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THE GEOLOGY OF THE CHARTERS TOWERS 1:250,000 SHEET AREA, QUEENSLAND

by

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SUMMARY

The geology of the Charters Towers 1:250,000 Sheet area*, north-east Queensland, was mapped by the Bureau of Mineral Resources and the Geological Survey of Queensland in 1963-64.

Charters Towers (population 8,000), which is near the northern edge of the area, is 80 miles south-west of the coastal city of Townsville, and lies on the trunk railway and highway which connect Townsville with Mount Isa. The climate is tropical; average rainfall is between 20 and 30 inches, most of which falls during a somewhat unreliable wet season between December and April. The Sheet area lies almost wholly within the dissected tableland which forms the eastern fall of the Great Dividing Range. Topographic relief is generally moderate, and extensive plains occur in the south-west.

Tertiary sediments and laterite cover half of the Sheet area, mainly in the south and west. In the remainder, early Palaeozoic granite batholiths, and sediments and volcanics, sporadically metamorphosed by these granites, crop out in the north; the northern end of the Devono-Carboniferous Drummond Basin occurs in the south-east; and part of the margin of the late Palaeozoic-Triassic Galilee Basin in the south-west. Late Palaeozoic granite stocks occur at the eastern and western margins of the Sheet area.

The oldest rocks are the Charters Towers Metamorphics, the Cape River Beds, and the Kirk River Beds, all of which are regarded tentatively as early Palaeozoic. However, no fossils have been found in them. Schists and quartzites of the Charters Towers Metamorphics, which crop out in and around Charters Towers, occur as roof-pendants in the Ravenswood Granodiorite. The Cape River Beds crop out in a discontinuous belt which trends east-west across the centre of the Sheet area. Where not metamorphosed, they can be recognised as a sedimentary sequence of mixed lithology,

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* In this report, for the sake of brevity, 1:250,000 Sheet areas will be referred to by their name only, in capital letters. For example, the Townsville 1:250,000 Sheet area is referred to simply as TOWNSVILLE

The Cape River Beds include an acid volcanic unit, the Mount Windsor Volcanics, which thins westwards. Foliation and bedding generally strike north-west to west, and low-to-medium grade metamorphism, although of "regional" aspect, is closely related to granite intrusion. The Kirk River Beds are an isolated remnant of probably contemporaneous deep-water sedimentation. The Charters Towers Metamorphics, Cape River Beds and Kirk River Beds were intruded by the late-syntectonic Ravenswood Granodiorite (Silurian-early Devonian), a large batholith which is exposed over at least 2,500 square miles. In the north-west the Cape River Beds are intruded by a post-tectonic batholith, the Lolworth Igneous Complex, which is only slightly younger than the Ravenswood Granodiorite. There followed a period of deep and widespread erosion, which is used in this and other recent reports on the geology of the region as a division between "early" and "late" Palaeozoic.

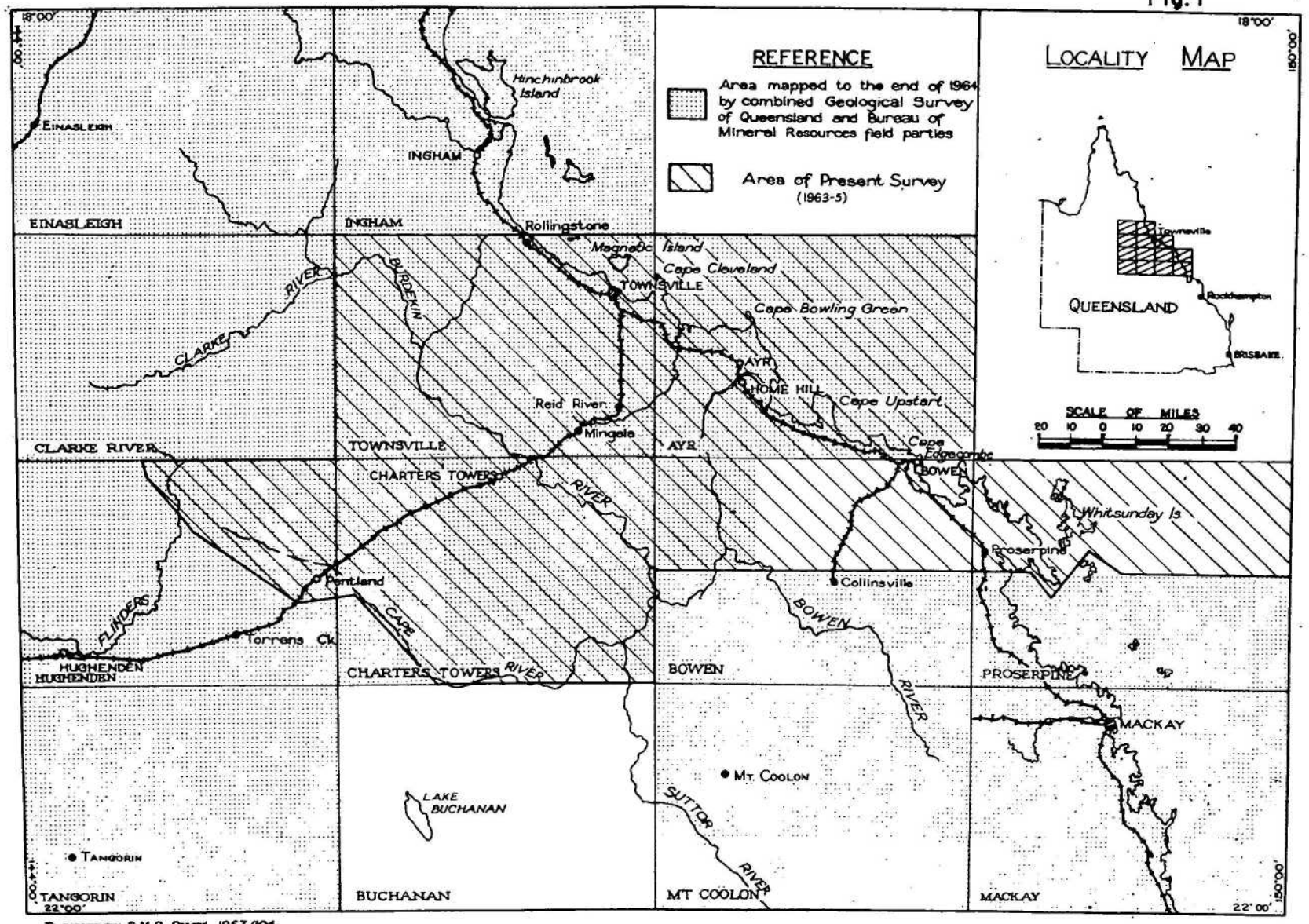
Renewed sedimentation is represented in the extreme south-east corner of the area by the Middle Devonian Ukalunda Beds, a moderately deep water marine sequence. Only siltstone and greywacke are represented on CHARTERS TOWERS, but limestone and conglomerate occur in the unit on BOWEN. The strike is predominantly north-east. The Ukalunda Beds are overlain unconformably by the non-marine sediments and acid volcanics of the late Devonian to Lower Carboniferous Drummond Group. The sediments are heterogeneous, and of shallow water type. Parts of the sequence were derived from the erosion of contemporaneous acid volcanics. The Drummond Group occupies the Drummond Basin, which extends north from Springsure for 250 miles to CHARTERS TOWERS. The northern margin of the Basin is formed by a shelf overlying the Ravenswood Granodiorite. The thicker axial zone of the basin has been tightly folded along north-east trending axes. The Upper Carboniferous and Lower Permian are represented only by igneous rocks, most of which are intrusive. Scattered outcrops of acid volcanics, broadly correlated with the Upper Carboniferous Bulgonunna Volcanics of BOWEN, occur in the north-east. Sill-like bodies of altered diorite and gabbro intrude the Drummond Group. Irregular intrusions of rhyolite and quartz-feldspar porphyry occur near the northern margin of the Drummond Basin. Small stocks, which range in composition from granite to quartz diorite occur in the east. The ages of the stocks are not well known, but two intrude the Drummond Group; they are collectively regarded as Upper Carboniferous to Permian in age, by analogy with similar

bodies in neighbouring Sheet areas. The epizonal Mundic Igneous Complex, which includes minor volcanics, forms rugged country in the north-west of the area. It is believed to be of Upper Permian age. The Upper Permian Betts Creek Beds and the Lower Triassic Warang Sandstone crop out in the south-west of the Sheet area, and dip gently to the south-west of the margin of the Galilee Basin. Both are fresh-water sequences. They are separated by a slight unconformity. On HUGHENDEN the Betts Creek Beds contain minor interbeds of tuff and some coal measures.

Thin lacustrine and fluviatile Tertiary sediments were deposited in two distinct periods, separated by a period of laterite development. The older sediments, which crop out in scattered pockets in the east, are probably no younger than Miocene. The younger Campaspe Beds, in the west, are regarded as Pliocene; they were laid down disconformably as piedmont deposits upon the eroded laterite land surface and form plains 2,500 square miles in extent. The Campaspe Beds in turn underwent a kind of lateritisation, which is represented by a thin capping of nodular ferricrete. Outpourings of olivine basalt in the late Tertiary to Quaternary are represented by the Nulla and Toomba Basalts; the Toomba Basalt may be Recent in age.

Charters Towers produced much of Australia's gold in the 1890's and early 1900's; total production is recorded at about 6,800,000 fine oz. By 1920 production had almost ceased, owing to the gradual depletion of the ore with depth. The ore occurred mainly as native gold in lodes in quartz-filled fissures in the Ravenswood Granodiorite. The gold was accompanied by pyrite, galena, and sphalerite. The smaller centre of Ravenswood in the north-east corner of the Sheet area produced some 900,000 fine oz of gold, which occurred mainly with sulphides. Minor, but still economically important quantities of silver, lead, and copper have been produced from the Sheet area.

Fig. 1



To accompany B.M.R. Record 1967/104.

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INTRODUCTION

This report deals with the regional geology of the Charters Towers 1:250,000 Sheet area. The area was mapped by a joint party of officers of the Bureau of Mineral Resources and the Geological Survey of Queensland during 1963 and 1964. Most of the mapping was of a reconnaissance or detailed reconnaissance nature. The area about the city of Charters Towers was not mapped, but a simplified version of Reid's detailed map of 1917 was incorporated in the 1:250,000 map (Enclosure).

The area is covered by planimetric maps at a scale of 4 miles to one inch, and partly covered by similar maps at 2 miles to one inch, or parish maps at 40 chains to one inch. All of these are available from the Department of Public Lands, Brisbane. The area is also covered by a recent topographic map at a scale of 1:250,000 produced by the Royal Australian Survey Corps in 1964.

A complete air-photo coverage is available at a scale of about 1:85,000. Photo coverage at a smaller scale is also available for certain 1-mile Sheet areas and other selected areas.

The largest town in the area is Charters Towers, which has a population of about 8000, and is situated on the Great Northern Railway and the Flinders Highway (Highway 78), 80 miles from Townsville on the coast. All other towns or settlements are situated on these routes except Ravenswood, which lies 25 miles south-east of Mingela with which it is connected by a good, formed road.

Access within the area is generally good, the most inaccessible parts being in the Robey Range and parts of the Seventy Mile Range. In the north and west of the Sheet area is the Flinders Highway, in the central part is the Gregory Developmental Road, and in the east the Ravenswood-Burdekin Falls road. Numerous shire roads give access from these roads to station homesteads from which, in turn, a system of tracks extends to neighbouring homesteads, muster camps, and watering sites. The main obstacles to road construction are the Burdekin River and the mountainous country which borders the eastern margin of the Sheet area.

The climate is tropical-continental. Most of the area receives less than 25 inches of annual rainfall, almost all of this being summer rain. East of a line from the old township of Kirk to Mount McConnell Homestead, the annual rainfall exceeds 25 inches, and rises to 30 inches on the Leichhardt Range in the extreme north-eastern corner of the Sheet area. The only temperature figures available are for Charters Towers, which is fairly representative of the whole area. There the mean annual maximum is 86.2°(F), and the mean annual minimum is 62.0°(F).

Vegetation comprises mainly open Eucalyptus forest; savannah with patches of brigalow scrub south of the Seventy Mile Range; and scrub of mixed tree types about Barrabas Creek and Rishton. The dominant grass is Heteropogon contortus (bunch spear).

The main industry is beef cattle raising. Citrus fruits and vegetables are grown on a small scale at Broughton, 10 miles from Charters Towers.

PREVIOUS INVESTIGATIONS

Before the commencement of field studies in 1963, little was known of the geology of this area except for a broad general outline. This outline was the result of a few early reconnaissance traverses and numerous spot observations, which were mainly the result of inspections of mineral deposits by officers of the Geological Survey of Queensland.

The first report on the area was by Daintree (1870) who briefly described the gold deposits at Ravenswood. In 1879, Jack described the granite and metamorphics at Charters Towers, the volcanics of the Seventy Mile Range and Mount Leyshon, the Tertiary sediments of Little Red Bluff, and those now called the Sellheim Formation. In 1885, Jack described more fully the volcanic rocks of Mount Leyshon and Mount Mawe.

In 1891 Rands made a reconnaissance traverse from Pentland to Mount Wyatt (BOWEN) via Thalanga, Charters Towers, Mount Leyshon, Dreghorn, Harvest Home, and Mount McConnell. This survey gave a general outline of the geology in the northern and eastern parts of the area.

Rands (1893) and Maitland (1893) made further studies of the rocks at Charters Towers.

Maclaren (1900) mapped a large part of the north-eastern section of the Sheet area when he reported on the Ravenswood Goldfield. Marks (1913) reported on the "outside" mines of the Charters Towers Goldfield, and published a large-scale map covering the southern part of the Goldfield. This map shows the state of geological knowledge of that area at the time and the generalised view of the regional geology of the whole Charters Towers Sheet area is shown on Dunstan's map of Queensland published in the following year (Dunstan, 1914).

Reid (1917) wrote a comprehensive report on the central part of the Charters Towers Goldfield, in which he described the petrology and sequence of the intrusive igneous rocks.

The only other major addition to the knowledge of the regional geology of the area was by Levingston (1956) when he mapped the area between Liontown and the Gregory Developmental Road.

ACKNOWLEDGEMENTS

R.R. Vine provided the data on the Warang Sandstone and the Betts Creek Beds, which were mapped by his field party in 1964 as an extension of their mapping of the Galilee Basin sediments.

Miss B.R. Houston, of the Geological Survey of Queensland, described numerous thin sections, and the results of her work have been incorporated in the text. The results of petrological work by W.R. Morgan and F. de Keyser have been similarly treated.

K.R. Levingston, District Geologist at Charters Towers, provided useful advice on the economic geology of the area.

PHYSIOGRAPHY

The Charters Towers Sheet area can be subdivided into six physiographic categories. These are shown in Figure 2.

(1) Hills and Ranges

Hills and ranges of widely varying elevation occur throughout the Sheet area, but mainly in the north-west and north-east. In the north-west the rugged Pentland Hills (granite) dominate the landscape. On all sides except in the north they rise abruptly from the lower country, reaching a height of over 3000 feet above sea level. Local relief here is up to 1700 feet. In the north-east of the Sheet area the Robey Range and the hills north-east of Ravenswood are quite rugged where formed from granitic rocks. Local relief is up to 1000 feet in places.

The Mount Windsor Volcanics give rise to smooth hills in the central part of the Sheet area. The Tuckers and Kirk Ranges are also formed of rather rounded hills consisting of gabbro and adamellite within the Ravenswood Granodiorite; these rock types do not weather as easily as the normal granodiorite and quartz diorite. In the south-east, isoclinally folded arenites of the Drummond Group give rise to discontinuous north-north-easterly trending ranges which are steep but rarely more than a few hundred feet high.

(2) Dissected Lower-Lying Country

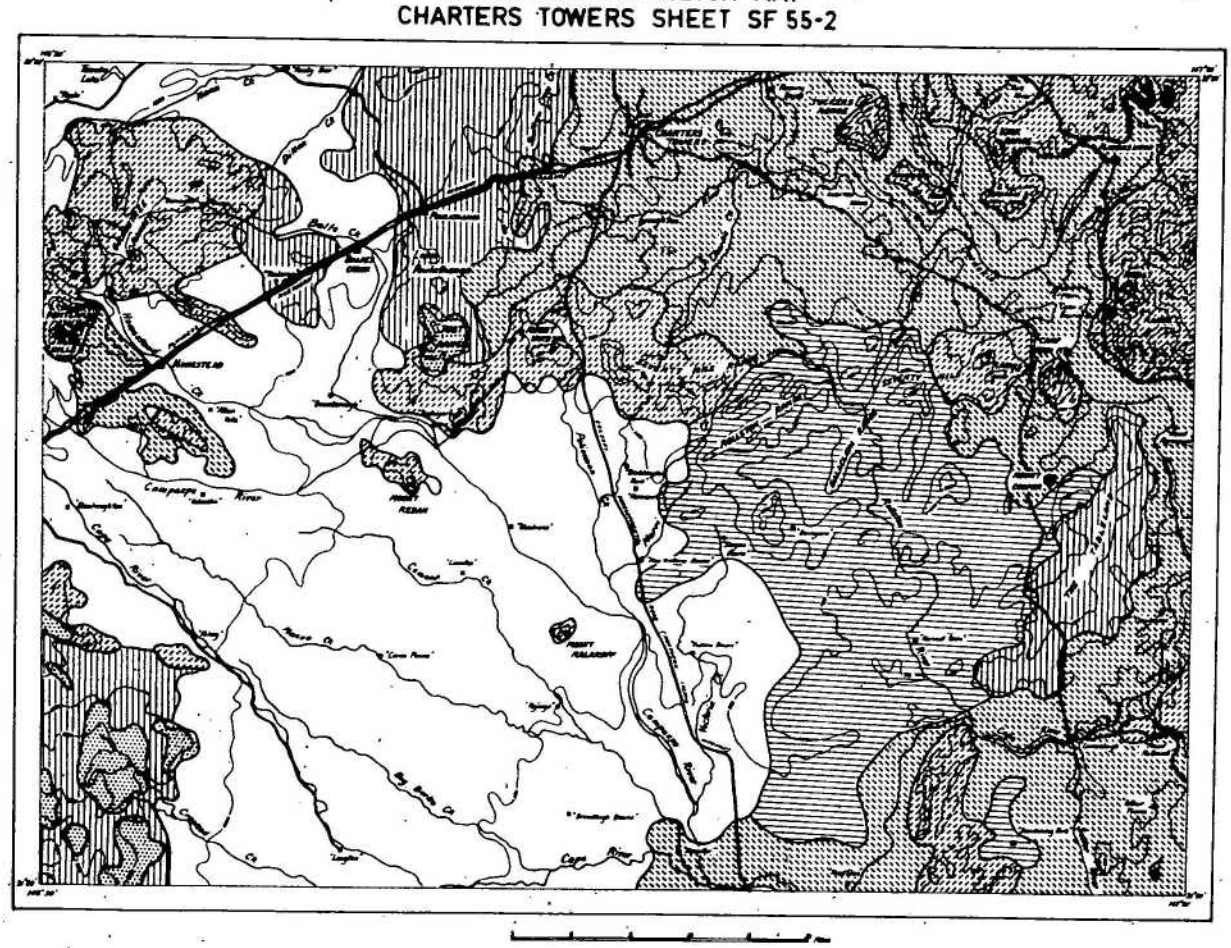
Much of the north-eastern part of the Sheet area is occupied by the Ravenswood Granodiorite which gives rise to rather low-lying country, with a close drainage pattern, containing scattered core-stones and a few low ridges of granite, and some outlying buttes and mesas of laterite. Similar country is found near Homestead, where it is developed on schists of the Cape River Beds, and also along the Suttor and Cape Rivers, where it is developed on the more easily eroded parts of the Drummond Group.

