Arkose" for the basal sandstone sequence. The term Fanning Group used by Wyatt (1961) is expanded to Fanning River Group in an attempt to avoid confusion with Fanning railway siding or Fanning Downs Homestead, which localities are commonly confused with Fanning River Homestead. The nomenclature used in this report will be -

Top

Cultivation Gully Formation	Fanning River Group
Burdekin Formation	
Big Bend Arkose	

Bottom

These subdivisions are the result of detailed mapping carried out during 1960-1962 by the Geological Survey of Queensland. As it was not practicable to delineate the constituent formations on a 1:250,000 map such as accompanies this report, only the Group has been shown.

Big Bend Arkose

(not shown separately on map)

Heidecker (1960) described a sequence of arkose and conglomerate typically developed at Big Bend on the Burdekin River about 15 miles north of Charters Towers. Although these beds were observed at this locality they were not studied in any detail during the present survey. The beds were studied more fully at the head of Emu Apple Creek, 10 miles north-north-east of Burdekin Downs Homestead, and at Golden Valley on the western side of Mount Success.

In the former area they consist of buff medium to coarse feldspathic sandstone and subgreywacke with interbedded more calcareous beds containing abundant large gastropods and small, stout, branching bryozoa and stout disphyllids. The sandstones weather readily, and do not give rise to good outcrop. However, the beds appear to be about 1'6" to 3'0" thick, but bedding is commonly poorly developed.

About Three-mile Mill on Three Mile Creek the lowest beds are red-brown sandy siltstones associated with large boulder conglomerates containing granite derived directly from the underlying Ravenswood Granodiorite. Farther to the north-west, near Sommerview Mill, red shale and siltstone, cream to brown feldspathic sandstone, and lithic arkose occur, but in this area the Fanning River Group is atypical, the coralline limestone development of the Burdekin Formation being absent, and the upper sandstone/shale sequence being indistinguishable from the Big Bend Arkose or the lower parts of the overlying Dotswood Formation.

At Golden Valley, cobble to boulder conglomerates are overlain by subgreywacke and feldspathic sandstone with occasional disphyllid corals. These sediments are about 50 feet thick.

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

North of Laroona, feldspathic sediments have been noted below the limestones, but the intrusion of rhyolite porphyry dykes obscures most of their outcrop.

At Reid Gap, arkose and feldspathic sandstone unconformably overlie biotite granodiorite immediately south of the lime-burning quarry. Here they measure about 50 feet thick. Similar strata occur at the base of the Group about 3 miles east-south-east of Reid Gap. Here they may measure up to 100 feet thick.

Elsewhere in the Reid Gap - Calcium area the basal beds consist of coarse white quartz conglomerate, for example, behind the main quarry at Calcium or on the strike ridge east of Reid Gap, where they are very thin. On the hill south-east of the Calcium quarry the sequence consists of contact - metamorphosed quartz sandstone, calcareous sandstone, and silty feldspathic sandstone. This sequence measures about 40 feet thick.

At most localities in the Burdekin Basin where the Big Bend Arkose has been observed the thickness of the sequence is between 50 and 100 feet, although in the Emu Apple Creek area it may exceed 200 feet, and at Big Bend Heidecker quotes a figure of 250 feet for his type section, but states that the Arkose is generally

300 feet thick. These figures suggest that the Arkose is thicker in the south-western part of the Burdekin Basin. However, the distribution of the Arkose appears to be erratic, and in places it is absent altogether, the limestone resting directly on the granitic basement.

The Big Bend Arkose is overlain by and interfingers with a calcareous sequence - the Burdekin Formation.

Burdekin Formation

(not shown separately on map)

The Burdekin Formation is typically developed in the Fanning River north of Fanning River Homestead. Although the name is derived from Burdekin Downs Homestead where Jack (1879a) first described the limestones, it is obvious that his later descriptions of the formation are based on observations made later in 1879 at Fanning River, where the sequence is much better exposed.

The Formation consists of calcareous shale, calcilutite and fossiliferous limestone, and coral, bryzoan, and shell coquinas. A few calcareous feldspathic
at the base, and at the top calcareous sandstones and shales are interbedded
sandstones and shales are interbedded. The whole sequence measures about 600 feet.

The strata are well-bedded, bedding averaging 4 to 6 inches, but beds up to 6 feet occur. In many places the coral and other organic remains have been somewhat sorted and rolled about, but it is not likely that much transport of materials has taken place. This is confirmed by the occurrence in some beds of stromatoporoid nigger-heads which still maintain their position of growth.

The limestones of Burdekin Downs, Valpre-Miles Lake area, and Laroona are all similar to those of Fanning River. At Calcium, however, the Formation has a different aspect owing largely to thermal metamorphism and intense faulting. Beds of argillaceous or sandy limestone at the base and top of the calcareous sequence have been metamorphosed to calc-silicate hornfels (G.S.Q. 15190), anthophyllite-cordierite hornfels (G.S.Q. 15191), and wollastonite-garnet hornfels (G.S.Q. 15181-15184, 15186), which are commonly interbedded with chert. These beds, which average about 6 inches in thickness, alternate with beds of fine grey marble of similar thickness. The marble beds are eroded by solution weathering much more readily than the hornfels or chert beds, so that these sections of the Formation exhibit a markedly banded appearance. These banded sections measure about 100 feet each, whereas the middle section of relatively pure limestone may be up to 200 feet thick. It is this part which is quarried for limestone.

Although Stringocephalus occurs in the Fanning River section, south-east of Reid Gap it forms prominent shell beds or coquinas, with a calcilutite matrix, up to 6 feet thick. It is possible that they will prove a useful marker bed for detailed mapping.

In the Valpré-Miles Lake area these limestones are the only part of the Fanning River Group observable. This is due mainly to the Burdekin Formation being more resistant to erosion than the Big Bend Arkose or the Cultivation Gully Formation. These latter formations erode to give land of low relief which is readily covered by the extensive Quaternary soils and alluvia of this area.

The limestones of the Burdekin Formation carry a rich reef fauna, and the rugose corals from the Burdekin Downs, Fanning River, and Reid Gap areas were studied by Hill (1942), who assigned a Givetian age to the strata. McKellar (1962a, b; 1963a) has also determined a Givetian age for the limestones at Valpré and Laroona and in a small unnamed creek between Turtle and Lime Creeks north-east of Dotswood Homestead. From Valpré, McKellar (1963a) has determined Acanthophyllum sweeti Eth. fil., Dohmorphyllum clarkei Hill, Stringophyllum irregulare Hill, Spongophyllum immersum Hill, "Cystiphyllum" australi Eth. fil., Heliolites daintreei Nich. and Eth., Alveolites sp., Thamnopora meridixonalis Nich. and Eth., Thamnopora aff. hillae James, and Actinostroma sp.

Cultivation Gully Formation
(not shown separately on map)

The Burdekin Formation is overlain by, but also interfingers with, a sequence of sandstones and shales described by Wyatt (1961) as the Cultivation Gully Formation. It is typically developed in a small creek, 1 1/3 miles north-east of Fanning River Homestead, which has been officially named Cultivation Gully.

The Formation consists of thin, buff-coloured shale, siltstone, and fine to medium sandstone. The sequence is generally feldspathic and micaceous. Occasional thin beds of calcareous sandstone are developed particularly in the lower 60 feet of the Cultivation Gully section where thin-bedded, sandy fragmental limestone and coquina also occur. Many of these limey beds are characterized by Stringocephalus sp. and Atrypa sp. Rare thin calcareous mudstone with gastropods occurs near the top of the sequence.

Beds are about 4 to 6 inches thick, and the strata are usually thinly laminated but not readily fissile. Small-scale current-bedding is occasionally developed.

In the Calcium-Reid Gap area the formation is represented by a feldspathic sandstone-micaceous shale sequence which is noticeably calcareous in its lower parts. Khaki and grey shales predominate in the lower parts of the sequence, which becomes progressively more arenitic upwards. South-west of Calcium these feldspathic sandstones have been converted to white or brown hornfelses by the microgranite which forms Brown Mountain. East of Plant Hill greenish grey subgreywacke occurs with the more normal feldspathic sandstone.

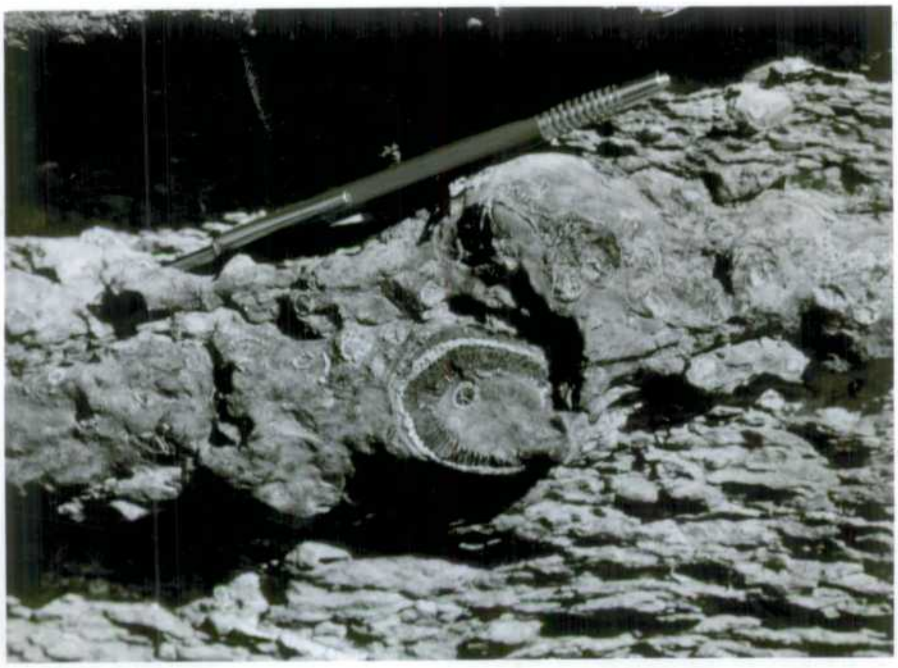


Photo Plate 2

Fossiliferous bedded limestone of the Givetian Burdekin Formation of the Fanning River Group. In bed of Fanning River, 1.8 miles north-east of Fanning River Homestead.
B.M.R. Neg. No. G/6820.

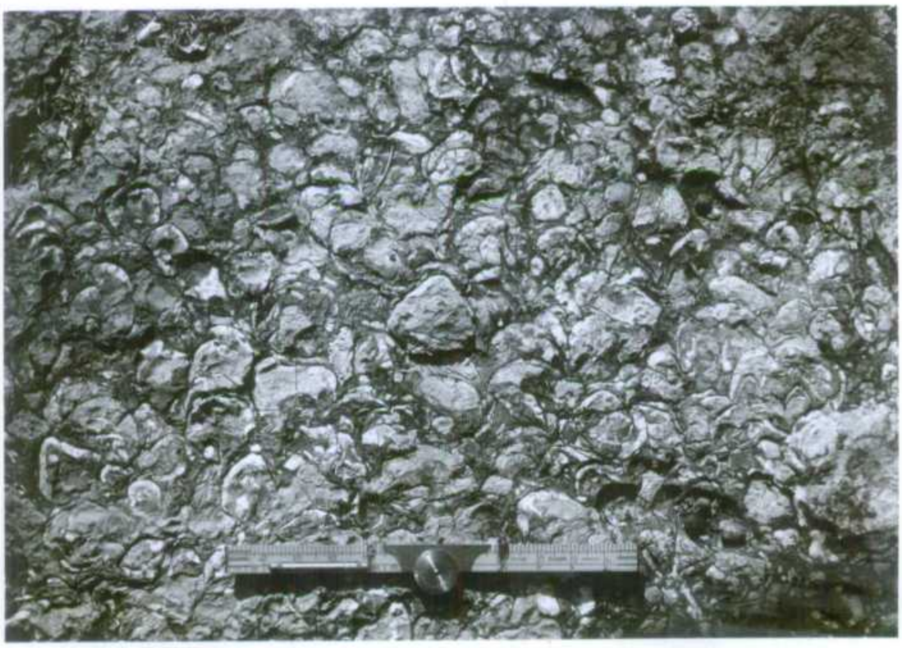


Photo Plate 3

Coquina of large Stringocephalus shells in Givetian Burdekin Formation (Fanning River Group), 2.7 miles north-east of Reid River Railway Siding (34 miles south of Townsville).
G.S.Q. Neg.

Fossils are confined mainly to the lower levels, i.e., to the zone where the typical Burdekin Formation lithology interfingers with the Cultivation Gully Formation. The Givetian age of the fossil assemblage, together with the interfingering of rock types, suggests that the Burdekin Formation and the Cultivation Gully Formation are simply facies variants, the Cultivation Gully Formation apparently overlying the Burdekin Formation because of migration of the facies limits with time. Fossils determined from this Formation include Warrenella sp., Uncinulus sp., Fistulipora sp., Atrypa desquamata Sow., Eodevonaria sp., Calceola sandelina Lin., Zonophyllum aff. pseudoseptatum, Metriophyllum sp., Disphyllum gregorii Eth. fil., as well as Chonetes sp., Schizophoria sp., Athyris sp., Productella sp., and Nucleospira sp. (Woods 1961a, b; McKellar 1962a). In the Reid Gap area, McKellar (1964) has determined Nuculidea sp., Edmondia sp., Tentaculites sp., Warrenella sp., Atrypa cf. desquamata Sow., Calceola sandelina Lin., Aulopora sp., Cypricardella sp., Chonetes sp., Kayserella sp., Ptychodesma sp., and Neoactinodonta amygdalina Heidecker.

The Cultivation Gully Formation is usually overlain by conglomerates which have been mapped as the base of the overlying Dotswood Formation. The Formation is 550 feet thick in the type area, and this is probably a maximum for the Fanning River-Burdekin Downs-Laroona area. However, in the Calcium-Reid Gap area present knowledge of structure indicates a thickness of between 2000 and 2800 feet. This thickness is very much in excess of thicknesses observed elsewhere, and until further details of the structure are known these figures should be regarded with caution.

UPPER DEVONIAN

Dotswood Formation (Dud)

Following on the Fanning River Group is a sequence of arkose, shale, sandstone, and conglomerate which Jack (1879a) designated as the Dotswood Beds. These beds are characterized by their red-bed lithology, and are here described as the Dotswood Formation. Current detailed mapping by the Geological Survey of Queensland shows that the formation can be further subdivided on lithological grounds, so that it will probably be raised to group status.

The Formation is known to crop out in the Mount Jack area in the lower reaches of the Star River, and again farther eastward below the junction of Speed Creek and Granite Creek. It is well developed between Fanning River Homestead and Dotswood Homestead north-west of Quilps Homestead and north of Burdekin Downs in the Mount Brown area. Although Jack named his Dotswood Beds from an area immediately north of Dotswood Homestead, the best development of the Formation is in numerous creeks and gullies west from Fanning River Homestead to Moody Dam. A section generally along the Fanning River - Dotswood road is designated as type section.

In this type area the Formation consists of a basal section of coarse, buff, feldspathic sandstone and subgreywacke with minor conglomerate and tuff, measuring 1475 feet, followed by a middle section of 3600 feet of red shale, siltstone, and sandstone with minor quartz sandstone, lithic conglomerate, and arkose. These are followed by an upper section of about 3000 feet of coarser-grained clastics in which arkose, feldspathic sandstone, and lithic conglomerate predominate over shale and siltstone.

Outside the type area there is very little variation in the Formation except for the relative importance of each of the three sections mentioned. Variation in the Formation is apparently due to a facies change related to distance from the source area. The Formation appears to have been essentially continental in origin, forming a broad piedmont deposit with a broad outwash plain and associated distributary river systems and shallow ephemeral lakes.

The base of the Formation appears to be always marked by conglomerate. North of Fanning River Homestead, at the top of the Fanning River Group these conglomerates consist of grey cherty mudstone fragments in a white clayey-quartz matrix which appears to be tuffaceous in places. This conglomerate and associated sandstones 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 a small creek flowing into Keelbottom Creek between Lime and Turtle Creeks north-east of Dotswood, the base of the Formation is represented by well-rounded quartz pebble conglomerate. In the Deadman's Gully area near Calcium a large boulder conglomerate with granite and limestone phenoclasts probably represents the base of the Dotswood Formation, but as the rest of the section is missing this interpretation is tentative. The occurrence of limestone phenoclasts indicates a period of erosion of the underlying Fanning River Group. The development of plant-bearing, tuffaceous sediments near Fanning River Homestead suggests a sudden change to continental conditions from the marine conditions of the Fanning River Group, and the quartz pebble conglomerates north-east of Dotswood Homestead also point to a period of quiescence during which time all labile materials were removed. No angular unconformity has been recognized between the Fanning River Group and the Dotswood Formation, but the lithologies of the basal conglomerates indicate that a disconformity exists.

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 non-conformably on the Ravenswood Granodiorite. Similarly, north-west from Mount Jack, 7 miles south-west of Star Homestead, the Fanning River Group is absent, and the Dotswood Formation rests unconformably on the Argentine Metamorphics.

Photo Plate 4

Polymictic pebble to cobble conglomerate of the Dotswood Formation, 1-2 miles south-south-east of Calcium Railway Siding (28 miles south of Townsville). G.S.Q. Neg.

Bedding within the Formation is normally well developed, particularly in the thin-bedded, fine red sandstones and shales of the middle section. In the conglomerate and sandstone of the upper section, bedding is not so well developed, the conglomerates often being broadly cross-bedded and unsorted. The shales in the upper section are less well-bedded than in the lower.

Tuff occurs in the lower feldspathic sandstone sequence cropping out in a narrow belt just west of Fanning River Homestead. It forms a low ridge which is quite prominent because of the pale green colour of the rocks in what is normally a brown to red sequence. A maximum of 30 feet of tuff is developed.

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

The remaining strata were possibly derived from a granite terrain, as evidenced by the abundance of feldspar. In the red-bed sequence of the middle section the grains have not been well rounded.

The Formation has so far proved to be poorly fossiliferous. The red beds of the middle and upper sections have not yielded any fossils. The only fossils so far obtained in the basal buff coloured sequence have been lepidodendroid plant debris. As already mentioned, Protolepidodendron occurs in conglomerate and sandstone north of Fanning River Homestead, and Leptophloeum australe occurs in tuffaceous sediments 4¼ miles south of the homestead. From a locality 2 miles south-east of Valpré Homestead, McKellar (1963a) has determined ?Protolepidodendropsis sp., cf. Protopteridium sp., Sublepidodendron sp., and Stigmaria sp. from strata which belong to the Dotswood Formation. McKellar suggests that this flora indicates an upper Devonian age.

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

Myrtlevale Beds (Dum)

Typically developed in the area north of Myrtlevale Hut (St. Michael Holding) to Moody Dam (Dotswood Minor Holding) is a sequence of marine strata which are here designated the Myrtlevale Beds. The strata were previously described by Wyatt (1961) under the title Moody Group which consisted of the Moody Dam Formation and the Myrtlevale Formation. The name "Moody" is, however, already occupied in Australian nomenclature. The two formations are apparently facies variants, and in some areas their boundary is not readily mappable in the field. For these reasons a simplification of nomenclature appears warranted, and the whole sequence is regarded as one unit.

The Beds appear to have been deposited over the whole of the Burdekin Basin. In the western half of the Basin they have been observed near the mouth of Back Creek, north of Lollypop Dam, on the track between Piccadilly and Evans Dam and west towards Morgans Dam, at Snakes Dam, and at the eastern heads of Tomato Creek. In the eastern half of the Basin they occur in the type area about Myrtlevale and Moody Dam, whence they extend north towards Mount St. Michael, and east to Percy Creek Mill. They have also been found in a synclinal structure east of Marlow Homestead, in a faulted synclinal structure north-west of Myrtlevale Hut, north of Dotswood Homestead, and in the Grasshopper Range.

Outcrops of these beds give rise to narrow belts of low ground which are normally readily photo-interpreted. These belts are of great assistance in delineating the structure of the area because of their narrowness. With their prominent Cyrtospirifer fauna, the Myrtlevale Beds are a key formation in the Devonian/Carboniferous sequence.

They consist of a lower, essentially sandstone, sequence overlain by an essentially siltstone/shale sequence, with interfingering of the two types in the middle. The basal coarse clastics consist mainly of feldspathic sandstone grading to subgreywacke but, in places, a thin basal quartzose conglomerate is developed. Pebbly sandstones also occur, but the pebbles invariably consist of resistant material (quartz, quartzite, chert, and jasper) as opposed to the labile porphyry and granite pebbles of the underlying Dotswood Formation. The sandstones in this part of the sequence tend to be coarsely bedded and cross-laminated. The only fossils so far observed in the beds are lepidodendroid plants amongst which Lepidodendron australe is recognizable.

In the middle part, where the upper and lower sequences interfinger, cherty quartz sandstones appear, and the sediments become finer and cleaner, and contain less feldspathic material. In this intermixed zone, lamellibranchs and Lepidodendron australe occur in the same beds. In the upper, finer-grained section khaki siltstones are plentiful, and the sandstones become thinner-bedded and ripple-marked; thin limestone (Cyrtospirifer) coquinas are interbedded with siltstones and shales, the latter rapidly becoming more important up the section. Rare thin limestone beds with solitary corals occur in the shale sequence. Near the top of the section calcareous and sandy Cyrtospirifer coquinas reappear. The whole sequence is indicative of deposits laid down in a shallow transgressive sea.

The Beds in the type area are 1050 feet thick, but over the whole basin they may have an average thickness more of the order of 900 feet. The sequence as just described is that of the type area. Complete sections have been observed elsewhere but have not been studied in detail, and the Beds have been recognized mainly by their faunal assemblage and their stratigraphic position above the red bed sequence of the Dotswood Formation. However, in all sections observed, a coarse, relatively unfossiliferous, lower sequence is overlain by a finer, richly fossiliferous, upper sequence.

McKellar (1962c) assigns a Famennian age to the strata. Fossil genera and species determined 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. "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., Serpulospira sp., Bellerophon sp., Pseudozygopleura sp., cf. Spyoceras sp., cf. Orthoceras sp., Cladochonus sp., and Leptophloeum australe.

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

UPPER DEVONIAN TO LOWER CARBONIFEROUS

Lollypop Formation (D-Cl)

Typically developed in Pintpot Creek, immediately north-west of Lollypop Dam is a sequence of feldspathic sandstone and conglomerate which was mapped by Wyatt (1962) as the Lollypop Formation. These strata extend east of the dam to the head of Boundary Creek, and west of the dam towards Billy Creek, where the Devono-Carboniferous sequence is covered by Quaternary sand and soil, and the Formation has not been differentiated. The Lollypop Formation is also developed west, south, and east of Pelican Dam between Broken Arm and Brumby Creeks, and also in the area about the head of Tinker Jack and Piccadilly Creeks.

In the Myrtlevale-Dotswood-Percy Creek area, a similar sequence was mapped by Wyatt in 1960 and 1962, and tentatively called the Topsy Formation. Although the rocks of this area are not continuous with those in the areas already mentioned, their lithological similarity and their stratigraphic position between strata readily recognizable by their fossil content leaves no doubt as to their equivalence with the Lollypop Formation.

The Lollypop Formation consists essentially of feldspathic sandstone with minor conglomerate, although the conglomerate becomes quite abundant east of Pelican Dam. The conglomerate occurs throughout the sequence, but may be slightly more abundant in the middle section. Bedding is fairly well developed in the sandstones, and the average thickness of individual beds is between two and four feet. Large-scale cross-bedding is developed in places, making measurement of the average dip somewhat difficult, particularly in the area south-east of Pelican Dam.

Many of the sandstones show secondary silicification near exposed surfaces, so that the rock becomes "case-hardened". This commonly gives rise to a bouldery outcrop. Compared with the shales of the underlying Myrtlevale Beds and the overlying Hardwick Formation, the Lollypop Formation is resistant to erosion, and generally forms higher ground. This physiographic expression is of great assistance in recognizing and photo-interpreting these stratigraphic units.

In the type area the Formation is about 1500 feet thick, but in the Pelican Dam area its thickness increases to between 2400 and 2700 feet. South of Mount St. Michael, near Dotswood, the thickness is probably of the order of 1000 feet.

The Formation has so far proved to be unfossiliferous. Fossils in strata immediately below the Formation in the Myrtlevale Beds indicate a Famennian age. Unfortunately, the fossils in the strata in the basal beds of the overlying Hardwick Formation indicate only an imprecise age of Upper Devonian or Lower Carboniferous, and it is not until 1000 feet or more higher, in the Hardwick Formation, that strata of definite Tournaisian age occur. These Tournaisian strata equate with Lower Tournaisian strata in the Star Beds, so that it is possible that the lower Hardwick Formation is, in part, Famennian. If this is so, then the Lollypop Formation, which is conformable below the Hardwick Formation, must be Famennian. However, the possibility still remains that the Hardwick Formation is entirely Tournaisian, in which case the Lollypop Formation may extend into the lower part of that stage.

Hardwick Formation (D-Ch)

Conformably following the Lollypop Formation is the Hardwick Formation. It is typically developed over much of the parish of Hardwick (county of Wilkie Gray) about the headwaters of Pintpot Creek between Piccadilly and Lollypop Dam. It is also well developed between ¾ mile and 1¼ miles north of Evans Dam (Quilps Holding) and in the headwaters of Tinker Jack Creek, north of Pelican Dam. These beds were described by Wyatt (1963) under the title Hardwick Formation. Similar strata occur in Topsy Creek south of Mount St. Michael, and also extend east of that mount towards Percy Creek. These beds were described by Wyatt (1961, 1963) under the tentative title of Topsy Formation. The two formations are regarded as being equivalent, and, as both occur within the Burdekin Basin, one name - Hardwick - has been applied to both.

The Formation consists, in its lower part, of poorly sorted arkoses or subgreywackes, with interbedded grey shales and siltstones, the finer-grained sediments carrying abundant plant remains in the upper levels. These are followed by a well-bedded unfossiliferous limestone between 2 feet and 4 feet thick. A similar limestone, believed to represent the same horizon, occurs in the Clarke River Formation, the Star Beds and the Game Hill Beds. This limestone is overlain by poorly sorted, feldspathic and limonitic arenites, which are followed by grey-brown fossiliferous marine shales. Within this shale sequence is a 4 to 6 feet bed of fossiliferous limestone, the probable equivalents of which have been observed in the Star Beds (in the headwaters of the North Branch of Little Star River) and in the Game Hill Beds (west of the north branch of Cattle Creek). These shales are followed by interbedded shales and feldspathic sandstones, the arenites being somewhat cleaner than those lower in the sequence, and the shales more brown and unfossiliferous. The sequence, as developed at the head of Pintpot Creek, measures about 2700 feet.

In Topsy Creek the lowest beds exposed that can be correlated with the type section are shales, siltstones, and mudstones often with innumerable small fragments of comminuted plant tissue. These are followed by medium to coarse feldspathic sandstones and subgreywackes, usually containing well-rounded, small to large quartz phenoclasts of pebble size. A gap of no outcrop equivalent to about 110 feet of strata is followed by a thin bed of highly silicified conglomerate. This conglomerate carries rare impressions of lepidodendroid plant stems. Shales overlying the conglomerates also show evidence of plant remains. Next follows a sequence of interbedded porrly sorted feldspathic sandstones and shales, the shales becoming darker up the section, and showing increased evidence of lepidodendroid plant remains. These are overlain by poorly sorted limonitic feldspathic sandstones and pebbly sandstones. Lack of outcrop obscures most of the remaining strata except for the topmost beds visible in this section, which consist of cleaner feldspathic sandstones that are conglomeratic in places.

Comparison of this section with that of Pintpot Creek suggests that the Topsy Creek section may lack some of the basal beds, and may not contain the topmost beds, although the highest beds that are exposed cannot be far below the top of the Formation. The basal beds have been lost by faulting and the topmost beds by erosion.

No definite marine horizons have been recognized in the Topsy Creek section. That marine conditions did exist outside the type area is evidenced by the occurrence of a marine sequence somewhat similar to that of the type area on the southern slopes of Mount St. Michael about $1\frac{1}{4}$ miles north of Topsy Creek. This sequence has been traced along strike for about 8 miles east of Mount St. Michael. It is most probable that this sequence occurs in the Topsy Creek area but has not been recognized, the area generally being one of poor exposure. It is possible that the marine shales seen elsewhere occupy the area of low relief and no outcrop mentioned above as occurring directly below the topmost beds exposed.

In the Topsy Creek area there are numerous faults and dykes which make calculation of thickness on present field evidence unreliable. Preliminary estimates suggest that some 1000-1200 feet of strata occur, although it is not known how much of the section may be missing. Estimates in the Mount St. Michael area give 1000 feet, but the top of the section is not exposed.

The upper part of the Hardwick Formation is Tournaisian. The evidence for this determination is based on a rich fossil assemblage in the upper third of the sequence. Whether the lower levels of the Formation extend down into the Famennian is unknown, as the meagre fossil evidence from the lower levels is not diagnostic.

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 elegante Maxwell, Athyris cf. randsi Etheridge fil. Aviculopecten sp., Straparollus sp., ?Spinulicosta sp. Palaeoneilo sp., Porcellia cf. pearsi Etheridge fil., Edmondia sp., Mucrospirifer kennedyensis Maxwell, and Leptophloeum australe McCoy (McKellar, 1962f).

The Hardwick Formation is conformably overlain by the Piccadilly Formation north of the Piccadilly Mine. It has been intruded by the Kitty O'Shea dyke swarm and by the Pall Mall Adamellite.

Star Beds (D-Cs)

Typically developed in the area of Horse Creek, south-east of Star Homestead, and also in the area of Hellhole Creek and Corner Creek, north-west of the homestead, is a sequence of strata which Jack (1879a) named the Star Beds. In 1892 Jack and Etheridge described the strata under the heading Star Formation. Dunstan(1913), Whitehouse (1930), Bryan and Jones (1946), David (1950), and Maxwell (1951) all used the term Star Series. Parts of the present Dotswood Formation were included. The Geological Map of Queensland (1953) shows also the area from Fanning River Homestead to Burdekin Downs Homestead as Star Group, thus including the present Dotswood

Formation and Fanning River Group, neither of which are present in the Star type area.

It therefore appears advisable that the term "Star" be restricted to strata of Jack's type areas; extension of the term to other areas should be dependent on future detailed stratigraphic and palaeontological studies. Much confusion in Queensland late Palaeozoic stratigraphy has resulted from too free a use of the term "Star" together with too little and in many cases no field work to support correlations.

Using the term Star Beds in the restricted sense, then, strata assigned to this formation extend from north to Dinner Creek, 4 miles south-east of Star Homestead, north to the Little Star River, and west to the Star River and Hellhole Creek. From here they extend north-eastwards to the east branch of the Star River and the lower reaches of Blue Gum Creek. Faulted parts of the formation also occur along the valleys of the western tributaries of the north branch of the Little Star River.

The strata comprise a basal sequence of quartz grit and conglomerate, commonly interbedded with minor red shale and siltstone at the base. These red beds were possibly derived from red soils which probably formed from the continental red beds deposited farther south in Frasnian times. The basal conglomerates when traced to the north-west become thicker, increasing from about 200 feet on a prominent hill south of Horse Creek to some 3000 feet about 2 miles north-north-west of Star Homestead. Accompanying this increase is a corresponding increase in the proportion of lithic fragments, and a decrease in sorting, as evidenced by the deposition of subgreywacke arenite and conglomerate.

The basal sandstone and conglomerate are followed by a marine sequence of olive to khaki shales which are richly fossiliferous and characterized by septarian nodules, particularly in their lower levels. Thin beds of limestone and calcareous sandstone occur throughout, and gradually become more abundant up the section until, between 900-1100 feet above the base, calcareous sandstone and shale attain about equal proportions. The shale in this section is still richly fossiliferous. Overlying this sandstone-shale section are more shales with mudstone in which marine fossils are not so abundant. Up section these strata gradually become darker, and are characterized by abundant plant remains, in particular Lepidodendron australe, which cover the entire bedding surface in places.

In Horse Creek, these shales are followed by a few feet of calcareous sandstone and shale and about 12 feet of well-bedded, fine, dark blue-grey limestone or calcilutite. This limestone has so far proved to be unfossiliferous. It is widespread over the whole district, having been observed at Corner Creek and north-west of Ponto Yards. Similar limestone has also been recognized in the Game Hill

Beds and in the Hardwick Formation, and is possibly present in the Clarke River Formation. This limestone represents the highest part of the Star Beds exposed in the Horse Creek section which measures about 1300 feet.