(3) Plains

Widespread plains are developed on the Cainozoic Campaspe Beds and basalts. These plains are regionally very flat, but in places the larger streams are incised 20 to 30 feet.

Fig 2.

PHYSIOGRAPHIC SKETCH MAP
CHARTERS TOWERS SHEET SF 55-2



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(4) Lateritic Tablelands

Very gently undulating, sand-covered tablelands are formed on the Miocene? lateritic land surface. From near Powlathanga to just west of Balfes Creek this surface merges into the broad plains which border Balfes Creek. Between Southern Cross Creek and the Just Range the eastern margin of the tableland is a low, broken scarp. Similar tablelands occur in the south-western corner of the Sheet area. A rather uniform lateritic plateau known as "The Tableland" occurs in the east; its surface is flat, but its north-eastern end dips gently towards the Burdekin River.

(5) Dissected Lateritic Tablelands

Between the Gregory Developmental Road and the Burdekin River are a thousand square miles of country from which the Miocene(?) lateritic capping has been largely stripped off, revealing scattered low hills and small ranges formed from rocks of the Cape River Beds and the Drummond Group. However, quite large lateritic mesas and slopes remain in places. This area is physiographically heterogeneous; it includes hills, small ranges, mesas, buttes, plateaux, and valleys of various widths and profiles.

(6) Sandstone Gorge Country

Where erosion has breached the lateritic tablelands and cut deeply into the underlying, sub-horizontal Warang Sandstone, steep gorges are developed with a prominent, close rectilinear pattern controlled by joints. This gorge pattern is geomorphologically quite distinct from other features in the Sheet area.

REGIONAL GEOLOGY

The stratigraphy and igneous rocks of the area are summarised in the stratigraphic table (enclosure).

EARLY PALAEOZOIC

Charters Towers Metamorphics (P_{zq})

In the vicinity of Charters Towers there are several roof-pendants of metamorphic rocks in the Ravenswood Granodiorite. The largest occurs immediately north-west of Charters Towers. Scattered small outcrops extend north of the town onto TOWNSVILLE. The most southerly occurrence was recorded

in diamond drill cores at the Mabel Jane East mine, in the east bank of Rocky Creek, eight miles south of the town.

The rocks at Charters Towers were described by Jack (1879), Maitland (1893), and Reid (1917). Bryan (1926) named them the "Charters Towers Series". However, in accordance with the Australian Code of Stratigraphic nomenclature, the term "metamorphics" is preferred. The name Charters Towers Metamorphics is therefore proposed, to embrace all roof-pendants of metamorphic rocks in the environs of Charters Towers.

The main roof-pendant consists chiefly of mica schist and quartzite. These rock types occur also east of Merry Monarch Creek. Chlorite schist forms the northern foot of Lincoln Hill, and is reported to occur near the racecourse (Reid, 1917). Staurolite hornfels, resembling rocks in the Cape River Beds where they are intruded by granite, occurs in Charters Towers itself. Quartz-feldspar-biotite schist, hornblende schist, and anthophyllite-andesine-quartz schist were recorded from the drill hole at the Mabel Jane East mine. Tucker (1962) regarded the Charters Towers Metamorphics as derived by regional and contact metamorphism of sediments and possibly basic volcanics.

Foliation in the Charters Towers Metamorphics strikes north-west, and dips either vertically or steeply north-east.

Reid (1917) estimated a thickness of 7,000 feet for part of the sequence, but allowed that the total thickness may amount to many thousands of feet more.

Bryan (1926) suggested a late Precambrian age for these rocks. However, the Charters Towers Metamorphics are probably no older than the Cape River Beds for which an early Palaeozoic age is favoured (see below). They are intruded by the Silurian to early Devonian Ravenswood Granodiorite. Rock types in the Charters Towers Metamorphics are not readily comparable with the Argentine Metamorphics or the Running River Metamorphics (TOWNSVILLE), which are believed to be Precambrian (Wyatt, et al., 1965; Wyatt, et al. in prep.). Although the Charters Towers Metamorphics are generally more schistose than those parts of the Cape River Beds which occur on CHARTERS TOWERS, the difference in degree of schistosity is probably due to shearing and granite emplacement,

and is not considered to denote a difference in age between the units.

Cape River Beds

Distribution and topography

The Cape River Beds extend in a slightly arcuate belt averaging 15 miles wide from near the Pentland Hills in the west of the Sheet area to the northern part of the Robey Range in the east. The belt is discontinuous, being intruded by the Ravenswood Granodiorite or covered by extensive Cainozoic sediments and laterite.

The type area of the Cape River Beds (Paine et al., 1965), is on HUGHENDEN Sheet from whence the Beds continue across onto CHARTERS TOWERS. Several distinct rock types occur within the Sheet area, but the variation in metamorphic grade and discontinuity of outcrops make correlation within, and consequently subdivision of, the unit almost impossible. However, belts composed mainly of acid volcanics can be mapped separately in places, and these are named the Mount Windsor Volcanics.

The Cape River Beds crop out as low hills with gentle slopes, which are rarely much higher than the level of the surrounding country, although in the Rollston Range they reach an elevation of 1700 feet at Mount Sunrise. The Mount Windsor Volcanics, however, give rise to more rugged and elevated topography and form the backbone of the range of hills culminating in Mount Windsor (1905 feet) and the Seventy Mile Range. They also form the northern hills of the Robey Range, where the elevation of the hill-tops generally exceeds 1500 feet. All these high points are between 300 and 700 feet above the surrounding Ravenswood Granodiorite and Cainozoic sediments.

Trend lines (mostly strike ridges) show well on air photographs in places, but generally the unit gives rise to a nondescript pattern which cannot always be reliably interpreted.

Lithology

Undivided metasediments (Pzc)

Because outcrop is discontinuous over wide areas within which accurate correlation is not possible, the Cape River Beds are not typically represented in any one area. Separate areas of outcrop are described here in turn, starting in the west, nearest the type area, and continuing eastwards to the Robey Range.

1a. North of Homestead, about the headwaters of Deadman Creek, is an area of poor outcrop in which fine-grained, brown micaceous schist and a few small outcrops of calc-silicate hornfels have been observed. The foliation in this area trends between south-east and east-south-east, and dips between vertical and steeply south-west. Farther north, near the Deadman Fault Zone, outcrop is still poor, but creeks contain numerous cobbles of hematitic phyllite, hornfels, and some actinolite schist. Rands (1891) reported outcrops of schist amongst granite in the headwaters of Homestead and Deadman Creeks.

One of the calc-silicate hornfelses consists of some 40% quartzofeldspathic material, 40% porphyroblastic garnet, epidote, and 20% clinopyroxene, probably diopside. Two cobbles obtained from a creek bed near the Deadman Fault Zone were sectioned. One is an actinolite schist containing bands of material resembling recrystallised mylonite, and the other consists of a groundmass of muscovite, biotite, quartz and cordierite with porphyroblasts of a mineral now completely altered to white mica and chlorite. This mineral has a cross-section typical of staurolite, but its alteration products are more characteristic of andalusite.

1b. West of Homestead, and north-west of the Flinders Highway, khaki hematite-sericite phyllite and schist are the most abundant rock-types. Other types noted are: (a) banded, blastoporphyritic hornfels, probably a meta-rhyolite, with up to 5% pyrite in thin stringers concordant with the banding.

(b) biotite-muscovite schist.

(c) strongly foliated, medium-grained, metadolerite or meta-basalt of the greenschist facies.

(d) weakly foliated granofels possibly derived from an acid volcanic rock or a micro-granite.

(e) recrystallised, fine, lithic subgreywacke with clasts of quartzite and sericite schist.

The foliation in this area generally trends east-north-east and dips steeply to the south.

1c. Farther to the south-west, in the Estland-Yarraman Park area, the main rock type is a banded granofels, but hematitic phyllite and flaggy, impure sericitic quartzite have also been noted. The granofels, which is composed essentially of biotite, quartz, and feldspar, was probably an acid volcanic rock. In this area the trend of the foliation ranges from east to north-east, and dips south or south-east at between 30 and 75°.

2. South-west of Allan Hills Homestead low hills trending north-west are composed of a number of strike ridges of quartz-mica phyllite and minor sheared fine-grained subgreywacke. In places the phyllites are dark grey, and are possibly slightly carbonaceous. Small amounts of muscovite-biotite schist crop out amongst phyllite in the low country north and south of the strike ridges.

3a. Similar phyllites occur in the low hills and rises north of the Campaspe River, west from Trafalgar Homestead. Both here and south-west of Allan Hills Homestead bedding can be recognised. Generally it is thin ($\frac{3}{8}$" to $\frac{1}{2}$") in the fine-grained sediments but thicker in subgreywacke. Locally, at least, it coincides with the slaty cleavage. The trend ranges from west-north-west near Trafalgar Homestead to north-west south of Allan Hills Homestead. Regional dip is to the south at between 25 and 40 degrees, but local northerly dips have been recorded.

3b. South-east of Mount Trafalgar the sequence consists of indurated and in places slump-bedded siltstone, dark grey mudstone and minor quartzite, which dip south-west at about 45 degrees. These sediments are associated with rhyolite-porphyry and andesite, but it is not known whether the igneous rocks comprise part of the sequence or are later intrusions. They have been mapped

for the present with the Mount Windsor Volcanics. The section exposed in this area is about 5000 feet thick.

4. In the Liontown area the sequence consists of thin-bedded phyllite, sheared arenite, and quartz-sericite schist. Fine-grained quartzite occurs 1 mile west of Liontown. These sediments are associated with acid volcanics, some of which are highly sheared. Other fine-grained igneous rocks are less sheared, transgress the trend of the sediments, and appear to be younger.

5. In the Windsor Homestead area the strata are severely jointed and fractured, and exposures are poor. The main rock types appear to be phyllite and grey impure quartzite. Trends are erratic, but the general direction appears to be east-west, and the general dip direction is to the south. In the hills south of Windsor Homestead are rock of the Mount Windsor Volcanics, which are described more fully on p. 14. In the low country south of these hills are more sediments - mudstone and arenite. These beds are only weakly cleaved and sheared, and are not metamorphosed.

6. About Mount Leyshon and south to the Seventy Mile Range, the rocks are similar to those about Windsor Homestead. South of the range formed by the Mount Windsor Volcanics, in the headwaters of Little Policeman Creek, a sequence of interbedded sediments and volcanics grades up section into a purely sedimentary sequence. The lower part of this sequence consists of passage beds from the essentially volcanic sequence of the Mount Windsor Volcanics below to the sedimentary sequence above. The volcanics in these passage beds consist of rhyolite, dacite, acid tuff, and minor (?)andesite.

The rhyolites and dacites range from purple to creamy white. They are aphanitic or saccharoidal and sparsely porphyritic. Both flow-banded and massive types occur. Some of the lavas show signs of having originally been partly vitric. The tuffs, all of which are acid, range in texture from coarse lapilli to fine-grained types. They are interbedded with the sediments and therefore were probably water-lain. Andesite has only been seen at one locality. Its relationship to the other strata is unknown.

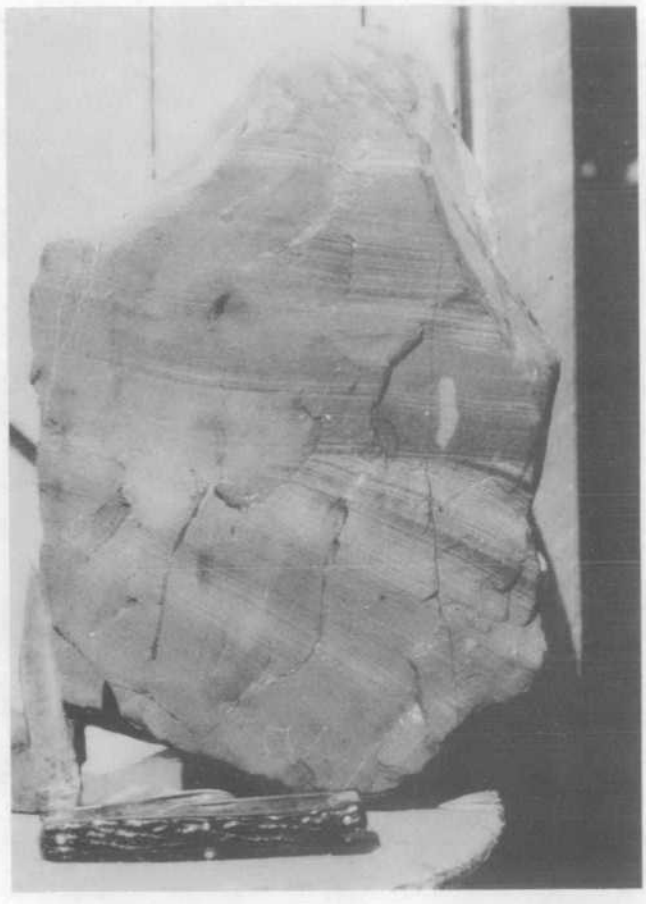

Photo Plate 1.

Finely cross-laminated indurated mudstone of the Cape River Beds. Little Policeman Creek, six miles north of Bletchington Park Homestead. B.M.R. Neg.No.M/381/4.

The sediments associated with the volcanics range from thin-bedded mudstone to thick bedded greywacke. Some mudstone probably grades into tuff; the greywacke appears to contain a high proportion of volcanic detritus.

In the sequence above the passage beds, the dominant rock types are cream to light brown and green, thin-bedded siltstone and mudstone. They are generally siliceous and hard but also include some soft, probably more clayey, siltstone beds. Cross-bedding structures have been observed (Photo Plate 1). Beds of sub-arkose with a high proportion of lithic grains are scattered through the sequence; some beds are graded.

Many of the strata are strongly jointed but not as intensely as the underlying volcanics (Mount Windsor Volcanics).

The dip of the sediments which overlie the Mount Windsor Volcanics shallows to the south. Assuming an average dip of 30°, a minimum thickness of 6,000 feet is present in this area.

7. Eight miles south-east of the Little Policeman Creek section, at the south-western end of the Rollston Range, thin beds of siltstone alternate with beds of silty arenite to give a striking banded appearance to the outcrop. The sediments, which are generally reddish-brown, contain small scour structures.

Three inliers of Cape River Beds in laterite occur two to three miles further to the south and south-east of these sediments. Here the chief rock types are light-coloured mudstone and dark, grey-green indurated arenite, micaceous in places.

8. About 6 miles east of the inliers, near Six Mile Creek (a tributary of Molly Darling Creek) and in the south of the Balaclava Range, the sediments are probably correlatives of those just described. Here they are metamorphosed to fine-grained, cream muscovite-biotite-quartz hornfels, spotted sericite hornfels, and hornfelsed siltstone. Minor hornfelsed calcareous siltstone, containing tremolite, also occurs.

9. In the Seventy Mile Range, about 10 miles west of Camp Oven Mountain, the sequence is composed of subgreywacke, greywacke, feldspathic sandstone and greywacke, indurated siliceous siltstone, quartzite, pyritic quartzite, arkose, shale and mudstone. The sediments are generally well bedded, the finer types commonly being very thinly bedded with a notably banded appearance. Slump structures are also common in the finer sediments. Graded-bedding is common in the greywackes. Ripple-marks were seen at one locality only, in a fined-grained quartzite; they had a wave-length of about 1 cm.

The sequence is contact metamorphosed by the Ravenswood Granodiorite and, although the grade varies considerably, it appears to decrease away from the granodiorite contact. South of Box Flat Dam the rocks consist of recrystallised feldspathic greywacke, subgreywacke, arkose and spotted mica-quartz hornfels. Three miles to the north-north-west and away from the outcrop of the granite contact the rocks comprise apparently unaltered arkose, feldspathic lithic sandstone, and sandy siltstone. However the Ravenswood Granodiorite probably underlies the sediments at a shallow depth in places, because, 5 miles north-north-west of the dam and 2½ miles from the nearest known outcrop of granodiorite, lithic greywacke and quartzite show granoblastic textures and abundant biotite in the matrix.

The Cape River Beds form a roof pendant in the Ravenswood Granodiorite 12 miles north-north-west of Box Flat Dam and 4 miles south-east of Cardigan Homestead. Here the rocks consist of fine, pink, quartz-feldspar-muscovite-biotite schist and gneiss, biotite quartzite and biotite gneiss. These rocks are intruded by numerous quartz veins and acid pegmatites. The pegmatites contain red-brown crystals of andalusite up to 1 inch long which are extensively altered to fine-grained aggregates of mica.

Two miles north-west of Camp Oven Mountain in a tributary of Dreghorn Creek, argillite and siltstone crop out extensively. Both are thinly laminated and both contain abundant pyrite concentrated in the coarser-grained laminations. In this area the pyritic strata exceed 150 feet in thickness. For 2 miles south of the creek near the granodiorite contact quartz-mica hornfels, calc-silicate hornfels, quartzite and recrystallised subgreywacke occur.

10. Ten miles west of Mount Cooper, the Cape River Beds form a range of hills about 400 feet higher than the surrounding country. The sediments consist of thermally metamorphosed greywacke, subgreywacke, pebble conglomerate and laminated siltstone. The clastic material in the coarser-grained rocks includes quartz, feldspar, micropegmatite, quartzite and sericitized argillaceous rock fragments. Metamorphic biotite is strongly developed in the fine matrix of the sediments. Locally the greywacke includes fragments up to two feet long of thin-bedded and slumped siltstone. Graded bedding is characteristic of the subgreywacke and very fine, even bedding is characteristic of the siltstone. The sediments are highly fractured and are intruded by lamprophyre dykes.

East of the Burdekin River, the Cape River Beds have been only rarely recognised. The unit appears to be represented here mainly by volcanics (Mount Windsor Volcanics).

11. At Mount Canton a sequence of metamorphosed impure arenite and siltstone is tentatively assigned to the Cape River Beds. The arenites are grey-brown, fine-grained, and composed of rather labile materials; scattered, large flakes of muscovite are characteristic. The siltstones are dark grey to black and carbonaceous. Fragments of fossil plants were found in siltstone (now andalusite hornfels) near the summit of the mountain but no identifiable structures are preserved in the plants. The rocks are quite strongly indurated and do not part readily along the bedding, which can be recognised only by a change in lithology. The andalusite hornfels consists of radiating rosettes of andalusite (average diameter of rosettes 0.5 mm), abundant sericite, carbonaceous material (probably graphite) black and brown iron oxides and some quartz grains. The induration and metamorphism may have been caused by a swarm of microgranite dykes which intrude the strata in the vicinity of Mount Canton itself and which are possibly related to a nearby late Palaeozoic granite.

The age of these rocks is not precisely known nor is their relationship with the Ravenswood Granodiorite; in view of the presence of plant fossils it is possible that this isolated block of hornfelses may be an outlier of the Drummond Group.

12. Small roof-pendants of feldspathic mica schist and corundum-cordierite-quartz-muscovite-biotite schist occur in the Ravenswood Granodiorite five miles south of Mount Canton.

Seven miles to the south-east, east of Mount Ravenswood Homestead, small but frequent outcrops of schist and quartzite occur between ridges formed by east-north-east-trending dykes.

13. In the Robey Range small isolated roof-pendants of high-grade hornfelses occur in granite of the acid phase of the Ravenswood Granodiorite. North-east of Carse Creek the rocks consist of quartz, muscovite, cordierite, chlorite, andalusite and sillimanite. Much of the chlorite is derived from aggregates of what was probably stilpnomelane. The sillimanite occurs as rare needles associated with poikiloblasts of cordierite. The andalusite, constituting at least 10% of the rock, occurs as aggregates of stumpy anhedra.

A similar hornfels occurs in a very small roof-pendant at the head of Carse Creek where euhedral crystals of dark red garnet up to 1 inch in diameter and large crystals of probable andalusite up to 3 inches in length, have been recognised in hand specimens.

Mount Windsor Volcanics (P_{zw})

The Mount Windsor Volcanics form a discontinuous belt within the Cape River Beds.

The type area is Mount Windsor and east therefrom to the western end of the Seventy Mile Range. The unit consists of rhyolite, dacite, minor andesite and basalt, and interbedded sediments. The proportion of sediments varies greatly. Tuffs and agglomerates, equivalent to the more acid volcanics, are also present.

At Mount Windsor, the dominant rock is rhyolite. Flow banding is distinguishable in places but generally the rock is even-textured and fine-grained. Fresh exposures are rare because the rocks are closely jointed and fractured. Many of the rhyolites are sparsely porphyritic in quartz and/or feldspar (1 to 2.5 mm). Some rhyolites are spherulitic. Pyrite, in well-defined, disseminated cubes, is common throughout the rhyolites.

Just east of the Gregory Developmental Road greenish-grey vesicular basalt(?) occurs. It is not extensive; it appears to be interbedded with the rhyolite.

Andesite occurs in the volcanics, largely as dykes, but possibly also as flows.

At Thalanga railway siding, a prominent ridge, trending north-west, is formed by strongly cleaved and recrystallised acid volcanics. The volcanics have been strongly hornfelsed by the Ravenswood Granodiorite. The hornfelses are composed of biotite, sericite, quartz and feldspar in varying proportions. The feldspar is usually a plagioclase, oligoclase having been specifically determined in one thin section, but microperthite has also been noted. Sheared agglomerate, volcanic breccia and quartz-mica slate and biotite-muscovite-quartz schist which may be metamorphosed tuffs or tuffaceous sediments are present in minor amounts. The rocks have textures ranging from granoblastic to lepidoblastic, and most are blastoporphyritic; the blasto-phenocrysts are generally quartz, which in places is bipyramidal, or chloritised biotite. All rocks contain disseminated cubes of pyrite.

In some places relict flow-banding is visible. It is commonly crenulated and makes a high angle with the strong, near-vertical cleavage which is a feature of this area. The cleavage trends north-west. Phenoclasts in the agglomerates and volcanic breccias have been stretched parallel to the cleavage. Veins of quartz-rich biotite pegmatite which intrude the volcanics have been boudinaged and attenuated where they trend parallel to this cleavage; where they transgress the cleavage they are isoclinally folded. Other pegmatites, which contain a bright red feldspar, show no such stress effects and were emplaced presumably at a later stage. A dyke, possibly originally a micro-diorite but now a schist composed of quartz, actinolite, biotite, clinozoisite and feldspar, intrudes the volcanics; it was emplaced before the cleavage was developed.

Three miles north of Homestead rhyolite crops out to the north of a number of low hills composed mainly of chloritic phyllite. The rhyolite is white and pale grey, rather siliceous and metamorphosed with a well developed foliation. In places, the foliation planes are occupied by numerous small stringers of pyrite which may amount to perhaps 10 per cent of the rock. A similar rock near-by contains layers crowded with small octahedra of magnetite; these layers are again in the foliation planes. Specimens of both rocks have been examined and described mineragraphically (I.R. Pontifex) and petrologically

(W.R. Morgan) (Appendix 2).

The volcanics have been observed at several places in the Seventy Mile Range east of the type area but exposures are not good. Fresh outcrops are difficult to find and a thin cover of lateritic material commonly masks the underlying rocks. Two miles north of Rollston Hut the Mount Windsor Volcanics consist of rhyolite, andesite, rhyolitic and andesitic breccia, basalt, dolerite and interbedded quartzite and minor pebble conglomerate and greywacke. The sequence is faulted against granite on its north-western side and intruded by the Ravenswood Granodiorite in the south-east. It is thermally metamorphosed throughout and locally silicified and brecciated. The thermal metamorphism has produced light grey, spotted quartz-mica hornfels from some of the more quartzose sediments. The interbedded quartzite is very fine-grained and well laminated, but not fissile. Laminae average $\frac{1}{4}$ inch in thickness.

Four miles north-north-west of Camp Oven Mountain, the Mount Windsor Volcanics consist of andesite, basalt (often amygdaloidal), rhyolite and doleritic volcanics with rare thin interbeds of grey quartzite. The sequence is faulted against the Cape River Beds on its southern margin and intruded by the Ravenswood Granodiorite on its northern and eastern margin. The volcanics are strongly hornfelsed, and contain garnet, epidote, hornblende, diopside and magnetite. The amygdules in the basalt now consist of cores of amphibole rimmed with plagioclase and diopside. Breccia, schistose rocks, and mylonite occur at the Ravenswood Granodiorite contact; the rocks at the contact include schistose cordierite-feldspar-amphibole hornfels, quartz-mica hornfels and quartz-mica-sericite hornfels.

Three miles west-north-west of the junction of Camp Oven Creek and Dreghorn Creek, andesite, blue-grey dolerite and spessartite lamprophyre occur. However the dolerite and lamprophyre are no doubt later intrusions.

South-east of Ravenswood an extensive area of volcanics forms the northern foothills of the Robey Range. The volcanics consist almost entirely of acid lavas, the most typical being a brownish-green spherulitic rhyolite. A few dark grey lavas, possibly dacite, also occur. Dacite is the dominant rock type in Fish Creek, three miles east of Connolly Homestead. A thin-sectioned specimen consists of phenocrysts of oligoclase (30%) and quartz (5%) in a

groundmass of feldspar (35%), quartz (20%) and chlorite (10%). Altered basalt and andesitic agglomerate and minor micaceous shale were also recorded in this area. The sequence is intruded by dykes of microdiorite and spessartite lamprophyre.

Maclaren (1900) described greywacke, slaty shale, altered sandstone and micaceous sandstone"in the neighbourhood of Tucker and Fish Creeks." Traverses in Fish Creek failed to locate these rock types in outcrop but rare floaters of recrystallised, medium subgreywacke were observed. This rock contains subangular to subrounded clasts of fine quartzite and sericitic quartzite.

South-east of Ravenswood, the Mount Windsor Volcanics are intruded by the Ravenswood Granodiorite and by late Palaeozoic granites.

Thickness

The total thickness of the Cape River Beds is unknown, due to discontinuity of outcrop and lack of structural information. In the main belt of outcrop south of Charters Towers at least 5,000 feet of section is exposed near Mount Trafalgar and at least 6,000 feet occurs north of Bletchington Park Homestead. The total thickness is clearly many thousands of feet.

Strong jointing is common throughout the Mount Windsor Volcanics and has made it difficult to recognise bedding or flow-banding. Even where flow-banding has been recognised it has not been consistent in direction for more than a few yards. Generally such banding seldom dips at less than 45°. If we presume that the Volcanics have a regional southerly dip similar to the Cape River Beds then to the north of Rollston Hut the Volcanics have a thickness of 10,000 to 15,000 feet. The unit probably consists of a number of localised volcanic piles which thin out away from each volcanic centre. A regional thinning to the west is also apparent; the volcanics are absent on HUGHENDEN.

Metamorphism

The metamorphism of the Cape River Beds appears to have been caused by the intrusion of the Ravenswood Granodiorite. A feature of the metamorphism was the severe dynamic component which commonly accompanied the thermal effects. In the central and eastern parts of the Sheet area, schistose or foliated rocks generally are not known to occur more than two to three miles from the granodiorite contact; north of Brittania Homestead, for example, the foliation, when traced to the south, dies out and gives way to strong jointing. The foliation was evidently produced by the intrusive force of the granodiorite, which is commonly foliated itself. The outcrop of the intrusive contact is irregular, and the contact evidently dips rather shallowly.

Mineralization

Most mineralization within the Cape River Beds occurs near the contact of the Ravenswood Granodiorite, and is probably related to its intrusion. For example, the silver-lead deposits at Liontown are probably related to porphyries which are interpreted as apophyses of the late granite phase (S-Da).

However, the gold mineralization at the "Old Homestead Diggings" 7 to 8 miles north of Homestead is probably related to the Lolworth Igneous Complex. Here much of the gold occurs in lodes at the contact between the granite and small roof pendants of schist.

The origin of the stibnite at The Antler mine, 3 miles west-northwest of Homestead, is not so obvious. It occurs in a sheared, altered, possibly volcanic rock. The nearest exposed possible mineralizing agent is a granite one mile to the south, mapped tentatively with the late acid phase of the Ravenswood Granodiorite.

Several minor mineral occurrences were recorded during the course of mapping. The pyrite and magnetite north of Homestead have already been noted. Thin veins of magnesite up to 2 inches thick and a sphalerite vein $\frac{1}{8}$ inch thick occur in the volcanics in the railway cutting east of Thalanga Railway Siding. The sphalerite vein was observed in a block broken during excavation of the cutting. Pyrite and minor chalcopyrite occur as sparse disseminations in this

area. Barytes was found as small pebbles in a creek bed at the south-eastern end of the low range which extends south-east of Thalanga Railway Siding.

Environment of deposition

The presence of poor sorting and graded bedding in many of the arenite units suggests a low-energy environment of deposition. This is also suggested by the abundance of thin laminated beds in many of the finer grained sediments. The greywackes, subgreywackes, and arkoses possibly represent the erosional products of the contemporaneous Mount Windsor Volcanics; their poor sorting could be a reflection of provenance rather than a true indication of the energy level of the depositional environment. At present there is insufficient evidence to establish the overall environment of deposition.

Age

The age of the Cape River Beds is not known. They are intruded by the Ravenswood Granodiorite which is older than Givetian. The results of three radiometric age determinations on the Granodiorite from TOWNSVILLE have given ages in millions of years of 420 (hornblende), 440 (biotite) and 420 (biotite). Levingston (1956) regarded the strata at Liontown as being of Lower Palaeozoic age.

Parts of the Cape River Beds somewhat resemble the probably Silurian Ewan Beds (TOWNSVILLE). At present the Cape River Beds are tentatively regarded as early Palaeozoic in age.

Kirk River Beds (Pzk)

The Kirk River Beds (Wyatt, et al., 1965) extend from TOWNSVILLE onto about 3 square miles of CHARTERS TOWERS, immediately west of Blue Mountain (seven miles north of Ravenswood). They crop out as dissected hills of low relief.

The Kirk River Beds were only briefly examined on CHARTERS TOWERS, and for further information the reader is referred to Wyatt, et al., 1965 or Wyatt, et al., in prep. On CHARTERS TOWERS they consist of micaceous shale, siltstone, feldspathic sandstone, and greywacke. They are poorly sorted and graded bedding and turbidity structures are characteristic.

No fossils have been recorded in the unit; however the unit is intruded by the Ravenswood Granodiorite and so can be no younger than early Devonian. Lithologically it resembles the Siluro-Devonian Kangaroo Hills Formation of TOWNSVILLE, CLARKE RIVER, and INGHAM, and also parts of the Cape River Beds.

Gold occurs in the Kirk River Beds at Bunkers Hill, on TOWNSVILLE.

Ravenswood Granodiorite

Introduction

The Ravenswood Granodiorite crops out over much of the northern half of CHARTERS TOWERS but in the north-west its true extent is largely masked by Cainozoic sediments or laterite.

The unit consists mainly of granodiorite but sub-units of granite and adamellite, diorite and gabbro have been mapped separately in places. The granodiorite gives rise to undulating country of low relief with a fairly closely spaced drainage pattern. The diorite and gabbro often give rise to areas of flat country with heavy, dark coloured soils and poor or no outcrop. The granite and adamellite give rise to hills higher than the granodiorite country with at times quite marked relief.

The Granodiorite is a large batholith which extends from near Argentine, on TOWNSVILLE, in the north, to the junction of the Burdekin and Suttor Rivers, on CHARTERS TOWERS, in the south; and from the Cape River, on HUGHENDEN, in the west onto AYR and BOWEN in the east.

The unit was described and named by Wyatt et al., (1965). In the area between The Bluff, Sellheim, Charters Towers and Mount Windsor the rocks have been described by Jack (1879, 1885), Rands (1891) and Reid (1917). Maclaren (1900) described granitic rocks belonging to this unit in the area from Ravenswood south to Saint Pauls Homestead.

Undivided granodiorite (S-Dr)

The granodiorite is normally medium-grained with a colour index of about 25 to 30. It may carry hornblende or biotite either alone or together; the hornblende-bearing varieties in places grade to quartz diorite (Maitland,

Photo Plate 2.

Garnet-biotite pegmatite intruding fine-grained melanocratic xenoliths in granodiorite of the Ravenswood Granodiorite. In bed of creek immediately south of Ravenswood-Burdekin Falls Road, two miles south of Lulu Pocket.

B.M.R. Neg.No. M290-17.

1891; Reid, 1917, p. 199). In some instances biotite granodiorite has been found to intrude hornblende granodiorite, for example six miles south-west of Ravenswood. The rock type here is a coarse porphyritic granodiorite which in places grades to an adamellite and therefore shows affinities with some of the rocks of the late acid phase. Tonalites have also been recorded e.g. in the mass 3 miles south-east of Ravenswood and beside the road 1.5 miles north-east of Two Creek hut.

In the area between Cardigan Homestead and Camp Oven Mountain a number of ridges, about 10 feet high, trend east-north-east. They occur in hornblende granodiorite and consist of silver-green micaceous rocks composed of coarse platy green chlorite, quartz and muscovite. They apparently represent zones of intense hydrothermal alteration in which the hornblende has been changed to chlorite and the muscovite has developed from feldspar.

Diorite (S-Dd)

Diorites have been mapped near Charters Towers by Maitland (1893), Rands (1891) and Reid (1917). From mine and surface mapping Reid described two ages of diorite, separated by the intrusion of aplitic granite. All three he considered to be younger than the main granodiorite phase. None of the occurrences of diorite shown on the map south of Roberts Creek could be allotted to either of the two diorite phases. The small mass south of Clarke Creek is a quartz diorite.

Gabbro (S-Db)

Reid (1917) mapped several small areas of gabbro in the vicinity of Charters Towers. He was not sure of their relationship to the other igneous rocks of the area except that they were intruded after the granodiorite but before the later of the two diorite phases. Although exposures are not good, evidence in the gabbro mass, 7 miles south-west of Charters Towers suggests that the gabbro was intruded before the aplite and pegmatite dykes.

Jack (1886), on his map of Queensland, shows the occurrence at Black Knob (15 miles south of Charters Towers near the Gregory Development Road) and the smaller one to the west under the heading of "Basalt and all other basic igneous rocks including diorite", but on his map of 1892 (Jack and

Etheridge, 1892) he records them simply as volcanic foci. These occurrences together with those shown on Reid's map appear to be the only basic rocks recorded in the area.

The rocks at Black Knob consist of gabbro, troctolite and similar rocks rich in amphibole. In hand specimen the rocks are commonly dark grey-green but may range from pale grey to black. They range in grain size from 0.1 mm to 20 mm and in parts show well developed layering. The layers, which are defined by differences in grain size, texture, or mineralogy, range from a few mm to more than 10 metres thick. In places the thinly layered rocks are highly disturbed, blocks having been disoriented and intruded by coarser grained basic material. In the south of the area of outcrop the basic rocks are very coarse-grained (some are orbicular) and consist essentially of plagioclase, olivine, hornblende and spinel; in the middle of the area of outcrop the rocks are finer grained, in parts show good small-scale banding, and consist essentially of plagioclase, pyroxene, hornblende and ore minerals; to the north of the banded rocks a relatively homogeneous plagioclase-hornblende rock crops out. This broad subdivision of the rocks into roughly east-west trending zones may represent large scale layering in a basic mass, or, if the main granodiorite phase is younger, it may be a contact phenomenon - the trend of the contact between the Ravenswood Granodiorite and country rock south of the basic rocks is approximately east-west.

The predominantly coarse-grained rocks in the southern zone may show porphyritic, even-grained or orbicular textures. Plagioclase (bytownite) phenocrysts lie in a slightly finer grained matrix of hornblende, olivine and alteration products of these three minerals. The coarse even-grained rocks contain plagioclase, olivine, hornblende, pyroxene, spinel, epidote, ?margarite, chlorite, calcite, quartz and a little magnetite and sulphides. In others a different amphibole occurs (Photo Plate 3). The orbicular rocks contain plagioclase, olivine, hornblende and some spinel in the orbicules, and plagioclase, hornblende and alteration products in the coarse-grained (?pegmatitic) material between the orbicules.

The layered rocks contain olivine, orthopyroxene, clinopyroxene, hornblende, biotite, iron oxides, iron and ?copper sulphides, plagioclase, apatite and quartz in varying proportions: clinopyroxene, hornblende and plagioclase are the most common minerals. Their textural range is wide; flow

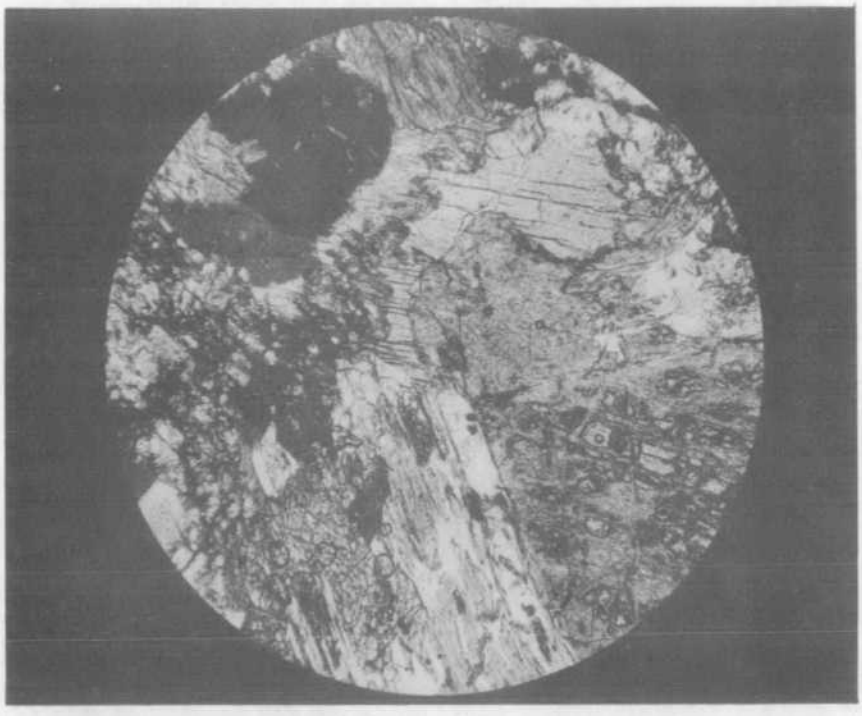

Photo Plate 3.

Spinel-amphibole-olivine gabbro (Ravenswood Granodiorite) X-nicols X 45. Spinel occurs in the N.W. quadrant adjacent to amphibole (tremolite, pargasite or tschermakite). In the S.E. quadrant altered olivine (right) is adjacent to margarite which, on the left, is altered to the light brown micaceous mineral dudleyite, the dudleyite is represented by darker patches in the elongated light coloured grain. In the S.W. quadrant, adjacent to the margarite, the 126° cleavages of amphibole are shown. Black Knob, 14 miles S.S.W. of Charters Towers.

Neg.No.G/6748, Rock No. 5.3.05 CT).

textures, lamination, ophitic textures, porphyritic and granular textures are present within a few metres of each other.

North of the layered rocks the main rock type is medium-grained and relatively homogeneous; it consists of plagioclase, hornblende and ore minerals, forming an hypidiomorphic granular texture.