At Corner Creek the limestone is followed by shale and siltstone, calcareous sandstone, coarse feldspathic sandstone, quartz grit, and conglomerate, which are succeeded by more mudstone with limestone beds, calcareous sandstone, chert, sandstone, and olive green shale and siltstone. The whole of this section possibly measures a further 1000-1400 feet. The uppermost shales carry 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 strata of the Clarke River Formation at Francis Creek and the fossiliferous shales of the Hardwick Formation.

These fossiliferous shales are the highest beds exposed at Corner Creek. Stratigraphically higher beds may be represented by chert, shale, and limestone in the area west of Dinner Creek, but extensive Quaternary cover conceals their relationships with the Corner Creek or Horse Creek sections, so that their stratigraphic position is not certain. On their regional attitude they appear to overlie the Corner Creek Beds. Fossils contained in these beds still indicate a Tournaisian age.

The age of the Star Beds ranges from Famennian to Tournaisian. The lower part of the Horse Creek section (say the lowest 900 feet) is characterized by Spinulicosta, Sentosia, Yunnanella, and Cyrtospirifer, and the upper part is characterized by Brachythyris, Prospira, and Rhytiophora. Genera and species so far determined in collections from Horse Creek include:- Prospira cf. striatoconvoluta Benson and Dun, Schuchertella sp., Rhipidomella sp., Tenticospirifer sp. Rhytiophora 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 McCoy, and Lepidodendron aff. veltheimianum Sternberg, as well as indeterminate solitary rugose corals and a fenestellid (McKellar, 1962d).

At Corner Creek the fossil assemblage indicates a Middle Tournaisian age. Fossils include :- Avonia kennedyensis Maxwell, Crurithyris sp., Retzia cf. radialis Phillips, Schizophoria sp., Chonetes cf. kennedyensis Maxwell, Athyris sp. Prospira typa Maxwell, Brachythyris sp., Camarotoechia sp., Schizophoria cf. resupinata Martin, Gurichella 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).

In the northern outcrop areas, e.g., north-west of Ponto Yards and north and south of Basin Yards, the Beds are very much faulted, and extensively intruded by granite and porphyry, and the stratigraphic sequence is disrupted and discontinuous. However, lithologies are similar to those in the Horse Creek and Star River areas, and the fossil assemblages again indicate a Tournaisian age.

The age range of Famennian to Tournaisian for the Star Beds indicates that they are equivalent, in part, at least, to the Myrtlevale Formation, Lollypop Formation, Hardwick Formation, and Clarke River Formation. The Star Beds are overlain by the Tareela Volcanics, probably disconformably. The Beds are intruded by the Oweenee Granite and by numerous porphyry dykes and possible sills apparently genetically related to the Oweenee Granite.

Game Hill Beds (D-Cg)

Typically developed in the area north-east and east of Game Hill in the Argentine Mineral Field is a sequence of sediments very similar to the Star Beds. In fact Jack (1886b) who first recorded these strata, equated them with his Star Beds. However, there are lithological differences which warrant the separation of these Beds until such time as more detailed work on them is undertaken. Further, in the light of fossil evidence from the Upper Devonian and/or Lower Carboniferous sequences which shows that marine conditions began earlier in the southern areas about Dotswood than in the northern areas about Blue Range, it is possible that deposition of the Game Hill Beds began earlier than that of the Star Beds.

The lowest beds are pebbly, coarse, feldspathic arenites, and quartz pebble and cobble conglomerates which unconformably overlie gneissic granite, possibly part of the Ravenswood Granodiorite, or schists of the Argentine Metamorphics. These basal beds are coarser near their base, and become less conglomeratic in their upper levels where red micaceous shales are interbedded. Overlying these feldspathic arenites are quartz sandstone, grey cherty mudstone, and thin-bedded khaki shale and siltstone with marine fossils (mainly brachiopods) and a few plant remains. These are followed by brown calcareous sandstone and shale with occasional cherty beds, all more or less fossiliferous. Next follow thin conglomerate beds, up to 18 inches thick, composed of well-rounded quartz and porphyry pebbles in a calcareous, arkosic matrix. These are overlain by fine sandstones with Leptophloeum australe and numerous marine fossils.

Above these sandstones is a coarser feldspathic subgreywacke followed by a well-bedded, grey limestone. The limestone is fossiliferous but fossil distribution is erratic. This same limestone occurs in Cattle Creek a few hundred yards upstream from its junction with Keelbottom Creek. The limestone probably equates with a similar limestone in the Hardwick Formation in the region of Mount St. Michael, near Dotswood.

The limestone is overlain by tough, greenish-brown, fine to coarse quartz sandstone which passes upwards into siliceous mudstones with plant debris, amongst which Lepidodendron sp. is recognizable. Following these mudstones are rhythmically bedded quartz pebble conglomerate passing up into pebbly sandstone and impure quartz sandstone. Higher in the section the sandstones become quite lithic, grading to subgreywacke and greywacke with graded bedding and poor sorting.

These greywackes are overlain by a felsite breccia (which may be an intrusion breccia) followed by andesites of the St. James Volcanics. The whole sequence, to the base of the breccia, dips eastward at an average of about 40°, and measures about 2500 feet.

The Game Hill Beds are folded into a number of basin and dome structures which extend north from Cattle Creek to Melon Creek. Each of these structures is separated from the others by faults, and all are downfaulted against Precambrian metamorphics to the west. Elsewhere the Beds are intruded by granite or overlain by the Tareela Volcanics. At the head of Bog Hole Creek, the Insolvency Gully Formation may overlie the Beds, but neither the stratigraphy nor the structure is well known in this area, and the relationship remains in doubt. The largest domal structure is centred on the Argentine - an old silver mining centre. The dome is about 8 miles in diameter, but has been extensively faulted by east-west and north-south faults, and the central part of the dome has been eroded away exposing the core of underlying metamorphics.

The age of the Game Hill Beds ranges from Famennian to Tournaisian. Fossils so far recorded include Chonetes sp., Camarotoechia sp., Cyrtospirifer sp., Cyrtospirifer sinensis var. australis Maxwell, Athyris sp., Gurichella cf. kennedyensis Maxwell, Schizophoria cf. resupinata Martin, Prospira prima Maxwell, Brachythyris sp., Cleiothyridina sp., Retzia cf. radialis Phillips, ?Avonia sp., Leptagonia cf. analoga Phillips, Waagenella sp., Euphemites sp., cf. Phillipsia sp., Orthonychia sp., Naticopsis sp., Straparollus sp., Baylea sp., Stigmaria ficoides Brong., and Leptophloeum australe McCoy (Dear, 1962).

The form of Cyrtospirifer sp. suggests an age older than Cyrtospirifer sinensis var. australis, so that the Game Hill Beds may range from Lower or Middle Famennian to Middle or Upper Tournaisian.

Undifferentiated Sediments (D-C)

On the map accompanying this report are six areas of sediments which are regarded as Devonian-Lower Carboniferous, but which can not be assigned to any named rock unit.

The southernmost of these areas, between Keelbottom Creek and the Burdekin River, south-west of Quilps Homestead, is one of poor outcrop owing mainly to a thick cover of sand, soil, and pebbles derived from the erosion of (?)Tertiary laterite mesas which also cover the area. The main rock type observed below this cover is red sandstone similar to that of the Dotswood Formation. It is probable that most of the area is occupied by a continuation of the Dotswood Formation seen to the north-east about Quilps Homestead and Hardwick tank, or south-east about Mount Keelbottom.

North-east of Valpré Homestead is a second area of undifferentiated Devono-Carboniferous rocks. This area is bounded on its southern and eastern margins by faults which separate it from Devono-Carboniferous rocks whose succession is fairly well established. Although the rocks of this area are undoubtedly a continuation of the Devono-Carboniferous sequence to the north, east, and south the problem in delineating the constituent formations is again due to cover rocks consisting of laterite, basalt, and billy as well as sand and alluvium. Variation in the direction of trend lines seen on air photos of this area suggests that the area may be extensively faulted, but owing to the cover rocks no faults were observed in the field.

South of Laroona Homestead is a small area of sedimentary rocks which are folded into an anticline plunging east-north-east. These rocks include fossiliferous limestone and sandstone which can be correlated with the Fanning River Group, both on lithological and palaeontological evidence. They also include fossiliferous marine sandstones and shales of Tournaisian age. These fossiliferous strata occur quite close to one another, but their relationship has not been established, owing mainly to soil and rubble cover not shown on the map. None of the characteristic red rocks of the Dotswood Formation have been observed. As a large thickness of this Formation exists only three miles to the south-east, it is unlikely that it has thinned out in this area. It therefore appears most likely that much of the upper Devonian sequence has been faulted out, probably by faults related to the Sybil Graben.

Three miles north-east of Lassie's Creek Homestead is a sequence of feldspathic sandstone, slate, and conglomerate. Most of these rocks are much weathered, and are overlain by a thin lateritic profile. Remains of very much decorticated, and now indeterminate, lepidodendroid plant tissue have been observed in these sediments. They are overlain by tuff, tuffaceous sediment, and rhyolite of the Carboniferous Hell's Gate Rhyolite.

Nine miles west-south-west of Lassie's Creek Homestead is a narrow belt of sediments which extends south from the Rio Tinto mine to Stockyard Creek. They do not crop out well, but sandstone and conglomerate have been observed. The conglomerate contains quartz and schist pebbles, and is very similar to a conglomerate observed in the Star Beds, a few miles south-east of Basin Yards.

These sediments appear to unconformably overlie (?)Precambrian amphibolite west of the Rio Tinto Mine. Faulting and late Palaeozoic rhyolite dykes make interpretation of the structure of the area quite difficult.

Seven miles north-west of Allensleigh Homestead is a small area of feldspathic sediments which are a continuation of the Clarke River Formation shown on the Clarke River 1:250,000 Sheet. They were mapped by photo-interpretation from areas studied farther west in the Clarke River 1:250,000 Sheet area in 1958. Here the sediments are not identical with those of the normal Clarke River Formation, and it is possible that they do not belong wholly to that Formation. For this reason they have been designated undifferentiated Devonian-Carboniferous on the map.

LOWER CARBONIFEROUS

Sedimentation was continuous from the Devonian through to the late Tournaisian. Strata laid down in this 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 the Star Beds. During the Visean stage these strata, together with the underlying Devonian sequence, were uplifted and probably intruded by the Oweenee Granite, so that continental conditions appear to have obtained during the remainder of the Carboniferous.

Piccadilly Formation (Ca)

Typically developed at the headwaters of Piccadilly Creek and Pintpot Creek is a sequence of medium to coarse arkoses, feldspathic sandstones, and conglomerates. The Formation was described by Wyatt (1963); previously it was placed in the Star Group on the Geological Map of Queensland (1953).

The conglomerates become more prominent up the section, and give rise to well developed strike ridges. These conglomerates are composed almost entirely of quartz or quartzite pebbles which are typically well-rounded and of moderate sphericity. The matrix, like the interbedded arenites, is feldspathic sandstone.

Bedding is fairly well developed throughout the Formation, and current bedding was noted in places, especially in the pebbly arenites and finer conglomerates.

In the type area north of the Piccadilly Mine, the Formation measures at least 1200 feet, and its probable maximum thickness is about 1700 feet at the head of Piccadilly Creek. The top of the sequence is not known in this area as the Formation has been faulted against older granite and sediments to the south.

The Piccadilly Formation is lithologically similar to the conglomerates of the Clarke River Formation as developed at Blue Range, although it does lack the prominent jasper pebbles of that area. However, its stratigraphic position above the Tournaisian Hardwick Formation, which is equivalent to the marine horizons of Francis Creek and Blue Range, places beyond doubt its equivalence with the upper part of the Clarke River Formation as developed in the Blue Range. The Piccadilly Formation can probably be correlated with conglomerates of the Star Beds which are unconformably overlain by the Tareela Volcanics.

Clarke River Formation (Cc)

This formation has been defined by White (1959b), and described by Wyatt and White (1960, p.178). The only part of this Formation developed in the Townsville 1:250,000 Sheet area occurs in the Blue Range as an outlier of the main outcrop area on the Clarke River 1:250,000 Sheet area. Here a basal sequence of sandstone, shale, and limestone unconformably overlies the Kangaroo Hills Formation, and is conformably followed by a sequence of quartz grits, sandstones, and conglomerates often with prominent red jasper pebbles.

In the basal sequence, e.g., in Francis Creek, a fossiliferous marine Tournaisian fauna is present. Fossils include *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., as well as indeterminate rugose corals, fenestellids, cephalopods, pelecypods, and brachiopods, including spiriferids and dielasmids (Woods, 1960). These marine fossiliferous beds are therefore probably equivalent to the marine fossiliferous beds of Corner Creek (Star Beds), Cattle Creek (Game Hill Beds), and parts of the Hardwick Formation.

During the excavation, in 1957, of Berts Dam on Mickey Creek, Blue Range holding, on the eastern margin of Clarke River 1:250,000 Sheet area, grey shales carrying abundant *Leptophloeum australe* were exposed. Similar shales were observed by Wyatt in 1961 in the unnamed creek south-east of Expedition Creek. These shales are similar to 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. A further lithological correlation is provided by an unfossiliferous limestone, very much recrystallized and apparently situated on a fault, which also occurs in the unnamed creek mentioned above. This limestone possibly correlates with a well bedded unfossiliferous limestone which overlies the plant beds in the Star Beds and the Hardwick Formation. From these lithological similarities, as well as the Tournaisian faunal assemblage, it is most probable that the basal Clarke River Beds at Blue Range are equivalent to parts of the Star Beds and the Hardwick Formation. The slightly feldspathic quartz grits, sandstones and conglomerates which conformably overlie the basal marine sequence, and which form the high country of Blue Range, can therefore be equated with the Piccadilly Formation. *L. australe* has been observed in these coarse clastics, which were possibly laid down in a continental environment.

The Formation is moderately folded along north-east axes. A strong north-south fault occurs near the western margin of the Formation, the western block being down-faulted relative to the eastern block. Another fault, trending west-north-west, transgresses the Formation near its northern margin where the beds show opposite dips on either side of the fault. It is possible that the limits of the Formation in the Blue Range area are fault-controlled.

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

Following deposition of the Tournaisian sediments the region appears to have suffered epeirogenic movements accompanied by uplift and slight warping. The change from marine to continental conditions in the

Clarke River, Hardwick, and Piccadilly Formations probably is an indication of these epeirogenic movements. It is possible that some granite was intruded during these movements (see Oweenee Granite, below).

Following uplift a short period of erosion ensured, and was followed by an extrusion of Carboniferous volcanics and the deposition of lithogenetically related sediments. As a consequence, the later Carboniferous strata unconformably overlie the Tournaisian strata, although the amount of erosion is so slight in places that the unconformity can be recognized only on a regional scale.

Continental deposits laid down after this 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 of the Fanning River-Hervey Range area.

CARBONIFEROUS GRANITES

In the Townsville 1:250,000 Sheet area are several granites whose relationships with other rocks suggest that they are older than many of the granites normally referred to the end of the Palaeozoic. These relationships are by no means conclusive or, in some instances, fully proven. They do indicate, however, that it is unlikely that all the late Palaeozoic granites and related rocks (adamellite and granodiorite) of the Townsville hinterland are of one age - late or post-Permian. There are indications that some of these granites may have been intruded some time in the Carboniferous after the Tournaisian.

Oweenee Granite (Cgo) and unnamed granite north-west 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) from work in the Clarke River Sheet area. Identical granite extending north-eastward from the Sybil Graben to the valley of Blue Gum Creek, a tributary of the Star River, is also referred to the Oweenee Granite. It thus forms the high country of the Coane Range east of the Burdekin River. The granite country north-west of the Running River Valley and Oakey and Bean Creeks is very similar to the Oweenee Granite. It might be possible to see the relationship of this granite to the Oweenee Granite of the Coane Range in the area north-east of Hidden Valley in the Ingham 1:250,000 Sheet area, but it was not investigated during the present survey. This granite has, therefore, not been included with the Oweenee Granite on the map, but designated Cg, together with some other unnamed granites in the Townsville district.

The Oweenee Granite is normally light-coloured, grading from pink to pinkish grey. The percentage of mafic minerals is low, and their outlines poorly defined, owing to partial or complete chloritization. The granite is normally porphyritic with large feldspar phenocrysts, and in places quartz is also prominent as phenocrysts.

The granite is strongly jointed and fractured in a north-west direction. The fractures become more abundant near the Sybil Graben.

The strata of the Sybil Group which occupy the graben show no sign of metamorphism by the Oweenee Granite. However, as the only contacts known are faulted, it is possible that the contact-zone has been faulted out.

In Tomahawk Creek there is a rhyolite vent which has been a feeder for the Hell's Gate Rhyolite. Granite fragments contained in volcanic breccia associated with this vent are identical with the granite (Cg) forming the watershed between Douglas Creek and Little Oakey Creek, which, as stated above, is similar to the Oweenee Granite.

Both these relationships suggest that the Oweenee Granite and the granite north of Running River are older than the Sybil Group, which is possibly late Middle or Upper Carboniferous. As the Oweenee Granite is known to intrude the Tournaisian Clarke River Formation, it is possible that the Oweenee Granite was intruded during the uplift at the end of the Tournaisian.

Unnamed Granites of the Townsville District (Cg)

The presence of granite phenoclasts in conglomerates of the Permo-Carboniferous sequence (C-Pv) in the Townsville district suggests that either granite or an older conglomerate containing granite pebbles was exposed to erosion at the time the Permo-Carboniferous conglomerate was being deposited. As the granite phenoclasts of such a conglomerate near Stuart are identical with the underlying granite, it is reasonable to assume that the granite gave rise to the phenoclasts in the conglomerate, and therefore that the granite is older than the conglomerate. As the granite does not resemble any of the known early Palaeozoic or Precambrian(?) granites, it is presumed that the granite is Carboniferous. On lithological grounds only, some other granites in the Townsville district are regarded as equivalent to the granite at Stuart.

The granite at Stuart and the overlying conglomerate were first described by Maitland (1892). He suggested a metamorphic origin for the granite owing to its seemingly gradational contacts with the conglomerate.

What was probably the same outcrop was investigated during the present survey at a locality about ½ mile south of Stuart. Here coarse, pink, leucocrate granite is overlain by a coarse conglomerate containing phenoclasts of a similar granite. The conglomerate is intruded by felsite dykes similar to those occurring elsewhere in the Townsville area. A similar conglomerate has been observed in the Ross River south-west of Mount Stuart where it is apparently part of the local volcanic/sedimentary sequence regarded as Permo-Carboniferous. Ferguson (1948) recorded conglomerate at the head of Dick Creek containing granite phenoclasts similar to the underlying granite.

The unconformable relationship of the conglomerate to the granite near Stuart is not everywhere convincing. For example, in places, massive granite passes up through brecciated granite and angular conglomerate to a conglomerate with well-rounded phenoclasts. This "transition" apparently led Maitland to suggest the possibility that the granite was metamorphic in origin. However, although the "transition" might possibly be explained by brecciation of the contact-zone during intrusion, the concept of origin by granitization is out of place in this presumed epizonal environment. Furthermore, no evidence of contact metamorphism of the conglomerate could be found. The relation seems best interpreted as an unconformity; the basal breccia could then be considered as a regolith derived in situ from the granite and overlain by similar but transported material.

Because of their lithological similarity with the granite at Stuart, four other granite areas are mapped at present as Carboniferous.

Muntalunga Range

In this Range there are several types of granite, some of which are petrographically similar to that at Stuart. Whether the different types are part of the same mass could not be determined in the field. Volcanic rocks also occur in the Range, but their relationship to the granite was not established. A north-east trending brecciated contact between granite and rhyolite in the centre of the Range is probably a fault-zone. The different types of granite observed comprise:

1. Massive, coarsely porphyritic microgranite with phenocrysts of albite, quartz, and chloritized biotite (3-4 percent), in a groundmass of quartz and potash feldspar. The plagioclase is locally epidotised. This rock forms part of the northern spur of the Range.

2. Massive, coarse, extensively sheared pink leucogranite with milky quartz and a little altered biotite occurs in the eastern part of the Range.

3. Massive, medium to coarse, sheared, white to pink adamellite with muscovite and biotite forms the eastern extremity of the Range.

4. Coarse, red, leucocratic granite occurs in the low hills east of the range.

5. Coarse, white adamellite with prominent phenocrysts of quartz occupies the centre of the Range. The rock is extensively sheared and locally weakly foliated.

Alligator Creek

About 1/3rd mile north-north-west of Alligator Creek Siding is a low rise composed of coarse, pink leucocratic granite. It has been slightly sheared. Outcrops of andesite and dolerite were found nearby, but no relationships were seen.

Mount Low

Mount Low, a north-west trending ridge near the mouth of the Black River, consists of granite and volcanics. At the western end, coarse red alaskite, containing a little altered biotite, is probably faulted against volcanics. Although the granite appears to truncate flow-banding in the volcanics, it shows no evidence of chilling, nor do the volcanics appear to be recrystallized.

Ranges South-east of Stuart Gaol

The north-eastern shoulder of the low range south-east of the gaol at Stuart consists of coarse, pink, leucocratic granite with milky quartz phenocrysts. Fine leucocratic granophyre also occurs there, but its relationship with the granite is not known.

LATE MIDDLE TO UPPER CARBONIFEROUS

The following continental sediments and volcanics were deposited and extruded after the Devonian-Lower Carboniferous succession had been uplifted and warped; Percy Creek Volcanics, St. James Volcanics, Insolvency Gully Formation, Tareela Volcanics, Ellenvale Beds, and the Sybil Group, as well as numerous occurrences of indifferentiated volcanics and sediments (C).

Percy Creek Volcanics (Cp)

North of Fanning River Homestead, in the region of Percy Creek, is a sequence of andesitic lavas that have been designated the Percy Creek Volcanics (Wyatt, 1961). They extend north-west from Plumtree Yards on the west branch of the Fanning River, along the valley of Percy Creek towards Gap Creek, and then trend east-north-east towards the headwaters of Grasshopper

Creek and the middle reaches of the west branch of the Fanning. Further developments occur in the Hervey Range but extensive faulting and granite intrusion in this area, as well as the ruggedness and inaccessibility of the range country, render accurate mapping and interpretation of the structure very difficult. However, in the Percy Creek-Grasshopper Creek area the Volcanics are well exposed in a synclinal structure which plunges to the east-south-east.

The Percy Creek Volcanics consist of porphyritic andesite flows and minor agglomerates. Many of the lower flows are vesicular, but the upper flows are more dense and homogeneous. The vesicles are normally filled with zeolites, calcite, or quartzo-feldspathic material. In the neighbourhood of Percy Creek bore, the Volcanics are some 600 feet thick.

The Percy Creek Volcanics unconformably overlie the Hardwick Formation east of Mount St. Michael. In other areas, e.g., south-east of Percy Creek Bore, major faults separate the Percy Creek Volcanics from the Devonian-Lower Carboniferous sequence, and the unconformity is not seen. Regionally, however, it is obvious that the Percy Creek Volcanics were deposited on the Devono-Carboniferous sequence following a period of erosion.

The Percy Creek Volcanics are lithologically similar to andesites of the Tareela Volcanics and the St. James Volcanics.

Unnamed Sediments and Volcanics (C)

In the Percy Creek-Grasshopper Creek area a sequence of sediments conformably overlies the Percy Creek Volcanics. These sediments were described and tentatively called the "Plumtree Formation" by Wyatt (1961). They are in turn overlain by volcanics tentatively designated the "Mount Douglas Rhyolite" and the "Wild Horse Formation" by Wyatt (1961). Representatives of these formations occur in the Hervey Range, but because of the structural complexity of that area it was not possible to differentiate these formations in the time available. Consequently all strata above the Percy Creek Volcanics and below the Ellenvale Beds have been mapped as undifferentiated Carboniferous sediments and volcanics.

The sediments are best developed in a triangular area between Plumtree Yards (Fanning River Holding), Percy Creek Bore, and Mount Douglas. The sequence here consists of shales, cherts, limestone, arenites, and conglomerates with a total thickness of some 3300 feet. It conformably overlies the Percy Creek Volcanics, and, like them, is folded synclinally, the syncline plunging to the east-south-east at 10° to 20°. No one section exhibits all the characteristics of the sequence. The gullies on Mount

Douglas, north of Percy Creek Bore, give the best general sections, but the fossiliferous black shales and impure limestones are best developed near Plumtree Yards, and some of the thin-bedded cherts are best developed on the east branch of the Fanning River.

North of Percy Creek Bore the sediments consist of an essentially feldspathic sequence of arkoses, siltstones, conglomerates, and shales. Bedding is fairly well developed, and current-bedding is sporadically developed in the coarser-grained pebbly arenites.

The arkoses are confined to the lower parts of the section, but the arenites of the upper parts are mainly feldspathic sandstones. Grainsize in all these arenites ranges from fine to medium.

The siltstones and shales are developed mainly in the lower parts. They are brown or grey-brown, and poorly laminated. Possible Stigmaria species occur in the brown shales. Associated with these lower beds are black cherts and a few black mudstones.

The conglomerates occur mainly in the middle of the section. They consist of rounded or sub-angular pebbles or small cobbles of quartz, rhyolite, and acid porphyry in a labile, feldspathic and lithic arenitic matrix. Their texture and composition suggest that they were formed from the poorly sorted, rapidly deposited debris of acid volcanic rocks.

In the upper part of the section, mainly above the conglomerates, black shales are interbedded with feldspathic sandstones and sub-greywackes. The shales are well bedded, thinly laminated, and readily fissile. Near Plumtree Yards the shales are associated with beds of impure limestone and calcareous sub-greywacke. The shales are fossiliferous, carrying the decorticated stems of large Lepidodendron veltheimianum and Ulodendron sp. (de Jersey, 1958). On this evidence these beds have been assigned to the Carboniferous.

Above the shales at Plumtree Yards, and also farther eastward along the Fanning River, intermediate flows, seldom more than two feet thick, are interbedded with the sediments. At Plumtree they are restricted to the top 50 feet of the sedimentary section, but in the east Fanning area they are more numerous, and first appear lower in the section.

This phase of renewed vulcanicity is followed by minor rhyolitic outpourings as evidenced by the fragmental rhyolite forming Mount Douglas. This rhyolite is conformable with the underlying strata, and seldom exceeds

50 feet in thickness. It is conformably overlain by 100 feet of sediments and minor volcanics. The sediments comprise shales with indeterminate plant fragments, fine to coarse micaceous and feldspathic sandstones, fine mudstones, commonly with small-scale contemporaneous slump and fault structures, and micaceous siltstones. These are followed by fluidal and fragmental volcanics, ranging from rhyolites to porphyrites, which are followed by coarse, slightly feldspathic sandstones and quartz pebble conglomerates.

These strata are succeeded by the next major development of intermediate volcanics which were informally designated by Wyatt (1961) as "Wild Horse Formation", and consist of andesitic (and possibly basaltic) flows and pyroclastics at least 800 feet thick. They have poor to moderate outcrop, and, in the main, give rise to gently undulating country with a red-brown or dark-grey soil cover.

North of Plumtree Yards these volcanics are the highest beds exposed in the synclinal structure occupied by the Percy Creek Volcanics and the overlying sediments. East of Plumtree Yards, at the head of Hellhole Gorge (a tributary of Reid River), possible equivalents of this volcanic sequence, represented by reworked agglomeratic material, are followed by rhyolites representing the base of the Ellenvale Beds. Faulting, however, makes interpretation of the structure uncertain, and the relationship of the Ellenvale Beds to these unnamed Carboniferous volcanics must remain in some doubt until more detailed mapping is done.

This unnamed Carboniferous sedimentary/volcanic sequence has been intruded by late Palaeozoic (?)microdiorite (Pzi) at The Brothers, and granite between the east and west branches of the Fanning River.

Ellenvale Beds (Ce)

Typically developed in the valley of the Reid River and its tributaries, upstream from Ellenvale Homestead as far as the Reid Gorge, is a sequence of volcanics and lithogenetically related sediments which are here designated the Ellenvale Beds. They were described by Wyatt (1963) under the title "Reid River Beds".

The Beds occur between the head of Hellhole Gorge and Reid Gorge in the north-west, and Piccaninny Mountain and Horse Camp Hill in the south-east; Ellenvale Homestead is situated near the centre of this area.

In the Reid River type-section the lowest beds consist of fragmental rhyolitic flows, tuffs, and agglomerates, overlain by water-worn and sorted agglomeratic material forming conglomerates and tuffaceous arenites. These are followed by interbedded spherulitic and flow-banded rhyolite and rhyolitic agglomerate.

Following this essentially volcanic sequence the lithology changed rather suddently with the deposition of a thick sequence of poorly sorted greywacke and sub-greywacke arenites and conglomerates, khaki to grey shales, and cherty mudstones. Towards the top of this sequence the arenites became somewhat better sorted, and lithic arkose was deposited. A thick conglomerate lens occurs in the middle of this section; it extends eastward from the mouth of Humpybong Creek for some 3½ miles, and attains a maximum thickness of about 200 feet.

Overlying this sedimentary section is a sequence of agglomerates, conglomerates, and lithic arkoses, which forms the prominent hog-back south of the Reid River, upstream from Ellenvale Homestead. The conglomerates are confined to two thick bands - the lower 80 feet and the upper 50 feet - interbedded in the agglomerates, and are well displayed in the northern face of the hog-back. Unless the sequence has been repeated by faulting there was a return to volcanic conditions during deposition of the upper part of the Ellenvale Beds. Neither of the comparable sequences, the Marsh's Creek Beds and Insolvency Gully Formation, show any such return to volcanic conditions. If it is assumed that there is no repetition by faulting the sequence near the Reid River measures about 10,000 feet.

Many of the finer-grained sediments contain plant remains, usually very much broken and poorly preserved. A Carboniferous age has been assigned to these Beds on the evidence of (1) fragments of cf. <u>Rhacopteris</u> sp. and indeterminate equisetalean stems (McKellar, 1963b), (2) the position of the Beds in the stratigraphic column higher than (a) known Tournaisian strata and (b) supposedly Carboniferous sediments with <u>Lepidodendron</u> <u>veltheimianum</u>, <u>Ulodendron</u> sp., and <u>Stigmaria</u>, (3) lithological similarity with the Sybil Group which is believed to be Carboniferous, and (4) the absence of any elements of a <u>Glossopteris</u> flora which would indicate a position higher in the succession than Carboniferous.

South from Reid Gorge the Beds have a general east-west trend and a uniform southerly dip averaging 35° to 40°. North-north-east of the gorge the dip apparently flattens quite suddenly to horizontal. Farther east the Beds are faulted against Devonian strata. South of the Reid River they are faulted against the Ravenswood Granodiorite and the Fanning River Group.

East of Ellenvale Homestead the Beds are covered by alluvia, and the structural relationship of the area east of the Great Northern Railway to the type area is unknown. The most notable feature is an apparently uniform northerly dip. The Beds are faulted against the Devonian north of Plant Hill, and presumably faulted against the Ravenswood Granodiorite south of Horse Camp Hill.

The most easterly development, at Horse Camp Hill, comprises acid volcanics consisting of grey, flow-banded rhyolite, rhyolitic breccia, and porphyritic rhyolites with either feldspar or abundant rounded quartz phenocrysts.

Farther north, about 2 miles east-south-east of Reid River Railway station, is a low hill composed of green and reddish brown tuff and agglomerate dipping 65° northwards. Farther north again in the bed of the Reid River are fragmental volcanic rocks, mainly agglomerates, which tend to weather readily. The typical rock is purplish brown, and contains sub-angular to well-rounded andesitic and rhyolitic phenoclasts. Some degree of water sorting and rounding is evident in these agglomerates.

Plant Hill, 1 mile north-east of Reid River road bridge, is composed of volcanics belonging to this sequence. The lowest beds are fine-grained andesites with pinkish white plagioclase phenocrysts, and acid and intermediate fragmental rocks. These are overlain by flow-banded rhyolites.

The highest beds observed east of the railway line occur just north of Plant Hill, and micaceous siltstones and shales, probably with a high proportion of fine-grained volcanic material in them. These sediments are highly fractured, probably owing to the nearby faults which separate this sequence from the Devonian strata to the north.

The Ellenvale Beds have been intruded by late Palaeozoic micro-granite (Pzug), e.g., the Mount Ellenvale-Brown Mountain mass, and by a basalt sill near the southern end of the Reid Gorge. The basalt is petrographically identical with Tertiary olivine basalt plugs occurring to the west near Fanning River, and to the south near Mingela.

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

Sybil Group (Hell's Gate Rhyolite and Marsh's Creek Beds)

Typically developed over much of the parish of Sybil, County of O'Connell, is a sequence of lithogenetically related volcanics and sediments which have been designated the Sybil Group (Wyatt, 1963).