Age relations with country rock and with granodiorite are not known. A specimen of granodiorite from near the coarse even-grained basic rocks contains hornblende, biotite, chlorite and epidote: chlorite has partly replaced biotite and epidote has partly replaced hornblende, biotite and chlorite. The epidotisation may have been caused by intrusion of the basic rocks or it may be connected with the intrusion of the pink feldspar - epidote - quartz dykes which occur throughout the Ravenswood Granodiorite. Rounded xenoliths of hornblende-plagioclase-biotite rock are common in the granodiorite(s) of the Ravenswood Granodiorite; these may originally have been part of a large mass similar to that in the northernmost of the three zones described above.

In the gabbroic mass 7 miles south-west of Charters Towers the most notable feature is the conspicuous development of orbicules averaging from two to three inches in length and half an inch to two inches in width. A crude banding is recognisable in places, the banding being due to a alternation of medium and coarse-grained material or to bands of orbicule-rich or orbicule-free gabbro. The orbicules are generally flattened parallel to the banding. The rock is an olivine gabbro but in places grades to a leucogabbro free of olivine. The orbicules comprise a central core of ophitic pyroxene, enclosing anhedral olivine and subhedral plagioclase, and an exterior rim of concentrically arranged layers composed in places of equidimensional olivine and elsewhere of olivine with plagioclase, the plagioclase often being radially arranged. The matrix between the orbicules is similar in composition to the cores but is generally coarser-grained. The composition of the orbicules is bytownite (40%), olivine (35%) augite (20%), hypersthene (5%) and minor opaques. The matrix is composed of labradorite (45%), augite (35%), olivine (10%) altered to serpentine, hypersthene (5%), hastingsite? (5%) and minor biotite and opaques.

Quartz monzonite at the eastern end of this mass has been mapped with the gabbro. Its extent and its relationship to the gabbro is unknown as outcrop is sporadic and both rock types give rise to similar soils of dark grey or brown colour and heavy texture.

The other occurrences of gabbro shown on the map have been mapped mainly on soil type but in most cases a few sporadic outcrops remain to confirm a gabbroic or basic parent rock. The rocks in these areas vary from gabbro to diorite and, in places, show banding or layering over small distances.

Gabbro and diorite, occur in the Tuckers Range, 10 miles south-east of Macrossan. The extent and relationships of these occurences are largely unknown. The Tuckers Range consists of a number of high ridges which rise sharply above the general level of the surrounding granodiorite. The ridges trend from north-east at the western end of the Range to south-east at the eastern end. They are composed of gabbro and diorite and appear to grade into the typical granodiorite in the low country. Biotite adamellite also occurs in the ridges but its relationships are not known. All these rocks are cut by rare veins of microadamellite, veins and sheets of pink leucogranite, possibly related to the coarse leucogranite between Pandanus and Oaky Creeks, and veins of epidote and quartz.

Gabbroic dykes occur in a swarm some 2 miles wide in the Ravenswood Granodiorite, a few miles north of the Valley Hut where they strike between east-south-east and east. A similar swarm occurs south-east of Mount Ravenswood Homestead where the dykes intrude both the granodiorite and the metamorphics of the Cape River Beds. No large gabbroic masses are known in either of these areas.

Granite and Adamellite (S-Da)

Granite and adamellite, which represent a late phase of intrusion in the batholith, are widely distributed over the northern half of the Sheet area. The main concentration of these more acid types is near the contact of the granodiorite with the Cape River Beds. This suggests that the granite and adamellite are late-stage differentiates intruded at the margin of the batholith. This hypothesis is supported by the variation in texture of these rocks

e.g. from granitic to pegmatitic, aplitic and porphyritic, and variation in grain size, e.g. from normal medium granite to fairly coarse pegmatite to microgranite and even fine-grained aphanitic porphyry in some instances. Generally the coarser types are near the granodiorite and the finer grained types occur at the contact with the Cape River Beds or within the Beds themselves; some of the porphyries which intrude the Beds near Liontown are probably apophyses from these acid intrusions. In most cases the younger age-limits of these bodies are unknown, and it is possible that some may be late Palaeozoic in age.

North of Ravenswood the granite, with minor adamellite, is a red, generally coarse rock composed of quartz, microperthite, microcline, oligoclase and biotite. It is commonly porphyritic with quartz phenocrysts. In this area the granite is intruded by numerous microdiorite dykes.

Six miles south-south-west of Ravenswood the rock is a pink biotite adamellite. It is inequigranular, grain size ranging from 0.2 mm to 2 mm. It consists of subhedral plagioclase (30%), anhedral and severely strained quartz (40%), anhedral microcline-perthite (30%) and very small quantities of ferruginised, flexed biotite and octahedral iron oxide crystals. Locally it is strongly porphyritic with quartz phenocrysts, and small patches of white mica are commonly developed. The adamellite is strongly fractured in a near east-west direction. The contact with the surrounding biotite granodiorite is sharp and pink biotite aplite and pink microadamellite dykes intrude the granodiorite near the contact.

Various granites occur in the Robey Range. Very little is known of their relationships but they have been included with the late granites of the Ravenswood Granodiorite mainly because of their similar lithology. The granites form high country in marked contrast to the low undulating country occupied by the granodiorite. Details of topography are controlled mainly by faults, joints and, to a lesser extent, by changes in rock type.

At the north-eastern end of the Range the typical rock is a coarse red leucocratic granite. To the south where it forms the walls surrounding Lulu Pocket it is a buff, fine to medium aplitic granite with scattered clots of biotite and poikiloblastic plagioclase. In the south-west, around Stony

Creek and Two Creek the granite is aplitic and very leucocratic and, in places, contains muscovite.

The relationship between these various granites is unknown but in this report they are considered as being phases of the one intrusion and have been mapped together as comprising the late acid phase of the Ravenswood Granodiorite.

Immediately south-east of Camp Oven Mountain is a pink biotite granite. In places it is strongly porphyritic. The granite is much fractured and brecciated and, in places, e.g. along Saint Pauls Creek, mylonitised. The breccias consist of angular granite fragments, ranging from a quarter of an inch to one foot in diameter, in a granulated granitic matrix. In places, however, the fragments are cemented by unbrecciated aplitic material. The granite is intruded by dykes of porphyritic andesite and intrusion breccia. It is overlain by a very small area of unaltered sediments of the Drummond Group.

Five miles south of Mount Cooper pink, porphyritic microgranite occurs. It consists of a fine graphic groundmass with phenocrysts of clear, round quartz crystals up to 4 mm in diameter and large feldspar crystals. Minor biotite is the only mafic mineral present. One mile east of Mount Cooper, and apparently part of the same mass, coarse biotite granite and microgranite form rugged hills.

North-west of the junction of the Burdekin and Suttor Rivers is an area of granitic rocks composed of leucocratic granite, biotite alkali microgranite and porphyritic microgranite intruded by numerous grey-green quartz porphyry and flow-banded rhyolite dykes. Pebbles of this granite occur in the basal sediments of the Drummond Group a few miles to the south.

Leucocratic granites also occur near the Valley Hut, south-south-west of Cardigan Homestead.

The granite immediately north of Mount Leyshon is fine to medium-grained and leucocratic. In places it is aplitic or grades to a porphyritic microgranite. Further west, south and south-south-west of Black Knob the

rock is more generally a porphyritic microgranite; further west again near Windsor Homestead it is again a medium granite. In this area the air photos show a north-north-east trend in the granite which, on the ground, can be related to low, poorly defined ridges separated by shallow soil-covered hollows which trend in the same direction. This soil is red-brown and rather clayey and similar to that developed in parts of the granodiorite or from dolerite dykes.

Four miles south-west of Balfes Creek, a foliated, medium, pink biotite granite forms a small hill south of the railway line. It is surrounded by Cainozoic deposits but on lithology it is correlated with the late acid phase granites. Coarse, red biotite granite north of Thalanga Homestead has also been assigned to this unit; this granite is intruded by gently dipping sheets of pegmatitic muscovite granite of the Lolworth Igneous Complex.

Six miles north of Homestead an elongate mass of granite forms a low range of rugged hills which culminates, at its south-eastern end, in Mount Glengalder. The granite intrudes the Cape River Beds parallel to their foliation. The granite is pink and consists of quartz (45%), microperthite (35-40%), oligoclase (10-15%) and biotite (5%). At its northern end it is foliated parallel to the Deadman Fault Zone. At Mount Glengalder, slightly foliated quartz feldspar porphyry occurs at the margin of the granite mass near a parallel fault zone.

An elongate stock of biotite granite occurs south-west of Mount Misery, west of Homestead. It again intrudes the Cape River Beds parallel to their foliation. Here the granite is massive, medium to coarse-grained and consists of microperthite (50%), quartz (40%), oligoclase (5%) and biotite (5%). It gives rise to undulating sand-covered rises with little rock outcrop. It has been exposed during excavations along the newly reconstructed railway line.

A coarse, red biotite granite occurs five miles west of River View Homestead where it forms small steep hills. The granite shows a weak foliation which dips steeply to the north and a vague lineation of mineral grains which plunges about 20 degrees to the east. At the foot of the northern hills, the granite has been weakly metasomatised tending towards a greisen. Again little is known of the relationships of this granite, which is tentatively correlated

with the late acid phase of the Ravenswood Granodiorite.

The age of the Ravenswood Granodiorite is early Palaeozoic. It is younger than the Cape River Beds and older than the Givetian Fanning River Group (TOWNSVILLE). It is thought to have been intruded during the orogeny which occurred in the Silurian-Lower Devonian. Radiometric age determinations on the granodiorite phase (TOWNSVILLE) give the following results:

420 m. yrs $\pm$ 3% on hornblende near Mingela
420 m. yrs $\pm$ 3% on biotite near Fanning River H.S.
440 m. yrs $\pm$ 3% on biotite near Mingela

(Determinations by A.W. Webb at the Department of Geophysics and Geochemistry, Australian National University).

As yet no ages are available for the later phases of the batholith.

The Lolworth Igneous Complex (see below) intrudes the late granite phase in the Deadman Fault Zone and near Thalanga Homestead.

Lolworth Igneous Complex (S-D1)

The Lolworth Igneous Complex (Paine et al., 1965) is a composite batholith which crops out on north-eastern HUGHENDEN (where it forms the Lolworth Range) and north-western CHARTERS TOWERS; it is about 500 square miles in extent, of which 200 square miles are within CHARTERS TOWERS. The complex forms a belt of hills between the Flinders Highway and the basalt plains to the north. It gives rise to broken and uneven country which, in places, has a relief of up to 800 feet (e.g. in the headwaters of Homestead Creek). The complex is partly covered by a more or less dissected veneer of sandstone and conglomerate of the Cainozoic Campaspe Beds, which mask the uneven topography. The granite weathers easily and has produced a widespread cover of Quaternary and Recent residual sands and soils. Lateritised granitic rocks which outcrop north of Glen Dillon Homestead have been included in the complex, but the lateritic cover makes accurate correlation impossible.

The dominant rock of the complex is a pink and white, banded pegmatitic, garnetiferous, muscovite granite or adamellite. The quartz content varies from 40 to 45 percent, microperthite from 30 to 40 percent, oligoclase from 10 to 20 percent; and muscovite is normally about 5 percent. Biotite is generally

very minor but in some specimens it may amount to 5 percent. Small euhedral pink crystals of garnet are almost ubiquitous. The percentage of oligoclase varies from 17 to 50 percent of the total feldspar content. One specimen, however, is a muscovite microtrondhjemite composed of 50% oligoclase, 40% quartz, 5% microcline-microperthite and 5% muscovite.

The texture varies from aplitic to graphic and pegmatitic. In places it is porphyritic with feldspar crystals embedded in an aplitic groundmass. The phenocrysts commonly average two to three inches in length but rare crystals up to 12 inches in length have been noted. The granite is characteristically banded. Individual bands range from a fraction of an inch to several inches, and rarely, several feet in thickness. The banding is due to variations in grain size, texture and composition and appears to be a primary feature. Muscovite is concentrated in some bands and absent in others. Where present it has generally crystallised in a dendritic form normal to the banding. Some of the thin bands are due to a high concentration of small garnet crystals.

The banding generally dips at low to moderately steep angles, and it has no obvious regional trend. In fact, even in a single outcrop the banding forms open, sinuous folds which have no consistent plunge direction.

Sheets of garnetiferous muscovite pegmatite, aplite and granite up to 20 feet thick intrude the granite and adamellite, transgressing the primary banding. They commonly dip at shallow angles. The sheets also intrude the Cape River Beds and the Ravenswood Granodiorite near their contact with the complex.

Besides the rocks described above, two small areas of slightly different granitic rocks have been included in the complex. They comprise a white, massive, coarse, biotite-muscovite granite or adamellite which occurs in a narrow belt between Oaky Creek and the Pentland Hills and a lateritised, coarse porphyritic "granite", similar to the porphyritic adamellites of the complex on HUGHENDEN, which forms the country rock at the old Big Hit mine north of Glen Dillon Homestead.

The Lolworth Igneous Complex intrudes the Cape River Beds and the Ravenswood Granodiorite. It is intruded by the Upper Permian? Mundic Igneous Complex. A radiometric age-determination of 400 m. yrs $\pm$ 3%, was determined by A.W. Webb, by the potassium-argon method on a specimen of garnetiferous muscovite granite from the headwaters of Reedybed Creek, 13 miles north-north-west of Homestead. Unlike much of the Ravenswood Granodiorite, the complex is not foliated and is therefore presumed to be a post-orogenic batholith intruded after the orogeny which folded the Cape River Beds and during which the Ravenswood Granodiorite was emplaced.

The southern margin of the Complex transgresses the trend of the foliation of the Cape River Beds and coincides essentially with the Deadman Fault Zone. Muscovite granite in this zone is not foliated whereas the Ravenswood Granodiorite is strongly foliated in the fault zone. This suggests that the fault was active before the Lolworth Igneous Complex was intruded, and in fact may have localised its southern margin.

Gold, lead, copper and arsenic mineralisation is associated with the Lolworth Igneous Complex at the "Old Homestead Diggings" in the headwaters of Homestead and Deadman Creeks. The Deadman Fault Zone may have played a part in localising this mineralisation. However, although the mineralisation occurs in the Lolworth Igneous Complex, it is possible that the Mundic Igneous Complex was the mineralising agent; on HUGHENDEN the gold and base-metal sulphide deposits at the Lolworth Diggings and Mount Stewart are believed to be related to the Mundic Igneous Complex.

Close of the early Palaeozoic

Emplacement of the Lolworth Igneous complex marked the final stage in a cycle of sedimentation and igneous intrusion which is regarded in this and other reports on the region as "early" Palaeozoic (Wyatt et al., 1965 and in prep., Paine et al., 1965, Paine et al., 1966 and in prep., Paine et al., in prep., and Clarke et al., in prep.).

There followed a period of deep and widespread erosion, during which the Ravenswood Granodiorite was exposed as a provenance for Middle Devonian sedimentation on TOWNSVILLE (Fanning River Group) and probably also on CHARTERS TOWERS (Ukalunda Beds). Palaeozoic rocks of Middle Devonian and younger age are referred to as "late" Palaeozoic.

Photo Plate 4.

Pencil-rodding lineation in cleaved siltstone, caused by several intersecting sets of close joints which have a common strike. Two further joint sets, more widely spaced than those which caused the lineation, dip to the right, one beneath the wrist-watch, and the other striking at right angles to the plane of the photograph. Ukalunda Beds, bed of gully 6.5 miles south-south-east of Arthur Plains Homestead.

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MIDDLE DEVONIAN

Ukalunda Beds (Dk)

On CHARTERS TOWERS, the Middle Devonian is represented by the Ukalunda Beds which extend into the extreme south-eastern corner of the area from BOWEN where they were described by Malone et al. (1962 and 1966). On CHARTERS TOWERS they cover about 15 square miles and give rise to an uneven landscape of low hills with a fairly close drainage pattern not obviously controlled by any structure in the Beds.

The Ukalunda Beds here consist of grey-brown, hematitic siltstone and fine greywacke. Eastwards towards the Sheet border the Beds become closely cleaved and phyllitic. Rare hornfels is interbedded with the phyllites. The metamorphism is apparently due to a granitic intrusion just within BOWEN.

Near the Sheet border the strata are intruded by swarms of quartz veins, many of which have been folded and boudinaged. Here also the strata show a "pencil-rodding" lineation plunging at 20 degrees to the south-south-west (Photo Plate 4).

Bedding is not easily recognisable owing to the cleavage and consequently little is known of the structure. No reasonable estimate of the thickness of the Beds in this area can be made.

Marine fossils from the Ukalunda Beds on BOWEN indicate a Middle Devonian age and a moderately deep-water (although not geosynclinal) environment of deposition.

The Ukalunda Beds are unconformably overlain by the Drummond Group on BOWEN. On CHARTERS TOWERS strike faulting obscures the unconformity but the difference in intensity of deformation suggests that one exists.

UPPER DEVONIAN-LOWER CARBONIFEROUS

Drummond Group (Cld)

Summary

The Drummond Group (mainly Lower Carboniferous) crops out in the south-eastern part of CHARTERS TOWERS. It represents the northern margin of the meridional Drummond Basin which crops out for 250 miles as far south as the Nogoa River (SPRINGSURE). On CHARTERS TOWERS the Group has not been formally subdivided, although a wide range of rock types has been mapped. Four broad lithological subunits have been recognised, as follows:

D (top)	Arkose, subarkose, lutite, some calcareous sediments
C	Feldspathic and lithic arenites, subarkose, subgreywacke, lutite, acid tuff and lava
B	Interbedded quartzose arenite, subarkose, and lutite
A	Intermediate and acid lava and tuff, with tuffaceous and labile sediments

The Drummond Basin on CHARTERS TOWERS is structurally asymmetrical, and the zone of most intense folding lies towards its eastern margin.

Structural complexity and lack of outcrop in critical areas make any attempt at estimating the total thickness of the Group very difficult. However, thicknesses of 10,000 to 15,000 feet have been estimated for parts of the succession.