They crop out over an area of about 170 square miles in the catchment of Marsh's Creek, and extend north of the Burdekin River to the lower reaches of Tomahawk Creek and east of the Burdekin about the lower reaches of Dingo Creek and Granite (or Lassie) Creek.

Wyatt (1963) subdivided the Group into three formations, but this subdivision was made as the result of relatively detailed mapping in a small area. During the present survey it was not possible to map in the same detail in the adjoining areas, so that, for the purposes of this report, the Group is divided into a volcanic sequence and a sedimentary sequence which can be readily mapped in the field and photo-interpreted.

Wyatt 1963	Present Nomenclature
Long Gully Formation Marsh's Creek Formation	Marsh's Creek Beds
Hell's Gate Rhyolite	Hell's Gate Rhyolite

Hell's Gate Rhyolite (Ch)

The Hell's Gate Rhyolite was first recorded by Saint-Smith (1922) who appears to have regarded it have regarded it as part of his "upper Devonian (now Siluro-Devonian) Kangaroo Hills series". Bush (1959) described the rhyolite at Hell's Gate, and the Geological Map of Kangaroo Hills Area (Bush and Tweedale, 1959) shows some of its distribution. Wyatt (1959) described and correlated rhyolite at the head of Marble Creek (a tributary of Marsh's Creek) with that at Hell's Gate, and suggested that they conformably overlie the Clarke River Formation. Wyatt (1963) later revised this opinion, having concluded that the Hell's Gate rhyolite unconformably overlies the Clarke River Formation.

The Hell's Gate Rhyolite is typically developed at Hell's Gate - a narrows on the Burdekin River 18 miles downstream from Blue Range Homestead. The formation extends in an arcuate belt some one to four miles wide from Dingo Creek (Lassie Creek Holding) to the head of Marsh's Creek and the lower reaches of Tomahawk Creek. It forms the high country at the western end of the Mount Fullstop Range and the eastern limits of the Perry Range.

The sequence consists of fluidal and spherulitic rhyolite with minor rhyolitic agglomerate, tuffaceous agglomerate, and tuffaceous sandstone. The thickness of this sequence is difficult to measure because of the development of numerous local piles of lava. Preliminary estimates suggest that the rhyolite may be up to 3000 feet thick in places.

The rhyolites which constitute the dominant rock type in the sequence are normally light coloured (cream to green) and usually show excellent flow structure. Spherulites are frequently developed, and generally range from microscopic size to about 20mm. diameter, but some larger ones have been observed. These rhyolites are lithologically similar to those of the Tareela Volcanics and the rhyolites at the base of the Ellenvale Beds.

The Hell's Gate Rhyolite overlies the Kangaroo Hills, Tribute Hills, and (?)Greenvale Formations with a marked angular unconformity. It overlies the Clarke River Formation with a slight unconformity. It is overlain conformably by the Marsh's Creek Beds, and unconformably by lateritized Tertiary sediments. The Rhyolite is down-faulted against the Oweenee Granite south-west of Marsh's Creek. Vent material in the Tomahawk Creek area contains granite fragments very similar to the leucocratic granite east of Douglas Creek, against which parts of the Sybil Group are also faulted.

The Hell's Gate Rhyolite is Carboniferous, lying as it does above the Tournaisian Clarke River Formation, and below the Carboniferous Marsh's Creek Beds.

Marsh's Creek Beds (Cm)

Developed over much of the catchment of Marsh's Creek is a sequence of sediments which is here named the Marsh's Creek Beds. More detailed work will probably allow these beds to be further subdivided.

The Beds consist of a lower section of conglomerates, subgreywackes, red siltstones and sandy limestones, feldspathic sandstones, and cherty tuffaceous mudstones, all typically developed in Marsh's Creek. The upper section consists of subgreywacke arenites and pebble to cobble conglomerates interbedded with dark grey to black, frequently carbonaceous, shales, siliceous mudstones, and siltstones together with minor arkoses and quartz grits. These strata are typically developed in Long Gully, a tributary of Marsh's Creek. The whole sequence is at least 4000 feet thick.

Bedding is well developed throughout. It is usually thin in the lower beds, but in the upper beds, particularly the coarser clastics, individual strata may be several feet thick. These upper beds also show a marked cyclic sedimentation; each cycle begins with conglomerate, which is followed by pebbly subgreywacke arenites, and concludes with dark shales. Large-scale current bedding is also evident in the coarser clastics.

The Beds are considered to be Carboniferous, possibly late Middle or Upper Carboniferous. The evidence for this age is based on palaeoniscid fish remains which have been referred to cf. Cryphiolepis sp. and cf. Elonichthys sp. by Woods (1963), and on plant remains referred to cf. Rhacopteris sp. by McKellar (1963), as well as on indeterminate equisetalean stems. There is no trace of the Lepidodendron veltheimianum flora seen in the Clarke River Formation, nor is there any evidence of a Glossopteris flora.

The occurrence of fish and plant remains suggests a fresh water environment or possibly an estuarine one. The occurrence of carbonaceous shales and coaly plant remains also indicates fresh water conditions of deposition.

The Marsh's Creek Beds follow conformably on the Hell's Gate Rhyolite, the lower part of the Beds comprising material derived directly from the volcanic terrain formed by the Rhyolite. The arenites of the upper part show a greater proportion of material derived from other rock types, in particular granite.

East of the Burdekin River the Marsh's Creek Beds are faulted against the Oweenee Granite, which here forms the Coane Range. The Beds are steeply inclined adjacent to the fault and no evidence of metamorphism by the granite has been observed.

The Marsh's Creek Beds are unconformably overlain by horizontal, lateritised Tertiary(?) sediments.

Other formations of comparable age and/or aspect to the Marsh's Creek Beds are the Insolvency Gully Formation and the Ellenvale Beds.

St. James Volcanics (Cs)

Typically developed in the northern tributaries of Cattle Creek in the north-western corner of the parish of St. James, County of Wilkie Gray, is a sequence of volcanics and sediments which are comparable in aspect to the Carboniferous volcanic and sedimentary sequences north of Fanning River Homestead. The sequence was partly described by Wyatt (1963) under the tentative name of Ben Lomond Volcanics but as "Ben Lomond" was previously occupied in Queensland stratigraphy the new name is proposed.

The Volcanics consist of a basal andesitic sequence followed by a sequence of sediments consisting of brown or greenish-grey, coarse-grained, poorly sorted arenites, which range from greywacke to subgreywacke. These arenites were formed mainly by erosion of andesitic volcanics. These strata are followed by rhyolitic agglomerates and flows, commonly spherulitic, which grade upwards into fragmental rhyolites, tuffs, and more flows.

The whole sequence has been folded into a syncline plunging to the north-east at about 20°. The St. James Volcanics are probably about 3000 to 3500 feet thick.

To the west of the Volcanics are Tournaisian sediments of the Game Hill Beds. Unfortunately the contact of the two sequences is obscured by an intrusive felsite breccia (Pzh). By analogy with other areas the St. James Volcanics could be expected to unconformably overlie the Game Hill Beds.

To the south, rhyolite porphyries (Pzp) are intruded north of Cattle Creek, where further contact with the Game Hill Beds could be expected. These same porphyries occur along the eastern margins of the outcrop area.

To the north the Volcanics are faulted against the Insolvency Gully Formation.

The rhyolites of the St. James Volcanics are lithologically similar to rhyolites in the basal section of the Ellenvale Beds, and to rhyolites in the Tareela Volcanics.

The sediments of the St. James Volcanics are similar to the sediments derived from reworked volcanic debris which underlie the rhyolites of the Ellenvale Beds at the head of Hellhole Gorge.

It therefore seems most likely that the basal andesitic flows and agglomerates of the St. James Volcanics are equivalent to Wyatt's (1961) Wild Horse Formation. If this is so, the Percy Creek Volcanics and Wyatt's (1961) Plumtree Formation are absent in the Cattle Creek area.

From their stratigraphic position above the Game Hill Beds, and their lithological similarity with dated strata north and north-east of Fanning River Homestead, the St. James Volcanics are assigned to the Carboniferous.

<u>Insolvency Gully Formation (Ci)</u>

Lying north of the St. James Volcanics and typically developed on the catchment of Bog Hole Creek (locally known as Insolvency Gully) is a sequence of sediments which were designated by Wyatt (1963) as the Insolvency Gully Formation. The strata were previously shown on the Geological Map of Queensland (1953) as Star Group.

The Formation consists of subgreywacke arenites and conglomerates, feldspathic sandstones, dark grey mudstones, siltstones, and cherts.

The rocks of the Formation are, on the whole, ill-sorted. Well-sorted arkoses are absent; the feldspathic sandstones usually contain fragments of volcanics and/or shale, and grade into subgreywacke arenites. The conglomerates and coarser arenites are more prominent near the base of the section, but are by no means limited to the lower stratigraphic levels. The dark grey shales occur throughout the whole section.

The strata in the lower part of the section are usually well-bedded, the arenites showing in places festoon cross-laminations, and the shales a well developed lamination. In the upper part of the section the mudstones and siltstones commonly form beds up to 4 feet thick with no internal structures or lamination. Some of these upper shales are slightly calcareous. Turbidity structures have been noted in some of the fine arenites associated with the shales of the upper levels. Ripple marks occur in a few of the finer-grained arenites. An interesting development of large ripples occurs in a medium-grained subgreywacke in Keelbottom Creek. These ripples have a wave length of about 9 inches and an amplitude of 0.5 to 1 inch. They are irregular in their trend, and do not persist far along their length.

Cyclic sedimentation appears to have prevailed during deposition of the Formation, as evidenced by the general development of units comprising coarse clastics followed by dark shales. The thickness of these units may range from a few feet to several tens of feet, and the relative proportions of coarse to fine clastics varies considerably.

The fossil assemblage consists mainly of plant remains amongst which Calamites sp. has been recognized (McKellar, 1963b). Some shales show well preserved tracks which may have been left by an annelid, but this is not certain. On the evidence of Calamites sp. and resemblance to parts of the Ellenvale Beds the Formation has been assigned to the Carboniferous.

The sedimentary environment appears to have been one of rapid deposition close to the source area. The presence of ripple marks and current laminations suggest a shallow water environment. The abundance of plant remains in dark shales suggests rapid burial and a lack of oxidising conditions. The cyclic sedimentation suggests the possibility of unstable tectonic conditions. The Formation may thus have been deposited in a fairly rapidly, but intermittently, subsiding basin in which the rate of sedimentation kept pace with the rate of subsidence.

On stratigraphic evidence from other Carboniferous formations in the region, the Insolvency Gully Formation might be expected to conformably follow the St. James Volcanics. The two appear to be separated by a fault, on either side of which marked differences in trend are apparent. The Insolvency Gully strata trend generally east-west, and have a uniform northerly dip averaging 30°. The St. James Volcanics are folded into a syncline plunging north-east in which the north-western limb trends north-south and the south-eastern limb trends east-north-east. There is therefore a marked discordance in strike between the two formations along their contact.

In the northern foothills of Ben Lomond West, the Insolvency Gully Formation appears, on regional structure, to unconformably overlie the Game Hill Beds, and the St. James Volcanics appear to be absent. This situation is unlikely as the St. James Volcanics and the Tareela Volcanics farther north are probably equivalent, and in all probability once formed a continuous formation. As neither of these volcanic sequences shows any sign of thinning it is unlikely that the volcanics were not deposited in the Ben Lomond West area. The absence of St. James Volcanics may therefore be due to faulting; for example, the fault which separates the Volcanics from the Insolvency Gully Formation may continue this far west. The structure of this area is complex, and will require considerable detailed study before exact stratigraphic relationships can be determined.

The Insolvency Gully Formation is intruded by Upper Palaeozoic granite (Pzug) east of Keelbottom Creek, and by granodiorite (Pzb) north of Ben Lomond West.

Tareela Volcanics (Ct)

Typically developed over much of the parish of Tareela, County of Wilkie Gray, is a sequence of volcanics which were designated by Wyatt (1963) the Tareela Volcanics. These Volcanics occupy a roughly triangular area of about 90 square miles between Taylor's Bore (Star Holding) in the east, the lower reaches of Coppermine Creek in the west, and the western headwaters of the North Branch of the Little Star River in the north.

The formation consists of a lower sequence of andesitic lavas and pyroclastics conformably overlain by an upper sequence of rhyolitic lavas and pyroclastics. The andesites are well exposed on the limbs of a syncline lying west of the Little Star River, and again in the core of a broad, gently folded anticline south-east of the Little Star River. The rhyolites are well exposed in the core of the syncline mentioned above.

The andesites commonly show well developed flow-banding and columnar jointing, particularly in their upper levels. Pyroclastics are developed in places, but appear to be subordinate to the flows. In the area between Little

Star River and Stony Bore (Star Holding), the andesite is commonly amygdaloidal and strongly epidotized like that in the lower parts of the Percy Creek Volcanics. About 6500 feet of andesite is exposed in the western limb of the syncline west of Little Star River.

The rhyolitic sequence consists of flows, commonly spherulitic or fragmental, and pyroclastics ranging from fine tuffs to coarse agglomerates. Between 3000 and 4000 feet of these acid volcanics are preserved. This part of the sequence is predominantly green or cream, and is rather similar to the Hell's Gate Rhyolite and the rhyolite at the base of the Ellenvale Beds.

The Tareela Volcanics overlie the Star Beds, possibly disconformably. They are also faulted against the Star Beds in many places, e.g., between the Great and Little Star Rivers north of Star Homestead, and west of the North Branch of the Little Star River.

No sedimentary sequence similar to that which occurs in the Sybil Group or the Ellenvale Beds has been observed overlying the Tareela Volcanics.

LATE PALAEOZOIC (POSSIBLY CARBONIFEROUS)

Undivided Volcanics (Pzv)

East from Stony Bore (Star Holding) to Thornton Gap and south from the bore to Bog Hole Creek is an area of upland which is composed essentially of rhyolitic flows and pyroclastics and minor andesitic volcanics.

South of Taylor's Bore the attitude of these volcanics suggests that they overlie the basal andesites and trachytes of the Tareela Volcanics. They may, therefore, be equivalent to the upper (rhyolitic) part of that formation. From photo-interpretation it appears that these volcanics are horizontal or near-horizontal and gently undulating. The steep-sided gorges in the valleys of Keelbottom Creek and its tributaries appear to be the result of these streams' cutting through the resistant rhyolites to the underlying andesites.

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 because of present uncertainties in structure and correlation they have been assigned simply to the late Palaeozoic.

A second area of volcanics occurs between the Little Star River and the coastal scarp between Saltwater Creek and Sleeper Log Creek. These volcanics form the high inaccessible country of the central part of the Paluma Range. Rain forest covers much of their northern outcrop area. In the area of the East Branch of Keelbottom Creek east of Taylor's Bore, the volcanics are apparently continuous with the volcanics discussed immediately above.

In the North Branch of the Little Star River the volcanics consist of flow-banded rhyolites, dipping eastward at about 55°, which overlie a pink late Palaeozoic granite; however, the nature of the contact could not be satisfactorily determined.

In the South Branch of the Little Star River the same rhyolites dip northward at about 50°. Photo-interpretation suggests that they continue farther eastward, and that the dip gradually changes more to the north-west. Thus the rhyolites may be part of a basin-shaped structure. Numerous north-westerly lineaments cross this structure; they are probably faults or joints.

North of the mouth of Saltwater Creek is an east-west ridge of sheared, spherulitic rhyolite. Indistinct banding, indicated by size and frequency variation of the spherulites, suggests that the rhyolites are gently folded.

All the occurrences discussed above are possibly related and of similar age. They have all been shown as undifferentiated late Palaeozoic Volcanics on the map.

Dark Grey Volcanics (Pzy)

At Frederick Peak and at numerous points in the Paluma Range are dark blue-grey volcanics. These volcanics appear to range in composition from dacite to rhyolite. Quite frequently they are distinctly fragmental, and contain rock fragments of similar composition. In places they are porphyritic, and resemble intrusive porphyries; in others, there are indications that they are flows.

These rocks give rise to very rugged topography which, together with the heavy vegetation cover of the coastal ranges, makes the task of deciphering their relationships quite difficult. However, it is thought that they may represent high level intrusives, breccias, and flows. The fact that the volcanics are restricted to a belt of country extending from north of the head of the Star River in the north-west to Frederick Peak in the south-east is probably significant but, because their structure and mode of occurrence remain obscure, the significance of this distribution cannot be assessed.

The most typical development of these volcanics is at Frederick Peak, south-west of Townsville, where they form the highest country. Here they consist of dacitic to rhyolitic porphyry composed of a dark blue-grey groundmass, clear quartz phenocrysts and xenocrysts, and white feldspar phenocrysts. In places the rock contains fragments of similar composition. The content of phenocrysts, xenocrysts, and autoliths is extremely variable.

Many of the crystals, as seen both in the field and in thin section, are broken, and the long axes of the crystal fragments are commonly aligned parallel to the long axes of the autoliths. The alignment appears to be of purely local significance. The contact of these volcanics with either the granites or metamorphic rocks of the Frederick Peak area was not seen.

These dark volcanics are similar to those in the Hervey Range, south-east of Murray's Hut, which are possibly faulted against representatives of the unnamed sequence of Carboniferous sediments and volcanics (C).

Mount Margaret is composed of dark blue-grey siliceous volcanics of possible dacitic composition similar to those of Frederick Peak. They are porphyritic, and contain abundant phenocrysts of white feldspar and rare quartz phenocrysts. Fragments of similar rock are commonly present in the aphanitic groundmass. The quartz phenocrysts are strained and embayed, whereas the feldspar laths are roughly aligned owing to flow-banding. Sparsely disseminated pyrite, sometimes in small stringers, is also present.

Patchy quartz veining, as thin stringers striking 105°, occurs on the southern flanks of Mount Margaret. This veining is crossed by a later set of joints striking 160°.

On the flat country immediately to the south of Mount Margaret, but isolated from it by Quaternary soil, is an outcrop of a possible porphyritic pale pink to brown welded tuff, consisting of coarse, euhedral quartz phenocrysts, red plagioclase phenocrysts averaging 1cm. length, and minor quartzite fragments set in a felsitic groundmass. The euhedral quartz phenocrysts are embayed and partly recrystallized.

At Mount Black similar siliceous volcanics have been noted. The volcanics appear to consist of flows and pyroclastics, one sectioned specimen being a welded tuff. Rare flow-banding strikes between 140° and 170°, and its dip is nearly vertical. The volcanics are intruded by fine-grained basic dykes. They are also probably intruded by microgranite dykes, numerous floaters of which occur on the steep slopes of the mountain.

At the eastern end of a narrow ridge which trends east-north-east from Mount Black are medium-grey siliceous, porphyritic volcanics. Along the southern edge of this ridge is a breccia which appears to represent a fault-zone. Indications of this fault have been observed between the western end of this ridge and the northern slopes of Mount Black. Many of the volcanics on this ridge carry fine disseminations or aggregates of pyrite. Possible flow-banding trending 080° occurs adjacent to the breccia-zone at the eastern end of the ridge. These lighter-coloured volcanics appear to be different from those of Mount Black, and are correlated with the (?)Permo-Carboniferous volcanics of the Townsville district. Other sheared volcanics, mapped with this unit in the north-eastern foothills of Frederick Peak, also carry pyrite.

North and north-west of Thornton Gap are similar volcanics to those of Frederick Peak. They appear to be intruded by adamellite in the region of Bog Hollow. To the west are undifferentiated late Palaeozoic volcanics, but their relationship to the dark volcanics is not known. To the east, the boundary between these dark volcanics and possible early Palaeozoic metamorphics truncates the trend of the metamorphics. It is not known whether the volcanics intrude or are faulted against the metamorphic rocks.

Banding is not common in this area, but in one locality near the metamorphics an orientation, defined by the alignment of the long axes of angular or rounded amygdaloidal fragments of acid volcanic rocks, trends 005°, and dips vertically; at this locality broken phenocrysts of quartz and feldspar are as numerous as xenoliths. In thin section, it is apparent that resorption of the quartz has occurred; about 50 percent of the rock is very fine-grained and altered to turbid material in which shard-like shapes can occasionally be recognized.

East of Godwin's Peak where Saltwater Creek emerges from the Paluma Range, a pink, porphyritic microgranite is overlain by blue-grey, porphyritic rhyolites with feldspar and quartz phenocrysts. Rare banding in these volcanics trends east-west.

Similar volcanics occur in the area of Blue Gum and Smith Creeks, tributaries of the Great Star River. They are mainly blue-grey, acid rocks, and are distinctly fragmental in places. They contain variable amounts of quartz and feldspar phenocrysts and fragments of acid volcanic rock. The attitude of these volcanics is extremely difficult to determine, but there are indications that they are flat-lying. The volcanics are continuous with those in Little Crystal Creek, north of the Paluma Road, where they are intruded by pink to red epidotised granite.

UNDIVIDED METAMORPHICS (MAINLY DEVONIAN AND CARBONIFEROUS) (Pzu)

Outcropping discontinuously at the foot of the coastal scarp between Mount Flagstone and the Black River are occurrences of generally low grade metamorphic rocks which are thought to be mainly of Devonian and Carboniferous age. These metamorphics have been observed in the following areas:-

(a) Thornton Gap

Two miles north-east of Thornton Gap is a ridge of low hills composed of banded metamorphosed rocks, comprising white quartzite and dark grey metamorphosed sandstone and arkose. The strata stike 130°, and dip 80° south-west. The ridge, however, is parallel to the boundary of the metamorphics and dark blue-grey acid volcanics lying to the west. These latter are unmetamorphosed, and truncate the bedding in the metamorphics, but it is not knownif the relationship is an intrusive or faulted one.

Three quarters of a mile south-east of Thornton Gap, banded and foliated arenitic and finer-grained metamorphosed rocks, now biotite schist, are included in late Palaeozoic granodiorite and adamellite. These rocks strike 040°, and dip vertically. They are similar to the metamorphic rocks on the north-west part of Frederick Peak.

(b) Frederick Peak

At the head of the Alice River, west and north-west of Frederick Peak, occur metamorphosed quartzose arenites and finer rocks. The degree of foliation varies considerably, the rocks being strongly schistose in places, whereas in others sedimentary structures such as cross laminations are still easily recognized. In most places the rocks have been raised to the biotite grade, but in others sillimanite has been developed (Photo Plates 5 and 6). Some of this metamorphism is related to the granites of this area, e.g., the development of garnet- and biotite-bearing gneiss at the metamorphic-granite contact, but the development of sillimanite is not so easily explained. The general grade of the metamorphism is not as high as one would expect for this mineral to develop.

(c) Mount Flagstone

At the head of Spring Creek, a tributary of Ross River, are developments of metamorphic rocks which extend south to the Mount Flagstone area. Mostly they consist of arenites, but fine-grained and calcareous strata also occur. Close to Mount Falgstone in the foot-hills of the coastal scarp at the head of Cattle Creek is a lens of hematite in metamorphosed limestone, now a tremolite-zoisite-calcite-garnet-(?)diopside rock. The grade of metamorphism of the limestone

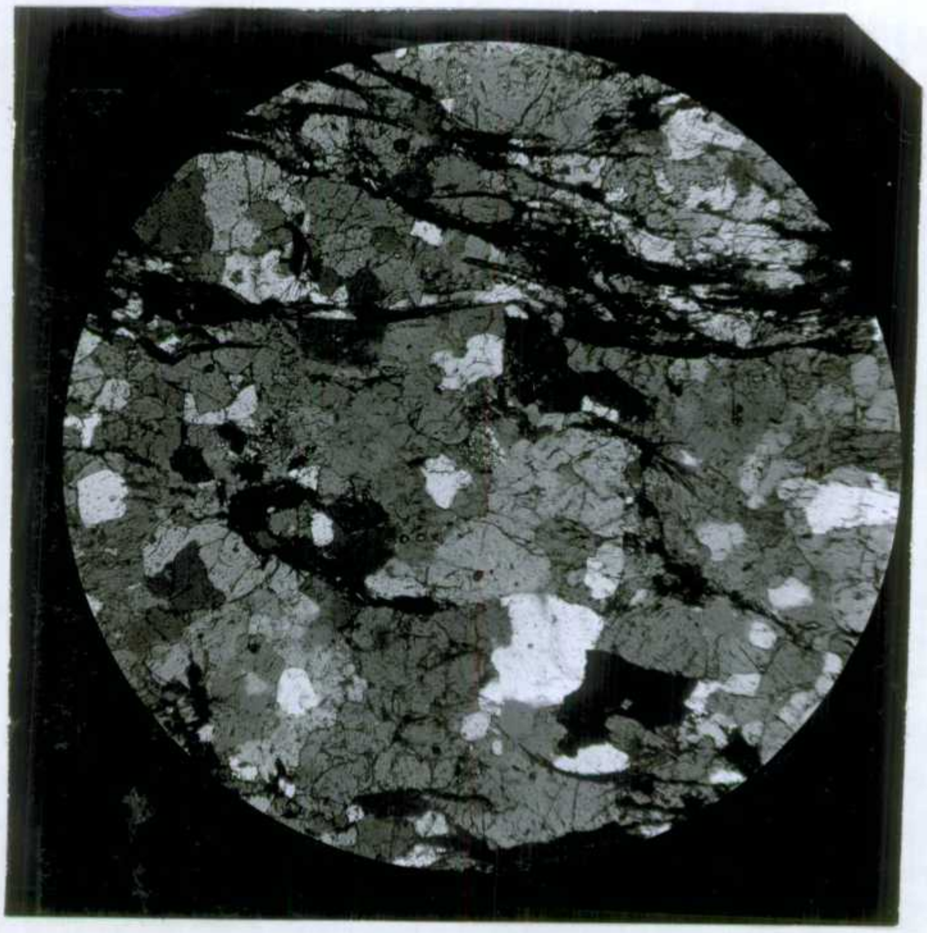


Photo Plate 5: Sillimanite gneiss (Pzu), near Alice River, 1.5 miles south of Mount Margaret.

The rock consists of quartz, biotite, plagioclase, sillimanite, pyroxene(?), and epidote(?). Sillimanite occurs in sheaves, aligned east-west; it may be pseudomorphing muscovite. Sillimanite needles also occur among the quartz grains. A plate of biotite at extinction is visible in the south east quadrant.

Crossed nicols X45. Microslide No. G.S.Q.15137.
B.M.R. Neg. No. G/6747.

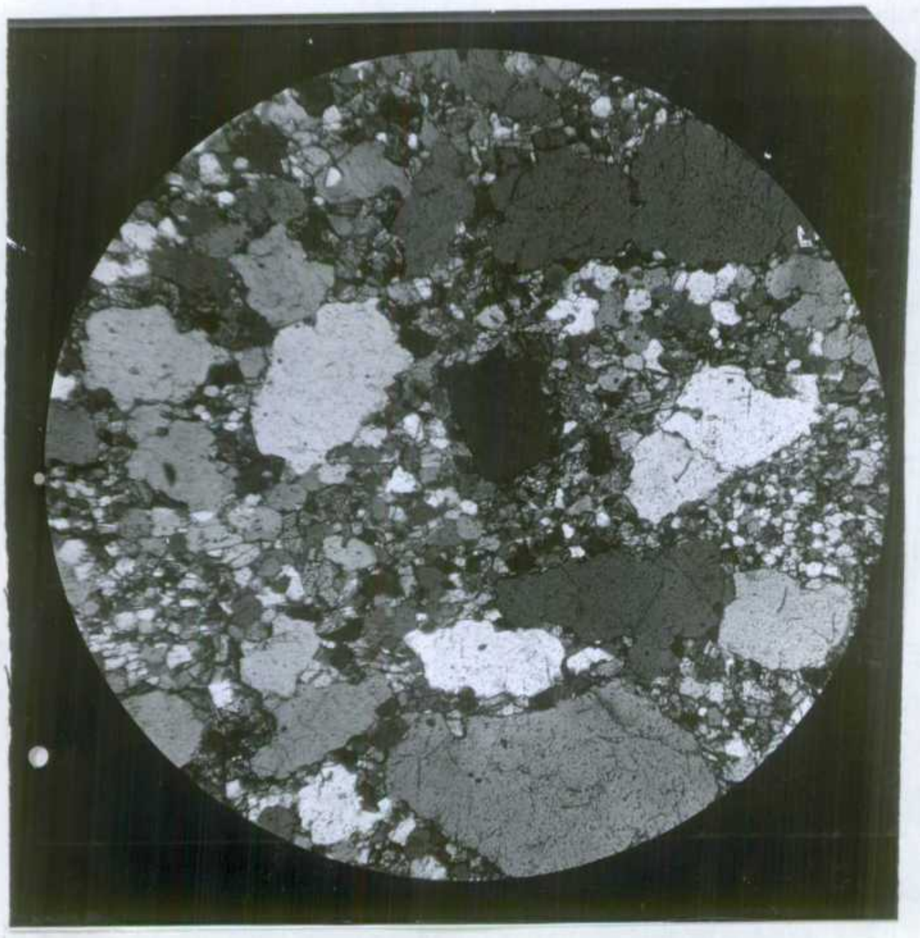


Photo Plate 6: Metamorphosed tuffaceous sandstone (Pzu), same locality as for Photo Plate 5. Irregular, elongate aggregates of quartz, with long axes sub-parallel, occur in a granular matrix of hornblende, quartz, plagioclase, sphene, and ore minerals.

Crossed nicols, X45. Microslide No. G.S.Q.15142.
B.M.R. Neg. No. G/6742.

decreases rapidly up the scarp to the westward. 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 striking north. Southwards the rocks show an increasing development of quartz and feldspar porphyroblasts, more of the rocks are pink, and aplite and pegmatite veins are more abundant. Near the centre of Mount Flagstone pink, porphyrobalstic rocks predominate, and there are minor occurrences of sugary-textured quartzite. Similar foliated and leucocratic rocks occur on the eastern and southern margins of Mount Flagstone. On the saddle linking Mount Flagstone with the coastal range and south to the head of Landsdowne Creek are metamorphosed sandstone, siltstone, and possible acid volcanic rocks. The rocks of the Mount Flagstone neighbourhood appear to be sheared and contact-metamorphosed parts of the Fanning River Group. If this is so, then many of the occurrences farther north-west at Frederick Peak and Thornton Gap may be merely Devonian and Carboniferous sediments sheared and foliated in a fault-zone along the coastal scarp.

However, not all these foliated rocks are sediments. For example, on the southern side of the valley where Landsdowne Creek emerges from the Hervey Range is a foliated, xenolithic rock composed of labradorite "phenocrysts" (15%) in a groundmass of quartzo-feldspathic material (75%), dioposide, epidote, and sphene (5%) and opaques (5%). The rock, which is gneissic, appears to have been derived by partial recrystallization of an igneous rock (Houston, 1963, G.S.Q.15215).

(d) Reid Gap - Calcium

R.L. Jack (1886b, 1892) mentioned "greywackes, slates, etc." occurring unconformably below the Devonian sequence in the Reid Gap area, but did not mention specific localities. Rocks which probably correlate with these strata were observed west of Black Mount, where they consist of mica schist, and four miles south-east of Reid Gap, where there is metamorphosed arkose.

(e) Haughton Valley

R.L. Jack (1879a) recorded granite and gneiss as occurring unconformably below the sandstone bluffs south of Haughton Valley, i.e., below the Collopy Formation. Results of the present survey indicate that the "gneisses" are sheared parts of the Ravenswood Granodiorite associated with major faults on the south side of the Haughton Valley. Mylonite and phyllonite, which occur farther east, near Four Mile Creek, are possibly of similar origin, but Morton (1931) reports mica schist and quartzite from the western spurs of Black Mountain, so that some of the cataclasites may be derived from rocks other than the Ravenswood Granodiorite.

Farther east again, at Horse Camp Hill are minor schists similar to those near Black Mount, near Calcium.

PERMO-CARBONIFEROUS

Unnamed Volcanics and Sediments (C-Pv)

Intermediate volcanics which form the low hills north-west of Rocky Springs Homestead have minor interbedded sediments which contain Glossopteris sp. No significant difference has been found between these volcanics and those which form much of the hilly country around Townsville, and extend south-east as far as the Haughton River (a few miles within the Ayr 1:250,000 Sheet area). These rocks are therefore mapped as one unit, which is regarded as Permo-Carboniferous.

The volcanics consist mainly of intermediate to acid flows and pyroclastics. Pyroxene andesite crops out at Woodstock Hill. The pyroclastics are commonly quite coarse, and many of the flow-rocks have a fragmental component. Phenoclasts of granite and volcanics are abundant in the pyroclastics and associated conglomerates. The prevalence of volcanic breccia and conglomerate suggests that the volcanics were erupted from centres within the immediate area. Large-scale structures are rare and discontinuous; individual flows could not be traced in the field. Dips of up to 80° have been recorded in the sediments, but even where lower dips occur, for example, in the hills around Rocky Springs Homestead, it is not certain whether ~~or not they are~~ original. In places dips have been measured and recorded in the volcanics on surfaces which have not been positively identified as original layering. The volcanics are generally quite massive, and many of the measured surfaces may simply represent the predominant parting direction. Platy and linear flow-banding are useful in places, but the few, widely scattered, reliable measurements made in the course of this survey are of little value in elucidating the regional structure.

The sediments consist of conglomerate, sandstone, arkose, shale, siltstone, and thin coal bands. They rarely crop out, and little is known of their stratigraphy and relationships. They are possibly very local, and appear to be wholly terrestrial in origin. They were probably laid down in isolated, swampy valleys among the volcanic eruption centres. Near Stuart, a conglomerate which is believed to be part of this unit rests unconformably on granite thought to be Carboniferous (see section on Carboniferous granites). It is possible that many of the granite and volcanic phenoclasts in the fragmental rocks were derived from Carboniferous granites and volcanics. R.L. Jack, in Jack and Etheridge (1892), described sediments containing Glossopteris leaves in a railway cutting near Stuart's Creek Station, and assigned a Permo-Carboniferous age to them. Walkom (1922) recorded possible Glossopteris indica from a railway cutting "six and a half miles from Stewart's Creek, Townsville (GSQ.F1811)" and at "Rodger's Mine, Stewart's Creek, Townsville (GSQ.F1847)". During the present survey fossiliferous sediments were observed at only one locality, 1¼ miles south-east of Stuart gaol, but Dunstan (1905) records "coal-measure sandstones" from bores as far south as Antill Plains railway station. Unfossiliferous conglomerates occur elsewhere, for example, in the eastern bank of the Ross River, west of Mount Stuart.

Lack of structural information and scarcity of fossil evidence have prevented normal stratigraphic methods from being applied to the mapping of these volcanics. The combination of lithological similarity and continuity of outcrop has been the main criterion in mapping them as a unit. Much of the volcanic rock in the Townsville district is lithologically similar to Carboniferous volcanics farther west in the Hervey Range, and the boundary of the Permo-Carboniferous volcanics has been set somewhat arbitrarily; they have been restricted to an area north-east of the belt of alluviated country between Mount Black and South Double Hill. It follows that the area mapped as Permo-Carboniferous may well contain volcanics of other ages.

The regional distribution of the late Palaeozoic volcanics and associated sediments in the Townsville hinterland suggests that vulcanicity began in the late Middle or Upper Carboniferous in the Marsh's Creek, St. James, and Percy Creek areas, and continued through to the Permo-Carboniferous, the sequence becoming progressively younger eastwards. Deposition probably ceased with the earth movements in the late Permian to Mesozoic.

Individual occurrences of volcanics assigned to the Permo-Carboniferous are described below under geographical headings:

(a) Magnetic Island

Volcanics form the north-western tip of Magnetic Island. They are intruded by the granite which forms the main mass of the island. The rocks are dark, massive, siliceous agglomerates, consisting of crystals of white feldspar, quartz, and rock fragments, set in a black flinty matrix. The rock fragments are commonly similar to the enclosing rock, but granite fragments also occur. Pyrite occurs in the matrix of some specimens.

The volcanics are intruded by granite (P-Mg) and by four kinds of dykes.

(b) Kulburn

Near Kulburn Siding, two small isolated outcrops occur north-east of the highway, on either side of the Black River.

North-west of the Black River is a low rise composed of a brown, porphyritic rock, which consists of 10 percent shattered phenocrysts of quartz and 10 percent red feldspar phenocrysts in a brown, microcrystalline groundmass. Phenocrysts and fragments are strongly flow-aligned around larger fragments of similar material up to 4 feet in diameter. The rock is sheared and epidotised.

Pink, purple and brown, medium- to coarse-grained, acidic, welded tuff forms a low rise south-east of the river. No flow-banding is apparent in outcrop, but the thin-section shows abundant phenocrysts of strongly shattered quartz and of plagioclase in a glassy, flow-textured matrix. The quartz phenocrysts are strongly shattered; some fragments of similar rock occur within the matrix, which also contains rare flakes of biotite and some fragments of lava whose appearance is similar to that of the host rock.

Kulburn Hill is a north-west trending strike ridge composed mainly of acid flows and pyroclastics; some intermediate types may also occur. Flow banding dips to the north-east at moderate to steep angles. Further volcanics have been photo-interpreted east of Purono Siding.

(c) Frederick Peak

Light-coloured volcanics, which are sheared and intruded by quartz veins, form the north-eastern shoulder of Frederick Peak. They form ridges along which a variety of rock types crop out; these range from acid volcanics (which may be porphyritic and/or pyritiferous) to intermediate lavas and pyroclastics.

The volcanics are strongly sheared at 110°, a direction which is parallel to a fault postulated to trend along the northern margin of Frederick Peak. They also appear to be faulted against the late Palaeozoic dark blue-grey volcanics (Pzy).

These light-coloured volcanics are somewhat similar to the volcanics of Kulburn Hill, 12 miles to the north-north-west.

Three dome-shaped plugs which form a rough circle occur at the northern end of Frederick Peak. They consist of a fine-grained cream or brown acid rock with phenocrysts of quartz and feldspar. Although no contact with the dark blue-grey volcanics (Pzy) was seen, the plugs probably intrude them.

(d) Mount Low

Grey-brown rhyolitic feldspar-porphyry occurs at the end of Mount Low, where it is in contact with granite (see section on Carboniferous Granites). The rock consists of phenocrysts of altered plagioclase and some potash feldspar (altered to sericite-epidote-kaolin) and altered biotite (chlorite, epidote, and ore) in an equigranular, xenomorphic quartz mosaic with numerous microlites of feldspar and biotite. In a second specimen phenocrysts of albite were identified.

Medium to coarse acid volcanics crop out in the eastern half of the ridge. They consist of quartz phenocrysts (20 percent) and white (locally pink) feldspar (30-40 percent) in a microcrystalline brown-grey matrix. No structure was evident.

These volcanics are probably younger than the granite.

(e) Many Peaks Range

The major part of Many Peaks Range appears to consist of volcanics. At the foot of the central part of the range a pale brown, medium to coarse, biotite-bearing trachytic rock crops out. Flow-banding dips steeply to the south-west and south. Two hundred feet up the hillside a junction between this rock and a purple, andesitic rock was seen; both are flow-banded parallel to the contact. Near the top of the range, pale trachytic or rhyolitic rocks are mingled with blocks of a darker rock which contains phenocrysts of pink feldspar, and appears to grade into porphyritic microgranite. The pale brown rocks resemble dyke rocks found elsewhere, and may be intrusive here too. Columnar jointing is commonly developed normal to the flow-banding.

Granite and microgranite are associated with possible volcanic rocks on top of the range, but nothing is known of their relationships. At the foot of the range trachytic rocks are intruded by thin dolerite dykes.

(f) Mount Stuart

Various apparently volcanic rock-types and some conglomerates occur on Mount Stuart, but their relationships are imperfectly known. The rocks in the southern and south-eastern foothills of Mount Stuart, including Big Jack and Mount Jack were not examined. These areas have been photo-interpreted as volcanics. Outcrops of probable extrusive rocks are abundant among outcrops of granite in the centre of the Mount Stuart range; however, they have not been differentiated from the granitic rocks on the maps.

The following rock-types were noted:-

(1) Half a mile south-west of summit: melanocratic, fine-grained intermediate flow-rock(?), with black iron oxide as the only dark mineral; possibly a welded tuff, dipping at 10° to the south-south-east.

(2) Beside the road, 2½ miles south-east of summit: coarse, massive, greenish volcanic breccia containing cobble and pebble phenoclasts of flow-banded porphyritic rhyolite and other rocks; some agglomerate, and mud-ball tuff.

(3) Centre of range: green, sheared, epidotised agglomerate and volcanic breccia; pink volcanic breccia (fragments of granophyre and volcanics in a felsitic groundmass); flow-banded, leucocratic, siliceous rhyolite; grey-white, welded, vitric tuff; brown trachyandesite(?).

(4) Northern and north-western foothills: dense, dark, blue-green tuff; massive, creamy rhyolite with large spheruloids; pink rhyolite; crumbly, weathered agglomerate, extensively quartz-veined.

(5) Ross River-Five Head Creek confluence: boulder and cobble, polymictic conglomerate with well-rounded phenoclasts of leucocratic adamellite, flow-banded rhyolite and darker porphyritic volcanics, and coarse quartz-feldspar porphyry, in friable, greenish, arkosic matrix; local, thin, cross-bedded lenses of similar arkose, containing grains of quartz and feldspar, conspicuous biotite flakes, and quartzite fragments. The rock dips steeply to the east-north-east.

(6) Village of Stuart (eastern flank of mountain, ½ mile south of village): massive, polymictic conglomerate with cobble and boulder phenoclasts of porphyritic, pink adamellite or granite, purple porphyritic quartz andesite, coarse crystal tuff, and other rock-types. Similar conglomerate is interbedded with tuff in a rail cutting nearby.

Maitland (1892), reported a "coarse conglomerate faulted against volcanic ashes" at Stuart Creek Railway Station, and also noted, in a rail cutting, sandstones, shales, impure coal, and an ashy conglomerate overlain by a sheet of lava. Near the summit of a ridge west of the station he reported lenses of lava among tuffs. He also described " a very coarse recent conglomerate" overlying the granite. Observations during the present survey suggest that this conglomerate is probably equivalent to the Permo-Carboniferous conglomerate described previously in the section on Carboniferous granites.

The field relations of these outcrops, where known, are described below:-

(1) Half a mile south-west of summit: this rock appears to dip off the intrusive rock which forms the summit of Mount Stuart. The question of its age-relations with the summit rock is briefly discussed in the section on Permian-Mesozoic granites (q.v.).

(2) Beside road, 2½ miles south-east of summit: the volcanic breccia here seems to be faulted against red granite, which is probably younger. A short distance to the south-west, there is a probable intrusive contact between micro-granite and agglomerate.

(3) Centre of range: no conclusions were reached on the relationships between volcanic and granitic rocks, beyond the observation that volcanic rocks appear to occupy the higher ground.

(4) Northern and north-western foothills: no relationship established.

(5) Ross River-Five Head Creek confluence: the conglomerate is intruded by keratophyre sills. Quartz microsyenite, probably intrusive into the volcanic-sedimentary sequence, crops out in the bed of the river a few yards away.

(6) Village of Stuart: the problem of whether the conglomerate is older or younger than the underlying granite is discussed in the section on Carboniferous(?)

granites. Both conglomerate and granite are intruded by dykes of rhyolite or rhyodacite.

In general, the volcanics are considered to be older than the central granitic stock of Mount Stuart, but younger than the granite at Stuart Village.

(g) South of Townsville Gaol

Maitland (1892) has briefly described the geology of this area. In general he found beds of sandstone and shale interbedded with volcanics. He also described horizontal blue-black shales with 6 inches of impure coal, overlain by volcanic ash, and baked, "porcellanised" shales dipping at 25° to the south-south-east.

During the present reconnaissance survey only the north-western part of this area was examined. The volcanics appear to be trachytic to andesitic, with flow-banding locally well developed. Poorly preserved Glossopteris leaves were seen on bedding planes in shales interbedded with the volcanics.

(h) Muntalunga Range and White's Creek Valley

Volcanics form the western limb of the Muntalunga Range, and small outcrops occur in the eastern foothills. The upper part and south-western slopes of the catchment area of White's Creek are formed of volcanics. Strong north-west-trending lineations appear on the air photos in a belt lying to the south-west of White's Creek, where the main rock-types are augite andesite (Photo Plate 7) and microdiorite. These lineations may indicate a dyke swarm; however no contacts were seen in the field. Epidotisation has severely affected all rocks in this belt.

Pale buff, porphyritic, acid volcanics crop out in the central and western part of the Range. Some andesitic rocks were also observed. Brecciation is quite common.

Massive, porphyritic blue-grey andesite and massive porphyritic pyroxene andesite occur in the eastern foothills.

In White's Creek valley (especially on the south-western slopes) the following rocks were noted: massive, coarse, greenish brown crystal tuff, pyritiferous agglomerate, brown to pink, rhyolite porphyritic in quartz and feldspar, dark green, bedded tuff, and augite-biotite andesite (possibly a dyke rock).

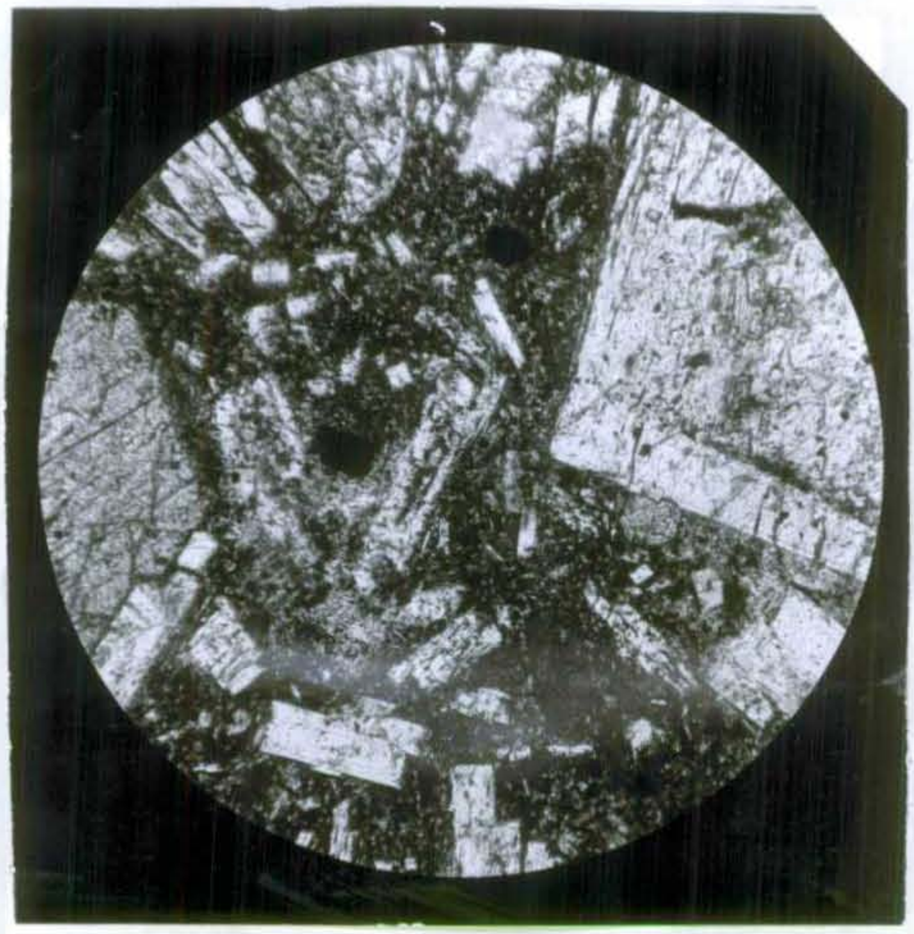


Photo Plate 7: Augite andesite, Permo-Carboniferous volcanics (C-Pv) south-west of Bruce Highway, ½ mile south of Smyth's Railway Siding.

Euhedral augite, ore minerals, and plagioclase lie in a turbid, fine-grained groundmass. Large, zoned plagioclase crystals enclose anhedral grains of augite (north-east quandrant). The groundmass texture is intersertal — granules of opaque minerals and semi-opaque ferromagnesian material occur between tiny laths of feldspar.

Plane polarised light X45. Microslide No. B.M.R. 15695.
B.M.R. Neg. No.G6743.

Photo Plate 8: Porphyritic, siliceous, volcanic rock, Permo-Carboniferous volcanics (C-Pv), Mount Black. An embayed, strained, quartz grain, with bubble trains, lies in a groundmass of very fine-grained turbid feldspar and quartz. Small turbid phenocrysts of altered feldspar occur in the north and east.

Crossed nicols. X45. Microslide No. G.S.Q.15116.
B.M.R. Neg. No. G/6750.

No structural or other relations were found in this area. Floaters of epidotised dolerite are ubiquitous, indicating widespread intrusion of basic dykes. Some of the andesites may be dyke rocks. The relationship between volcanics and granite in the area is discussed in the section on granites.

(i) Woodstock Hill and environs

Massive, rather coarse, porphyritic pyroxene andesite is by far the commonest rock, and seems to be characteristic of the immediate area. The rock would be a coarse basalt if oligoclase were not abundant in the groundmass. This characteristic relates it to the mugearites. Nevertheless, olivine was not seen, and so the rock is better described as a pyroxene andesite. It is the most mafic of the Permo-Carboniferous volcanics in the Townsville neighbourhood.

Rhyolite forms part of the steep hill immediately to the south of Woodstock Hill. Dolerite dykes intrude pyroxene andesite near the summit of this hill, and dolerite is widespread as floaters on the hill-slopes.

South of the rail cutting one mile west of Killymoon Siding, microgranite appears to intrude pyroxene andesite. No other relationships with granitic rocks were seen.

(j) The Sisters Mountains

The summit of The Sisters Mountains consists of spheruloidal rhyolite, rhyolitic autobreccia, and other fragmental rocks. The north-western and south-western foothills consist of less acidic rocks.

The following rock-types were seen in the south-western foothills: epidotised volcanic breccia and agglomerate containing rare granite fragments; rubble of purple, altered, porphyritic dolerite (possibly a dyke-rock) amongst abundant definite dyke-rock rubble; and spotted, buff and cream autobreccia consisting of darker fragments of rhyolite (porphyritic in milky quartz and cream feldspar) and other, somewhat glassy fragments in a flow-banded buff matrix containing a high proportion of creamy feldspar laths.

Massive, largely aphanitic, pale grey to white, kaolinised rhyolite, with undulating flow-banding, forms the western end of the summit ridge; this rock contains local concentrations of spherular structures of all sizes up to 6 inches in diameter. Agglomerate, volcanic breccia, and rhyolitic autobreccia containing disoriented rafts of flow-banded rhyolite up to 4 feet long, occur at the eastern end of the ridge.

The north-eastern foothills contain spheruloidal rhyolite, massive agglomerate with a crystal tuff matrix, coarse volcanic breccia, and brownish-purple porphyritic andesite or trachyandesite.

(k) Mount Elliott-Saddle Mountain

A belt of volcanic rocks, narrowing to the south-east, occupies the valley between the granites of Mount Elliott and Saddle Mountain. This valley is drained by the upper reaches of Alligator Creek. Small remnants of volcanic rocks are locally preserved around the margins of the two granite masses. A more extensive tract is preserved against the south-eastern sector of the Mount Elliott stock; this tract is largely within the Ayr 1:250,000 Sheet area.

The following rock-types have been noted:

(1) Upper Alligator Creek: massive, epidotised volcanic breccia; rhyolitic feldspar porphyry (with sanidine); greenish grey, medium to coarse, porphyritic welded tuff; coarse, flow-banded, spherulitic rhyolite (intrusive?); epidotised hornblende andesite and andesitic agglomerate; spherulitic dacite or rhyolite; and dark, blue-grey, pyritiferous volcanic breccia with fragments of andesite and of leucocratic micrographic adamellite.

(2) South-eastern part of Mount Elliott: the area mapped as volcanics is extrapolated from the Ayr 1:250,000 Sheet area to the east, where volcanic breccia, agglomerate, and probable conglomerate were observed.

(3) South-western part of Mount Elliott (Spur End): red and green recrystallized porphyritic rhyolite; dark grey recrystallized volcanics; volcanic breccia with quartzite fragments.

The volcanic rocks described above are regarded as older than the granites of Mount Elliott and Saddle Mountain (see section on Permian to Mesozoic granites). Microgranitic marginal phases and recrystallized volcanic country rock have been noticed at several places around the contacts of these granites. Rare aplite veins intrude the volcanics.

Volcanic breccia in the bed of Alligator Creek is intruded by thick, flow-banded felsite dykes which are themselves intersected by dolerite dykes.

(l) Mount Landers

Volcanics have been photo-interpreted at Mount Landers and in the surrounding low hills. The area was not examined in the field.

LATE PALAEOZOIC INTRUSIVE ROCKS

Granites (Pzug, Pzb)

Many bodies of granite and related rock-types occur in a north-west trending belt which forms the Paluma, Hervey and Leichhardt Ranges. Most of these granitic rocks are medium-to coarse-grained, and are cream or pink, except for the more basic types (Pzb) which are grey. A few grade to microgranite, and others are distinctly porphyritic. All except the more basic types give rise to rugged topography.

Most of these granites intrude either undivided late Palaeozoic volcanics (Pzy, Pzv) or late Middle to Upper Carboniferous volcanics and sediments. A few, for example those north of Haughton Valley Siding and in the Leichhardt Range, intrude early Palaeozoic rocks. Others, such as the diorite at Mount Kitty O'Shea or the Pall Mall Adamellite, intrude Devono-Carboniferous rocks. All, however, have the same general aspect, and have been grouped together as late Palaeozoic intrusives. Some granitic rocks in the Townsville district have been assigned to this unit. This undivided unit no doubt includes granites of more than one age in the late Palaeozoic.

Individual occurrences are described below:

In the Leichhardt Range, east of Bunker's Hill Mine, is an irregularly-shaped, composite body of granite and granodiorite, measuring about ten miles by four miles, intruded into the Ravenswood Granodiorite and the Kirk River Beds. This body gives rise to elevated, rugged country. The rocks of this mass are usually light-coloured and of medium grain-size, and have a typical granitic texture. They usually contain both biotite and hornblende. The granodiorite appears to intrude the granite as small, circular stocks along the eastern and southern margins of the mass.

At Black Mountain, nine miles south-east of Reid River, there is an adamellite body which trends east-west, and crops out over an area of about four miles by one and a half miles. The adamellite is pink and fine- to medium-grained with a hypidiomorphic or crudely micrographic texture. Quartz, potash feldspar, oligoclase, chloritized biotite, and muscovite are the main constituents. In the immediate vicinity of Black Mountain the adamellite is hydrothermally altered. The feldspars are heavily sericitised, chlorite is abundant, and muscovite forms radiating sheaths. Morton (1931) reported the occurrence of gold in greisenised granite adjacent to the western contact of the Black Mountain mass with metamorphic rocks.

Two and a half miles north of Black Mountain, a mass of adamellite and granite, about three miles long and two miles wide, forms the rugged country of Mount Norman. Microperthite, quartz, oligoclase, and biotite are the main constituents of the coarse, pink granite which crops out on the eastern and south-western parts of the range. A fine- to medium-grained grey biotite adamellite, very similar to the unaltered adamellite of Black Mountain, crops out extensively in the central part of the Mount Norman range. Rare aplite dykes intrude the adamellite.

At Mount Squarepost, an oval mass of biotite adamellite, five and a half miles long and two miles wide, intrudes the Ravenswood Granodiorite along its western and north-western margin, and an unnamed granodiorite, possibly likewise of late Palaeozoic age, along its north-eastern margin. To the east and south its margin is covered by alluvium. The adamellite gives rise to elevated and rugged country. It is pink and medium-grained, and has a typical granitic texture. It is intruded by feldspar-hornblende porphyry dykes and quartz flows.

Lying north of the Mount Squarepost adamellite in the Mount Sugarloaf area is an irregularly shaped mass, about four miles long and three miles wide, of granite, granodiorite, and adamellite which appears to be intruded by the Mount Squarepost adamellite. These rocks, which are generally grey or pink and of fine to medium grainsize, form a complex composite intrusion into the Ravenswood Granodiorite. They give rise to generally rugged topography, but are not greatly elevated above the Ravenswood Granodiorite to the west. Much of the ruggedness of the country in this area is also due to the abundant dykes of rhyolite and andesite which intrude the complex.

At Mount Prince Charlie, and in the range to the west, is a coarse red granite covering a roughly rectangular area five miles long and two miles wide. This granite contains biotite (partly altered to chlorite) as its dark constituent, and has a hypidiomorphic-granular texture. The granite intrudes the Ravenswood Granodiorite, and is faulted against Devonian sediments. It is intruded by rhyolite, microgranite, and andesite dykes.

At Brown Mountain is an irregular, elongate mass of pink, micrographic granite trending west-north-west, and measuring about six miles by two miles. This granite gives rise to the very high country between Calcium and Ellenvale Homestead. It is uniformly leucocratic, and contains only very minor amounts of biotite. The micrographic granite intrudes the Fanning River Group south-west of Calcium.

Four and a half miles west of Calcium is a circular depression, about two miles in diameter, in whose centre rises Black Mount. The rocks forming the Mount and the depression range from tonalite to granodiorite, and contain biotite, hornblende, and clinopyroxene. They are grey and of fine to medium grain-size, and intrude Givetian sediments, the microgranite at Brown Mountain, the Ravenswood Granodiorite, and undifferentiated Palaeozoic sediments (Pzu). The granodiorite at Black Mount is intruded by felsite dykes of unknown age.

Also in the Calcium area, three miles north-east of Reid River, is a small, roughly circular stock, about a quarter of a mile in diameter, composed of light grey, fine to medium adamellite with muscovite and tourmaline. This mass intrudes the Ravenswood Granodiorite and the Fanning River Group. It is intruded by felsite dykes of unknown age.

At Mount Flagstone, seven and a half miles north-west of Calcium, and also in the low country to the north-east and north-west of the mountain, are a number of granitic bodies which may represent different phases of a large composite intrusion, or several bodies of distinctly different ages or, as is more likely, a combination of these. The most widespread rock-type is a coarse hornblende-biotite granodiorite which covers an area of about twenty-four square miles in the low country bordering the northern and north-western foothills of the mountain. This granodiorite intrudes steeply dipping greywackes and sandstones of undetermined age (Pzu) which are possibly sheared representatives of the Devonian sequence in the coastal fault zone (see chapter on structure). However, the granite is somewhat similar to the unstressed, massive parts of the Ravenswood Granodiorite, so it is possibly early Palaeozoic in age.

The southern and eastern margins of Mount Flagstone consist of leucocratic, foliated rocks composed of quartz with some feldspar and biotite, the latter in lenses aligned in a northerly direction, and dipping vertically or nearly so. Towards the centre of the mountain these rocks grade into porphyritic granite in which irregular and, in places, large crystals of quartz and feldspar lie in a groundmass of quartz, pink feldspar, and biotite.

On the northern side of the mountain similar fine-grained, leucocratic, biotite-bearing rocks are intruded by pink granite which in turn is intruded by veins of pink microgranite and pink pegmatite. The pink granite also intrudes the granodiorite of the low country. This pink granite is variable in grainsize, and is composed of quartz, potash feldspar, plagioclase, and biotite. In places it is especially rich in quartz. The granite forms a prominent cliff on the side of the mountain; the upper slopes of the mountain above the cliff consist of porphyritic granite similar to that occurring near the centre of the mountain. It is possible that the pink granite forms a flat sheet-like intrusion later than the porphyritic granite. The pink granite is intruded by a north-west trending porphyritic microgranodiorite dyke with phenocrysts of quartz, plagioclase, and hornblende.

In the low country north of Mount Flagstone the coarse granodiorite already mentioned gives way to a light pink adamellite which has given off aplitic and pegmatitic veins that intrude sheared arenites of undifferentiated Palaeozoic age. About six miles north-west of Mount Flagstone is an elongate mass, trending north-west, of coarse, porphyritic granodiorite. It contains phenocrysts of feldspar, up to 2cm. long, and scattered rounded quartz xenoliths(?) up to 3cm. long. The relationship of this mass to the pink adamellite cannot be established with certainty, but its form suggests that it is intrusive into the adamellite.

That portion of the Hervey Range which lies west of this adamellite is composed of pink adamellite which is probably part of the same mass, but here the rock shows a wide range of grainsize and quartz content. A prominent north-west-trending ridge in the dissected scarp of the Hervey Range at the head of Oaky Creek consists of a coarse pink biotite adamellite which appears to intrude the adamellite of the range.

It will be noticed that several of the granitic bodies described above have a north-westerly orientation. As this is one of the main fault directions in this area it is probable that the emplacement of many of these bodies is fault-controlled.

At the northern end of the Hervey Range about Thornton Gap, several different granitic masses can be distinguished by photo-interpretation. These masses are recognized mainly on geomorphological grounds. In the field, although different geomorphological units can be recognized, the rock types within these units are in many places barely distinguishable in hand specimen. In the main, the low country is composed of granodiorite and the high country of adamellite. Small areas of still higher country are composed of granite or granite porphyry.

Granodiorite crops out mainly at the head of Speed Creek, but it also occurs farther south-west in the valleys of Granite and Fryer's Creeks, where adamellite is probably more abundant.

The adamellite occupies the high country to the north and east of Fryer's Homestead. Judging by morphology, two intrusions appear to be present here. Both probably intrude the granodiorite, and the eastern mass, i.e., the one forming Mount Pretty, probably intrudes the northern mass, i.e., the one forming the rugged country between Fryer's Homestead and the Thornton Gap road.

The granite and granitic porphyry occur in two areas - the first three miles south-south-east of Murray's Hut (Hervey Range) and the second three miles south-west of Fryer's Homestead. The latter appears to intrude the adamellite, so that in the Thornton Gap suite of rocks the later ones become more alkalic in composition.

As the granodiorite, the granite, and granite-porphyry intrude volcanics believed to be Carboniferous in age, the whole suite may be regarded as post-Carboniferous. All these rocks contain biotite, and the adamellite and granodiorite also contain hornblende. In the granite and porphyry the biotite is usually strongly chloritized. Colour ranges from grey in the granodiorite to pinkish grey in the granite. Grain-size is coarse in the adamellite, medium in the granodiorite, and fine to medium in the granite. Basic inclusions are quite numerous in the granodiorite, but decrease in abundance in the more acidic types.

In many respects these rocks are similar to those occurring in the Mount Flagstone area. In fact, all the granitic intrusions of the Hervey Range area, from Calcium north to Thornton Gap, are probably closely related.

Forming the peak called <u>Mingoom</u> and the high country extending west across Keelbottom Creek, is a pink leucocratic granite which ranges from medium-grained to microgranite. It is slightly vuggy, and the minor amounts of biotite present are usually altered to chlorite. This granite is probably related to the granite of the Thornton Gap suite. It intrudes late Palaeozoic (probably Carboniferous) volcanics to the north, and intrudes the granodiorite of Thornton Gap to the east. To the south it is faulted against the Insolvency Gully Formation and porphyries which are probably genetically related to the granite of the Thornton Gap area.

The southern and northern foothills of <u>Frederick Peak</u>, thirteen miles south-east of Thornton Gap are composed of pink biotite adamellite. This rock is rather similar to the pink adamellite which occurs in the low country north of the granodiorite at Mount Flagstone. In many places the biotite is altered to chlorite. The adamellite intrudes sheared and metamorphosed sediments of undifferentiated Palaeozoic age (Pzu). The adamellite is itself intruded by pegmatite veins containing biotite up to one inch long, and feldspar up to four inches long. These veins occur in the northern outcrop area in the Alice River. In the southern outcrop area, the adamellite is cut by sheets of drusy leucogranite in which variation of grainsize gives rise to banding parallel to the sheet walls.

No contact was observed between the adamellite and the dark blue-grey acid volcanics (Pzy) of Frederick Peak. Between these two rock types on the south-western side of the Peak are sporadic outcrops of diorite, dolerite, and porphyritic microgranite composed of large crystals of biotite and plagioclase in a groundmass of quartz, feldspar, and biotite. The diorite and dolerite of this area are cut by pegmatite veins, up to one inch wide, composed of hornblende and plagioclase. The mutual relationships of microgranite, diorite, and dolerite are unknown.