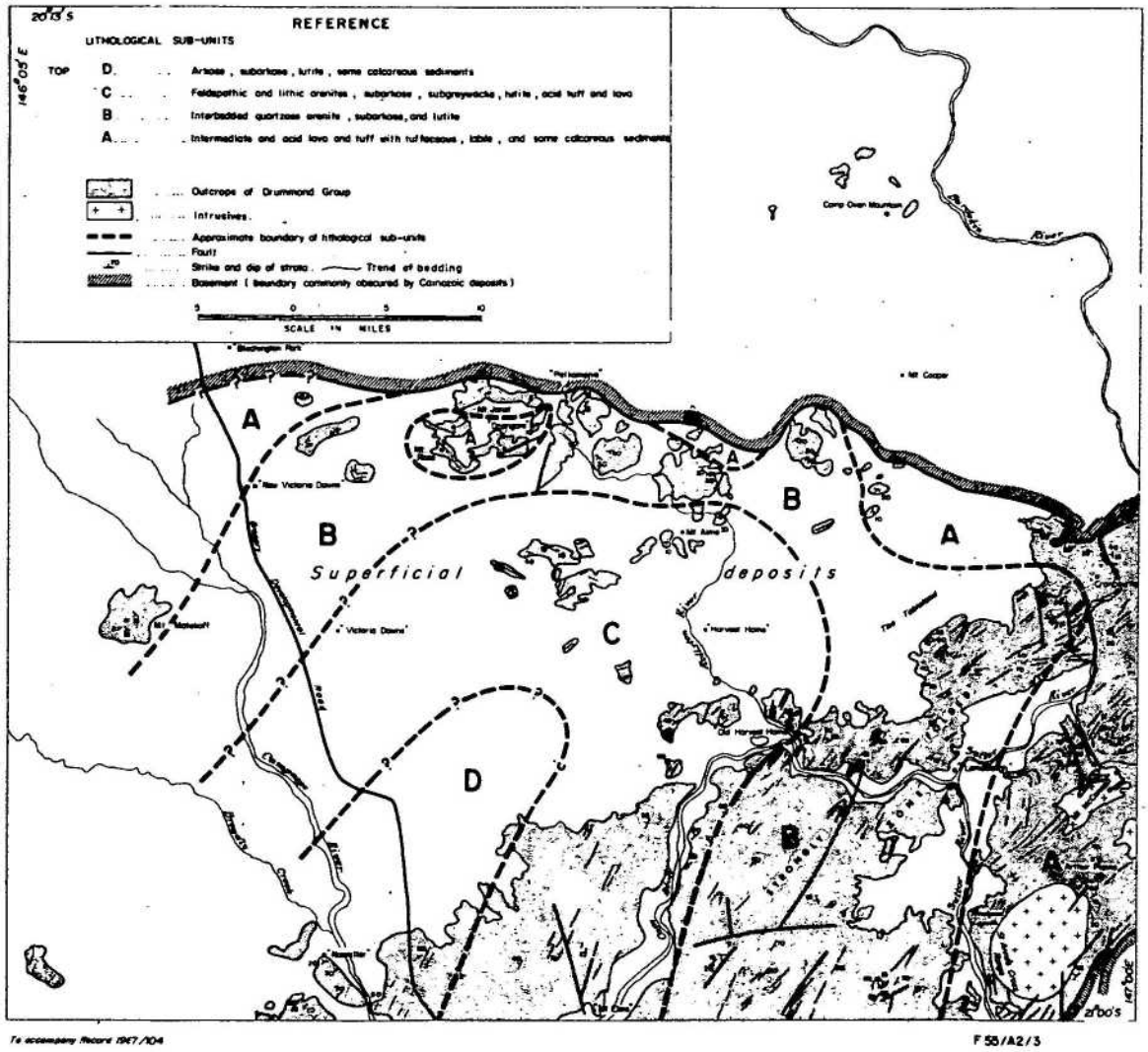
The Drummond Group is a fresh-water sequence. Lower Carboniferous plants are common in the sequence on CHARTERS TOWERS; Protolepidodendron (Upper Devonian) has been recorded from the base of the sequence on BUCHANAN.

Nomenclature

The name "Drummond Beds" was first used by Jack (Jack & Etheridge, 1892), for the rocks of the Drummond Range, including those at Bogantungan (EMERALD), from which Tenison Woods (1883) and Etheridge (1891) determined Lepidodendron sp; Jack regarded the rocks as Permo-Carboniferous. Reid (1930b) mapped other areas of outcrop of these rocks, and referred to them as the

Fig 3

LITHOLOGICAL AND STRUCTURAL SKETCH MAP OF THE DRUMMOND GROUP
CHARTERS TOWERS 1 : 250,000 SHEET AREA



To accompany Record 1967/104

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"Drummond Series" of Upper Devonian to Lower Carboniferous age. Hill, in the geological map of Queensland (1953) referred to the unit as the Drummond Group. Tweedale (in Hill and Denmead, 1960), summarized knowledge of the unit up to 1960. More recently the Bureau of Mineral Resources in association with the Geological Survey of Queensland has mapped the unit, and in some areas to the south and south-east it has been subdivided into formations.

In this report the sequence of volcanics and sediments unconformably overlying the Ukalunda Beds is referred to the Drummond Group. On BOWEN Malone et al. (1962) in places mapped an intervening unit (undifferentiated Devonian to Carboniferous volcanics) between the Ukalunda Beds and the Drummond Group. However, no equivalent unit has been recognised on CHARTERS TOWERS.

Distribution, Topography, and Photo Pattern

The Drummond Group crops out in the south-central and south-eastern parts of CHARTERS TOWERS, and extends onto BOWEN and BUCHANAN and Sheet areas further south. On CHARTERS TOWERS it extends as far north as Mount Billygoat and Camp Oven Mountain. The northern limit of outcrop is represented by scattered outliers, but the original extent of the sedimentary basin is unknown.

The topography of the area occupied by the group varies. Near Pallamana Homestead dissected mesas rising up to 400 feet above the surrounding country are the most common land form. A little to the west, Mount Janet (1720 feet) and Mount Ross, the highest hills of the area, are composed of rocks belonging to the Group. Between the Cape and Suttor Rivers many very steep and persistent strike ridges form hills up to 300 feet above the surrounding plain. Elsewhere the unit forms low undulating hills and low, mainly discontinuous, strike ridges partly masked by Cainozoic sediments.

Most of the south central part of the Sheet area is very flat and almost devoid of outcrop. The rivers and larger creeks contain some good exposures, but their beds are mostly occupied by alluvium. However the photo pattern is distinctive in this area. The bedding stands out clearly, and even where the rocks are covered by soil the vegetation

reflects the strike of the underlying beds. Between the Cape and Suttor Rivers the sub-parallel sandstone strike ridges can be readily recognized on air photos. Between Arthur Plains and Mount McConnell Homesteads the smooth dark grey photo-pattern of basic intrusions (Pzi) is hard to distinguish from that given by andesitic tuffs of the Drummond Group. In the centre of CHARTERS TOWERS the pattern is not distinctive, and may be confused with that of the Cape River Beds.

Lithology

For the purposes of this survey, the Drummond Group on CHARTERS TOWERS has been subdivided informally into four lithological sub-units: "A" (Base), "B", "C", and "D" (Top). The approximate boundaries of these sub-units are shown on the accompanying sketch map (Figure 3). Near the northern margin of the basin there are areas where sub-unit "B" apparently directly overlies the basement of Cape River Beds and Ravenswood Granodiorite.

Sub-unit A

East of the Suttor River the lower part of Sub-unit A consists of subgreywacke (commonly fine-grained) and siliceous siltstone; minor rock types are agglomerate, tuff, andesite, orthoquartzite, limestone (in places oolitic), calcarenite, and calcareous feldspathic sandstone. The middle of the section is predominantly composed of dark blue-grey, grey-green and pale buff intermediate and acid tuff; in places the tuff contains mud balls. Interbedded with and overlying the tuff are greywacke and subgreywacke, slumped and cross-bedded arkose with some pebbly beds, porphyritic dacite, and calcareous and ferruginous siltstone containing Lepidodendron and Stigmaria. In the upper part of the sequence (two to three miles west of Mount McConnell Homestead) acid tuff, in places welded, is interbedded with well bedded but poorly sorted labile arenite, siltstone, and conglomerate, and with tuffaceous siltstone and minor calcareous siltstone. Near the top and bottom of sub-unit "A" east of the Suttor River, bedding and strike ridges are well developed. However, in the middle part of the section the tuffs are commonly massive.

Five miles south-south-west of Mount Cooper sub-unit "A" consists of blue-grey porphyritic andesite, agglomerate, volcanic breccia, feldspathic tuff, and coarse feldspathic and tuffaceous sediments. A similar sequence

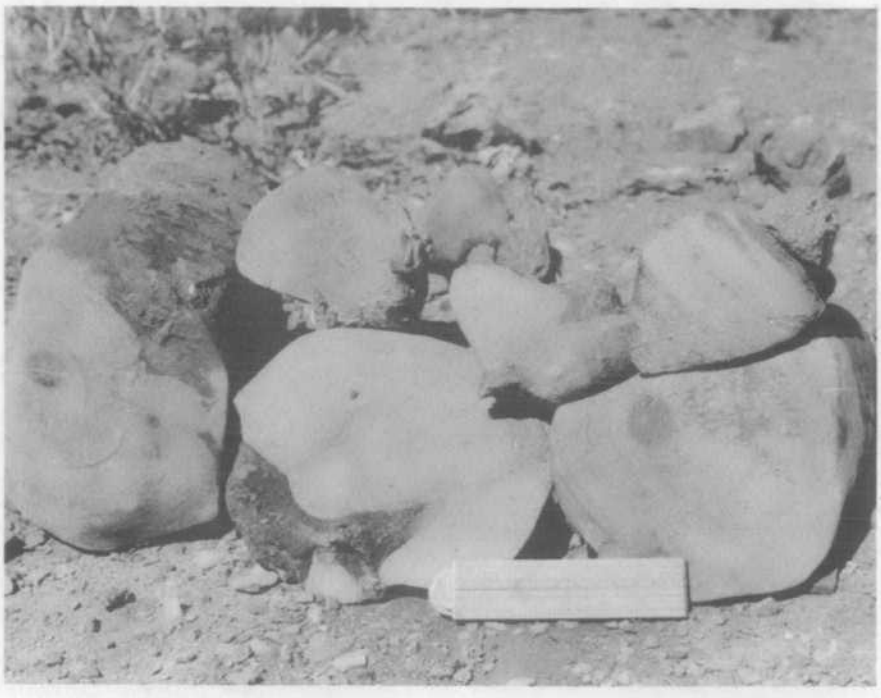

Photo Plate 5.

Algal structures in blocks of limestone weathered out of a thin bed in "Sub-unit A" of the Drummond Group 2.4 miles north-east of Cranbourne Homestead.

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directly overlies the Ravenswood Granodiorite north of Box Camp Creek, near Cranbourne Homestead, and is overlain by a siltstone, inorganic limestone, and fine micaceous subarkose sequence containing Crossopterygian fish scales cf. Strepsodus decipiens, Woodward, and fragments of a palaeoniscid fish, possibly Elonichthys (Appendix 1).

Volcanics, and sediments derived from volcanics, form the basal beds in the Mount Ross-Doongara-Pallamana Homesteads area. Dark red porphyritic andesite, tuff, agglomerate, volcanic breccia, tuffaceous sandstone, cobble conglomerate and minor tuffaceous siltstone are the chief rock types. Mount Ross is formed of medium and fine-grained andesite, in places porphyritic in plagioclase and hornblende. Porphyries, maroon tuffaceous sandstone and tuff occur between Mount Ross and Mount Janet. At Mount Janet the sequence is intruded by thick flow-banded quartz porphyry dykes.

Ten miles north of Harvest Home andesitic breccia, agglomerate, tuff and subgreywacke unconformably overlie the Ravenswood Granodiorite. The subgreywacke contains grains of quartzite and fragments of very fine-grained micaceous metamorphics.

Tuff (including mud-ball tuff), agglomerate, lithic sandstone, subgreywacke and minor volcanics crop out between four and eight miles south of Mount Cooper.

Algal limestone has been noted at a number of localities within this sub-unit. Large concentric structures (Photo Plate 5) are developed in blue grey silty limestone interbedded with fine-grained calcareous arenites 2.4 miles north-east of Cranbourne Homestead. One algal structure is developed around a pebble of granite 3 inches in diameter. The limestone forms a number of thin beds none of which exceeds three feet in thickness. Similar limestone is interbedded with green calcareous siltstone two miles south-west of Cranbourne Homestead.

A thick bed of argillaceous limestone, lacking any obvious algal structures, occurs just south of Box Camp Creek 1.6 miles north-west of Cranbourne Homestead. The limestone is interbedded with green grey labile sandstone, conglomerate and green calcareous siltstone, which overlie andesite

and pyroclastics. The siltstone and fine sandstone contain fish scales, plant fragments and fossil fish remains. The limestone contains abundant fish scales and rounded structures which superficially resemble fossils but which are probably mud-balls.

The limestone may occur at more than one horizon but in the vicinity of Cranbourne Homestead it appears to be restricted to the top of sub-unit A. Fine-grained, lithic, mud-ball tuff and labile sediments crop out at Mount Malakoff.

Sub-unit B

The major development of sub-unit "B" appears to be in the south with a gradual thinning towards the east and a general thinning towards the north, although the thickness in the north is variable. In some areas in the north sub-unit "B" forms the basal beds of the group (e.g. around Pallamana Homestead).

Along the upper reaches of the Rollston River sub-unit "A" is overlain by up to 3000 feet of subgreywacke, subarkose, micaceous subarkose, protoquartzite and very minor siltstone. These sediments form dissected mesa-like hills. In places they rest directly on the Cape River Beds. The arenites are generally thickly bedded, well sorted, and strongly cross-bedded; in many places they contain small aggregates of pyrite. Plant fragments are abundant. Rare acid and andesitic porphyry dykes intrude the sediments.

South-east and south of The Tableland the sediments of sub-unit "B" are tightly folded. White subarkose, micaceous siltstone, and micaceous mudstone predominate. Other rock-types include pebbly protoquartzite, rare pebble to cobble conglomerate, and shale. The arenites are very well sorted and strongly cross-bedded. Well rounded, milky quartz pebbles are characteristic of the arenites in this area. Quartz veining and slight recrystallization occur in the more tightly folded sections. Siltstones between the arenite strike ridges are generally poorly exposed, forming areas of soil between arenite strike ridges. However, 3.5 miles south-west of Cranbourne Homestead, there is a well-exposed sequence of grey to green micaceous siltstone and mudstone over 150 feet thick (Photo Plate 6). The siltstone is thinly bedded ($\frac{1}{2}$ inch), and the mudstone forms beds up to a foot thick.

Photo Plate 6.

Regularly bedded siltstone of "sub-unit B" of the Drummond Group 3.5 miles south-west of Cranbourne Homestead. The thinner beds are reddish-brown, and the thicker beds are grey and slightly micaceous. Compaction structures occur nearby.

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Compaction and slump structures occur in this sequence, which is strongly faulted and folded.

Between the Cape and Suttor Rivers the sequence consists of massive, well bedded, generally very well sorted, medium-grained protoquartzite, feldspathic sandstone, pebble conglomerate, and siltstone. The feldspathic sandstone in places grades to subarkose and arkose. The beds range in thickness from two to forty feet. The thinner beds tend to form flags. Low-angle cross-bedding is developed in places. Quartz-pebble conglomerate, ranging from a single layer of pebbles to beds about 20 feet thick, occurs throughout. The arenite and pebble conglomerate are hard, competent rocks, with a crude parting in places; many have a siliceous cement, and are veined by quartz. The beds are tightly folded, and the arenite and conglomerate stand out as high, very steep strike ridges. Between the strike ridges there are rare, small outcrops of highly jointed siltstone and mudstone.

Sub-unit C

Near Mount Elsie Homestead the break between the quartzose clastics of sub-unit "B" and the labile clastics and volcanics of sub-unit "C" is very sharp. Farther north, however, the change is apparently gradational.

Near Mount Elsie Homestead, and for about six miles to the north, sub-unit C comprises white and light grey to brown rhyolite and tuff, and some siltstone, mudstone and tuffaceous sandstone, as well as rare greywacke or coarse tuff. All these rocks are very strongly jointed. The rhyolite is typically leucocratic and porphyritic. The tuff ranges from fine to coarse-grained, and in some places glass shards are recognisable in hand specimen. The arenites are generally quite well sorted. Fossil plant remains were found in the fine-grained sediments in this area.

Near Mount Alma the rocks of sub-unit "C" are poorly exposed, but they appear to be strongly folded. Subarkose, hard cream porcellanous siltstone, subgreywacke (some of it calcareous), mudstone, tuff, agglomerate, and polymictic pebble conglomerate were observed. The subgreywacke contains fragments of chert, chalcedony, and volcanic rocks. Some of the rocks contain abundant silicified wood and poorly preserved plant fragments.

Sub-unit D

Sub-unit "D" crops out near Nosnillor Homestead. There the sequence consists of arkose, subgreywacke, siltstone, mudstone and calcareous lutite with some bands of pebble conglomerate. The rocks are generally light brown to grey and many of them are very well sorted and bedded. Some show pronounced slump structures. Cross-bedding is poorly developed; it makes a very shallow angle with the bedding. Ripple marks are well developed in some places. The arenites are often thinly laminated. Individual arenite beds range from six inches to twenty feet thick. Mud pellets are common in some arenite beds.

Small areas of sediments north-west of Camp Oven Mountain are believed to be outliers of the Drummond Group. The sequence begins with a thin, basal conglomerate which contains rounded pebbles and cobbles of siltstone, quartz, and intermediate volcanics. This is followed by a sequence in which reddish-brown subgreywacke and protoquartzite predominate. Thin beds of carbonaceous arenite and highly carbonaceous shale contain abundant, indeterminate, carbonised plant material.

Strongly cross-bedded, blue-grey subgreywacke and minor siltstone occur as a small down-faulted block in the central hollow of Camp Oven Mountain (a volcanic centre of Upper Carboniferous age). They contain indeterminate lepidodendroid plant and carbonized wood fragments. The sediments are intruded by rhyolite dykes.

Micaceous shaly siltstone forms a low hill just north of Camp Oven Mountain. Very small scattered outcrops of micaceous siltstone occur five miles south-south-east of Camp Oven Mountain.

Structure

The Drummond Basin on CHARTERS TOWERS consists of a shelf in the north and a trough in the south and south-east. On the shelf dips are generally rather gentle and bedding trends somewhat haphazard. In the trough the folding is tight and has a strong north-easterly trend; isoclinal folds are common and overturning has occurred in places, for example between Lornesleigh and

Cranbourne Homesteads. Between the Cape and Suttor Rivers the plunge of fold axes is commonly quite steep and may change from north-east to south-west within a few miles. Broad open folds are developed east of the Suttor River. Dips in sub-unit D are consistently to the north-west; no overturning has been observed.

Thickness

A thickness of about 6000 to 7000 feet is estimated for sub-unit A east of the Suttor River. Sub-unit D and the upper part of sub-unit C between Mount Elsie and Nosnillor Homesteads may be more than 10,000 feet thick. It is impossible to estimate the thickness of the sediments in the centre of the basin, owing to intense folding.

Relationships and Age

The Drummond Group unconformably overlies the Cape River Beds, the Ravenswood Granodiorite, and the Middle Devonian Ukalunda Beds.

Fossil assemblages, chiefly of poorly preserved plant fragments and rare fish scales and fragments, have been identified by R.G. McKellar (G.S.Q.) (Appendix 1). Wherever the quality of the material has enabled a distinction to be drawn, the assemblages appear to be Lower Carboniferous rather than Upper Devonian. However, the basal beds, especially in the south-eastern and northern parts of the basin, are apparently unfossiliferous and they may extend down into the Upper Devonian. Protolepidodendron (Upper Devonian) has been collected from the base of the Group at the Saint Ann's crossing of the Suttor River on north-eastern BUCHANAN (Malone et al., 1964). However, on-lap of successive rock-units in the north and widespread facies variation appear to have occurred, and therefore we cannot be sure that the Upper Devonian sediments at Saint Ann's Crossing are represented on CHARTERS TOWERS.

Rocks of the Group have been intruded by basic sill-like bodies (Pzi), granite (Pzug), granodiorite (Pzb), quartz feldspar porphyry (Pzp), and rhyolite (Pzh).

Immediately to the east, on BOWEN, the Drummond Group is overlain by the Upper Carboniferous Bulgonunna Volcanics with a strong unconformity.

Metamorphism

Four miles west-south-west of Arthur Plains Homestead, massive quartz-pyroxene-albite hornfels crops out close to the granite contact. This rock was possibly an andesitic crystal tuff. In a gully south of the road, one third of a mile east of Arthur Plains Homestead, orthoclase-sericite-quartz hornfels is in contact with intrusive granodiorite (Pzb); this rock was probably an impure, fine-grained arenite.

The basic intrusions (Pzi) have recrystallised the nearby volcanic rocks two miles south of Mount McConnell Homestead. Near where Bilga Creek joins the Cape River an intrusion into lutites has caused induration and some overturning of the beds.

Mineralization

Disseminated small cubes of pyrite and thin coatings of marcasite occur in rocks of the Drummond Group close to the north-eastern margin of the Saint Anne's Cross Range granitic stock (Pzug) in the south-east corner of the area. No other mineralization is known.

Provenance and Depositional Environment

Contemporaneous vulcanism was undoubtedly the main source of detritus in the lower parts of the Drummond Group. Detritus from the basement rocks is also evident, for example, in the south-east the sediments contain fragments of metamorphic and granitic rocks derived from the Ukalunda Beds and the granites which intrude them to the east of the Sheet area; and in the north, detritus was derived from the Cape River Beds and the Ravenswood Granodiorite.