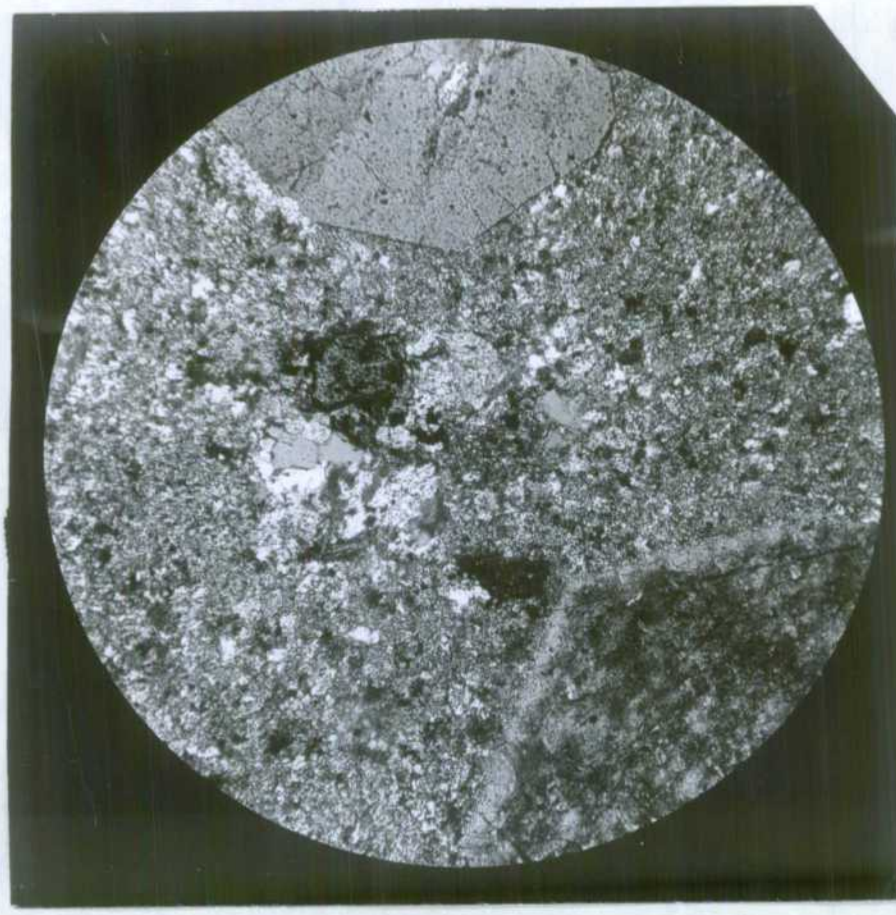


Photo Plate 9: Porphyritic microgranite (Pzug), 3 miles south-west of Rollingstone (30 miles north-west of Townsville). Quartz (top) and alkali feldspar (bottom right) occur as phenocrysts in a microgranitic groundmass. The central patch of coarser-grained rock consists of quartz, altered feldspar, garnet, muscovite, green biotite, and ore grains; it is probably xenolithic.

Crossed nicols, X45. Microslide No.G.S.Q.15110.
B.M.R. Neg. No.G/6745.

In the Rollingstone Creek, Ollera Creek, and the Paluma Range road area, the main rock types, besides the country rock of dark blue-grey acid volcanics (Pzy), comprise pale pink adamellite, grey porphyritic adamellite, red leucocratic granite, porphyritic microgranite (Photo Plate 9), and dark blue-grey dyke rocks. These rocks vary in their composition and texture, and the igneous assemblage appears to be petrographically quite complex. The rocks give rise to a rugged terrain which, together with the dense rain forest cover of the area, makes it difficult to map the complex geological relationships. Consequently, the geology shown on the accompanying map is very much simplified.

In the lower country bordering the Paluma Range the dominant rock is a pale pink biotite adamellite. In places it forms ridges which appear to be due to hardening of the adamellite along faults or fault-zones. Typically the adamellite shows no directional structures except for a crude foliation along some shears.

Where the Bruce Highway crosses Rollingstone Creek, the adamellite is coarse, and, in addition to biotite, contains some hornblende. Farther west, closer to its contact with either pink porphyritic microgranite or dark blue-grey, acid volcanics the adamellite is finer-grained, suggesting that it may intrude these rocks. Truncation by the adamellite of banding in the volcanics, due to the alignment of xenoliths and possible xenocrysts, confirms this relationship. At this contact the volcanics, which in hand specimen resemble porphyritic felsites, are crowded with xenoliths and (?)xenocrysts which decrease in abundance westward away from the adamellite until only quartz (?)xenocrysts and feldspar (?)xenocrysts and phenocrysts remain in the dark groundmass. Continuing westward, the groundmass changes colour from dark blue-grey to buff and finally pink; also the phenocryst/(?)xenocryst ratio increases, and bi-pyramidal quartz appears in the pink porphyritic variety.

In Ollera Creek good exposures show the relationships between three porphyritic rock types and two granites. The earliest rock is a grey, medium to fine, porphyritic adamellite with feldspar phenocrysts. In places, it contains basic inclusions and a few rounded quartz blebs up to two inches long. It also contains rafts of gneiss of intermediate composition. These rafts generally trend north-west, but in detail are contorted and irregular in outline. Their origin is unknown. The porphyritic adamellite is extensively developed in the upper parts of Ollera Creek and on the Paluma Range road. Its relationship with the adamellite of the Rollingstone district is unknown. Also occurring in Ollera Creek is a pink porphyritic granite which contains xenoliths of the porphyritic adamellite, but no actual contact between the two masses was observed. This granite is in turn intruded by thin sheets and veins of pink porphyritic microgranite. A pink to red, epidotised granite, which may be related to the porphyritic granite, intrudes the porphyritic adamellite, but no exposures showing the mutual relationships of the two granites were found. In Little Crystal Creek north of the Paluma Range road this same epidotised granite intrudes the dark blue-grey acid volcanics which form the country rock of this area. Also on the Paluma Range road the adamellite is cut by dark blue-grey porphyritic dykes trending north-west, and by thin sheets of porphyritic hornblende-pyroxene dolerite.

In the Ollera Creek-Crystal Creek area, the contacts between rock types usually trend north-west. This is also the direction of dyke intrusion, epidote veining, and faulting, which suggests that many of the contacts are faulted or fault-controlled.

In the Townsville district there are numerous isolated occurrences of granite and related rocks whose relationships with the country rock are either masked by alluvium or otherwise not known. For these reasons they have been separated from the Permian-to-Mesozoic granites which intrude the Permo-Carboniferous sequence and from the Carboniferous(?) granites which unconformably underlie the same sequence.

The most prominent of these granites is that which forms Castle Hill, a ridge, elongate in a north-west direction, rising 938 feet above the city of Townsville. The unaltered rock is a coarse biotite granite. However, it is rarely found thus, being extensively sheared and epidotised along north-west-trending planes. In places, shearing is so intense that the granite has been mylonitised. In a quarry high on the western side of the hill, fresh grey granite and weathered, epidotised red granite are cut by dolerite dykes which strike north-west. Aplite veins in the granite are also sheared and epidotised. North-west of the summit the granite is cut by a dyke of weathered and extremely closely jointed, dark blue-grey rock with phenocrysts of quartz and feldspar. Its relationship to other dyke rocks of the area is not known.

Next to the oil storage depot at Townsville Harbour is a hillock composed of pink granite, with scattered phenocrysts of plagioclase, which is cut by veins of epidote. Unlike the granite of Castle Hill, this granite contains fine-grained basic inclusions, up to two feet long, with feldspar porphyroblasts.

At Kissing Point, a coarse, pink granite without inclusions occurs close to, but was not observed in contact with, a grey hornblende granodiorite which is crowded with fine-grained basic xenoliths. The granodiorite is cut by dolerite sheets striking 095° and dipping 45° southward, and by quartz veins striking 050° and dipping vertically.

Next to the cemetery to the north of Castle Hill is a low rise composed of a dark green rock with phenocrysts of quartz and feldspar. This rock is intruded by a probable dyke of dolerite or microdiorite.

At the eastern end of Mount Louisa is a very weathered red granite similar to that of Castle Hill. North of Mount Louisa, there are sporadic outcrops of pink microgranite with feldspar and euhedral quartz phenocrysts. Coarse granite and porphyritic microgranite also occur in the low ground marginal to the volcanic ridges which extend north from Mount Louisa to the Black River. In none of these places could the relationship of the granitic rocks and the volcanics be conclusively established.

In the neighbourhood of Stanley Siding and Antil Creek is an area of granitic porphyry, but its regional relationships are unknown. Just behind a disused quarry west of the highway one mile south of Stanley Siding, the rock is a red, massive adamellite porphyry with large phenocrysts of clear quartz and altered red plagioclase in an altered groundmass of quartz, plagioclase, and potash feldspar. Mafic minerals have been completely altered to aggregates of chlorite, epidote, ore minerals, and calcite. Farther south, near the right bank of Antil Creek, three quarters of a mile east of the highway, the rock is similar, but is generally green rather than red, and has a granodioritic composition: large phenocrysts of plagioclase (albite-oligoclase), quartz and some potash feldspar occur in a medium to fine groundmass of quartz, oligoclase, and potash feldspar.

At both localities the porphyries are intruded by felsite, microdiorite, and other fine-grained, probably intermediate, dykes.

A leucocratic, porphyritic microgranite is exposed in a road cutting one mile east-south-east of the Copper Refinery, Stuart. It consists of phenocrysts of quartz, potash feldspar, and albite in a microgranitic groundmass of quartz and potash feldspar, rare chloritised biotite, and clusters of epidote and magnetite.

A shattered and brecciated porphyritic, leucocratic microgranite occurs on a small rise one mile east of the Copper Refinery.

The relationships of both these bodies are unknown.

On a reconnaissance traverse around the northern slopes of Mount Stuart several occurrences of leucocratic, granitic rocks were observed. They cannot at present be correlated definitely with any of the other granitic rocks of Mount Stuart.

South of Major Creek near the border of the Townsville Sheet area, a small area of granitic rocks has been photo-interpreted amongst the Permo-Carboniferous volcanics. This area has a similar photo pattern to that of an area of brecciated, red, porphyritic microgranite which crops out two miles to the east in the Ayr Sheet area. Its field relationships are unknown, but it is intruded by microdiorite and dolerite dykes which are not brecciated.

At the south-western end of the Cape Cleveland hills, just within the Ayr 1:250,000 Sheet area, are outcrops of a gneissic adamellite. In the regional sense the boundary between this rock and the massive Permian-Mesozoic adamellite which forms the hills to the north transgresses the foliation in the gneissic adamellite at a high angle. Furthermore, Dr. P.J. Stephenson (pers.comm.) has found a similar relationship in outcrop, and there seems little doubt that the gneissic adamellite is intruded by the massive adamellite. The two rocks are of very similar composition.

On the crest of the central part of the Many Peaks Range rubble of red leucocratic granite and scattered outcrops of porphyritic microgranite occur amongst the volcanics which form the bulk of the Range. These granitic rocks apparently intrude the volcanics. Dr. Stephenson (pers.comm.) reported outcrops of granite on the northern flank of the Range.

One third of a mile west of the Alligator Creek ford, which is three quarters of a mile south-south-west of Alligator Creek Siding, is a low rise the top of which is strewn with boulders of coarse to medium hornblende-biotite granodiorite. The mafic minerals occur in clusters, and comprise about 30 percent of the rock.

An isolated outcrop of greenish-white, altered, coarse, intermediate rock, too small to be shown on the map, occurs near the western corner of the Saddle Mountain granite, where Killymoon Creek flows on to the coastal plain. This rock is strongly chloritised and epidotised; it is perhaps a hornblende-quartz monzonite.

North-west of Dotswood Homestead, roughly centred at Pall Mall yards, is an adamellite stock measuring some ten miles long and six miles wide. The long axis of this intrusion trends east-north-east. Wyatt (1962) named this mass the Pall Mall Adamellite. The adamellite is coarse-grained, and its colour ranges from pink to grey. In places it is distinctly porphyritic, and contains large phenocrysts of oligoclase, potash feldspar, and quartz in a finer-grained matrix consisting of the same minerals together with biotite (about 10 percent of rock), which in general is wholly or partly altered to chlorite.

The mass gives rise to rugged topography which in places is masked by a mantle of granitic sand derived from breakdown of the adamellite. The headwaters of Brimagee Creek have eroded a saucer-shaped depression out of the central part of the stock. The reason for the more rapid weathering of the central part compared with the marginal zone has not been established.

The youngest strata intruded by the Pall Mall Adamellite are Tournaisian in age. However, the Adamellite cuts across the fold pattern of the Devono-Carboniferous sequence, which pattern was probably not imposed until the orogeny closing the Palaeozoic. The Adamellite is, therefore, probably very late Palaeozoic in age.

Kitty O'Shea Intrusives

Intruding the Devono-Carboniferous sequence in the region about Mount Kitty O'Shea, north-west of Fanning River Homestead, are numerous andesitic dykes radiating from a small granodiorite (Pzb) intrusion at Mount Kitty O'Shea.

The dykes are normally porphyritic, and the ratio of phenocrysts to groundmass is extremely variable. The groundmass is invariably fine-grained, but the phenocrysts range up to three quarters of an inch long. Augite and plagioclase normally occur together as phenocrysts, but plagioclase also occurs alone.

The dykes are seldom more than ten to twelve feet wide, and are usually much less, four to six feet being the average. Some have been traced as far as one and a half miles.

A few small intrusives with oval outcrop occur, each covering an area of a few square chains. They are similar in composition to the dykes, and are undoubtedly derived from the same magma. They are usually intruded with the greatest length of outcrop parallel to the strike of the sediments. The dykes, on the other hand, are usually intruded across the strike, and most are normal or almost normal to it.

The majority of dykes are grouped in the sector between west-south-west and south-south-west. Another group, trending north-west and south-east of Mount Kitty O'Shea, forms a swarm some half a mile wide along the axial region of a large, open anticline in the Devono-Carboniferous sediments. A third group trends north and south from the Mount. No dykes have been recorded in the quadrant lying north-east of Mount Kitty O'Shea.

The dykes appear to have been emplaced along large-scale tension fractures produced either during folding of the Devono-Carboniferous strata or during upwelling of the granodiorite magma. Although it is known that slight warping and uplift of the Devono-Carboniferous strata took place at the end of the Tournaisian, it is unlikely that they were folded to their present form until the close of the Palaeozoic era. It was probably during this later folding that granodiorite intruded the core of the anticlinal structure, giving off dykes into tension fractures in the nearby country.

Light-coloured Rhyolite and Dacite (Pzh)

Distributed over a wide area of the Townsville Sheet area are some occurrences of presumably intrusive rocks of rhyolitic to dacitic composition. These rocks tend to form isolated, frequently conspicuous hills. All show flow banding, and are extremely fine-grained. Their colour is generally off-white to light grey-brown. Rarely are they porphyritic.

Many of these occurrences have a roughly circular, plug-like form - e.g., Mount Success, the intrusion three miles east-south-east of Marlow Homestead, and the intrusion five miles north-west of Battery Homestead. Others have a distinctly sheet-like form, and are commonly nearly parallel to the strike of the enclosing strata - e.g., Mount St. Michael and the intrusions five miles south of Dotswood, four miles west of Quilps Homestead, two miles south-east of Star Homestead, two and a half miles north of Laroona Homestead, and near Mount Keelbottom. The remaining occurrences shown on the map have forms which appear to be irregular or dyke-like.

Two of the occurrences have coarse fragmental material associated with them - e.g., on the north-eastern side of Mount Success, and five miles south of Dotswood. In both places the fragmental material is associated with flow-banded rhyolite. The Mount Success occurrence is somewhat similar to that at Broughton (Charters Towers 1:250,000 Sheet area), where a central rhyolitic intrusion is bordered to the east by intrusion breccia(?) and rhyolitic and intermediate flows.

The age of these intrusions is unknown. They have been emplaced into sediments ranging in age from Givetian to Tournaisian. No relationships which might establish their younger age limit have been found. They may have been intruded at the time when the acid volcanics of the Carboniferous were extruded, or possibly in the Permo-Carboniferous. A similar acid plug, Mount McConnel, in the Bowen 1:250,000 Sheet area, has been regarded as Tertiary (Malone et.al., 1962); such a young age can not be ruled out for any of these acid plugs. However, the occurrences north-west of Battery Homestead and east-south-east of Marlow Homestead are overlain by lateritic material which appears to belong to the main (Miocene) period of lateritization. The volcanics at Broughton on the Charters Towers Sheet area are older than the overlying Sellheim Formation (Pliocene-Pleistocene(?)).

Although all these light-coloured acid volcanics have been grouped together for the sake of mapping, there is no proof that they are the same age. For the present they are tentatively regarded as late Palaeozoic. They may even belong to the same period of intrusion as the dyke swarms in the Oweenee Granite.

Dyke Swarms in the Oweenee Granite

In the Oweenee Granite both south-west and north-east of the Sybil Graben are swarms of dykes which parallel the faults bounding the graben.

These dykes are quartz-feldspar porphyries, which are generally light grey or cream. Cameron (1901) records dolerite dykes at the Macauley Creek Mines, but these were not observed during the present survey.

The dykes occupy fractures which are obviously subsidiary to the main graben faults, and are therefore younger than Middle or Upper Carboniferous. They are possibly related to the intrusive rhyolite and dacite (Pzh).

Dolerite and Microdiorite (Pzi)

In the area between the head of Fryer's Creek, Dotswood Homestead, and the east branch of the Fanning River are a number of hillocks or low ridges composed of microdiorite or dolerite. They usually have an irregular outline, and overall dimensions rarely exceed one and a half miles by one mile. An exception to this is a dyke-like body nine miles north-west of Dotswood Homestead which appears on lithological similarity to belong to the same group of intrusives.

These rocks intrude the Ravenswood Granodiorite, the Givetian-Tournaisian sequence, and the unnamed volcanic/sedimentary sequence overlying the Percy Creek Volcanics. At the head of Fryer's Creek is a diorite which has been mapped with this group of intrusives, as it appears to be more closely related to them than to any of the other igneous rocks of the area. This diorite is intruded by late Palaeozoic granite.

Five miles north-east of Dotswood these rocks are confined to the noses of three tight folds in Upper Devonian strata. They do not appear to be folded themselves, so that they were probably intruded into weakened zones of the folds during or after the folding of these strata at the close of the Palaeozoic. Contrary evidence is provided by four similar bodies which crop out in the central zone of a syncline in Carboniferous volcanics and sediments north of Fanning River Homestead. Here the intrusives are so intimately associated with andesitic volcanics and pyroclastics as to suggest that they may have been feeders to the extrusives. Further mapping may prove the rocks in these two areas to be different, or prove different field relationships. For the present they have been grouped together for convenience in mapping, 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.

Massive Acid Porphyry grading to Microgranite (Pzp)

Closely associated with many of the late Palaeozoic granites are masses of porphyry which are undoubtedly related to the granites. Three main areas of such development have been noted -

(i) Between Ben Lomond East and Granite Creek, 17 miles north and north-north-east of Dotswood Homestead;

(ii) Between the Little Star and Great Star Rivers; and

(iii) East and north-east of Mount Halifax, south of Rollingstone

About Ben Lomond East is a mass of fine-grained, cream to pinkish-brown, quartz porphyry. Generally it is quite massive, and gives rise to steep, conspicuous hills which culminate in Ben Lomond East itself. However, flow banding does occur at its southern margin about Cattle Creek. On its southern and western margins it intrudes Upper Devonian-Lower Carboniferous sediments and Carboniferous volcanics, respectively. 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 into which it may be intruded, but the relationship is not clear.

East of Ben Lomond East, across Keelbottom Creek, is another hill composed of quartz or quartz-feldspar porphyry whose groundmass tends to be more greyish and slightly coarser-grained. The rock appears to be a finer-grained equivalent of some of the granitic rocks occurring immediately to the north. A similar porphyry occurs just east of Granite Creek, a tributary of Speed Creek.

Between the Great and Little Star Rivers are a number of irregular and sill-like bodies of porphyry which appear to be related to the Oweenee Granite, which lies to the west and north-west. They have a fine-grained matrix, and contain clear quartz phenocrysts which are commonly euhedral. Many grade to porphyritic micro-granite. These intrusions are not quite conformable with the Devono-Carboniferous sediments in which they are emplaced, but appear to dip south-eastward at a somewhat steeper angle. Preliminary studies of the structure of the sediments suggest that some of the intrusions may occupy high-angle reverse faults bordering the margin of the Granite.

North-east and east of Mount Halifax the porphyries are essentially porphyritic microgranites (see Photo Plate 12). They consist of phenocrysts, up to 3cm. long, of feldspar and euhedral or broken quartz, and pseudomorphs of chlorite and sphene, possibly after hornblende, in an intergranular groundmass of quartz and feldspar. Some of the quartz is resorbed, and the feldspar is commonly sericitised.

Magnetite and garnet occasionally occur as phenocrysts or xenocrysts. The porphyries are associated with adamellite, which generally occupies the low ground. Owing to difficulties in mapping in this rugged, rain-forest area, most occurrences of porphyritic microgranite have been mapped with the granite (Pzug) of the Paluma Range. Three occurrences near Kurukan have, however, been shown separately as porphyry.

The age of these porphyries is probably similar to that of the associated granitic rocks, and probably ranges from Carboniferous to Permian.

PERMIAN TO MESOZOIC

Granites (P-Mg)

In the Townsville-Woodstock area are several granite bodies which intrude the Permo-Carboniferous volcanic/sedimentary sequence. The massive nature of these granites and their possibly faulted margins give rise to rugged mountains with precipitous slopes, such as Mount Elliott, Saddle Mountain, Mount Stuart, and Magnetic Island.

These granites are younger than some of the dark dykes which intrude the Permo-Carboniferous Volcanics. Therefore it seems unlikely that they are older than Upper Permian. In view of some Lower Cretaceous isotopic ages recently obtained from granites west of Proserpine (A.W. Webb, pers.comm.), a Lower Cretaceous age can not be ruled out for these young granites of the Townsville district.

(a) Mount Elliott

Mount Elliott is the highest peak of a rugged and precipitous granite range which rises to over 4000 feet above sea level. The granite has been intruded as one elliptical stock, measuring twelve miles by nine, with well defined curvi-linear margins. The margins have been strikingly exposed by differential erosion, which has possibly been accentuated by faulting. The centre of the stock has been deeply eroded by the headwaters of Major's Creek.

Only the margins of the granite were examined during this survey, and they were found to be rather uniform, both lithologically and texturally. The rock is a pink, coarse, porphyritic granite (sensu stricto) with large, deep pink, potash feldspar phenocrysts averaging 1cm. in length. The groundmass consists of coarse, zoned plagioclase (andesine to albite), partly chloritized biotite, green hornblende, and minor magnetite, apatite, zircon, epidote, and orthite. Dr. P.J. Stephenson (pers.comm.) reported outcrops of dioritic rock near the head of Major Creek.

Microgranite occurs in a narrow zone near the contact, and also as a sheet-like body intruding volcanic breccia in the north-eastern foothills. Volcanics south-west of Mount Elliott are recrystallized; the granite, therefore, probably intruded the volcanics, but no exposures were seen which conclusively proved an intrusive relationship.

(b) Saddle Mountain

Saddle Mountain is a granite stock (about 4 miles across) situated immediately north-east of the Mount Elliott stock. The summit of Saddle Mountain rises to 2800 feet; it lies just east of the Sheet area. The Saddle Mountain stock covers about sixteen square miles; it has rather straight sides, best seen in the Ayr Sheet area.

As with Mount Elliott, only the margins of the stock were examined; however, the rocks around the margin of Saddle Mountain are more variable in their lithology and texture than those of Mount Elliott. Among rock types recorded are pink, medium-grained leucogranite with strong granophyric intergrowths; red, drusy leucocratic microadamellite with fine micrographic intergrowths and a little chloritised biotite; the microgranite locally developed at the contact. Boulders of medium-grained hornblende-quartz gabbro were found in a small creek which flows across the granite contact 1½ miles south-east of Hidden Vale Homestead. The gabbro consists of labradorite, hornblende, pyroxene commonly enclosed in hornblende, minor potash feldspar associated with quartz, and accessory epidote, magnetite, sphene, and apatite. This gabbro may perhaps be related to the earlier of the two phases of basic dykes seen on Magnetic Island. Similar small boulders occur near the south-eastern flank of Saddle Mountain (Ayr 1:250,000 Sheet area). These are cut by thin pegmatite veins, which may indicate that they are older than the granite.

Andalusite in quartzite near the north-eastern margin of the Saddle Mountain granite is probably a result of the intrusion of the granite; the age of this quartzite is, however, unknown. Nevertheless, the development of microgranite near the contact, and the well defined stock-like form, indicate that the Saddle Mountain granite is also intrusive into the Permo-Carboniferous volcanics.

(c) Magnetic Island

Most of Magnetic Island consists of adamellite which intrudes probable Permo-Carboniferous volcanics. The volcanics are confined, as far as is known, to an area of about one square mile at the western end of the island. The adamellite is medium to coarse, leucocratic, and slightly porphyritic in feldspar. Accessory, partly chloritised biotite, ore minerals, and zircon also occur. Irregular patches of pegmatite occur in the adamellite and agglomerate close to the contact at Hungtingfield Bay. Thin aplite veins cut both rock-types. Sporadic druses in the adamellite have quartz-albite-epidote (P.J. Stephenson, pers.comm.) and pegmatitic infillings. Rare rounded xenoliths of a darker, medium-grained rock, apparently granodiorite, occur in the adamellite. They may represent remnants of a contaminated border phase.

(d) Cape Cleveland

The major part of the Cape Cleveland Peninsula (mostly in the Ayr 1:250,000 Sheet area) consists of adamellite which intrudes probable Permo-Carboniferous volcanics at the northern end of the cape. The adamellite is considerably coarser than the Magnetic Island adamellite. It is a massive, leucocratic, coarsely porphyritic rock, with pink perthite phenocrysts up to 3cm. long in a coarse, pale greenish-grey groundmass of quartz, zoned plagioclase, and biotite and hornblende (together about 5 percent). Dykes of felsite and granophyre which intrude the volcanics at the Cape are probably genetically related to the adamellite, as they appear to thicken southwards towards it; they may in fact be off-shoots of it.

(e) Mount Stuart

The centre of Mount Stuart consists of a small circular stock ranging in composition from hornblende-quartz monzonite to leucogranite. This stock intrudes Permo-Carboniferous volcanics, and possibly intrudes granite, with which it is in contact in the west and north.

Although Mount Stuart was given more attention than the rest of the Townsville district, field work revealed merely a varied suite of rocks, whose mutual relations are still largely unknown. At the summit, the rock is an intrusion breccia (see Photo Plate 10). It consists of closely packed, rounded xenoliths of fine, grey-brown micrographic rock, rich in mafics, embedded in a matrix of medium-grained micrographic adamellite. The xenoliths range from microgranite to very fine hornblende-quartz syenite and hornblende-quartz monzonite. These rocks contain both brown-green and blue-green hornblende and conspicuous acicular crystals of actinolitic amphibole. They also contain accessory magnetite, epidote, sphene, and chlorite. The adamellite forming the matrix of the breccia is porphyritic with plagioclase phenocrysts in a groundmass of quartz, feldspar, and hornblende; accessory minerals are magnetite, epidote, sphene, and chlorite. The xenoliths have partly resorbed and recrystallized margins.

Permeating the intrusion breccia are irregular veins and ill-defined patches of a pink, medium-grained hornblende granite which in places can be seen to intrude the adamellite.

The whole complex is traversed by a sparse network of epidotised aplite veins. Disseminated pyrite and chalcopyrite occur in these rocks at the summit.

Massive adamellite or quartz monzonite of similar composition to, but of coarser grain than, the rocks described above crops out half a mile south-east of the summit (Photo Plate 11). Coarse red granite occurs near the eastern margin of the central stock on a ridge 1½ miles south-east of the summit.

Photo Plate 10: Granitic intrusion-breccia (P-Mg), summit of Mount Stuart, five miles south of Townsville. Outcrop beside road, near television station.

Xenoliths of sparsely porphyritic, mafic-rich microgranite to micromonzonite in a matrix of strongly porphyritic and somewhat coarser micrographic hornblende adamellite. The xenoliths are closely packed and moderately rounded; they have dark, recrystallized rims.

B.M.R. Neg. No. G/6817.

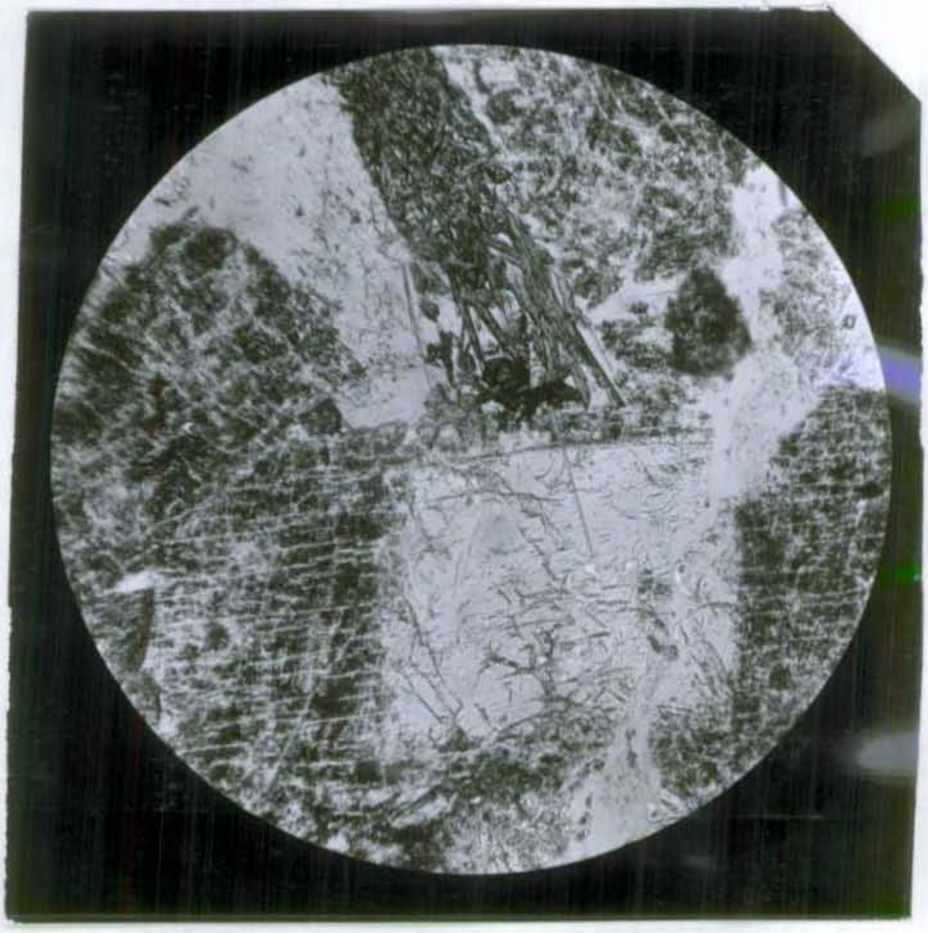


Photo Plate 11: Adamellite or quartz monzonite (P-Mg) at roadside, ½ mile south-southeast of summit of Mount Stuart. The rock consists of turbid alkali feldspar, plagioclase, quartz, hornblende, chlorite, sphene, and epidote. At the top of the photograph acicular hornblende is associated with plagioclase and sphene; a needle of hornblende extends into the large zoned plagioclase crystal in the low 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 polarised light, X45. Microslide No. B.M.R.15660.
B.M.R. Neg. No. G/6741.

Other rock types recorded in the Mount Stuart area, and regarded as part of the central stock, include:-

1. Coarse, pink micrographic leucogranite in Sachs Creek, 2½ miles south-south-east of the summit.

2. Red, leucocratic, quartz microsyenite in a creek bed 2½ miles south of the summit.

3. Coarse, pink to grey, micrographic hornblende adamellite or quartz monzonite with prominent laths of hornblende and plagioclase in a creek bed 2½ miles south-south-west of the summit.

4. Medium, pink to buff, micrographic leucogranite with hornblende and biotite, or with abundant acicular hornblende crystals, occurring on the ridges flanking the western side of Mount Stuart.

Red, blocky, porphyritic quartz microsyenite lithologically similar to much of the rock of the central stock of Mount Stuart occurs in the bed of Ross River near its junction with Five Head Creek.

Microgranite crops out in a north-westerly trending belt in the south-western foothills of Mount Stuart (Dr. P.J. Stephenson, pers.comm.); this probably also intrudes the Permo-Carboniferous volcanics.

No actual contact between the central stock and the surrounding rocks was observed in the field, but on regional structure and form the stock is regarded as intrusive into the surrounding granites and volcanics. Maitland (1892) regarded Mount Stuart as a volcanic vent or neck. However, the textures of the various rock-types indicate that they cooled beneath a mantle of country rock, and it is likely that the intrusion did not rise as far towards the surface as is implied by Maitland's terms "vent" or "neck". Hence the term "stock" is used in this report. Part of what may have been the roof rocks still remains near a small dam half a mile south-west of the summit where dark aphanitic volcanic rocks appear to dip 10° to the south-south east. These volcanics rest on rocks similar to those occurring at the summit, but they show no obvious contact metamorphic effects in thin section. The close proximity of the roof is also suggested by intrusion breccia at the summit of Mount Stuart.

The northern and north-eastern margins of the stock are very sharp, and can be readily photo-interpreted; they are probably marked by faults. Photo-interpretation of the remainder of the margin is difficult, and the boundary shown on the map is dependent on one reconnaissance traverse only.

When viewed from the north, the vertically jointed cliff escarpment of Mount Stuart suggests that the summit may be formed by a shallowly dipping, sill-like intrusion. However, closer examination did not support this interpretation.

Rocks of the central stock are intruded by felsite (including keratophyre) and dolerite dykes.

(f) The Sisters Mountains

Erratic boulders of medium to coarse pink "granite", with large laths of hornblende and plagioclase, occur in a creek bed two miles north-east of the summit of The Sisters Mountains. These floaters were probably derived from a small body intruded into the volcanics near the headwaters of the creek. In hand specimen the rock closely resembles the hornblende adamellite or quartz monzonite of Mount Stuart.

Dykes

Dykes are a feature of the Townsville neighbourhood. They appear to have been emplaced largely during the Permo-Carboniferous igneous activity although some dykes may be younger: very few rock outcrops of appreciable extent were observed, especially among the volcanics, that were not intruded by dykes. Excellent exposures showing typical basic and acid dykes can be seen at Huntingfield Bay on Magnetic Island, and at Cape Cleveland (Ayr Sheet area).

The dykes can be subdivided into two broad groups; dark (basic to intermediate) and pale (felsitic). The basic to intermediate dykes seem to occur everywhere. The pale dykes are not found far from the Permian-to-Mesozoic granites, to which they seem to be genetically related.

In places the relative ages of individual dykes can be elucidated in outcrop. At Huntingfield Bay on Magnetic Island (Photo Plates 13 and 14) a basic dyke has been cut by a felsite dyke. The felsite dyke is truncated by granite which is itself intruded by other dark dykes. Here the dark dykes clearly belong to separate episodes of intrusion. On Rattlesnake Island (Photo Plate 12) and Acheron Island (which lies just within the Ingham 1:250,000 Sheet area to the north) dark dykes intersect other dark dykes, but whether or not they represent more than one intrusive episode is uncertain, because no major igneous event, e.g., granite intrusion, is known to have intervened. On the mainland, in the rare places where dark and pale dykes were seen in contact, the dark dykes are invariably younger.

Photo Plate 12: Northern coast of Rattlesnake Island. Basic to intermediate dykes in two swarms, here intersecting at right angles. The country rock is a pale grey, massive porphyry (Pzp). The dykes are probably Permian.

B.M.R. Neg. No. M287/27.

Basic to Intermediate Dykes

The earlier of the two dark dykes at Huntingfield Bay, although hornfelsed by nearby granite, is recognizable as a dolerite. It consists of labradorite, hornblende, biotite (as a thermal metamorphic product), and rare pyroxene. The later dyke, by contrast, is a very fine-grained microdiorite with large embayed crystals of quartz (possibly xenocrysts) sparsely scattered among microlites of oligoclase, pale brown hornblende, and rare pyroxene.

The Magnetic Island granite is intermediate in age between these two dark dykes, which themselves are sufficiently distinctive to tempt one to postulate a two-fold division of melanocratic dykes in the Townsville district, i.e., an earlier dolerite suite, and a later microdiorite one. However, although about 30 specimens of melanocratic dykes were sectioned, brief examination reveals that they do not fall easily into two groups. Certainly some are microdiorites, and others (the majority) are dolerites, but still others cannot easily be assigned to either category. The dolerites frequently contain appreciable amounts of interstitial quartz and potash feldspar, and tend to be albitic.

The dark dykes are commonly four to five feet thick, but one twenty feet thick was seen, and others (mostly apophyses) range down to less than one inch in width. The strike direction of the dykes is predominantly north-west, but north-east and north-south dykes are also known.

Felsite Dykes

The term "felsite" is used to denote a pale-coloured, acid dyke rock. These dykes are locally very abundant, and appear to be closely related to the Permian-to-Mesozoic granites. Typically they are leucocratic rhyolites and soda rhyolites, with or without quartz and feldspar phenocrysts, and they are almost invariably flow-banded. Albitic quartz trachytes, or quartz keratophyres, and leucocratic micro-adamellites were also recorded.

The banding may be either parallel to the margins, or broadly plicated, or even highly contorted. Spherulitic texture is common, and small pyrite cubes occur locally. In some thin sections epidote, calcite and sericite were seen as abundant alteration products.

The felsite dykes are usually twenty to thirty feet thick. In places, outcrops are too small to expose the contacts, making it difficult to recognize the bodies as dykes.

These dykes are well exposed in the upper part of Alligator Creek just south of its confluence with Cockatoo Creek. Dolerite dykes are also abundant at this locality.

Photo Plate 13: Huntingfield Bay, Magnetic Island. Adamellite, P-Mg (which forms most of the island) intruding and truncating sinuous flow-banding in a felsite dyke. The felsite has been recrystallized to a siliceous mosaic. Corrosion by salt spray has given rise to a pock-marked weathered surface in the adamellite. Fig. 2 illustrates diagrammatically the relationship of rock units at this locality.

B.M.R. Neg. No. G/6826.

Photo Plate 14: A few yards north-west of photo plate 13.
A thin aplite dyke (from nearby adamellite P-Mg) intruding a coarse agglomerate(C-Pv) and a dolerite dyke.
B.M.R. Neg. No. G/6822.

Rock Types and Field Relationships

(a) Magnetic Island: (see Photo-Plates 13 and 14)

At Huntingfield Bay the following order of emplacement can be observed (see Fig. 2):

(1) Agglomerate and volcanic breccia
(2) Dolerite dyke
(3) Felsite dyke
(4) Adamellite and aplite
(5) Microdiorite dykes

At West Point, the volcanics are intruded by dykes of dolerite and hydrothermally altered quartz-feldspar porphyry, but the two dykes were not seen in contact. No evidence was found to indicate where these dykes fit into the sequence of intrusion seen at Huntingfield Bay. In texture and general aspect the quartz-feldspar porphyry dykes are unlike the typical felsites.

(b) Many Peaks Range:

Some of the flow-banded rocks of this area may be intrusive, as mentioned in the section on volcanics. They resemble felsite dykes known elsewhere. Banding is sub-vertical, and its strike ranges from 020° to 125°. About the middle of the Range, on its southern slopes, rhyolite (or felsite) is intruded by thin north-west striking dolerite dykes, which consist of phenocrysts of basic plagioclase, green hornblende, violet titanaugite, magnetite, rare quartz, and patches of secondary chlorite and carbonate.

(c) Muntalunga Range:

Dark, north-north-east-striking dykes, five to six feet wide, intrude coarse leucogranite in the centre of the range. They consist of calcic plagioclase, brown basaltic hornblende, a little clinopyroxene, some quartz, and magnetite, epidote, chlorite and calcite. One dyke, on the northern flank of the range, is intersected by thin concordant veins of hornblende aplite. Somewhat coarser, porphyritic dolerite dykes intrude both granite and volcanics in the eastern foothills across the railway line.

(d) Southern White's Creek Valley:

Augite-biotite andesites observed in this area may be intrusive, but their field relationships were not seen. Some floaters of altered alunite-bearing albite dolerite were also found. This rock consists of albite, clinopyroxene, chlorite, magnetite, alunite, and a little free quartz. It is uncertain whether or not the albite is primary. The alunite is presumed to by hydrothermal in origin. It may be natro-alunite, in view of the soda content of the rock.

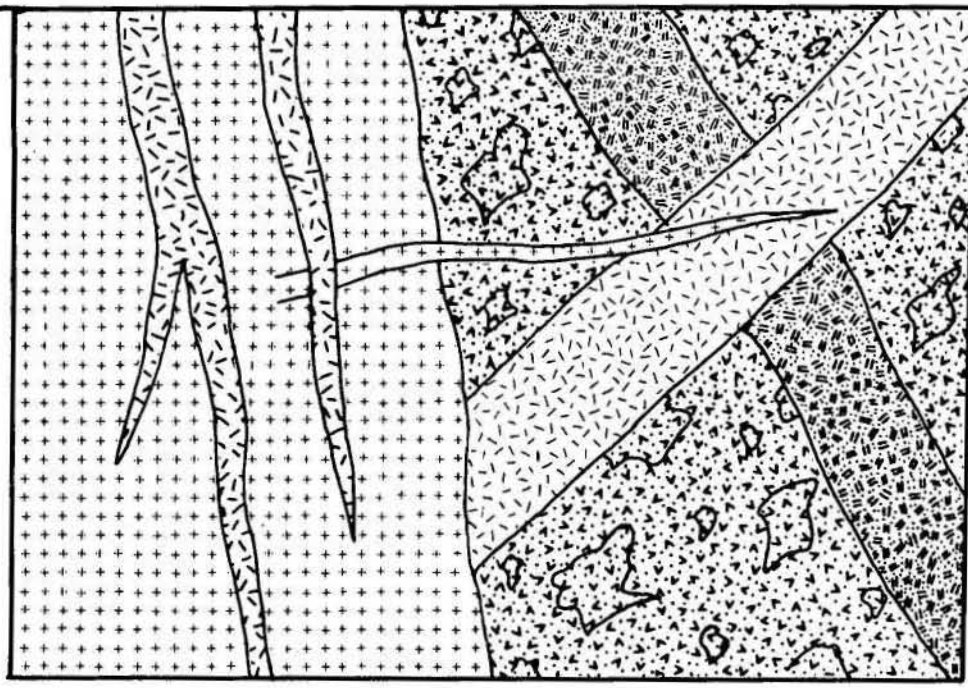
FIG. 2

DIAGRAMMATIC SKETCH PLAN

— showing —

RELATIONSHIPS BETWEEN PERMIAN VOLCANICS, DYKES AND ADAMELLITE NEAR HUNTINGFIELD BAY, MAGNETIC ISLAND

(Townsville 1:250,000 Sheet Area)



— Reference showing —

Rock types in order of emplacement

1 *Agglomerate*

2 *Dolerite*

3 *Flow-banded felsite*

4 *Adamellite*
Aplite

5 *Microdiorite*

(e) Mount Stuart:

Dykes of brown porphyritic keratophyre intrude granitic rocks of the central stock beside the road within two and a half miles of the summit. They consist of phenocrysts of albite (partly altered to carbonate and sericite) in a hypidiomorphic groundmass of albite, potash feldspar, quartz, chlorite, and magnetite. These dykes strike 095° to 125°.

In the right bank of the Ross River at its confluence with Five Head Creek a sill of pale brown quartz keratophyre intrudes conglomerate which dips steelpy to the east-north-east. This dyke consists of phenocrysts of albite in a fine-grained hypidiomorphic groundmass of potash feldspar, quartz, and albite. Some biotite occurs in fine-grained aggregates. In the bed of the Ross River near the opposite (left) bank, apparent multiple dykes of basic to intermediate aspect strike 130°. Their country rock was not exposed. They are intruded by small aplite veins, and enclose small ovoid fragments of rock containing acicular hornblende similar to that at the summit of Mount Stuart.

Two miles south-east of the summit of Mount Stuart, dykes of dark greenish blue, spherulitic, albite rhyolite striking 100° intrude granite. About half a mile west of this outcrop a dolerite dyke twenty feet wide, and striking 120°, intrudes microsyenite. Coatings of pyrite or marcasite were noticed. The contacts of the dyke are jagged and re-entrant, implying fracturing of the granite in several directions before intrusion of the dyke. This dyke consists of calcic plagioclase, magnetite, green hornblende, violet titanaugite, chlorite, and rare quartz.

(f) Village of Stuart:

On the hillside where conglomerate overlies granite (see section on (?)Carboniferous granite), a thin dyke of rhyolite or rhyodacite has been intruded along a small fault between granite and conglomerate. The dyke consists of xenomorphic quartz and phenocrysts of plagioclase in a murky, fine-grained groundmass of probable potash feldspar, plagioclase, quartz, and devitrified (?)glass, but no recognizable mafics. A short distance away an apparent dyke of coarser, mauve-brown, porphyritic rhyodacite intrudes the granite. It consists of phenocrysts of potash feldspar and oligoclase in a groundmass of plagioclase, xenomorphic quartz, some chlorite, and finely disseminated ore. The phenocrysts are largely altered to calcite and chlorite. Farther down the hill a six feet wide dyke of decomposed dolerite striking 120° intrudes pink aphanitic rhyolite (probably also a dyke).

(g) South-east of Townsville Gaol:

Half a mile south-east of the gaol, dykes of white, fluidal soda-rhyolite intrude granite (Cg). The banding dips at 40° towards the west-north-west, and strikes 200°. The rhyolite consists of rare glomerocrysts of albite and small glomerocrysts of quartz in a medium- to fine-grained hypidiomorphic quartz-alkali feldspar groundmass. A few patches of fine sericite, usually associated with quartz, also occur.

(h) The Sisters Mountains:

In a traverse through the Sisters Mountains abundant blocks of dolerite were found on the hill slopes, but no actual dykes were observed.

(i) Woodstock Hill:

Rubble of spherulitic, flow-banded rhyolite(?) was found near the base of the hill immediately to the south of Woodstock Hill. These may have been shed from dykes. Near the top of the hill typical dolerites (locally pyrite-bearing) intrude pyroxene andesite on a north-west strike. The pyrite may have been introduced with small quartz veins.

(j) Mount Elliott-Saddle Mountain

Near the western corner of the Saddle Mountain granite, a dyke of coarsely porphyritic microdiorite (or dolerite), three feet wide, intrudes a large boulder of welded tuff. The rock contains hornblende and some uralite, a little quartz, and plagioclase with An content greater than 50.

In upper Alligator Creek, thick, flow-banded dykes of rhyolite and albite rhyolite intrude massive volcanic breccia with a predominant north-north-east strike. Flow-banding throughout the thickest dyke (400-500 feet) is very contorted, but in the thinner ones (20-30 feet) it is usually parallel to the margins and absent in the centres. Biotite occurs sparsely in the groundmass of these dykes, which are all strongly epidotised. Pyrite cubes are common. A swarm of dolerite dykes, averaging four to six feet in width, intrudes the felsite dykes on a regional east-south-east strike. These dykes contain colourless clinopyroxene and rare potash feldspar and quartz.

At Spur End (south-western tip of Mount Elliott), dark, porphyritic rhyolite intrudes recrystallized volcanics. This rhyolite consists of large pink phenocrysts and glomerocrysts of alkali feldspar (including microcline or anorthoclase(?))in a dark blue, aphanitic, devitrified groundmass containing a few corroded flakes of partly chloritized brown biotite.

Age of the Dykes

(1) Dark Dykes:

Some melanocratic dykes are known to be intermediate in age between the volcanics of Magnetic Island, which are assumed to be Permo-Carboniferous, and granite (P-Mg), which intrudes the volcanics. Such dykes may reasonably be regarded as Permian in age.

Other melanocratic dykes intrude the youngest granites. The age of these granites is unknown; as discussed above, they are probably upper Permian, but they may possibly be Mesozoic, by analogy with granites near Proserpine. It is considered unlikely that the dykes which intrude them are related to the Cainozoic basalts. The nearest occurrences of such basalt are small plugs east and south-east of Fanning River Homestead and some 35 miles south-west of Stuart, or as a sill intruding the basal beds of the Ellenvale Formation about 28 miles south-south-west of Stuart. These are typical olivine basalts similar to the flood basalts of North Queensland. The dykes of the Townsville-Stuart area, however, are quite free from olivine, and tend, if anything, to be slightly tholeiitic. These compositional differences suggest that the dykes are not related to the Cainozoic olivine basalts, but represent a phase of the igneous activity which gave rise to the youngest granites.

FFurthermore, the dykes are frequently jointed and faulted, and have clearly been affected by later tectonic events. Earth movements are known in the Cainozoic, and it was probably during some of these movements that fractures were formed or re-opened, thus allowing for the intrusion of the olivine basalt mentioned above. If this fracturing and that affecting the dykes took place at the same time, the dykes must be older than the Cainozoic basalt. This then allows a period ranging from the close of the Palaeozoic to, say, middle Tertiary times for intrusion of these dykes. However, the most likely possibility is that they are part and parcel of the igneous activity closing the Palaeozoic.

(2) Pale Dykes:

These dykes appear to be closely associated with the Permian-Mesozoic granites. At the Magnetic Island locality, (Huntingfield Bay) a felsite dyke is intruded by one of these granites. On Mount Stuart a keratophyre dyke intrudes another of these granites. Broadly speaking these dykes are considered to be essentially contemporaneous with the Permian granites, and may, in places, be offshoots from them.

MESOZOIC(?)

No strata positively identified as Mesozoic have been recognized in the Townsville Sheet area. However, Mingela Bluff, which rises above the alluvial plain of the Haughton Valley, consists of a sequence of sandstones which may be of this age.

These sediments were first described by Jack (1879a, pp.8-9) who tentatively suggested that they were younger than "at least part of the Devonian about Dotswood but older than the Desert Sandstone". Jack did not name these strata, and they are here described as the Collopy Formation.

Collopy Formation (Mc)

This formation takes its name from Collopy Holding where the main development of these strata forms Mingela Bluff, a part of the Leichhardt Range. In this area it covers about five square miles. An area of similar size (three and a half square miles) in the headwaters of the Kirk River, two miles west of Bunkers Hill, is occupied by coarse sandstone. This sandstone appears to be the remnant of what was originally an extensive sub-horizontal sheet, and is here correlated with the sandstone at Mingela Bluff.

The Formation consists chiefly of medium to coarse micaceous sandstone, coarse quartz sandstone and feldspathic sandstone, arkose, and conglomerate. The type section has been measured in a cliff section of Mingela Bluff at longitude 146° 42' 52"E and latitude 19° 53' 26"S. At the base of the section is coarse, micaceous, feldspathic sandstone and lesser, clean quartz sandstone. Thin conglomeratic bands, composed largely of moderately well rounded milky quartz, are common. About one hundred feet up the section is a thick (fifty feet) band of conglomerate containing rounded cobbles of quartz, quartzite, quartz porphyry, microgranite, volcanics, and shale averaging about two inches in diameter. In the upper two hundred feet, beds of coarse sandstone separate sections up to fifty feet thick of relatively thin-bedded, fine, micaceous, feldspathic sandstone. Two indeterminate fragments of plant stems were observed in these finer sandstones. Where very micaceous, these sandstones weather readily, and large caves and overhangs have become etched in the cliff face. Coarser feldspathic sandstones occupy the topmost fifty feet. The estimated thickness of this section is five hundred feet but a slightly thicker development probably occurs at the eastern end of the Bluff.

Current-bedding is widely developed in the Formation. Bedding is thick - generally of the order of twenty feet - irregular, and laterally discontinuous. The overall colour of the sediments is light brown, but in places they are reddish brown.

At Mingela Bluff the strata have an average dip of 10° to the south-east, but two miles north-east of Grass Hut they are horizontal. A major, east-north-east-trending, transcurrent fault which displaces the Collopy Formation causes local higher dips.

West of Bunkers Hill are mainly coarse quartz sandstone and coarse, conglomeratic, lithic sandstone containing granite and volcanic phenoclasts.

The Collopy Formation unconformably overlies sheared granite and granodiorite of the Ravenswood Granodiorite. West of Bunkers Hill the sandstones overlie microgranite of the Ravenswood Granodiorite which is here intruded by dyke swarms of rhyolite, andesite, and microgranite. These dykes do not intrude the Collopy Formation. In this area the base of the sandstone is at much the same level as the present erosional surface of the Kirk River Beds, and it is quite probable that the Collopy Formation once overlay the Kirk River Beds.

The sediments appear to be of fresh water origin, but in the absence of more information this cannot be confirmed.

The age of the Formation is unknown. Somewhat similar sandstones occur in the Just Range twenty-five miles south-west of Charters Towers. The Just Range strata are regarded as an outlier of the Lower Triassic Warang Sandstone which forms part of the Mesozoic sequence of the Great Artesian Basin. The Collopy Formation may be of similar age.

CAINOZOIC

Except for a narrow belt of marine deposits along the present coast line, all deposits of Cainozoic age cropping out in the Townsville 1:250,000 Sheet area are of continental origin. They comprise lacustrine and fluviatile deposits and basalt.

Lateritic profiles as an aid to subdividing the Cainozoic

An important feature of the Cainozoic continental deposits is the preservation of zones of laterite and/or ferricrete. Two lateritic weathering profiles are known to have developed at different times during the Cainozoic: the older and thicker profile is thought to represent the main period of lateritisation in Australia (Miocene?); the younger profile (Pliocene?) has been developed in the Campaspe Beds, which disconformably overlie the older profile (for example, at Red Falls on Lolworth Creek). The younger profile can be positively identified only on the Campaspe Beds.

If these zones are to prove useful as markers for the subdivision of the Cainozoic sediments then it is imperative that they be distinguishable from each other. Unfortunately this is not always possible. A number of features which may eventually prove to be criteria for the separation of these ferricretes are set out as follows:-

Feature	Older Ferricrete	Younger Ferricrete
Thickness	25'-30', commonly more, seldon less	About 5', but frequently less
Colour	General red aspect	General brown aspect
Profile	3'-6' iron-rich zone, generally of scoriaceous appearance, grading downswards into mottled and pallid zones and altered parent rock	1'-2' generally nodular, iron-rich zone passing rather suddently downwards into mottled zone and apparently unaltered parent rock
Topographic expression	Tends to form prominent mesas up to 40' high. Tops of mesas form part of an old Miocene peneplain	May form a low step 3'-4' high, but frequently gives no topographic expression. Where developed on Campaspe Beds a vague scarp borders the interfluvial flats. Level of ferricrete does not suggest that it is part of a peneplain surface
Soil	Gives sandy soil, occasionally with buckshot gravel	Gives sandy soil, usually with buckshot gravel

These characteristics are derived essentially from exposures in the Red Falls area, where the two zones can be seen separated by the Campaspe Beds. Using these two zones the Cainozoic deposits may then be subdivided as follows:-

(1) those deposited prior to the first ferricrete, e.g., those typically developed in the Featherby Wall, west of Charters Towers, and those which form the falls at Red Falls;

(2) those deposited between the first and second ferricrete, e.g., the Campaspe Beds and possibly the Lassie Creek Gravels; and

(3) those deposited after the second ferricrete, e.g., the Sellheim Formation, recent river alluvia, and colluvium and alluvia of the coastal region.

Evidence as to the age of the basalts relative to these ferricrete zones is, in part, conflicting. Some, for example the Toomba Basalt, are definitely later than the second ferricrete. The Nulla Basalt shows evidence in places of being older than the first ferricrete, whereas in other places it shows evidence of being younger than the second ferricrete. However, this basalt was probably extruded over a considerable period.

Consideration of the present day physiography and of the geomorphological expression of the Cainozoic rock units and their depositional environments suggests that the history of the Cainozoic era may be far more complex than usually considered,

Cainozoic Geological History
Probable Range of Rock Units

Fig. 3

	Epoch	Sedimentation	Fossil Remains	Volcanic Activity	Tectonics	Process
QUATERNARY	Present Recent	*Coastal dunes, strand lines and associated deposits* *Lacustrine deposits*	*Marine shells* *Diatoms* *? Unio*	*Toomba Basalt*	? Renewed Uplift	*General period of degradation inland*
	Pleistocene	*River alluvia* *Colluvium and Alluvia of coastal plain*				*General period of aggradation*
TERTIARY	Pliocene	*Sellheim Formation and Lassie Creek Gravels* *Campaspe Beds*	*Diprotodontus* *Fossil wood*	*Nulla Basalt*	Uplift with Faulting	*Generally a period of degradation* *Ferricrete development*
	Miocene					*Active erosion of highs, deposition in lows* *Lateritisation*
	Oligocene					
	Eocene	*Unnamed sediments as at Featherby Wall*	*Dicotyledonous plants*		Stable	*Peneplanation*

as well as being more complex than represented above. A simplified history is given in Figure 3.

A further point worth considering in the light of the apparent restriction of the second ferricrete to the Campaspe Beds, is that its development is due to some inherent property of these Beds. If this is so, then some of the formations shown above as being younger than the Campaspe Beds, could, in fact, be of similar age, as they may not possess this property. However, all these formations appear to have closely similar lithologies, and it is very unlikely that, if all are of the same age, the second period of ferruginisation would have affected only the Campaspe Beds. Other considerations, which will be mentioned under the appropriate formations, also indicate that those formations not possessing a ferricrete development are younger than the Campaspe Beds.

Unnamed Tertiary Sediments
(not shown on map)

Underlying the laterite capping between Southern Cross Creek and Sandy Creek is a sequence, fifty feet thick, of horizontal sandstone and shale which has been lateritised in its upper levels. This sequence appears to be lithologically similar to that at Little Red Bluff and Featherby Wall, near Charters Towers (Charters Towers 1:250,000 Sheet area), which has been described by Morton (1945) as well as by Jack (1879a), Marks (1913), Reid (1917), and Saint-Smith (1921). Dicotyledonous Tertiary plant remains have been found in these beds near Charters Towers.

The sediments occupied depressions in a granitic terrain prior to the Miocene peneplanation. The contact of the sediment and granite can now be seen only in cliff sections of the laterite mesas. Sandy soils, derived from the erosion of both lateritised granite and sediments, frequently border the mesas, and obscure the contact. As it is not possible to extrapolate beneath the laterite cover, and as exposures of contacts in cliff faces are scarce, it has not been possible to differentiate these Tertiary sediments on the map.

Other sediments which appear to have suffered the same degree of lateritisation occur on the Oweenee Granite or along its borders. These sediments consist of redistributed granite debris, and form a piedmont deposit at the foot of the high country occupied by the Oweenee Granite. This piedmont spreads out over the northern part of the Nulla Basalt which here must be older than the lateritised sediments.

The mode of occurrence of these sediments is more in keeping with that of the Campaspe Beds rather than those at Featherby or Little Red Bluff, where they appear to be lacustrine deposits laid down in depressions on a granite basement of moderate relief (Morton, 1945). They may, therefore, be equated with the Campaspe Beds, in which case they were affected by the second period of ferricrete development, and not the first. If this is so, then degree of lateritisation is no criterion for subdivision of the Cainozoic strata.

Campaspe Beds (Tc)

Thin Cainozoic sediments occurring between the Cape and Campaspe Rivers (Hughenden 1:250,000 Sheet area) were mapped variously as the "Cape-Campaspe Series" and the "Campaspe-Cape Series" by Dunstan, (1913). The present survey has shown that these strata extend over a wide area in the Hughenden, Charters Towers, and Townsville Sheet areas. "Campaspe Beds" has been accepted as a formal name for these strata; Red Falls on Lolworth Creek is the type locality. In the Townsville Sheet area the Beds cover about one hundred and fifty square miles, mainly south of Lolworth Creek and west of the Burdekin River. The unit gives rise to sandy plains which are being dissected by streams incised some ten to twenty feet below the level of the plain.

The Campaspe Beds consist of white to pale buff argillaceous, gritty sandstone and fine to medium sandstone are rare siltstone. Many of the coarser sandstones tend to be pebbly. Small calcareous nodules occur locally in the finer beds. The sandstones consist 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 strata are typically poorly sorted and poorly bedded, although stratification is just detectable in most outcrops. The sediments are fairly well consolidated, although somewhat friable.

Cross-bedding can be seen at Red Falls (see Photo Plates 15 and 16), where the Beds fill a scour in the underlying lateritised sediments. In general, cross-bedding and other sedimentary structures are rare.

In the interfluvial areas the Campaspe Beds are capped by a poorly preserved layer of nodular to pisolitic ferricrete which in many places has disintegrated to buck-shot gravel. Where dissected by streams the ferricrete commonly gives rise to a sharp step at the top of the uneven slopes bordering the streams, but in some areas it appears to have been completely removed. The ferricrete reaches a maximum thickness of three to four feet. A zone of weak mottling underlies the ferricrete, commonly with a rather abrupt transition. This mottled zone is between two and five feet thick, and passes gradually into what is regarded as the unaltered Beds within a few feet, but which may possibly represent a pallid zone.

The Campaspe Beds are essentially horizontal in the Townsville Sheet area, but primary dips occur closer to the source areas in the Hughenden and Charters Towers Sheet areas.

Photo Plate 15: Right bank of Lolworth Creek, at Red Falls. Fifteen to twenty feet of buff, argillaceous grit of the Campaspe Beds (Pliocene?) unconformably overlying Miocene(?) ferricrete (Tl) developed on older Tertiary sediments. Nearby the Campaspe Beds are themselves capped by a thin layer of ferricrete.

B.M.R. Neg. No. M/290/21.

Photo Plate 16: Close-up of unconformity shown in Photo Plate 15. Foresets indicate a current direction opposite to that of Lolworth Creek at the present day.

At Red Falls the unit is between fifteen and twenty feet thick, and the maximum thickness over the whole of its extent on the Townsville Sheet area is probably less than thirty feet.

The Campaspe Beds disconformably overlie Miocene(?) ferricrete at Red Falls. They are overlain by the Nulla Basalt in the Charters Towers Sheet area, where the Homestead-Myola track crosses Hann Creek. Here the ferricrete found on the Campaspe Beds is missing; this suggests that a period of erosion intervened before the basalt was extruded. However, other exposures along Hann Creek suggest that the Nulla Basalt and the Campaspe Beds may abut against each other.

The stratigraphic relationship of the Campaspe Beds to the Sellheim Formation is not well established, as contacts are obscured by the sandy soils derived from both formations. In the Hann Creek-Gains Creek area the Sellheim Formation is topographically higher than the Campaspe Beds, and is therefore probably younger.

The source of the Campaspe Beds has been the coarse, granitic rocks of the Lolworth Range. The unit has the form of a broad, sheet-like piedmont extending out from the foot of this range. These sheets have since been extensively dissected.

The marked lack of sorting, the consistently poor, and locally absent, stratification, the apparently random orientation and distribution of mica flakes, and the persistence of the coarser fraction for long distances from the source area all indicate that the unit was laid down under torrential conditions. The preservation of feldspar indicates that little weathering took place in the source area, and that transportation and burial were rapid in an environment not conducive to chemical weathering. An arid climate with heavy seasonal rainfall in conjunction with a sparse cover of vegetation would provide such conditions. The apparent absence of fossil remains also suggests rather harsh conditions.

Considering that the Campaspe Beds were laid down on the earlier ferricrete, which developed on a peneplaned land-surface, it is interesting to speculate on how these piedmont deposits could have been formed. As has already been mentioned, this old Miocene land surface may not have been such a marked peneplain as the word implies. A change in climatic conditions may have stripped the Miocene laterite cover from the rocks of the higher regions which were then exposed, and provided the material for the Campaspe Beds. It is likely that the basal beds were derived directly from the Miocene(?) ferricrete. This would imply a high initial iron content, which in turn would provide the material for the development of the younger ferricrete. Regional uplift in late Tertiary time also probably caused rejuvenation of streams, which would then have cut back into the higher ground. No evidence for local uplift of the source area is known.

The Campaspe Beds are tentatively regarded as Pliocene. They are younger than the main laterite period generally regarded as Miocene, but older than the Toomba Basalt which is probably sub-Recent. They are probably older than the Sellheim Formation which is tentatively regarded as late Pliocene to Pleistocene.

Lassie Creek Gravels (Czl)

In the headwaters of Lassie Creek is an occurrence of pebbly, arkosic sandstone, grit, and minor conglomerate. These sediments are similar to the Campaspe Beds in their lithology and form, and they may be of similar age.

The Formation crops out discontinuously over an area of about twelve square miles at the heads of Lassie and Spring Creeks. The formation has filled in hollows and gullies on the surface of the Oweenee Granite, which was the source rock for the sediments. The thickness is very variable, and reaches a maximum of twenty to twenty-five feet.

The sediments are fairly well consolidated, but are, on the whole, ill-sorted, and show little evidence of transport. All show slight mottling owing to an uneven distribution of iron oxides. It is not known whether or not this mottling is related to a mild lateritic process, but nowhere has a ferricrete horizon been observed. As the original surface still remains in places, it is unlikely that a ferricrete horizon, if developed, has been removed.

The formation is being dissected and eroded by present-day streams. It is in these streams that the only exposures can be seen.

The Lassie Creek Gravels are very similar to, and were probably formed under similar conditions as, gravels in the Brimagee Creek area described by Wyatt (1962), and mentioned by Jack (1879a). These gravels contain billy pebbles, which fact might be of value if it could be established that billy was formed at one particular period. Billy is known to occur beneath basalt at Blueberry Hills, a few miles north of the Brimagee Creek gravels, but it has also been observed in the Fanning River-Mount Success area (Wyatt, 1961), where its origin is unknown but unlikely to be due to basalt.

Nulla Basalt (Czn)

In the south-western part of the Townsville 1:250,000 Sheet area is the eastern extension of the Nulla Basalt described by Twidale (1956) and White et al. (1959b) from Nulla Nulla Homestead in the Clarke River Sheet area. In the Townsville Sheet area it covers about six hundred square miles, extending north-west of Hann Creek and west of the Burdekin River as far north as Hillgrove and Allensleigh Homesteads.