Rates of sedimentation probably varied considerably throughout the basin in time and space. At times of active vulcanism the sedimentation rate probably exceeded the rate of subsidence. Overall conditions of sedimentation were those of shallow fresh water.

UNDIVIDED PALAEOZOIC

Acid volcanics (Pzo)

At Mount Leyshon, 15 miles south of Charters Towers, volcanics of unknown age and association have been mapped separately from other volcanics within the Sheet area. They have previously been described by Jack (1885), Rands (1891) and Morton (1932b).

Hills of rhyolite, rhyolitic and dacitic porphyry, agglomerate, and volcanic breccia represent volcanic necks which have been intruded along the contact of the Cape River Beds, with porphyritic granite of the Ravenswood Granodiorite.

The volcanics have been mineralized by sulphides which occur both as disseminations and as thin veins filling fractures. Weathering and alteration of the sulphides has altered the appearance of the rocks so that they cannot be confidently correlated lithologically with other volcanics in the area. The association of acid volcanics and volcanic breccia is similar to the intrusions at Cornishman Hill and at Mount Success (TOWNSVILLE) and it is conceivable that Mount Leyshon is of similar age, viz., late Palaeozoic.

In the granodiorite north-east of Mount Leyshon are a number of dykes of flow-banded, quartz-feldspar porphyry which are possibly related to the Mount Leyshon volcanic centre. The dykes are generally somewhat altered; the rocks are partly greisenized and stained by iron oxides along partings parallel to the flow banding.

The age of the volcanics at Mount Leyshon is unknown, beyond the fact that they are younger than the Ravenswood Granodiorite.

LATE PALAEOZOIC

Following on the deposition of the Drummond Group the remainder of the Palaeozoic era appears to have been a time of igneous activity, both intrusive and extrusive, with little sedimentation until the Upper Permian. In most cases the ages of the igneous rocks are not precisely known. They have been mapped into groups according to rock type, but in most instances the relationships between each type are largely unknown. These igneous rock units are:

Post-Lower Carboniferous

(1) Dioritic intrusives (Pzi)

(2) Quartz-feldspar porphyry intrusives (Pzp)

(3) Rhyolite intrusives (Pzh)

(4) Granitic bodies

(a) Granite, adamellite, minor granodiorite (Pzug)

(b) Granodiorite, quartz diorite (Pzb)

Upper Carboniferous

Acid volcanics (Cuv)

Upper Permian

Mundic Igneous Complex (Pug, Pud, and Pue)

The only sedimentary rock unit is the Betts Creek Beds (Pub).

POST-LOWER CARBONIFEROUS

Dioritic Intrusives (Pzi)

Diorite, intrudes the Drummond Group in many places on CHARTERS TOWERS.

Two and a half miles north-east of Cranbourne Homestead an area of approximately one square mile of black soil contains scattered outcrops of diorite. The area extends onto BOWEN and probably totals about three square miles. The diorite is poorly exposed; on air photographs the black soil has a characteristic smooth texture and dark grey tone. The rocks are extremely altered, but medium-grained diorite appears to be the dominant rock type. Fine and coarse-grained diorites are also present, the coarser rocks containing plagioclase and hornblende crystals up to half an inch long. Plagioclase identifications have been uncertain, and it is possible that gabbro may occur also. Generally the original texture and composition have been obliterated by deuteric alteration to prehnite, chlorite, epidote, calcite, clinozoisite and clay minerals. Probably also the result of deuteric alteration are the development of prismatic quartz crystals up to 2.5 mm long in strongly epidotised narrow bands in the coarser parts, and the development of geodes lined with an outer layer of calcite and an inner layer of prismatic quartz. Some olivine dolerite occurs as blocks in the black soil but its relationship to the diorite is unknown. On BOWEN the main rock types are pyroxene diorite

and greenish grey, pyroxene monzonite. The latter contains numerous small clusters of pink feldspar and quartz which form interleaved, radially disposed sheaves.

A sill, twenty feet thick, 3½ miles north of the junction of the Sellheim and Suttor Rivers, consists of an altered greenish-grey, medium-grained pyroxene diorite.

West of the Suttor River and south of the Cape River, six individual areas of diorite have been shown on the map. The largest area is twelve miles north-north-east of Mount Elsie Homestead. A specimen from here is a fine-grained leucocratic biotite-quartz-augite diorite, which has a granitic to sub-ophitic texture. The occurrence about seven miles west of Dandenong Park Homestead consists of a coarse diorite with granitic texture; the diorite is composed of plagioclase (about 65 percent), secondary alteration products (about 30 percent), augite (5 percent) and minor quartz. The alteration products include serpentine, epidote, clinozoisite, chlorite and calcite; calcite veins are common in the diorite. The four other areas mapped have not been visited and are delineated by photointerpretation only.

East of the Suttor River many individual dioritic intrusions have been photo-interpreted. Half a mile north-east of Arthur Plains Homestead a uralitized gabbro crops out amongst recrystallized andesitic tuffs of the Drummond Group. It is uneven-grained and has a granitic texture, and is composed of labradorite? (30 percent), uralitized clinopyroxene (35 percent) and chlorite, prehnite, and actinolite (35 percent). Sparse outcrops of altered dolerite occur beside the road two miles south of Mount McConnell Homestead. This rock has a granitic texture and consists of altered andesine-labradorite (65 percent), clinopyroxene (15 percent), and serpentine, calcite, epidote, and minor siderite (20 percent).

Most of these bodies have an irregular outcrop but between Mount McConnell and Arthur Plains Homesteads a certain parallelism with the strike of the Drummond Group is apparent.

The age of these diorites is not known beyond the fact that they are younger than Lower Carboniferous.

Quartz-feldspar porphyry intrusives (Pzp)

In the south-eastern border region of the Sheet area quartz-feldspar porphyry intrudes the Drummond Group in five places. In all instances it forms low rocky rises or ridges.

The largest body is immediately north of Box Camp Creek, eight miles north of the junction of the Suttor and Sellheim Rivers. It consists of quartz porphyry, quartz-feldspar porphyry, porphyritic rhyolite, and minor pink, porphyritic andesite. Some quartz-feldspar porphyry contains xenoliths of rhyolite and rhyolite porphyry and some porphyritic rhyolite is fragmental and contains angular fragments of sediments and medium-grained biotite granite.

In the north-west of the body a pink unidentified zeolite is common in a brecciated zone associated with a strong fault which trends north-east.

Near the centre of the body there are a number of north-east trending quartz veins, five feet wide and over a hundred yards long, which appear to fill fault zones. They strike roughly parallel to broad ridges which are apparent on the air photos. As no bedding or layering is apparent in the field, the trends are probably due to fractures, similar to those containing the quartz veins.

White rhyolite dykes up to forty feet thick intrude the Drummond Group near the contact of the main mass. Some of these dykes are traceable back to the main intrusion.

The fragments of granite which occur in porphyritic rhyolite are identical with granite of the late acid phase of the Ravenswood Granodiorite. This granite crops out a few miles to the north of Box Camp Creek where it also is intruded by large quartz porphyry dykes.

Both the Box Camp Creek body and the nearby Drummond Group are intruded by andesite dykes.

The four remaining occurrences of quartz-feldspar porphyry are all small. They all consist of rather uniform red and pink quartz-feldspar porphyry. The occurrence one mile east of Mount Stone appears to be an off-shoot of a body of massive porphyritic microadamellite which occurs on BOWEN. The microadamellite is presumed to be late Palaeozoic in age.

As all these porphyries intrude the Drummond Group they are all younger than Lower Carboniferous. Similar porphyries on BOWEN were regarded by Malone et al. (1962) as Tertiary but similar porphyries on TOWNSVILLE appear to be comagmatic with late Palaeozoic granites (Wyatt, et al., 1965). For the present, the porphyries of CHARTERS TOWERS are regarded as late Palaeozoic in age.

Rhyolite intrusions (Pzh)

Twelve isolated intrusive bodies, composed dominantly of flow-banded rhyolite, have been mapped in the Sheet area. Most are confined to a belt about seven miles wide between Camp Oven Mountain, in the north-east and Mount Malakoff in the south-west. Other occurrences are at Cornishman Hill near Broughton, and at Mount Stone in the south-eastern corner of the Sheet area; one doubtful occurrence is in the extreme north-eastern corner of the Sheet area.

At Mount Bellevue and near Pallamana Homestead the rhyolites are largely concealed by a lateritic cover but elsewhere they form hills which vary from a few tens of feet above the surrounding country to several hundred feet. On air photographs they do not always show a distinctive pattern or tone. They commonly support sparsely distributed broad-leafed iron bark trees.

The individual occurrences are listed below:

1. Six miles west of Camp Oven Mountain a mass of flow-banded rhyolite, measuring about three miles by two miles, intrudes the Cape River Beds. The form of the mass suggests that it is an old volcanic plug. In a small creek on the south-west margin of the mass poorly consolidated medium, yellow to pink, tuffs occur. These tuffs contain fragments of acid porphyry, fine intermediate volcanics and quartz. They may be an extrusive phase or a marginal intrusive tuff. Half-a-mile north of the main mass a north-east-trending

rhyolite dyke intrudes the Cape River Beds sub-parallel to the margin of the main mass.

2. Five miles west of Camp Oven Mountain, an irregular mass of rhyolite intrudes the Cape River Beds. The mass consists of thick sills which extend to the north-east and south-west of a small central body. In a tributary of Pinnacle Creek, at the base of a sill 150 feet thick, the rhyolite is strongly flow-banded within 4 feet of the contact and has a strong parting parallel to the contact. Further away from the contact the rock is a fine white porphyry with phenocrysts up to 1.5 mm. across of rounded quartz and orange feldspar. There is a strong joint system normal to the contact.

3. Four miles north-north-west of Mount Cooper a number of quartz porphyry dykes intrude the Ravenswood Granodiorite at the Three Sisters. Small irregular intrusions probably also occur and form part of the Three Sisters. The dykes are not unlike dykes which intrude the Ravenswood Granodiorite and Cape River Beds about Camp Oven Mountain where they are thought to be related to the volcanics forming that mountain.

4. Near Pallamana Homestead a low ridge of rhyolite a few hundred yards wide trends south-westward. The rhyolite is purplish brown and strongly flow-banded but locally it is spherulitic, porphyritic and autobrecciated. It also includes blocks of country rock consisting of subhorizonal fragmental volcanics and sediments of the basal Drummond Group. Vertically flow-banded rhyolite intrudes sediments at the base of the Drummond Group at the south-western end of the ridge. The rhyolite is strongly fractured, generally at right angles to the flow banding. The fractures are filled by red jasperoid material up to 6 inches thick.

5. Near New Victoria Downs Homestead a group of low hills also called the Three Sisters, is composed of thinly flow-banded rhyolite. The rhyolite is glomeroporphyritic with clusters of quartz phenocrysts in a felsitic groundmass. The flow-banding is well developed but very contorted and generally near vertical in attitude.

6. Similar rhyolite to that near New Victoria Downs Homestead occurs in a washaway 2 miles south-west of Slogan Downs Homestead.

7. Mount Raglan, 3 miles south of New Victoria Downs Homestead, is composed of pink, holocrystalline porphyritic rhyolite. The rhyolite is strongly flow-banded, the flow-banding being much contorted and steeply dipping.

8. Mount Bellevue, 5 miles south-east of Mount Raglan, is composed mainly of purple porphyritic dacite. Much of the mass shows very contorted, steeply dipping, thin flow-banding. The flow layers of holocrystalline material are separated by layers of glass 1mm. thick.

9. North-east of Mount Malakoff are a number of low hills composed of flow-banded, fine porphyritic trachyandesite which is presumed to intrude the Drummond Group. The flow banding is contorted and steeply dipping.

10. Mount Stone, 5 miles south of Mount McConnell Homestead, is composed of pinkish buff to white, spherulitic rhyolite.

11. The Cornishman south of Broughton is composed of flow-banded rhyolite and porphyritic rhyolite. It intrudes the Ravenswood Granodiorite with intrusion breccia at the contact. West of the hill, dykes from the main mass intrude the granodiorite. Many of these dykes have a curvilinear trend, sub-parallel to the margin of the main mass. The rhyolites probably form the plug of a volcano which extruded the acidic lavas which lie immediately east of the Cornishman.

12. Blue Mountain, five miles north of Ravenswood, appears to be capped by rocks different from the nearby granite. The rocks, seen only from a light aircraft, have a general colour, joint system and physiographic form (including cliffs) characteristic of occurrences of rhyolite elsewhere in the region.

13. Light grey acid intrusion-breccia forms numerous irregular dykes in brecciated and mylonitised granite of the late acid phase of the Ravenswood Granodiorite 5 miles north-north-east of Mount Cooper. The rock consists of quartz (10 percent), feldspar (15 percent), clinopyroxene and hornblende (5 percent), minor tourmaline, and abundant lithic fragments, chiefly red acid granite, basic volcanics, hornfels, and chlorite schist in a very fine matrix altered to clay minerals. The source of the fragments of basic volcanics,

hornfels and schist is unknown.

The precise age of the rhyolites is unknown. Some are definitely post Lower Carboniferous, being intruded into the Drummond Group, and most are pre-Miocene or pre-Pliocene as they are overlain by laterite (Miocene?) or by the Campaspe Beds (Pliocene?). The similarity of acid lavas east of the Cornishman to the Bulgonunna Volcanics on BOWEN suggest they are the same age, (Upper Carboniferous, Malone et al., 1966). If this is so, then the Cornishman rhyolite plug is also Upper Carboniferous. All the rhyolites concentrated in the Slogan Downs - Mount Bellevue - Mount Malakoff area are probably of the one age, as they are so similar in lithology and form. The possible age range for the rhyolites is Lower Carboniferous to early Tertiary with the probability that they are of late Palaeozoic age.

Granitic bodies

Seven separate granitic intrusions which post-date the Ravenswood Granodiorite have been delineated in the eastern border region of CHARTERS TOWERS. All apparently represent small stocks. They are divisible into two categories - those that are composed dominantly of granite and/or adamellite with minor granodiorite and those that are dominantly granodiorite and quartz diorite. They have been tentatively assigned to the late Palaeozoic by analogy with similar bodies on TOWNSVILLE and the Mundic Igneous Complex on CHARTERS TOWERS.

Granite, adamellite and minor granodiorite (Pzug)

(a) Molybdenite Creek body

The Molybdenite Creek body crops out mainly on TOWNSVILLE but it extends onto CHARTERS TOWERS between Blue Mountain and Hillsborough. On CHARTERS TOWERS the body forms the high rugged country drained by Molybdenite Creek. It is a composite body: north of the creek it appears to consist essentially of granodiorite, ranging to leucocratic microgranite, but south of the creek it is a pinkish-grey, medium-grained, biotite adamellite which appears to intrude the other rocks (Photo Plate 7). Other recorded rock types are: pink or cream, medium to fine-grained, biotite granodiorite with abundant dioritic xenoliths; grey, medium-grained biotite granodiorite with dioritic xenoliths; and cream, medium to fine-grained granite with 5% acicular hornblende and containing small dioritic xenoliths. The Molybdenite Creek body

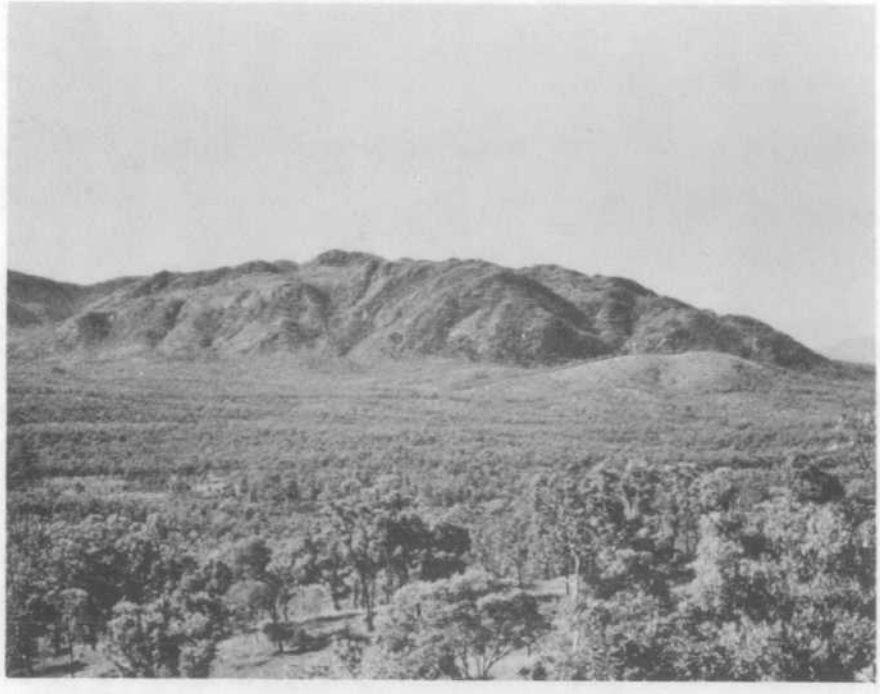

Photo Plate 7.

Range formed by a stock of late Palaeozoic biotite adamellite (Pzug) seven miles north-east of Ravenswood. Roughly oval in plan, the stock is the youngest intrusion of a composite body drained by Molybdenite Creek. It intrudes the Ravenswood Granodiorite, which forms the surrounding lower-lying country.

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intrudes the Ravenswood Granodiorite.

(b) Robey Range

A stock 3 miles in diameter intrudes the Mount Windsor Volcanics and the Ravenswood Granodiorite in the Robey Range, north-east of Mount Canton. This stock forms rugged hills which rise several hundred feet above the surrounding country. It was examined only at its north-western margin where it intrudes the Mount Windsor Volcanics. Here it is a red and brown, porphyritic, biotite leucogranite. Flow-banded felsite dykes intrude the country rock nearby. The dykes are similar to dykes found associated with late Palaeozoic plutons elsewhere, e.g. Mundic Igneous Complex.

(c) Stony Creek

A small body of medium-grained biotite adamellite is centred 1 mile south-south-west of Mount Canton and also north of Stony Creek. The body is semi-circular in plan, its diameter (approximately $2\frac{1}{2}$ miles) trending north-east. The greatest length is along the south-eastern margin where the body appears to be faulted along its contact with Upper Carboniferous volcanics (Cuv). The adamellite is cream to pale pink and contains small xenoliths of fine diorite with abundant small acicular crystals of hornblende. Such hornblende occurs in other late Palaeozoic granitic bodies e.g. in the Mundic Igneous Complex. This stock is intrusive into the Ravenswood Granodiorite.

(d) Saint Anne's Cross Range body

The Saint Anne's Cross Range body is an oval stock of adamellite/granodiorite in the south-eastern corner of CHARTERS TOWERS; its south-western margin forms the Saint Annes Cross Range. Most of this stock has rather low relief where it is drained by the upper reaches of Rockpool Creek, but in the Saint Annes Cross Range relief is up to 350 feet. The stock has been examined 2 miles west-south-west of Arthur Plains Homestead; the rock has a texture which varies from granitic to micrographic and is composed of oligoclase 50%, potash feldspar 25%, quartz 20% and red-brown biotite 5%. In this area a narrow zone of quartz-feldspar porphyry occurs at the margin of the stock. Two small bodies of similar quartz-feldspar porphyry intrude the Drummond Group nearby and are probably offshoots of the stock. In places, marcasite coats joints and fractures in the country rock adjacent to the north-eastern contact of the stock.