The Nulla Basalt consists of a number of olivine basalt flows which form a broad, slightly domed plateau centred about Nulla Nulla Homestead. In the Townsville Sheet area, most of these flows appear to have a regional easterly dip. Many of the flows tail off into narrow flows which have followed major stream courses that bordered the main field of basalt. Such a ribbon-like flow is well developed along the west bank of the Burdekin River from a point some twelve miles north-west of Gainsford Homestead south-east to the junction of Anabranch and the Burdekin River. A similar flow occurs south of the Basalt River, and possibly represents an old course of that river. A third occurs parallel to and north of Hann Creek. The old "river" flows are shown on the map, although their differerentiation is geomorphological rather than geological.

By photo interpretation, four main levels of flows have been recognized. The highest of these levels is confined to the central part of the basalt field from Southwick Homestead west to Allingham Homestead (Clarke River Sheet).

The Nulla Basalt is deeply eroded, and soil has developed on most of it. It gives rise to boulder-strewn, red or black soil plains. Many streams (e.g., Allingham Creek and Basalt River) are deeply incised into this basalt, and expose sections up to seventy to eighty feet thick. The maximum thickness is unknown, but is unlikely to exceed one hundred and fifty feet.

North-west of Hillgrove the basalt appears to be overlain by lateritised sediments which have formed as outwash fans from the Oweenee Granite. The degree of lateritisation is similar to that near Charters Towers at Little Red Bluff and Featherby Wall, where the lateritic profile is believed to have been formed before the Campaspe Beds were deposited. If this interpretation of the northern laterite is correct, then the basalts about Hillgrove are quite old - possibly Miocene. However, in Hann Creek (see Paine et al., 1965), basalt of the Nulla Province overlies the Campaspe Beds. A sample taken from the Nulla Basalt in Hann Creek in the Charters Towers Sheet area has been dated by the total rock method (K/Ar) at 1.32 million years ± 3% (determination by A.W. Webb at the Department of Geophysics and Geochemistry, Australian National University, Canberra). To explain these apparently contradictory relationships it must be assumed either :-

(1) that the relationship of the lateritised sediments and basalt north-west of Hillgrove is wrongly interpreted; or

(2) that the sediments were not lateritised during the same period as those at Charters Towers, but some time later; or

(3) that the basalts near Hillgrove are older than the basalt sampled at Hann Creek.

Considerably more detailed mapping will be required to solve this problem. If, however, the basalts prove to be of such widely differing ages as to allow for a period of lateritisation to have occurred between them, then it is debatable whether or not they should all be included under the one name - Nulla Basalt.

Undivided Cainozoic basalt (Czb) and associated billy (Czy)

East of the Burdekin River north from Plains Creek to Pintpot Creek are isolated small mesas of olivine basalt which were possibly once part of the main Nulla Basalt. These basalts cover only a small area, but their once greater extent is indicated by the numerous occurrences of billy (Czy) which formed below the basalt flows, and which can be seen under the remaining basalts. This billy has probably been formed by the silification (during weathering of the basalt) of quartz sands and gravels which probably occupied water courses at the time of basaltic extrusion.

Similar basalt mesas with associated billy occur north of the Burdekin River about Cleanskin Creek and Blue Range Creek (Clarke River 1:250,000 Sheet area), and also south of the Burdekin River north-west of New Moon Homestead.

In the area bounded by Arthur Peak, the head of Hellhole Gorge (a tributary of the Reid River), Grass Hut, and Exley are nine known occurrences of basalt. Most are plug-like in form, but a few, near Mingela, are too small to show any distinct form, but they all have a roughly circular outcrop. Some of these plugs are situated on major faults, and it is possible that all the occurrences have a similar setting. The relationship is well displayed by three plugs associated with a north-west trending fault extending from the Burdekin Highway crossing of Seven-Mile Creek, near Exley, to Myrtlevale Hut. A small occurrence between Grass Hut and Mingela is likewise associated with a major fault extending eastwards from Fanning rail siding.

All occurrences consist of olivine basalt. Some - e.g., Arthur Peak and a plug east-north-east of Fanning River Homestead - are characterized by xenocrysts of dark green glassy pyroxene which occurs in irregular masses up to 10 to 15mm. across.

Some of these occurrences have no relief at all (e.g., those about Mingela) whereas others (e.g., Arthur Peak) form steep hills three hundred to four hundred feet above the surrounding countryside. Their average relief is about fifty to one hundred feet. One occurrence east-south-east of Fanning River Homestead has a crater-like form apparently breached on its northern side; flow phenomena are still preserved on lava surfaces in the breach. Preservation of these physiographic and structural forms suggests that some, at least, of these plugs and vents are not of great antiquity.

An isolated hillock east of Star Homestead also belongs to this group of basalt plugs, as do the basalts of Blueberry Hills, twelve miles north-north-west of Dotswood Homestead.

All these plugs have been intruded through granitic rocks of the Ravenswood Granodiorite or through the Charters Towers Metamorphics.

An isolated plug-like mass of olivine basalt occurs in the lower reaches of Tomahawk Creek, twelve miles west-north-west of Ewan. This basalt is intruded into strata of the Sybil Group.

Sellheim Formation (Cze)

Typically developed in the Charters Towers Sheet area west of the Burdekin River south of Sellheim Railway Station to near the farming area of Broughton, is a thin cover of flat-lying sediments which cap the underlying Ravenswood Granodiorite. This occurrence was first observed by Jack (1879a). Here they cover an area of eight to ten square miles, but only the extreme northern part of this outcrop area lies within the Townsville 1:250,000 Sheet area. Similar sediments which have been included in the Formation occur north of the Burdekin about the lower reaches of Quilps Creek; east of the Fanning River, north of the junction of Station Creek; and north-north-west of Charters Towers, between Southern Cross Creek and Hann Creek. All these areas are small, together aggregating about fifteen square miles. Each of these occurrences forms a low sandy capping on the underlying rocks, and carries a characteristic vegetation - Burdekin Plum, Bottle Tree, and low scrub.

The Formation consists of sandy claystone, brown or buff quartz sandstone, and small-pebble conglomerate with a fine sand or clayey matrix, but commonly with little or no matrix or cement. At or near the base there is usually a highly ferruginous quartz sandstone. The Formation is mostly mottled orange brown and cream, but the mottling is everywhere due to bleaching adjacent to generally near-vertical tubules, up to 1cm. in diameter, filled with off-white clay. These are regarded as being root cavities filled by clay after the wood tissue had decomposed. Humic acid formed during decomposition probably bleached the nearby sandstone.

Because of the survival of the ferruginous sandstone near the base, it is reasonable to suggest that the unit has not undergone lateritic weathering. If this is a valid deduction, then it follows that the unit is younger than the Campaspe Beds, which have undergone such weathering.

The Formation contains fragments of silicified wood, the fragments usually being small. This wood has not been of assistance in dating the Formation. It is probable that the remains of <u>Diprotodontus</u>, reported by Jack (1879a) from near Gilgunyah Homestead, near Rishton (Charters Towers Sheet area), were found in sediments now mapped as Sellheim Formation.

The strata are horizontal. Although rock-types are readily distinguishable, bedding is not everywhere well developed. Vague cross-bedding was found in a few places. The observed maximum thickness of the Sellheim Formation is ten feet.

The Formation, as so far mapped, lies close to the Burdekin River or to its major tributary the Fanning River. This implies that the strata may represent old, high-level deposits of the Burdekin River and its tributaries. At Sellheim the strata are about one hundred and ten feet above the present stream bed, but in the Hann Creek area the relative elevation is less.

The Formation nonconformably overlies the Ravenswood Granodiorite. As suggested above, it may be younger than the Campaspe Beds. Its relationship to the Nulla Basalt is unknown, but it appears to be at a higher topographic level than the basalt near Hann Creek. A sandy soil is usually well developed on top of the Formation, whose age is tentatively regarded as late Pliocene to Pleistocene.

<u>Toomba Basalt</u> (Qt)

Typically developed north of Toomba Homestead, and extending north-eastward between Lolworth and Fletcher Creeks is an area of olivine basalt which gives rise to a distinctive air-photo pattern. The basalt forms low rises which are part of the "Great Basalt Wall". This basalt was termed the Toomba Basalt by Twidale (1956), who considered it the youngest flow of the Nulla Province.

The Toomba Basalt occupies an area of about one hundred square miles in the Townsville 1:250,000 Sheet area, but also extends south-westward towards Lolworth Homestead in the Hughenden 1:250,000 Sheet area. The basalt is vesicular, and has a well developed ropy structure. It shows numerous flow phenomena such as collapsed lava tunnels and pressure ridges.

No definite eruption centre has been determined for this basalt. North-east of Lolworth Homestead is a shield-like elevation near the western extremity of the Toomba Basalt which may represent an eruption centre. The outcrop area of the basalt and the way it gradually narrows to the north-east, eventually forming a narrow flow parallel to the Burdekin River in the lower Lolworth Creek area, and near "The Rocks", suggest that the lava flowed eastwards.

The Toomba Basalt is moderately well covered by scrubby vegetation, but no soil has yet formed on the basalt surface. Vegetation grows only in clefts and openings where accumulations of leaves, moss, lichen, etc., have favoured the establishment of plants.

The Basalt has ponded many of the small streams of the area, and caused the development of small lakes. Many of these lakes contain diatomaceous earths (Ql).

The Toomba Basalt has a very youthful aspect. Its lack of erosion and soil cover, and its influence on streams, all point to a very young age, probably Recent. It is very similar to the Kinrara Basalt (White, 1961, 1963).

<u>Beach Deposits</u> (Qr)

(i) Bordering the present coastline between Cape Cleveland and the mouth of Bluewater Creek is a discontinuous belt of fixed coastal dunes up to two miles inland from the coast. These dunes are old strand-lines. They are seldom more than ten feet higher than the nearby salt flats which are almost at sea-level.

(ii) Maitland (1892) described a "beach-rock" composed of shell debris cemented by calcium carbonate which formed in the littoral zone on Magnetic Island. These deposits were noted during the present survey, but they cover too small an area to be shown on the map. Similar beach rock was observed on Acheron Island just outside the sheet area to the north. The beach rock is now being eroded. A pumice beach, similar to those described by Maitland (1892) on Magnetic Island, was observed on the north-eastern side of Cape Cleveland.

<u>Alluvium and Colluvium</u> (Qa)

(i) Deposits of alluvium, in places up to fifty feet thick, border many of the major streams in the area. They are thickest along the Burdekin River or in the lower reaches of its tributaries. They consist essentially of grey silt. These deposits show good stratification, and some of the older ones even show vague signs of old soil profiles. Along Keelbottom Creek and Fanning River the oldest deposits exposed are usually mottled by iron oxides.

(ii) On the coastal lowlands are large areas of alluvial deposits which grade into colluvium near the foot of the coastal scarp. Most of the wedges of talus which form the colluvium are now stabilized by vegetation. Generally these deposits are being dissected by present-day streams, and the only areas of active deposition appear to be in the deltas of the coastal streams and in the littoral zone of the present coast.

The thickness of the deposits on the coastal plain is unknown. Jack (1886d) records depths of "drift" up to one hundred and nine feet in bores in the "Stuart" Creek area, so that these "drifts" accumulated on a rock-bed that now lies about seventy feet below sea level. Whether the whole of this thickness can be assigned to the Quaternary is not known. Jack (1879a) records the presence of <u>Unio</u> and decayed, rather than fossilized, mammalian remains in these deposits to which he assigned a post-Tertiary age. No evidence was obtained during the present survey to alter this assessment.

Sand and soil, chiefly residual (Qs)

(i) Much of the low country in the area between Mount Boddington and Gainsford Homestead is covered by residual sand and sandy soil apparently derived from the Ravenswood Granodiorite, the Sellheim Formation, Campaspe Beds, and unnamed lateritised Tertiary sediments.

(ii) Farther north near Dotswood are low rises covered with soil and pebble-cobble rubble. This material appears to be older than the alluvium along Keelbottom Creek. The pebble-cobble fraction consists mainly of quartz or quartzite, and is similar to the coarser fractions of the Sellheim Formation. These may be lag deposits left after erosion of strata equivalent to that Formation. Silicified wood is commonly associated with the pebble-cobble fraction, and this also suggests that it is derived from the Sellheim Formation.

(iii) Other soil and pebble-covered areas occur between the Little and Great Star Rivers, and west of the Great Star River. The coarser fraction appears to be confined mainly to the area between the two rivers above their confluence or north-west of Corner Creek where streams descending from the Coane Range are checked before entering the Great Star River. Farther to the west and south-west deep soil masks much of the underlying rock.

STRUCTURE

The structure of the individual rock units has been discussed under the appropriate headings. Only the overall structural features are discussed in this section.

One of the most notable of these 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. This faulting developed late in the tectonic history of a region which has gradually become more stable since Precambrian times. This progressive stabilization is demonstrated by the different types of fold structures and degree of metamorphism suffered by strata of successive periods, as well as by the depositional environments in which these strata were laid down.

Precambrian

The Precambrian strata have been isoclinally folded; development of shear-cleavage has given rise to a strongly developed vertical or near-vertical schistosity. Flow-folding and mineral segregation have developed in places, suggesting dynamic metamorphism at moderate to high temperatures and pressures. Bedding is normally unrecognizable, and the succession is unknown.

The trend in the Precambrian strata ranges from north-west in the Charters

Towers district to north-north-east and north-east in the White Springs and Running River areas, respectively. Individual fold closures can generally not be recognized.

Early Palaeozoic

The structures shown by strata of this age are quite different from those discussed above. The strata have been crumpled into numerous small folds, commonly with a near-vertical plunge. Dips are moderate to steep. Bedding is still quite recognizable, and the order of superposition determinable. Folds are usually similar, and fracture cleavage is well developed. The early Palaeozoic sequence has apparently been folded into a broad synclinorium of which only part of the south-east limb appears in the north-western part of the Townsville Sheet area. Individual fold closures are readily decipherable within this major structure.

These strata were apparently laid down in shallow water in an actively subsiding area probably adjoining the Tasman Geosyncline. When folded at the end of the Lower Devonian they did not undergo any marked minerological change.

Late Palaeozoic

The Middle Devonian to Lower Carboniferous strata have been folded into a number of irregular basin and dome structures. In these, dips are shallow to moderate, and individual fold closures are readily discernible. The axial trends of these closures are quite variable, but appear to be closely related to the proximity of the underlying rigid rocks - mainly granite and minor schists and gneisses.

These strata have also given way by faulting, particularly near the underlying granite which has failed by fracturing. Near the granite margins of the sedimentary basin the structure is quite complex, and dips are generally steeper, folds tighter, and faulting more intense.

In the Middle to Upper Carboniferous strata, folding appears to be much more open. However, as these strata are now confined to separate and rather small areas bounded by faults it is difficult to assess the regional significance of their structure.

Very little is known of the structure of the Permo-Carboniferous sequence, but its general structural style appears to be similar to that of the Middle to Upper Carboniferous strata.

The older of these strata were laid down in an epicontinental environment, and the later deposits in a continental environment on a fairly rigid cratonic basement.

During the orogeny which closed the Palaeozoic these sediments suffered little metamorphism, but were simply folded; the fold structures are related to differential movements in the basement. The movements may have been Saxonic in type.

Mesozoic

The strata assigned to the Mesozoic are gently undulating and regional dips rarely exceed 10 to 15 degrees. Steeper dips occur locally near faults. The gently undulating attitude of these strata is probably due to slight differential movement during epeirogenic uplift.

Cainozoic

Faulting continued throughout the Cainozoic. It was during this time that the coastal scarp was uplifted. This uplift gave a westerly tilt to the Miocene peneplain land surface in the area between the coastal scarp and the Burdekin River.

The sequence of these different types of movement suggests that from a mobile region in the Precambrian the area has become much more stable. Faulting has played a more obvious part in the later earth movements, particularly at the close of the Palaeozoic.

Two main directions of faulting can be recognized. One trends south-east, swinging more to east-west near the coast. The other trends east-north-east.

In the Devono-Carboniferous sequence, where displacements along these faults can be best observed, the south-east faults have a strong horizontal component of movement, whereas the east-north-east set have a strong vertical component. Apparent horizontal displacements up to twelve miles have been observed on the former, and vertical movements of the order of 15,000 to 20,000 feet occur in the latter.

A notable feature in the south-east fault system is the development of a graben-like structure in the Oweenee Granite, south-west of Ewan. It is within this graben that the Sybil Group is preserved, so it is referred to as the Sybil Graben. It ranges in width from fifteen miles at its north-western end to five miles at the south-eastern end, where the structure becomes obscured by a thin Tertiary laterite cover. Movements on the faults bounding this graben appear to have been essentially vertical, which is an exception to the statement made above that faults with a south-east orientation show essentially horizontal movement. Subsidiary faults parallel to the main faults occur outside the graben in the Oweenee Granite. These faults have been the loci of intrusion of quartz-feldspar porphyry dykes. Strata of the Sybil Group have been disturbed adjacent to the graben faults, and it is probable that the Group is a down-faulted block of a once more extensive sequence, rather than a sequence laid down in a pre-existing graben.

Structures associated with the late Palaeozoic granites

Many of the late Palaeozoic granites show strongly curvilinear boundaries. Some of the granites are composite bodies in which a central circular stock apparently intrudes a body with more irregular outline.

A further interesting aspect of these granites is the distribution and orientation of individual bodies. First, the Oweenee Granite forms a belt trending north-east across the north-western part of the Townsville Sheet area in the Perry Ranges and the Coane Range. Secondly, there is a north-north-west trending belt of separate granite outcrops in the eastern part of the Townsville Sheet area in the Paluma and Hervey Ranges. Both these directions correspond generally to the major fault directions. Considering individual granite bodies, of those which have an elongate outcrop, two preferred directions, similar to those already mentioned, can be recognized. For example, the Oweenee Granite, the Pall Mall Adamellite, the granite of Mount Square Post, that between the east and west branches of the Fanning River, and the granite at the head of Bluewater Creek, all have their long axes oriented in directions ranging between north-east and east-north-east. On the other hand, many of the granites of the Mount Flagstone area in the eastern and south-eastern parts of the Sheet area have their long axes orientated in directions ranging between north-west and north-north-west. The remaining granite bodies, constituting some sixty percent of the individual occurrences, have outcrops which are irregular or more or less equidimensional in outline.

Most of these granites are small, apparently isolated bodies. The one exception to this is the Oweenee Granite which forms a continuous belt (except for the Sybil Graben) at right angles to the granitic belt of the coastal range.

Now, in the Clarke River Sheet area the Middle Devonian limestone are delimited to the south, and the Precambrian metamorphics are delimited to the north by an east-north-east trending fault. If this fault is extended to the east-north-east it corresponds roughly with the axial region of the Oweenee Granite. It is interesting to speculate as to whether or not the Oweenee Granite was emplaced along a major zone of weakness extending from the head of the Gregory River east-north-east towards Paluma. Further, it may be possible that the limestones seen at Laroona are the continuation of the limestones/of the Broken River Formation whose nearest outcrop occurs in the Clarke River Sheet area near Craigie Outstation. Again, the northern margin of the Broken River Embayment (Clarke River Sheet area) is bounded by a fault, with the Dido Granodiorite forming the northern block. This Granodiorite is rather similar to the Ravenswood Granodiorite, which is not known to extend north of the Oweenee Granite, so that the possibility exists that these two granodiorites are faulted and displaced parts of the same batholith.

If these speculations could be proved, then the Townsville hinterland is an area intersected by some enormous strike-slip faults; for example, the possible matching ends of the Devonian limestones are some sixty to seventy miles apart.

ECONOMIC GEOLOGY

The Townsville Sheet area, although it shows a wide variety and distribution of mineralization, has not been a rich mining district. Amongst the metalliferous deposits, by far the greatest production, both in tonnage and value, has been that of tin from the Kangaroo Hills Mineral Field, but this production is small when compared with that from other fields, e.g., Herberton. In recent years the value of limestone quarried at Calcium has far outstripped that of all other minerals being produced from the Townsville Sheet area.

A fuller account of the economic geology of the Sheet area is in preparation, and will be issued as a separate Record (K.R. Levingston, in prep.).

Tin

Until recent years, when large scale quarrying of limestone began at Calcium, the annual value of tin concentrates exceeded that of all other minerals produced in the Sheet area.

Most of the tin has come from lodes in late Palaeozoic granites (in particular the Oweenee Granite) which occur in the north and west of the Sheet area, and in sediments and metamorphics adjacent to these granites. Lesser production has come from deep leads at Waverley, where stanniferous gravels occur at the base of a Tertiary sandstone sequence overlying granite and overlain by Tertiary(?) basalt. Very minor quantites have come from alluvial deposits.

The main production area has been, and still is, the southern part of the Kangaroo Hills Mineral Field, about Oaky Creek and Running River. Tin has also been produced at Tinvale in the Sandy Creek area west of Hillgrove, and to a lesser extent in the Gowrie area, near Mount Stockyard, and at the head of Marsh's Creek.

Most ore shoots are small, and occur as pipe-like shoots or small leaders in fissure-type lodes. At the Sardine, the largest mine and largest producer in the Kangaroo Hills Mineral Field, the ore-bodies are near-vertical and tabular, and consist of numerous closely packed lenses. The occurrence here of separate shoots of cassiterite ore and stannite-cassiterite ore suggests that there may have been at least two periods of tin deposition.

Most ore produced has been cassiterite, except at the Sardine which also produces tin-copper concentrate with a high percentage of stannite. Saint-Smith (1922) tentatively determined stannite in the ores of the Salmon and Goldfish mines (15 chains west of the Sardine) so that it is possible that other deposits besides the Sardine, which is the deepest mine on the field, would also show stannite ores at depth.

Production has fluctuated considerably over the years since the field was first worked for tin in 1883, owing mainly to the following factors:

(i) Changes in the price of tin;

(ii) The generally small size and discontinuity of the orebodies;

(iii) The poor access to the field until 1937.

As the overall annual production of the field is small (40-50 tons of concentrate annually) production can vary greatly from year to year depending on the fortunes of one mine or prospect.

At Tinvale, the most important producer was the Daintree mine.

Total production for the Kangaroo Hills Mineral Field is about 8,300 tons of cassiterite and 220 tons of stannite concentrate. Although the field extends to the Ingham 1:250,000 Sheet area, 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, and most of this has come from the Daintree mine.

Tungsten

Wolfram has been mined in several areas, notably at the head of Ollera Creek and in the upper reaches of Pine Creek and Williams Creek, tributaries of Running River. The deposits occur in late Palaeozoic granite and quartz porphyry and in the Running River Metamorphics and Ewan Beds close to their contact with such intrusives. Associated minerals are molybdenite, fluorspar, garnet, and chalcopyrite.

At Ollera the deposits occur as pipes; elsewhere they occur either as pipe-like shoots or leaders associated with lineaments such as shears, fractures, or joints. Gangue minerals are usually quartz and/or chlorite. Alluvial deposits also have been worked in the Ollera district.

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

Copper

Copper mineralization is widespread in the Sheet area, much of it associated with deposits which were worked primarily for other minerals, notably tin. In most areas the mineralization appears to be related to late Palaeozoic granites and porphyrie but that in andesitic lavas of the Percy Creek Volcanics if of unknown origin. Of the more notable mines worked essentially for copper, the Mount Thekla and True Blue occur in the Ewan Beds, the Kennedy and Great Northern (see Footnote) in the Star Beds, the Rio Tinto in undifferentiated Devono-Carboniferous sediments (D-C), and the Macaulay groups in the Oweenee Granite. All deposits, except the Great Northern, whose character is unknown, consist of small veins or shoots in fissure-type lodes. None proved payable below the zone of oxidation, and slight secondary enrichment, which mostly extended to between one hundred and one hundred and fifty feet. In most mines the main workings did not go below this level. Deeper workings at the Mount Thekla encountered chalcopyrite, but no economic 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 silver-bearing galena and sphalerite. Production from these mines is unknown, but it is unlikely to have exceeded 500 tons of ore averaging, say, 20 percent copper.

Gold

Part of the Townsville Sheet area is included in the Charters Towers and Ravenswood Gold and Mineral Fields. However, it lies to the north of the richly auriferous parts of those fields and gold production has been quite small. The main mining centres and the nature of their deposits, etc., are shown in Table 3.

The Grass Hut and Fanning deposits, like those of Charters Towers and Ravenswood, are associated with the Ravenswood Granodiorite. In the other centres the mineralization appears to be related to late Palaeozoic intrusives in Devonian sediments. It is probable that much of the gold mineralization in the Townsville Sheet area is younger than that at Charters Towers and Ravenswood.

Gold also occurs at Bunkers Hill (Ravenswood Granodiorite and Kirk River Beds), Ponto and Argentine Extended (Argentine Metamorphics), Mount Norman (late Palaeozoic granite), and Six-Mile (late Palaeozoic Granodiorite). The workings at Ponto and Mount Norman were not located during this survey; however, they are believed to be of very minor importance.

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

TABLE 3: SUMMARY OF GOLD MINING AREAS, TOWNSVILLE 1:250,000 SHEET AREA

Mining Centre	Mines	Country Rock	Mineralizing Agent	Type of Deposit	Associated Minerals	Main Production Years
Piccadilly	Piccadilly P.C. Piccadilly No.1W	Upper Devonian sandstone, shale	?	Quartz reef	Pyrite	1894 - 1909
Far Fanning	Several mines on three main lines of lode	Upper Devonian sediments and late Palaeozoic porphyry	Late Palaeozoic porphyry ?	(a) Quartz leaders in steeply dipping felsite dykes (b) Shallowly dipping stockworks	Pyrite, arseno-pyrite, rare chalcopyrite	1895 - 1908
Mount Success	Mount Success	Porphyry and Fanning River Group	Late Palaeozoic porphyry of Mount Success	Contact replacement	Pyrite, sphalerite	1895 - 1906
Golden Valley	Golden Valley P.C. Golden Valley Block " " No.1E " " No.1W " " No.2W	Felsite and Ravenswood Granodiorite	Late Palaeozoic porphyrities and felsite of Mount Success	Quartz reef with felsite hangingwall and granite footwall	Pyrite, sphalerite	1898 - 1907, 1922, 1934
Grass Hut	Numerous mines on several lodes	Ravenswood Granodiorite	Late phase of Granodiorite	Quartz reefs in fissures?		1887 - 1895
anning - Salas Siding	Numerous mines on several lodes	Ravenswood Granodiorite	Late phase of Granodiorite	(a) Quartz reefs in fissure, e.g., Rose of Allandale (b) Pipe-like body of greisenised granodiorite, e.g., Welcome	Pyrite, galena, sphalerite, argentiferous tetrahedrite, chalcopyrite	1890 - 1900 Some revival 1930 - 1940

Total production of gold from all sources within the Sheet area is low, and it is impossible to give even an approximate production figure because returns cannot be separated from those for the Ravenswood and Charters Towers Fields as a whole.

Silver-lead

Silver has been worked at two main centres in the Sheet area: at Donnybrook Creek (2 miles north-north-west of Ewan) as silver-lead deposits in limestone of the Ewan Beds, and at Argentine, also as silver-lead deposits in the Argentine Metamorphics, the Game Hill Beds, and late Palaeozoic granodiorite. Silver-lead-copper deposits were worked at Stockyard Creek in 1892 (Maitland, 1893), but the exact location is unknown.

At Donnybrook Creek, the deposits are contact-metamorphic lodes related to late Palaeozoic porphyry intruding limestone. The Argentine deposits are fissure-type lodes. Little is known of the Stockyard Creek deposits, but they also are probably fissure lodes.

As with gold, it is impossible to arrive at the true figure for silver production within the Sheet area. About 50,000oz. can be credited to 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.

Iron

Iron ore occurrences are known at Willett's Knob (near Mount Moss, north of Ewan); 3 miles north-east of Laroona Homestead; and 3 miles west-south-west of Mount Flagstone, near Woodstock. The Willett's Knob and Woodstock occurrences are contact-metasomatic deposits associated with limestones in the Ewan Beds and Fanning River Group, respectively. In both places, mineralization is probably related to late Palaeozoic granites. The Laroona deposits occur in calcite-actinolite schists of the Argentine Metamorphics and the mineralization may again be related to late Palaeozoic granite. Magnetite, at Willett's Knob, and magnetite and hematite, at Woodstock and Laroona, are the chief minerals. The Woodstock deposit is the only one that has been worked; the total production, which is small, has been used in the manufacture of cement at Stuart; the output in 1963 exceeded 3000 tons.

Limestone

The only limestone deposits in the area which have been worked commercially occur near Calcium and Reid River. Production is from limestone of the Fanning River Group and from "earth lime", apparently formed by weathering in situ of andesitic agglomerates of the Ellenvale Beds.

The limestone has been used for the production of quick-lime for cyaniding at Charters Towers, for lime for use in sugar mills, for agricultural purposes, and for cement manufacture. Following the virtual cessation of cyaniding in Charters Towers about the time of the 1914-18 war, production was erratic until the North Australian Cement Co.Ltd.began production in 1955. Since then output has gradually increased. In 1963 the annual production of limestone for cement was 122,856 tons and for burnt lime 1400 tons. Production of earth lime was 2932 tons.

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

Clay

Clay has been quarried for brick manufacture from Quaternary alluvium north of Townsville for about the last five years. The main production is from Kurukan, where some 6500 tons were produced during 1963.

Clay shale for cement manufacture is quarried at Partington, about half a mile east of Stuart Railway Station. In 1963, production was about 14,500 tons.

Aggregate

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

CONCLUSIONS

This survey has shown that the Townsville hinterland has been an area of prolonged sedimentation and igneous activity and varied depositional environments. The deposits least understood are those of the Precambrian and the late Palaeozoic. Solution of the stratigraphy of the Precambrian strata is complicated mainly by the effects of regional metamorphism. More detailed mapping should, however, result in formational subdivision without much difficulty. Problems associated with the late Palaeozoic are due to the lack of suitable criteria for the subdivision of the Carboniferous and Permian sequences, [illegible] the intense faulting that these strata have suffered, and the widespread Cainozoic cover of the coastal region which make correlation difficult. Resolution of these problems may not be easy, even with very detailed mapping.

The survey has shown that a variety of intrusive and extrusive igneous rocks of different ages exists in the area. Some of these rocks can be dated within fairly close limits, but the majority cannot. It is likely that dating of these rocks will have to depend largely on absolute age determinations. Numerous samples were collected for radioactive age determination during 1964.

The mapping of the Devonian-Carboniferous sequence has resulted in some detailed subdivisions within the middle to late Palaeozoic. This, in turn, has led to a better understanding of the sedimentary environments and history of these deposits, which have always been regarded as type sections for the Middle and Upper Devonian and Lower Carboniferous sequences of Queensland.