Granodiorite, quartz diorite (Pzb)

(a) First Pocket body

The First Pocket body comprises a fine to medium-grained quartz-hornblende-biotite diorite which forms a depression, just east of Black Pinnacle, among the northern foothills of the Robey Range. The surrounding hills are formed from the Mount Windsor Volcanics, which the stock appears to intrude. The northern and southern boundaries of the intrusion are rectilinear, in places, which suggests that they may be faulted.

(b) Lulu Pocket body

Lulu Pocket, 16 miles south-south-east of Ravenswood, is another depression in the Robey Range. It is formed by a sub-circular body of white to grey medium-grained granodiorite, 2½ miles in diameter, surrounded by high country formed by granites of the late acid phase of the Ravenswood Granodiorite.

The granodiorite includes very abundant xenoliths of fine to medium-grained granodiorite which contains a high percentage of acicular hornblende.

The contact between the granodiorite and the surrounding granite was seen at one locality but it did not reveal which body was intrusive. The shape of the granodiorite body suggests it is a small stock intruding the granite and concentric joints in the high granite country which surrounds the granodiorite may possibly be a result of tension caused by the emplacement of the stock.

(c) Mount Stone body

The Mount Stone body is a hornblende-biotite granodiorite which crops out in two places near Arthur Plains Homestead in the south-east of the Sheet area. These outcrops apparently belong to a partly unroofed body which intrudes the Drummond Group. The intrusive contact is exposed south of Mount Stone where impure arenites have been metamorphosed to orthoclase-sericite-quartz hornfels with minor poikiloblastic muscovite and chlorite.

UPPER CARBONIFEROUS

Acid volcanics (Cuv)

In the north-eastern part of CHARTERS TOWERS acid to intermediate lavas and pyroclastics crop out in several places. All of the volcanics are younger than the Ravenswood Granodiorite and those at Camp Oven Mountain are younger than the Drummond Group i.e. they are post-Lower Carboniferous in age. They resemble and may be equivalent to the Upper Carboniferous Bulgonunna Volcanics of BOWEN.

The various occurrences are discussed below:

1. Acid lavas and minor pyroclastics crop out near the Cornishman about 14 miles east-south-east of Charters Towers. The flows appear to dip at low angles away from the intrusive rhyolite of the Cornishman. The flows are apparently derived from the plug but no direct relationship has been observed.

2. At Camp Oven Mountain the lavas consist of rhyolite and andesite in arcuate ridges around a central oval depression. The sequence inwards towards the depression is dark blue-grey andesite, medium to coarse-grained pyritic andesite, light creamy purple flow-banded rhyolite with phenocrysts of feldspar and biotite, tuff, rhyolitic breccia and agglomerate. The rhyolitic agglomerate forms the most prominent ridges; rhyolitic flows and agglomerates dominate the sequence. In the depression itself rhyolitic breccia, fragmental flows and agglomerate occur together with andesite, andesitic tuff and porphyritic andesite. The central depression probably represents the vent of an ancient volcano. Where observed west of the vent individual flows dip vertically or very steeply outwards. In the south-east the volcanics appear to dip towards the vent. A small block of Drummond Group sediments intruded by rhyolite dykes related to the volcanics occurs in the central depression.

Numerous rhyolite and andesite dykes which intrude the country surrounding Camp Oven Mountain are probably related to the volcanics.

(3) Headwaters of Connolly Creek

Ten miles south-east of Ravenswood a sequence of rhyolite, rhyolitic breccia, coarse bluish-black welded tuff, and dacitic and andesitic breccia form a broad ridge above the surrounding country. The rocks dip steeply, and

on air photographs they appear to form an arcuate syncline which trends north to north-east. The welded tuff is similar to that which characterises the Upper Carboniferous(?) volcanics on BOWEN. It consists of scattered sub-rounded fragments of felsite, spherulitic in places, in a matrix of devitrified glass shards. The fragments range up to 1.5 cm. in diameter.

(4) South-east of Mount Canton

One mile south-east of Mount Canton, in the Robey Range, an area of about five square miles is occupied by sediments and (?)volcanics. The rocks were only briefly examined at their north-western margin, where they consist chiefly of conglomerate. The conglomerate is massive and contains pebbles and cobbles of porphyritic rhyolite, granite, and labile arenites similar to those interbedded with the Mount Windsor Volcanics in Fish Creek. Most of the cobbles are well rounded. Rare well bedded tuff and tuffaceous silty shale are interbedded with the conglomerate. Rhyolite appears to be interbedded in the sequence. Granite similar to that which forms boulders in the conglomerate crops out in places between the ridges of conglomerate.

On their north-western margin the sediments dip at 80 degrees to the north-west and are probably faulted against the Stony Creek adamellite stock. Vague trend lines which conform to the measured strike direction are visible on air photographs further east.

(5) The Twins

The north-eastern member of the Twins (18 miles south-south-east of Mount Canton) is composed of weathered brown and greenish-brown porphyritic rhyolite and possibly intrusive quartz-feldspar porphyry. The rocks are brecciated in places; pyritic coatings occur on some of the breccia fragments. Near the telegraph line north-east of the Twins the rhyolite is flow-banded; the banding is vertical and strikes north-west.

LATE PALAEOZOIC OR TERTIARY

Acid volcanics (Cv/Tv)

On BOWEN several outcrops of volcanics have a youthful topographic form which suggests they may be younger than the volcanic bodies already described. On CHARTERS TOWERS, the rocks at Mount Cooper are included in this group.

Mount Cooper is a steep-sided mountain rising some 700 feet above the surrounding granite country. It is composed of multicoloured, fluidal rhyolite and rhyolite-breccia which intrude coarse, biotite granite and adamellite of the Ravenswood Granodiorite. Rands (1891) first described the occurrence of breccia and quartz porphyry at Mount Cooper.

The outcrop is circular and there is little doubt that Mount Cooper is a volcanic plug. McLaren (1900) mapped it as a volcanic focus or neck.

The rocks at Mount Cooper are correlated with similar rocks at Mount McConnell, on BOWEN. On BOWEN they have been assigned a Tertiary age (Malone et al., 1966) but this age is by no means firmly established. The only positive evidence of age for the Mount Cooper rocks is that they are younger than the Ravenswood Granodiorite. Their age may thus range from Palaeozoic to Tertiary.

UPPER PERMIAN

On CHARTERS TOWERS, the Upper Permian is represented by sediments of the Betts Creek Beds, which are best developed on HUGHENDEN, and by the Mundic Igneous Complex.

Betts Creek Beds (Pub)

In Betts Creek, near Pentland (on HUGHENDEN) a sequence of 400 feet of mixed rock types is exposed; it has been named the Betts Creek Beds (Vine et al., 1964). The Beds consist of lithic sandstone, thick quartzose pebble and cobble conglomerate, siltstone (in places sandy or pebbly), mudstone, carbonaceous shale, coal and minor tuff. These Beds unconformably overlie the Cape River Beds and are in turn unconformably overlain by the Lower Triassic Warang Sandstone. A Glossopteris assemblage from the type locality and exposures further west indicates an Upper Permian age (White,

1964) which has been confirmed by palynological evidence (Evans, 1964).

The Betts Creek Beds extend onto CHARTERS TOWERS south of the Cape River, to a point 3 miles south-east of Milray Homestead where they are covered by Cainozoic sediments. Outcrop is poor and the only rocks exposed are isolated thick to very thick beds of lithic sandstone, commonly kaolinitic, in which devitrified glass dominates the labile fraction. These arenites are mainly fine to very fine-grained but some thin beds of coarser arenites and of quartzose pebble and cobble conglomerate are also present. Coarse siltstone and sandy siltstone, generally more quartzose than the arenites, and mudstone occur as rubble in creek beds. The mudstone is mainly blocky and only rarely micaceous and fissile. Some indeterminate plant material is present in the finer sediments. No real estimate of the thickness of the Betts Creek Beds on CHARTERS TOWERS can be made, but it is probably similar to that in the type area i.e. 500 feet.

The coal seams and carbonaceous shales in the upper part of the Betts Creek Beds on HUGHENDEN indicate a continental, probably swampy, environment for that part of the unit. The grains of the arenites are little altered and mainly sub-angular to sub-rounded, suggesting only a short period of transport, so that source areas may have been nearby. Contemporary acid vulcanicity is indicated by the presence of tuff and by volcanic material in the sediments. These points together with the absence of any evidence of marine conditions and the variability of the lithology of the unit suggest that it was deposited in a non-marine environment. The Betts Creek Beds possibly represent broad out-wash plain and piedmont deposits.

Mundic Igneous Complex

The Mundic Igneous Complex comprises two granite stocks with associated volcanics, minor intrusives and dykes. One of the stocks crops out on CHARTERS TOWERS, the other on HUGHENDEN. The stock on CHARTERS TOWERS forms the rugged and prominent range known as the Pentland Hills, north-west of Homestead. In this range and its northern foothills the Complex crops out over about 15 square miles. The Complex is named from Mundic Creek, a tributary of the Campaspe River, which rises in the Pentland Hills.

TABLE 3: STRATIGRAPHY OF THE CHARTERS TOWERS 1:250,000 SHEET AREA

ERA	AGE	ROCK UNIT	LITHOLOGY	TOPOGRAPHY	STRUCTURAL/DEPOSITIONAL ENVIRONMENT	RELATIONSHIPS AND THICKNESS	ECONOMIC GEOLOGY	PRINCIPAL REFERENCES
CAINOZOIC	QUATERNARY	Qa	Alluvial sand, gravel, silt	Flat	Alluvial, along stream courses and in broad valleys	Superficial	Good water at shallow depths near major rivers and creeks	
		Qs	Sand, silt, gravel	Higher than stream alluvia	Colluvial and outwash deposits in broad valleys. Thickness very variable, possibly up to 200 feet near Harvest Home Homestead	Superficial		
		Toomba Basalt Qt	Vesicular olivine basalt	Plains. Surface very broken; impassable to vehicles.	Vesicular to scoriaceous lava flow; ropy flow surface preserved	Superficial. Overlies Nulla Basalt	Numerous permanent and temporary springs	Rands 1891 Morton 1932C Twidale 1956 White 1962 Wyatt et al., 1965 and in prep. Paine et al., 1965
	UNDIFFERENTIATED	Sellheim Formation Cze	Semi-consolidated argillaceous sandstone, ferruginous sandstone, pebble conglomerate	Low tablelands and terraces	High level river sands and gravels; possibly also in part lacustrine	Superficial. Overlies Ravenswood Granodiorite. 10-15 feet thick; abundant silicified wood; Diprotodon australis recorded by Jack	Minor gold leads at base of formation at Rishton	Jack 1879 Howard 1959 Wyatt 1963
		Czo	Grey and brown soils	Flat	Probably derived from calcareous lacustrine deposits	Superficial		
		Czg	Sand, gravel, silt; semi-consolidated	Flat to gently sloping	High level alluvial and outwash deposits	Superficial; 30-40 feet thick	Underground water	
		Nulla Basalt Czn	Olivine basalt, rare sand lenses	Plains; largely soil covered	Thin. Marginal to large basalt plateau (CLARKE RIVER)	Overlies Lolworth Igneous Complex and Campaspe Beds. Maximum thickness in Sheet area about 20 feet	Underground water	Twidale 1956 White 1962
	TERTIARY	Tf	Nodular ferricrete; weathers to ironstone pebbles	Interfluvial plains	Part of weathering profile	Formed on Campaspe Beds; probably present but not readily recognised on older units. Thickness 2-4 feet		Wyatt et al., 1965 and in prep. Paine et al., 1965
		Campaspe Beds Tc	Buff argillaceous sandstone, some conglomerate and siltstone	Beds and banks of creeks	Poorly sorted, weakly cemented piedmont deposits. Essentially flat-lying except adjacent to foothills of Grasstree Range where initial dips are up to 10°	Overlies the Lolworth Igneous Complex and laterite. Thickness 30-50 feet	Gold in deep lead near Pentland (HUGHENDEN)	Wyatt et al., 1965 and in prep. Paine et al., 1965

ERA	AGE	ROCK UNIT	LITHOLOGY	TOPOGRAPHY	STRUCTURAL/DEPOSITIONAL ENVIRONMENT	RELATIONSHIPS AND THICKNESS	ECONOMIC GEOLOGY	PRINCIPAL REFERENCES
CAINOZOIC	TERTIARY	Tl	Laterite. Ferruginous, mottled and pallid zones	Tablelands and mesas	Weathering profile.	Formed on all older units irrespective of rock type. Overlain disconformably by Campaspe Beds. Thickness 5-30 feet		Saint-Smith 1921
		Tu	Argillaceous sandstone, feldspathic sst, pebbly sandstone conglomerate, minor siltstone and claystone. Locally silicified	Mainly beneath laterite (Tl) in tablelands and mesas	Lateritized; probably lacustrine with intermittent fluviatile sedimentation	Overlies the Ravenswood Granodiorite; unconformable on Drummond Group. Thickness 0-120 feet. Rare Eucalyptus sp.	Minor gold in leads at Little Red Bluff and Puzzler Walls	Rands 1891 Morton 1945
MESOZOIC	LOWER TRIASSIC	Warang Sandstone Rlw	White, kaolinitic quartz sandstone, minor red and white siltstone	Dissected sandstone hills	Probably fluviatile; large scale trough cross-stratification. Lateritized.	Unconformably overlies Betts Creek Beds. Thickness about 500 feet		Vine et al., 1964 Evans 1964
LATE PALAEOZOIC	UPPER PERMIAN	Lundic Igneous Complex — Pug	Drusy leucogranite	Rugged Pentland hills, up to 3000 feet above sea level	Epizonal stock	Intrudes Cape River Beds, volcanics (Pue) and minor intrusives (Pud)	Gold, with minor copper, lead, zinc, tungsten, arsenic, bismuth, and molybdenum, at Lolworth Diggings on HUGHENDEN	Paine et al., 1965
		Lundic Igneous Complex — Pud	Microgranite, microadamellite, micromonzonite, microdiorite, diorite, dolerite	Northern shoulders - foothills of Pentland Hills	Minor intrusives. Small bosses and bodies of unknown shape. Roof pendants on Pug	Some intrude Pue and are intruded by Pug. Others intrude Lolworth Igneous Complex.		
		Lundic Igneous Complex — Pue	Volcanic breccia on north-west flank of Pentland Hills. Dacite and rhyolite on eastern side	N.W. shoulder of Pentland Hills. Scree-covered slopes on north-east side	Extrusive. Crudely bedded on NW flank of Pentland Hills	Unconformably overlies Lolworth Igneous Complex. Intruded by Pud and Pug		
		Betts Creek Beds Pub	Lithic sandstone and mudstone, in places tuffaceous; quartzose conglomerate	Low rises and plains	Outwash plain or piedmont deposits; contemporaneous vulcanicity	Unconformably overlie Ravenswood Granodiorite. Overlain by Warang Sandstone with regional unconformity. Indeterminate plant remains. About 400 feet thick	Coal seams on HUGHENDEN	Vine et al., 1964

ERA	AGE	ROCK UNIT	LITHOLOGY	TOPOGRAPHY	STRUCTURAL/DEPOSITIONAL ENVIRONMENT	RELATIONSHIPS AND THICKNESS	ECONOMIC GEOLOGY	PRINCIPAL REFERENCES
LATE PALAEOZOIC OR TERTIARY		Cu/Tv	Rhyolite, rhyolite breccia	Mount Cooper Prominent circular hill, 700 feet above surrounding country	Volcanic plug	Intrudes Ravenswood Granodiorite		Rands 1891 MacLaren 1900
LATE PALAEOZOIC	UPPER CARBONIFEROUS	Cuv	Rhyolite, agglomerate, andesite, tuff, volcanic breccia, minor labile conglomerate and sediments	Uneven hills	Associated with isolated eruption centres; also plug and dyke-like masses	Intrude or overlie Ravenswood Granodiorite. At Camp Oven Mountain intrudes the Drummond Group		
	POST-LOWER CARBONIFEROUS	Pzug	Granite, adamellite, some granodiorite	Both positive and negative relief	Epizonal stocks	Some intrude Ravenswood Granodiorite, others the Mount Windsor Volcanics; two intrude the Drummond Group		
		Pzb	Granodiorite, quartz diorite	Negative relief. "Pockets"				
		Pzh	Intrusive rhyolite, some quartz porphyry; minor dacite and trachyandesite	Variable. Some isolated steep hills	Small intrusive masses, plugs and sheets; possibly volcanic feeders	Intrude Cape River Beds, Ravenswood Granodiorite and Drummond Group		
		Pzp	Intrusive quartz porphyry, quartz feldspar porphyry, porphyritic rhyolite, fragmental porphyritic rhyolite, minor andesite	Low hills and rises	Small masses and sheets	Intrude Ravenswood Granodiorite, Ukalunda Beds, and Drummond Group		
		Pzi	Altered diorite, gabbro, dolerite	Hollows and low rises of black soil	Numerous irregular and sill-like bodies	Intrude Drummond Group		
UNDIVIDED PALAEOZOIC		Pzo	Rhyolitic and dacitic porphyry; agglomerate	Mount Leyshon	Volcanic neck	Intruded at contact of Cape River Beds and Ravenswood Granodiorite	Gold (Mount Leyshon)	Jack 1885 Rands 1891 Morton 1932b

ERA	AGE	ROCK UNIT		LITHOLOGY	TOPOGRAPHY	STRUCTURAL/DEPOSITIONAL ENVIRONMENT	RELATIONSHIPS AND THICKNESS	ECONOMIC GEOLOGY	PRINCIPAL REFERENCES
LATE PALAEOZOIC	UPPER DEVONIAN - LOWER CARBONIFEROUS	Drummond Group Cld	Sub-unit D (top)	Arkose, subarkose, subgreywacke, siltstone, mudstone, conglomerate, calcareous lutite	Hills and ranges, dissected plains. Prominent strike ridges	Generally shallow freshwater deposition in asymmetrical basin. Contemporary volcanicity prominent in basal parts only. Intensely folded axial belt	Unconformably overlies Cape River Beds, Ravenswood Granodiorite, and Ukalunda Beds		Jack and Etheridge 1892 Malone et al., 1962, 1966 McKellar 1964a, b
			Sub-unit C	Feldspathic and lithic arenite, subgreywacke, subarkose, siltstone, mudstone, acid and intermediate tuff, agglomerate and lava					
			Sub-unit B	Subarkose, protoquartzite, subgreywacke, siltstone, mudstone, conglomerate					
			Sub-unit A (base)	Andesite, tuff, agglomerate, volcanic breccia, siltstone, subgreywacke, algal limestone, conglomerate					
	MIDDLE DEVONIAN	Ukalunda Beds Dk		Phyllite, siltstone, fine greywacke	Dissected rises and small hills	Marine, moderately deep water; widespread cleavage, and hornfelsing due to granite intrusion	Unconformably overlain by Drummond Group. Favosites, Mesophyllum, Keriophyllum, Atrypa, and Receptaculites occur on BOWEN	On BOWEN, unit is intruded by granite with which is associated gold, silver, copper, arsenic, and bismuth mineralization	Malone et al., 1962 and 1966
EARLY PALAEOZOIC	UPPER SILURIAN - LOWER DEVONIAN	Lolworth Igneous Complex S-Dl		Banded, pegmatitic and aplitic, garnetiferous granite and adamellite. Minor massive biotite adamellite	Hills and ranges. Grasstree Ranges	Post-tectonic batholith	Intrudes Cape River Beds and Ravenswood Granodiorite. Intruded by Mundic Igneous Complex. Radiometric age, 400 m. yrs ± 3% (one determination only), indicates early Devonian age	Gold, associated with Pb, Cu and As, at Old Homestead Diggings	Rands 1891 Paine et al., 1965