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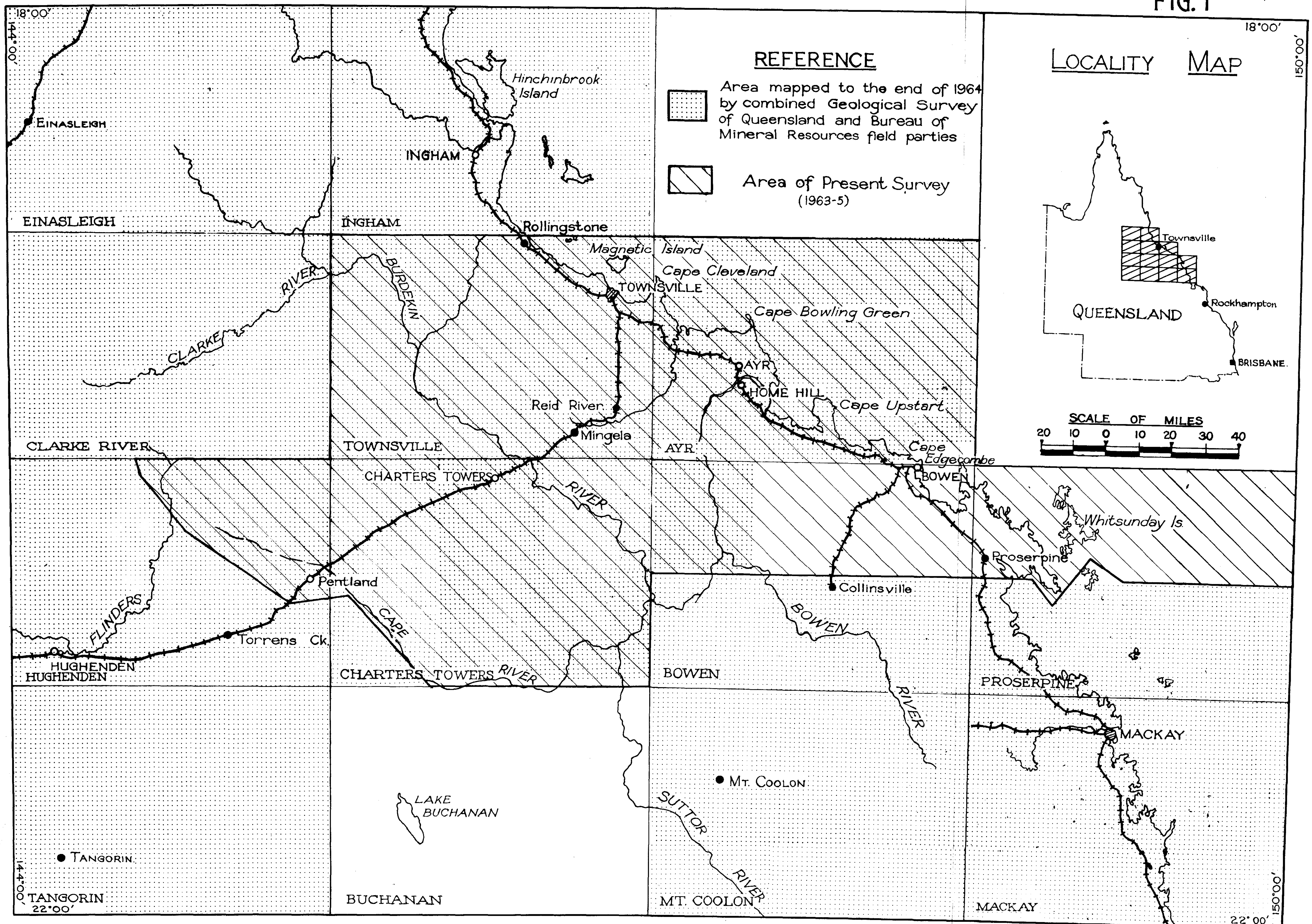
FIG. 1



REFERENCE
Area mapped to the end of 1964 by combined Geological Survey of Queensland and Bureau of Mineral Resources field parties
Area of Present Survey (1963-5)
LOCALITY MAP
QUEENSLAND
Townsville
Rockhampton
BRISBANE
SCALE OF MILES
20 10 0 10 20 30 40
18°00'
144°00'
150°00'
22°00'
EINASLEIGH
INGHAM
CLARKE RIVER
TOWNSVILLE
AYR
HUGHENDEN
CHARTERS TOWERS
BOWEN
PROSERPINE
TANGORIN
BUCHANAN
MT. COOLON
MACKAY
Einasleigh
Ingham
Hinchinbrook Island
Rollingstone
Magnetic Island
Cape Cleveland
Townsville
Cape Bowling Green
Ayr
Home Hill
Cape Upstart
Reid River
Mingela
Cape Edgecombe
Bowen
Charters Towers
Whitsunday Is.
Proserpine
Collinsville
Pentland
Torrens Ck.
Hughenden
Mackay
Mt. Coolon
Lake Buchanan
Tangorin
Burdekin River
Clarke River
Flinders River
Cape River
Bowen River
Suttor River

TABLE 1. SUMMARY OF STRATIGRAPHY AND IGNEOUS ACTIVITY, TOWNSVILLE 1:250,000 SHEET AREA

ERA	PERIOD	STAGE OR EPOCH	ROCK UNIT	LITHOLOGY	RELATIONSHIPS	REMARKS	REFERENCES	ECONOMIC GEOLOGY
CAINOZOIC	QUATERNARY		Qs	Sand and soil	Superficial	Chiefly residual. Some transported.		
			Qa	Sand, silt, and gravel.	Superficial	Alluvial, colluvial, and outwash deposits of the coastal plain and along water courses.		Gravel used as road ballast, concrete aggregate. Underground water.
			Qr	Sand	Superficial	Coastal dunes representing old and present shore-lines.		
			Ql	Lacustrine deposits, including diatomaceous earth.	Superficial	Deposited in lakes ponded by Toomba Basalt.		
			Toomba Basalt Qt	Olivine basalt	Overlies Sellheim Formation, Campaspe Beds, Fanning River Group, and Ravenswood Granodiorite.	Youngest flow in area. Similar to Kinrara Basalt. (Einasleigh Sheet area).	Twidale (1956)	
	UNDIFFERENTIATED	PLIOCENE TO PLEISTOCENE	Sellheim Formation Cze	Sandstone, sandy claystone, pebble conglomerate.	Nonconformably overlies Ravenswood Granodiorite, and perhaps also Campaspe Beds.	May be old high-level gravels related to Burdekin River.	Jack (1879a)	
			Czb and **Czy**	Olivine basalt, **overlying billy** (silicified quartz sandstone and conglomerate).		Undifferentiated. Remnants of flows northeast and east of the Nulla Province. Small plugs in the east.		
			Nulla Basalt Czn	Olivine basalt.	Unconformably overlies Devono-Carboniferous sequence. Nonconformably overlies Ravenswood Granodiorite. Overlies Campaspe Beds probably disconformably.	Erupted west of Bluff Downs and Southwick. Flowed eastwards along watercourses. One sample dated 1.32 million years, but some flows older than this.		
			Lassie Creek Gravels Czl	Pebbly, argillaceous sandstone, grit, and arkose.	Nonconformably overlie Oweenee Granite.	Material derived from Oweenee Granite. Weakly mottled by iron oxides.		
	TERTIARY	PLIOCENE?	Tf	Ferricrete	Developed on Campaspe Beds.			
			Campaspe Beds Tc	Argillaceous sandstone and rare siltstone.	Disconformably overlies Miocene(?) ferricrete. Nonconformably overlies Lolworth Igneous Complex.	Material derived mainly from Lolworth Igneous Complex. Thin ferricrete commonly developed.		
		MIOCENE TO PLIOCENE	Tl	Ferricrete and/or laterite.	Developed on Tertiary sediments, possibly parts of Nulla Basalt, Oweenee Granite, Lolworth Igneous Complex, Devono-Carboniferous sequence. Ravenswood Granodiorite, and Charters Towers Metamorphics.			

ERA	PERIOD	STAGE OR EPOCH	ROCK UNIT	LITHOLOGY	RELATIONSHIPS	REMARKS	REFERENCES	ECONOMIC GEOLOGY
CAINO-ZOIC	TERTIARY		Unnamed Tertiary Sediments (not shown on map)	Sandstone, shale.	Nonconformably overlie Ravenswood Granodiorite.	Lateritized. Lacustrine. Plant fossils. 50 ft. thick.	Morton (1945) Jack (1879a) Marks (1913)	Rare auriferous deep leads at base of sequence. (Charters Towers Sheet area).
MESOZOIC?			Collopy Formation Mc	Quartz and micaceous sandstone, feldspathic sandstone, arkose, conglomerate.	Nonconformably overlies Ravenswood Granodiorite.	Large-scale current-bedding. Rare indeterminate plants. At least 500 ft. thick.	Jack (1879a)	
LATE PALAEOZOIC	PERMIAN TO MESOZOIC		d, f	Dolerite, microdiorite, felsite dykes.	Intrude Permo-Carboniferous sedimentary-volcanic sequence (C-Pv). Some dykes intrude youngest granites (P-Mg).	Possibly two ages of basic to intermediate dykes, separated by felsite dykes and granite intrusion (P-Mg).	Maitland (1892)	
			P-Mg	Chiefly biotite granite and adamellite. Minor quartz monzonite, quartz syenite, hornblende-quartz gabbro, microgranite.	Intrude Permo-Carboniferous sequence.	Epizonal stocks.	Maitland (1892)	Rare occurrences of gold at Magnetic Island and Mount Elliott.
	UNDIFFERENTIATED		Pzp	Quartz porphyry, quartz-feldspar porphyry, microgranite.	Intrude Devonian sediments and Carboniferous volcanics, late Palaeozoic volcanics (Pzv), and Argentine Metamorphics.	Appear to be closely related to Palaeozoic granites.		
			Pzi	Dolerite and microdiorite.	Intrude Devonian and Carboniferous sequences. Intruded by late Palaeozoic granite (Pzug).	Occur as irregular bodies and dykes. Possibly related to the earliest Permo-Carboniferous dykes		
			Dykes in Oweenee Granite	Quartz-feldspar porphyry.	Intrude Oweenee Granite.	Dykes in fractures parallel to Sybil Graben. Possibly related to intrusive rhyolite, etc. (Pzh).		
			Pzh	Rhyolite, dacite, rare intrusion-breccia(?).	Intrudes Ravenswood Granodiorite, Devono-Carboniferous sequence, and Oweenee Granite.	Isolated plug-like intrusions or sills.		Gold at Mount Success.
			Kitty O'Shea Intrusives	Andesite dykes.	Intrude Frasnian-Tournaisian sediments.	Appear to be genetically related to diorite (Pzb).		
			Pzug and Pzb	Granite, adamellite, granodiorite, porphyritic granodiorite; diorite.	Intrude undifferentiated Permo-Carboniferous, Carboniferous, and Devonian sequences.	More basic types are probably earlier phase.		
	PERMO-CARBONIFEROUS		C-Pv	Intermediate and acid flows and pyroclastics; rare conglomerate, sandstone, shale, coal.	Stratigraphic relationship with Carboniferous sequence unknown.	Thickness unknown, probably several thousand feet.	Jack (1892) Maitland (1892) Dunstant (1905)	Thin seams of coal in Stuart-Antill Plains area.

ERA	PERIOD	STAGE OR EPOCH	ROCK UNIT	LITHOLOGY	RELATIONSHIPS	REMARKS	REFERENCES	ECONOMIC GEOLOGY
LATE PALAEOZOIC	UNDIFFERENTIATED		Pzu	Schist, hornfels, gneiss, quartzite; metamorphosed siltstone, sandstone, arkose, and limestone.	Largely unknown.	Undifferentiated. Some areas probably equivalent to the Devonian and Carboniferous units. Mainly contact metamorphics.	Jack (1886b, 1892)	
			Pzy	Dark rhyolitic and dacitic flows; agglomerate and volcanic breccia.	Intruded by Oweenee Granite and other late Palaeozoic granites.	Form unknown, may be high-level intrusives as well as extrusives.		
			Pzv	Rhyolitic and andesitic flows and pyroclastics.		Probably Carboniferous, but evidence to establish ages so far lacking. Thickness unknown.		
	LATE MIDDLE TO UPPER CARBONIFEROUS		Tareela Volcanics Ct	Andesitic and rhyolitic flows and pyroclastics.	Unconformably(?) overlies 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 (Pzug) and granodiorite (Pzb).	3500 ft. thick. Plant fossils. Animal tracks.	Wyatt (1963) McKellar (1963b)	
			St. James Volcanics Cs	Andesitic flows and pyroclastics, subgreywacke, rhyolitic flows and pyroclastics.	Unconformably(?) overlies Game Hill Beds. Faulted against Insolvency Gully Formation. Intruded by porphyry (Pzp).	3000-3500 ft. thick. Possibly equivalent to Tareela Volcanics.	Wyatt (1963)	
			Sybil Group: Marsh's Creek Beds. Cm	Conglomerate, sub-greywacke, siltstone, arkose, quartz sandstone, shale, tuffaceous mudstone, limestone.	Conformably overlies Hell's Gate Rhyolite. Unconformably over-lain by lateritized Tertiary sediments.	At least 4000 ft. thick. Fish and plant fossils.	Wyatt (1963)	
			Sybil Group: Hell's Gate Rhyolite Ch	Rhyolitic flows and pyroclastics; minor tuffaceous sediments.	Unconformably overlies Clarke River Formation and Silurian-Devonian sequences. Faulted against Oweenee Granite.	Variable thickness; max. 3000 ft.	Saint-Smith (1922) Bush (1959) Wyatt (1963)	
			Ellenvale Beds Ce	Rhyolitic flows and pyroclastics. Sub-greywacke, feldspathic sandstone, conglomerate, shale, mudstone.	Possibly conformably overlies unnamed Carboniferous sediments and volcanics (C). Faulted against Ravenswood Granodiorite and Fanning River Group. Intruded by granite (Pzug) and porphyry (Pzp).	Probably about 10,000 ft. thick. Plant fossils.	Wyatt (1963)	

[illegible]	PERIOD	STAGE OR EPOCH	ROCK UNIT	LITHOLOGY	RELATIONSHIPS	REMARKS	REFERENCES	ECONOMIC GEOLOGY
	LATE MIDDLE TO UPPER CARBONIFEROUS		C	Shale, chert, limestone, sub-greywacke, conglomerate. Rhyolite. Andesitic flows and pyroclastics.	Conformably overlie Percy Creek Volcanics. Possibly conformably overlain by Ellenvale Beds.	About 3300 ft. of sediments, 800 ft. of volcanics. Plant fossils.	Wyatt (1961)	
			Percy Creek Volcanics Cp	Andesitic flows and pyroclastics.	Unconformably overlie Givetian-Tournaisian sequence. Conformably overlain by unnamed Carboniferous sediments and volcanics (C).	About 600 ft. thick.	Wyatt (1961)	Copper east of Dotswood.
			Cg	Granite, porphyritic microgranite.	At Townsville overlain nonconformably by Permo-Carboniferous sequence. Intrudes Silurian-Devonian sequences near Ewan.	Intrusive contact with older rocks not known in coastal area.	Maitland (1892)	Tin deposits north-east of Ewan.
			Oweenee Granite Cgo	Granite, porphyritic microgranite.	Intrudes Silurian-Devonian sequences near Ewan, Running River Metamorphics, Devonian and Carboniferous sequences. Faulted against Sybil Group.		White et al. (1959b)	Tin deposits south and east of Ewan, Sn-Cu at Macaulay Creek and Mount Oweenee area.
	UPPER DEVONIAN TO LOWER CARBONIFEROUS	TOURNAISIAN	Clarke River Formation Cc	Sandstone, shale, limestone, conglomerate.	Unconformably overlies Kangaroo Hills Formation. Intruded by Oweenee Granite and possibly by diorite (Pzb).	Thickness unknown, probably several thousand feet. Equivalent in part to Piccadilly Formation. Marine and plant fossils.	White (1959b) Wyatt and White (1960)	
			Piccadilly Formation Ca	Arkose feldspathic sandstone, quartz conglomerate.	Conformably overlies Hardwick Formation.	At least 1200 feet thick, probable maximum 1700 feet.	Wyatt (1963)	
		UNDIFFEREN-TIATED	D-C	Sandstone, shale, conglomerate, limestone.	Undifferentiated equivalents of the Fanning River Group, Dotswood Formation, Star Beds, Clarke River Formation.	Six separate areas where outcrop is too poor to enable formational boundaries to be mapped.		
		FAMMENIA TO TOURNAISIAN	Game Hill Beds D-Cg	Feldspathic and quartzose arenites, shale, siltstone, limestone, conglomerate, sub-greywacke.	Unconformably overlies Argentine Metamorphics. Overlain, probably unconformably, or at least disconformably, by St. James Volcanics. Intruded by porphyry (Pzp).	About 2500 feet thick. Abundant marine fossils and plants. Probably equivalent to Star Beds.	Jack (1886b) Wyatt (1963)	
			Star Beds D-Cs	Sandstone, shale, siltstone, limestone, arkose, sub-greywacke, conglomerate.	Unconformably overlies Argentine Metamorphics. Unconformably overlain by Tareela Volcanics. Intruded by Oweenee Granite and porphyry (Pzp).	About 2300-2700 feet thick. Abundant marine fossils and plants.	Jack (1879a) Wyatt (1963)	Copper in Coppermine Creek area probably related to Oweenee Granite.

ERA	PERIOD	STAGE OR EPOCH	ROCK UNIT	LITHOLOGY	RELATIONSHIPS	REMARKS	REFERENCES	ECONOMIC GEOLOGY
LATE PALAEOZOIC	UPPER DEVONIAN TO LOWER CARBONIFEROUS	FAMMENIAN TO TOURNAISIAN	Hardwick Formation D-Ch	Feldspathic sandstone, arkose, subgreywacke, shale, limestone, siltstone.	Conformably overlies Lollypop Formation. Conformably overlain by Piccadilly Formation. Intruded by Pall Mall Adamellite (Pzug).	About 2700 feet thick. Marine and plant fossils. Equivalent to parts of Star and Game Hill Beds and Clarke River Formation.	Wyatt (1963)	
			Lollypop Formation D-Cl	Feldspathic sandstone, conglomerate.	Conformably overlies Myrtlevale Beds. Conformably overlain by Hardwick Formation. Intruded by Pall Mall Adamellite.	At least 1500 feet thick. No fossils so far observed.	Wyatt (1961, 1963)	
	DEVONIAN	FAMME-NIAN	Myrtlevale Beds Dum	Feldspathic sandstone, siltstone, shale, rare limestone, conglomerate.	Conformably overlies Dotswood Formation. Conformably overlain by Lollypop Formation.	900-1000 feet thick. Abundant marine fossils. Rare plants.	Wyatt (1961, 1962, 1963)	
		FRASNIAN	Dotswood Formation Dud	Feldspathic sandstone, arkose, red shale, siltstone, conglomerate, tuff.	Possibly disconformably overlies Fanning River Group. Intruded by Pall Mall Adamellite, Kitty O'Shea Intrusives, and dolerite and microdiorite (Pzi).	About 8000 feet thick. Continental deposits. Rare plant fossils.	Jack (1879a) Wyatt (1961, 1962, 1963)	Gold at Far Fanning diggings. Gold-copper at Great Caesar mine. Gold at Piccadilly mines. Copper at Mount Keelbottom.
		GIVETIAN	Fanning River Group Dmf	Arkose, subgreywacke, coralline limestone, sandstone, shale.	Nonconformably overlies Ravenswood Granodiorite. Overlain possibly disconformably or with overlap by Dotswood Formation.	About 1200 feet thick. Abundant marine fossils. Limestone is biostromal reef deposit.	Jack 1879a,b) Hill (1942) Wyatt (1961, 1962, 1963)	Limestone deposits in Calcium area. Gold at Mount Success and Golden Valley. Gold prospect near Calcium. Iron near Woodstock.
EARLY PALAEOZOIC	SILURIAN - LOWER DEVONIAN		Lolworth Igneous Complex S-Dl	Deeply lateritised porphyritic "granite".	Overlain by Cainozoic sediments. Otherwise no field relations seen.	Small areas near Fern Springs Homestead. Correlated with Lolworth Igneous Complex, Hughenden and Charters Towers 1:250,000 Sheet areas. Tentatively regarded as Lower Devonian.		Gold ("Big Hit" mine just south of Sheet area).
			Ravenswood Granodiorite S-Dr, S-Da	Granodiorite, granite, aplite, pegmatite, adamellite, diorite, gabbro.	Intrudes Argentine Metamorphics, Charters Towers Metamorphics, Kirk River Beds.	Covers about 700 square miles of the Sheet area. In places strongly foliated. 420-440 m.y. - 3 determinations.	Jack (1879a) Reid (1917) Wyatt (1961, 1962, 1963)	Gold mainly near Charters Towers and silver-lead mainly near Ravenswood in Charters Towers 1:250,000 Sheet area.
			Kangaroo Hills Formation S-Dk	Quartz arenite, shale, greywacke, conglomerate.	Possibly overlies Tribute Hills Sandstone. Unconformably overlain by Clarke River Formation and Sybil Group.	Quartz arenite and shale in thin beds, arenite generally current-bedded.	White et al. (1959) White and Wyatt (1960)	
			Tribute Hills Sandstone S-Dt	Quartz sandstone and siltstone.	Doubtful. Possibly equivalent to Perry Creek Formation. If so, older than Kangaroo Hills Formation.	3500-5000 feet thick.	White et al. (1959b) White and Wyatt (1960)	

ERA	PERIOD	STAGE OR EPOCH	ROCK UNIT	LITHOLOGY	RELATIONSHIPS	REMARKS	REFERENCES	ECONOMIC GEOLOGY
EARLY PALAEOZOIC	SILURIAN-LOWER DEVONIAN		Greenvale Formation S-Dg	Siltstone, greywacke, subgreywacke, silty quartz sandstone, feldspathic sandstone.	Doubtful.	Thickness unknown owing to tight folding.	White et al. (1959b) White and Wyatt (1960)	
	UNDIFFERENTIATED		Kirk River Beds Pzk	Micaceous shale, lithic, feldspathic sandstone, arkose, siltstone.	Intruded by and faulted against Ravenswood Granodiorite.	About 12,000 feet thick. Slumping, convolute bedding in arenites.		Gold associated with Ravenswood Granodiorite at Bunkers Hill.
			Ewan Beds Pze	Greywacke, lithic and quartzose conglomerate and sandstone, siltstone, limestone, andesitic and rhyolitic volcanics.	Unconformably overlies Running River Metamorphics. Intruded by Oweenee Granite.	Thickness unknown probably between 5000 and 10,000 feet. Very much fractured. Poorly preserved corals.	Jack (1892) Saint-Smith (1922) Reid (1931) Bush (1960) Wyatt (1963)	Tin, copper related to Oweenee Granite and other late Palaeozoic granite (Cg).
			Charters Towers Metamorphics Pzq	Mica schist, quartz plagioclase-biotite gneiss.	Intruded by Ravenswood Granodiorite.	Occurs as small roof pendants in Ravenswood Granodiorite. Thickness unknown.	Jack (1879a) Reid (1917) Wyatt (1963)	Small gold deposits near Charters Towers.
PRECAMBRIAN			Argentine Metamorphics p€a	Mica schist, quartzite, quartz schist, garnetiferous mica schist and quartzite, actinolite schist, marble, amphibolite, gneiss, migmatite.	Intruded by Ravenswood Granodiorite. Unconformably overlain by Givetian-Tournaisian sequences.	Strongly foliated, trend ranges from E-W to N.N.E.	Jack (1879a) Wyatt (1963)	Silver at Argentine. Gold in Ponto area.
			Running River Metamorphics p€r	Mica schist, quartzite, amphibolite.	Unconformably overlain by Ewan Beds. Intruded by Oweenee Granite.	Strongly foliated, trend N.E. Thickness unknown.	Bush (1950) Wyatt (1963)	Small tin deposits associated with Oweenee Granite.

PRELIMINARY EDITION, 1966

SUBJECT TO AMENDMENT

AUSTRALIA 1:250,000

TOWNSVILLE
QUEENSLAND

1:250,000 GEOLOGICAL SERIES SHEET SE 55-14

Reference

- Geological boundary
- Anticlinal axis
- Synclinal axis
- Fault

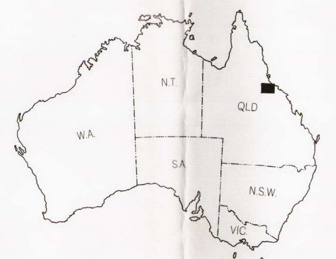
Where location of boundaries, faults and folds is approximate, line is broken; where inferred, queried; where concealed, boundaries and folds are dotted, faults are shown by short dashes

- Lineament (Air-photo interpretation)
- 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
- Strike and dip of cleavage
- Vertical cleavage
- Strike and dip of foliation
- Vertical foliation
- Direction and plunge of lineation
- Strike and dip of joint
- Vertical joint
- Horizontal joint
- Fossil locality, general
- Macrofossil locality
- Microfossil locality
- Plantfossil locality
- Dyke or vein: q-quartz, f-felsite, P-pegmatite, p-porphyry, d-dolerite/micro-diorite, a-aplite, an-andesite

- •Cu Minor mineral occurrence
- Mine — Abandoned mine
- Prospect — Quarry — Abandoned quarry
- Cu Copper — Fe Iron
- Au Gold — Bi Bismuth
- Pb Lead — Mo Molybdenum
- Ls Limestone — Cl Clay
- Ag Silver
- Sn Tin
- W Tungsten
- T.V./T. Television transmitter
- Lighthouse
- Well
- Windpump
- T Tank
- E Earth tank or "dam"
- Dam on watercourse
- Waterholes
- Falls
- Swamp
- Mangroves
- Highway
- Graded road
- Vehicle track
- Building or hut
- Yard
- Railway line
- Railway line abandoned
- Telegraph line
- Power transmission line
- Airport
- Landing ground
- Trigonometrical station
- •374' Height in feet, instrument levelled (Datum: mean sea level, Brisbane)
- •263' Height in feet, barometric (Datum: mean sea level, Brisbane)

Drawn and compiled by the Drafting Section, Department of Mines, Queensland, and issued by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development, in conjunction with the Geological Survey of Queensland. Topographic photo compilation supplied by the Royal Australian Survey Corps. Aerial photography by Adastra Airways Pty. Ltd.; complete vertical coverage at 1:80,000 scale. Transverse Mercator Projection

Geology by: D.H. Wyatt (G.S.Q.) 1960-1963, D.W. Dearne (G.S.Q.) 1961-1962, A.G.L. Paine (B.M.R.) 1963, R.R. Harding (B.M.R.) 1963, D.E. Clarke (G.S.Q.) 1963.
Compiled by: D.H. Wyatt and W.J. Rowland, 1963
Drawn by: W.J. Rowland, Drafting Section, Dept. of Mines, Queensland, 1964.



INDEX TO ADJOINING SHEETS
Showing Magnetic Declination

RED RIVER SE 54-8	ATHERTON SE 55-5	INNISFAIL SE 55-6		
GEORGETOWN SE 54-12	EINASLEIGH SE 55-9	INGHAM SE 55-10		
GILBERTON SE 54-16	CLARKE RIV. SE 55-13	TOWNSVILLE SE 55-14	AYR SE 55-15	
RICHMOND SF 54-4	HUGHENDEN SF 55-1	CHARTERS TOWERS SF 55-2	BOWEN SF 55-3	PROSERPINE SF 55-4
MANUKA SF 54-8	TANGORIN SF 55-5	BUCHANAN SF 55-6	MT. COOLON SF 55-7	MACKAY SF 55-8

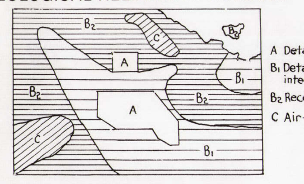
ANNUAL CHANGE 2°30" E.

Scale 1 : 250,000

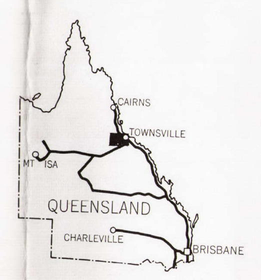
5 0 5 10 15 MILES

5 0 5 10 15 20 25 KILOMETRES

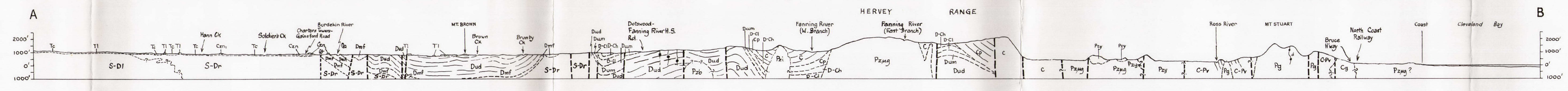
GEOLOGICAL RELIABILITY DIAGRAM



- A Detailed traverses
- B_1 Detailed reconnaissance with air-photo interpretation
- B_2 Reconnaissance and air-photo interpretation
- C Air-photo interpretation



Section A-B
(Quaternary units omitted from section)



Reference

CAINOZOIC	QUATERNARY		Qs	Residual sand and soil
			Qa	Alluvium and colluvium
			Qr	Old coastal sand dunes and beach deposits
			Ql	Lacustrine deposits, diatomaceous earth
		Toomba Basalt	Qt	Olivine basalt
	PLIOCENE — PLEISTOCENE	Sellheim Formation	Cze	Sandstone, sandy claystone, pebble conglomerate
			Czb	Olivine basalt
			Czy	Silicified quartz sandstone and conglomerate ("billy")
		Nulla Basalt	Czn	Olivine basalt
			Czn_1	Basalt flows in old stream channels
		Lassie Creek Gravels	Czl	Pebbly argillaceous sandstone, grit, arkose
	PLIOCENE ?		Tf	Ferricrete
		Campaspe Beds	Tc	Argillaceous sandstone, rare siltstone
	MIOCENE — PLIOCENE		Tl	Ferricrete (including laterite)
MESOZOIC		Collopy Formation	Mc	Quartz sandstone, micaceous sandstone, feldspathic sandstone, arkose, conglomerate
	PERMIAN TO MESOZOIC		P-Mg	Mainly biotite granite and adamellite; minor quartz monzonite, quartz syenite, microgranite, and hornblende-quartz gabbro
LATE PALAEOZOIC	UNDIFFERENTIATED		Pzp	Massive acid porphyry grading to microgranite
			Pzi	Dolerite and microdiorite
			Pzh	Light-coloured rhyolite and dacitic intrusion breccia
			Pzug	Granite, adamellite
			Pzb	Granodiorite, diorite; Porphyritic granodiorite
	PERMO — CARBONIFEROUS		C-Pv	Intermediate and acid flows and pyroclastics, rare conglomerate, sandstone, shale, coal
	UNDIFFERENTIATED		Pzu	Mica schist, hornfels, gneiss, quartzite; metamorphosed siltstone, sandstone, arkose, limestone
			Pzy	Dark rhyolitic and dacitic flows; volcanic breccia and agglomerate
			Pzv	Rhyolitic and andesitic flows and pyroclastics
	LATE MIDDLE — UPPER CARBONIFEROUS	Tareela Volcanics	Ct	Andesitic and rhyolitic flows and pyroclastics
		Insolvency Gully Formation	Ci	Subgreywacke, feldspathic sandstone, siltstone, mudstone, conglomerate, chert
		St. James Volcanics	Cs	Andesitic flows and pyroclastics, subgreywacke, rhyolitic flows and pyroclastics
		Sybil Group: Marsh's Creek Beds	Cm	Conglomerate, subgreywacke, siltstone, arkose, quartz sandstone, dark shale, tuffaceous mudstone, limestone
		Sybil Group: Hell's Gate Rhyolite	Ch	Rhyolitic flows and pyroclastics, minor tuffaceous sediments
		Ellenvale Beds	Ce	Rhyolitic flows and pyroclastics, subgreywacke, feldspathic sandstone and conglomerate, shale, mudstone
			C	Shale, chert, limestone, subgreywacke, conglomerate; rhyolite, andesitic flows and pyroclastics
		Percy Creek Volcanics	Cp	Andesitic flows and pyroclastics
			Cg	Coarse pink granite, minor porphyritic microgranite
		Oweenee Granite	Cgo	Pink porphyritic granite and microgranite
	LOWER CARBONIFEROUS	Clarke River Formation	Cc	Sandstone, shale, limestone, conglomerate
		Piccadilly Formation	Ca	Arkose, feldspathic sandstone, quartz conglomerate
	UPPER DEVONIAN — LOWER CARBONIFEROUS		D-C	Sandstone, shale, conglomerate, limestone
		Game Hill Beds	D-Cg	Feldspathic and quartzose arenites, shale, siltstone, limestone, conglomerate, subgreywacke
		Star Beds	D-Cs	Sandstone, shale, limestone, arkose, subgreywacke, conglomerate
		Hardwick Formation	D-Ch	Feldspathic sandstone, arkose, subgreywacke, shale, limestone, siltstone
		Lollypop Formation	D-Cl	Feldspathic sandstone, conglomerate
	UPPER DEVONIAN	Myrtlevale Beds	Dum	Feldspathic sandstone, siltstone, shale, rare limestone and conglomerate
		Dotswood Formation	Dud	Feldspathic sandstone, arkose, conglomerate, shale, siltstone, tuff
	MIDDLE DEVONIAN	Fanning River Group	Dmf	Arkose, subgreywacke, coralline limestone, sandstone, shale
EARLY PALAEOZOIC	SILURIAN — LOWER DEVONIAN	Lolworth Igneous Complex	S-Dl	Porphyritic granite
		Ravenswood Granodiorite	S-Dr	Granodiorite, quartz diorite, gabbro; foliated in places
			S-Da	Late "acid-phase" granite, aplite, adamellite; 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?	S-Dg	Siltstone, greywacke, subgreywacke, feldspathic sandstone, silty quartz sandstone
	UNDIFFERENTIATED	Kirk River Beds	Pzk	Micaceous shale, siltstone, lithic and feldspathic sandstone, arkose
		Ewan Beds	Pze	Greywacke, lithic and quartzose conglomerate and sandstone, siltstone, limestone; andesitic and rhyolitic volcanics
		Charters Towers Metamorphics	Pzq	Mica schist, quartz-plagioclase-biotite gneiss
PRECAMBRIAN		Argentine Metamorphics	p€a	Quartzite, mica schist, garnetiferous mica schist and quartzite, marble, amphibolite, quartz schist, actinolite schist, gneiss, migmatite
		Running River Metamorphics	p€r	Quartzite, mica schist, amphibolite

TOWNSVILLE

SHEET SE 55-14