ERA	AGE	ROCK UNIT		LITHOLOGY	TOPOGRAPHY	STRUCTURAL/DEPOSITIONAL ENVIRONMENT	RELATIONSHIPS AND THICKNESS	ECONOMIC GEOLOGY	PRINCIPAL REFERENCES
PALAEOZOIC	UPPER SILURIAN - LOWER DEVONIAN	Ravenswood Granodiorite	S-Dr	Hornblende, and biotite granodiorite, quartz diorite, adamellite, some gabbro and diorite. Foliated in places. Forms major part of unit	Mainly dissected plains, some hills and ranges	Late syntectonic batholith	Intrudes Cape River Beds. Unconformably overlain by Lower Middle Devonian Fanning River Group (TOWNSVILLE). Radiometric age 420-440 m. yrs (3 determinations)	Gold, notably at Charters Towers and Ravenswood. Silver at Totley. Also Cu, Mo, Sb.	Jack 1879 Reid 1917 Wyatt, et al., 1965 and in prep.
			S-Da	Pink and red biotite granite and adamellite, microgranite, biotite pegmatite and aplite. Foliated in places	Variable. Rises and hills higher than S-Dr. Robey Range	Irregular masses within the batholith. Minor dykes	Intrudes S-Dr	Mineralization at Ravenswood?	MacLaren 1900 Wyatt, et al., 1965 and in prep.
			S-Dd	Quartz diorite, diorite	Black soil areas of very low relief	Small, often sheet-like masses			Maitland 1891 Rands 1891 Reid 1917
			S-Db	Olivine gabbro, leucogabbro, hornblendite, diorite, quartz monzonite	Black soil areas of low relief; isolated hills	Irregular and dyke-like masses showing layering and orbicular structure	Possibly older than the aplite and pegmatite dykes of the S-Da phase		Reid 1917
	UNDIFFERENTIATED	Kirk River Beds Pzk		Micaceous shale, siltstone, feldspathic sandstone, greywacke	Low dissected hills	Poorly sorted; graded bedding and turbidity structures	Intruded by Ravenswood Granodiorite; probably equivalent to Cape River Beds	Gold at Bunkers Hill (TOWNSVILLE)	Wyatt et al., 1965 and in prep.
		Cape River Beds Pzc		Homestead-Allan Hills: mica schist, phyllite, granofels, sericite quartzite, recrystallized subgreywacke. Mount Trafalgar-Liontown: phyllite, metamorphosed subgreywacke, siltstone, mudstone, phyllitic shale,	Generally low hills and ranges	Dynamic and thermal metamorphism related to Ravenswood Granodiorite and Lolworth Igneous Complex. In general, degree of metamorphism decreases away from contacts; decreases from west to east and from north to south	Intruded by the late syntectonic Ravenswood Granodiorite. No fossils found	Lead, silver, zinc, gold, copper (Liontown). Numerous small gold workings S.W., S., and S.E., of Mount Leyshon. Gold south of Dreghorn, also in Connolly Creek area, and New Homestead Diggings	Rands 1891 Jack 1885 MacLaren 1900 Levingston 1956 Paine et al., 1965

ERA	AGE	ROCK UNIT	LITHOLOGY	TOPOGRAPHY	STRUCTURAL/DEPOSITIONAL ENVIRONMENT	RELATIONSHIPS AND THICKNESS	ECONOMIC GEOLOGY	PRINCIPAL REFERENCES
EARLY PALAEOZOIC	UNDIFFERENTIATED	Cape River Beds Pzc (Continued)	sheared arenite, quartz-sericite schist, quartzite. Headwaters Little Policeman Creek: siltstone, mudstone. Pallamana Homestead-Camp Oven Mountain: hornfelsed greywacke, subgreywacke, siltstone, arkose, pebble conglomerate; pyritic silty argillite, quartzite, shale, mudstone; rare calc-silicate rocks					
		Mount Windsor Volcanics Pzw	Acid to basic volcanics; hornfels, schist, rare labile sediments	Hills and ranges				
		Charters Towers Metamorphics Pzq	Mica schist, quartzite, quartz-felds-par-biotite schist, hornblende schist, cordierite hornfels, andalusite hornfels, staurolite hornfels, chlorite schist and marble	Plains, low rises, and small hills	Scattered roof pendants	Intruded by Ravenswood Granodiorite. Probably equivalent to Cape River Beds	Very minor gold deposits at Charters Towers	Jack 1879 Rands 1893 Maitland 1893 Reid 1917 Bryan 1926

AUSTRALIA 1:250,000

CHARTERS TOWERS

QUEENSLAND

1:250,000 GEOLOGICAL SERIES SHEET SF 55-2

PRELIMINARY EDITION, 1966

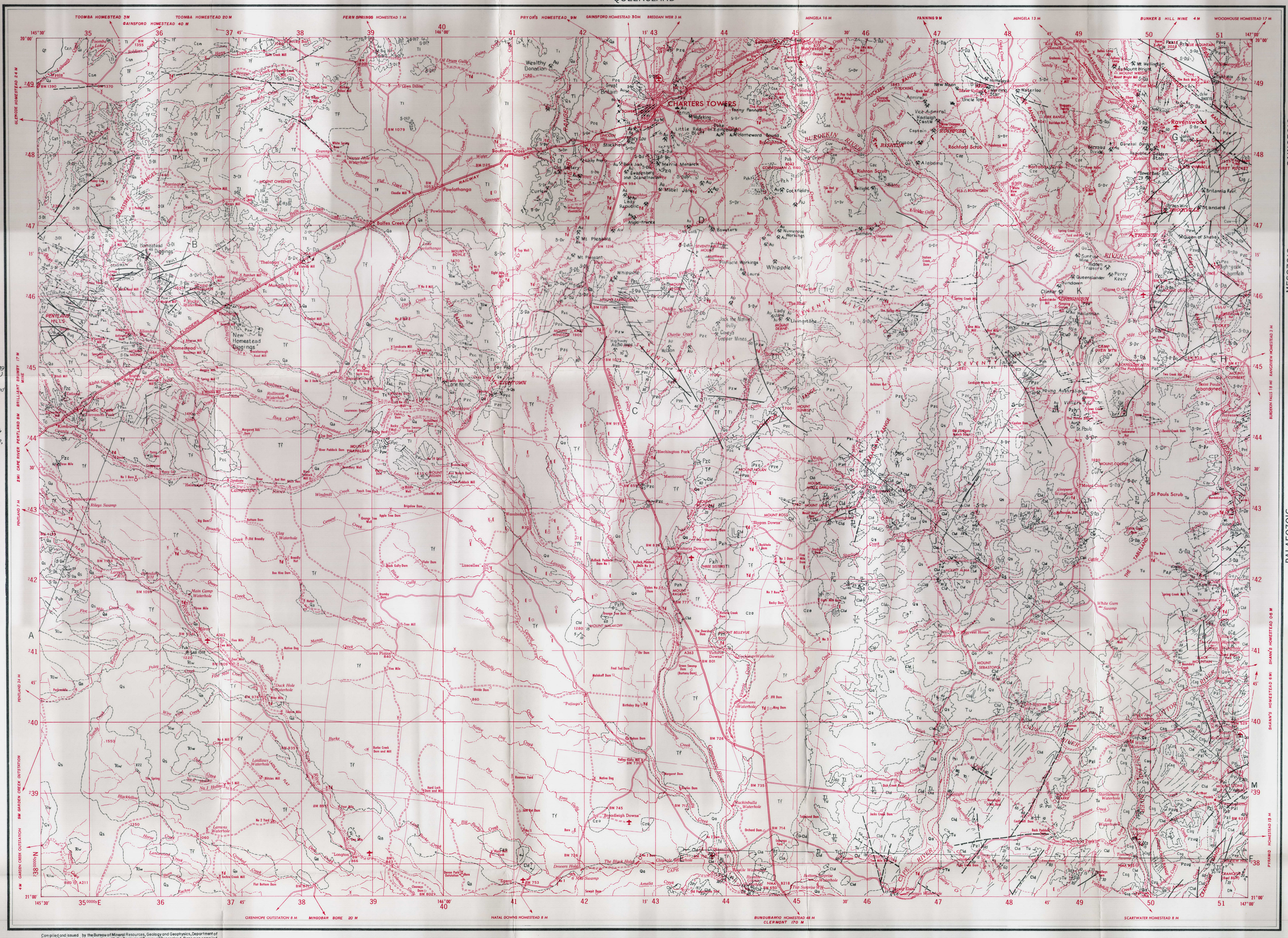
SUBJECT TO AMENDMENT

Reference

- Geological boundary
- Anticline
- Fault, showing relative horizontal movement
- Slickenside on fault
- Lineament (air-photo interpretation)
- Where location of boundaries, folds and faults is approximate, line is broken; where inferred, queried; where concealed, boundaries and folds are dotted, faults are shown by short dashes
- Strike and dip of strata
- Prevailing strike and dip of strata
- Vertical strata
- Horizontal strata
- Overturned strata
- Dip < 15° } air-photo interpretation
- Trend lines } air-photo interpretation
- Joint pattern } air-photo interpretation
- Horizontal strata } air-photo interpretation
- Strike and dip of foliation
- Vertical foliation
- Strike and dip of cleavage
- Vertical cleavage
- Plunge of lineation
- Strike and dip of foliation with plunge of lineation
- Inclined platy flow
- Vertical platy flow
- Strike and dip of banding in granite
- Microfossil locality — GAB 1068-ref. no. of collection described in B.M.R. Record No.1964/39 (Vine, et al.)
- Macrofossil locality, Plant fossil locality, Fossil wood — C4..........ref. no. of collection described in Appendix 1 of B.M.R. Record (in prep.) to accompany this map
- Dyke or vein; a-aplite, an-andesite, bp-biotite pegmatite or aplite, br-intrusion breccia, d-dolerite, microdiorite, di-diorite, e-epidote, f-felsite (mainly rhyolite), gb-gabbro, gd-granodiorite, mg-microgranite, p-quartz-feldspar porphyry, q-quartz. Absence of letter symbol indicates photo-interpretation
- Mine — KIRK Old mining township
- Abandoned mine
- Abandoned alluvial diggings
- Battery
- Abandoned battery
- •Ba Minor mineral occurrence

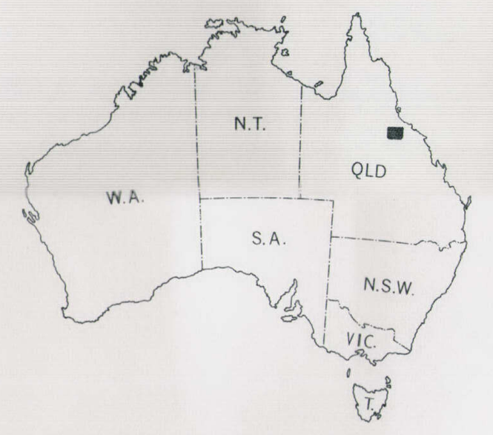
Ag	Silver
Au	Gold
Ba	Barytes
Bi	Bismuth
Cu	Copper
Ms	Magnesite
Mt	Magnetite
Pb	Lead
Py	Pyrite
Sb	Antimony
Zn	Zinc

- Water bore, with registered number and station number
- Earth tank
- Windpump
- Dam
- WH Waterhole on stream
- Swamp
- Highway
- Road
- Vehicle track
- Railway with station and siding
- Fence
- Telephone line
- "Milray" Homestead
- Hut
- P.O. Post Office
- Yd Yard
- Airport
- Landing ground
- Astronomical station
- Trigonometrical station
- 1540' Height in feet, instrument levelled; datum mean sea-level
- BM 935 Bench mark



Compiled and issued by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development in conjunction with the Geological Survey of Queensland. Base map compiled by the Royal Australian Survey Corps. Aerial photography by Adastra Airways Pty. Ltd. vertical coverage at 1:85,000 scale. Transverse Mercator Projection

Geology 1963 & 1964 by D.H.Wyatt, D.E.Clarke (G.S.Q)
A.G.L.Paine, R.R.Harding, C.M.Gregory & R.R.Vine (B.M.R.)
Compiled 1963 & 1964 by W.J.Rowland (Queensland Mines Dept) & A.G.L.Paine
Drawn by J.L.McGovern, W.W.Webb & A.Tatarow (B.M.R.)

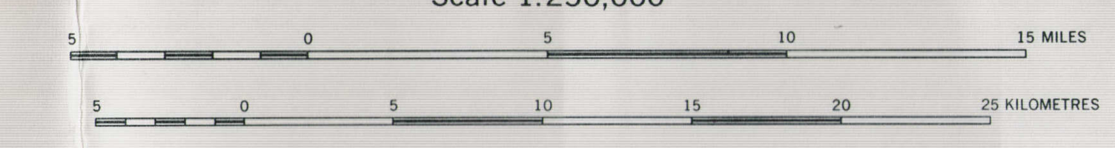


INDEX TO ADJOINING SHEETS

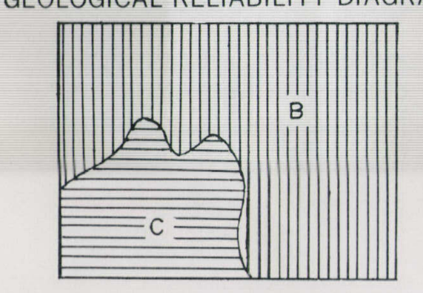
Showing Magnetic Declination

GEORGETOWN SE 54-12	EINASLEIGH SE 55-9	INGHAM SE 55-10		
GILBERTON SE 54-16	CLARKE RIVER SE 55-13	TOWNSVILLE SE 55-14	AYR SF 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	MOUNT COOLON SF 55-7	MACKAY SF 55-8

Scale 1:250,000

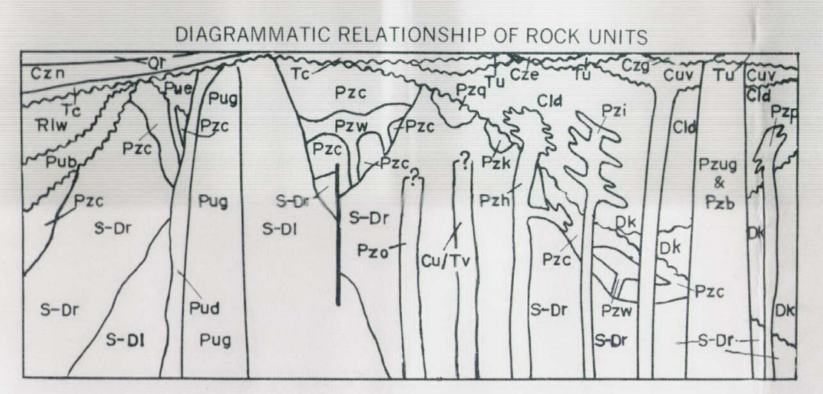


GEOLOGICAL RELIABILITY DIAGRAM



B Detailed reconnaissance with air-photo interpretation
C Some traverses - mostly air photo interpretation

DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS

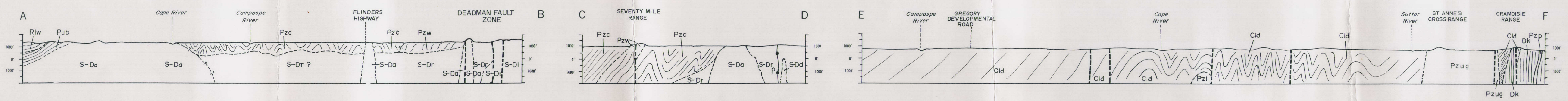


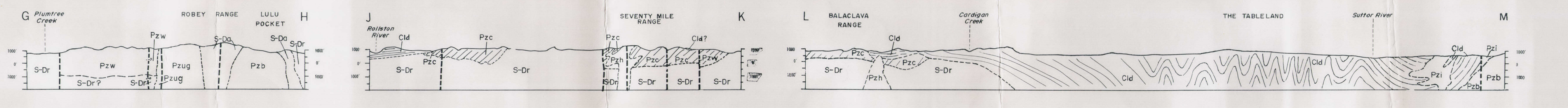
Reference

Era	Period	Formation	Symbol	Description
CAINOZOIC	QUATERNARY		Qa	Alluvium
			Qs	Superficial sand
		Toomba Basalt	Qt	Vesicular olivine basalt
	UNDIFFERENTIATED		Czo	Grey and brown soils
			Czg	Semi-consolidated alluvial and outwash deposits
		Sellheim Formation	Cze	Argillaceous sandstone, ferruginous sandstone, pebble conglomerate
		Nulla Basalt	Czn	Olivine basalt
	TERTIARY		Tf	Younger ferricrete
		Campaspe Beds	Tc	Buff argillaceous sandstone; some conglomerate and siltstone
			Tl	Older ferricrete (including laterite)
			Tu	Argillaceous sandstone, feldspathic sandstone, pebbly sandstone and conglomerate; minor siltstone
MESOZOIC	LOWER TRIASSIC	Warang Sandstone	Rlw	White, kaolinitic, quartz sandstone; minor red or white siltstone
PALAEOZOIC	UPPER PERMIAN	Mundic Igneous Complex	Pug	Drusy leucogranite
			Pud	Minor intrusives: microgranite, microadamellite, micromonzonite, microdiorite, diorite, dolerite
			Pue	Volcanic breccia, some dacite and rhyolite
		Betts Creek Beds	Pub	Lithic sandstone and mudstone, in places tuffaceous
	LATE PALAEOZOIC OR TERTIARY		Cu/Tv	Rhyolite, rhyolite breccia (Mount Cooper)
	UPPER CARBONIFEROUS		Cuv	Rhyolite, agglomerate, andesite, tuff, volcanic breccia; minor labile conglomerate and sediments
	POST-LOWER CARBONIFEROUS		Pzug	Granite, adamellite, some granodiorite
			Pzb	Granodiorite, quartz diorite
			Pzh	Intrusive rhyolite; some quartz porphyry; minor dacite and trachyandesite
			Pzp	Intrusive quartz porphyry, quartz feldspar porphyry, breccia, porphyritic rhyolite
			Pzi	Diorite, gabbro, dolerite
	UNDIFFERENTIATED		Pzo	Rhyolitic and dacitic porphyry; agglomerate (Mount Leyshon)
	UPPER DEVONIAN — LOWER CARBONIFEROUS	Drummond Group	Cld	Arkose, orthoquartzite, siltstone and mudstone, tuff, agglomerate, intermediate and acid lavas, conglomerate, minor calcareous sediments
	MIDDLE DEVONIAN	Ukalunda Beds	Dk	Phyllite, siltstone, fine-grained greywacke
	SILURIAN — LOWER DEVONIAN	Lolworth Igneous Complex	S-Dl	Banded, pegmatitic and aplitic, garnetiferous granite and adamellite. Minor massive biotite adamellite
		Ravenswood Granodiorite	S-Da	Pink and red biotite granite and adamellite, microgranite, biotite pegmatite and aplite. Foliated in places.
			S-Dd	Quartz diorite, diorite
			S-Db	Olivine gabbro, leucogabbro, hornblendite, diorite, quartz monzonite
			S-Dr	Hornblende and biotite granodiorite and quartz diorite; adamellite; minor gabbro and diorite. Foliated in places.
	?	Kirk River Beds	Pzk	Micaceous shale, siltstone, feldspathic sandstone, greywacke
		Cape River Beds	Pzc	Schist, quartzite, phyllite, metavolcanics; siltstone, mudstone, arenite, pyritic shale, minor tuff; rare hornfels, marble, and calc-silicate rocks
		Mount Windsor Volcanics	Pzw	Acid to basic volcanics, hornfels, schist, rare labile sediments.
		Charters Towers Metamorphics	Pzq	Mica schist, quartzite, quartz-feldspar-biotite schist, hornblende schist, cordierite hornfels, chlorite schist

Sections

Cainozoic sediments omitted from sections. Attitude of faults not known





CHARTERS TOWERS

SHEET SF 55-2

MUNDIC IGNEOUS COMPLEX

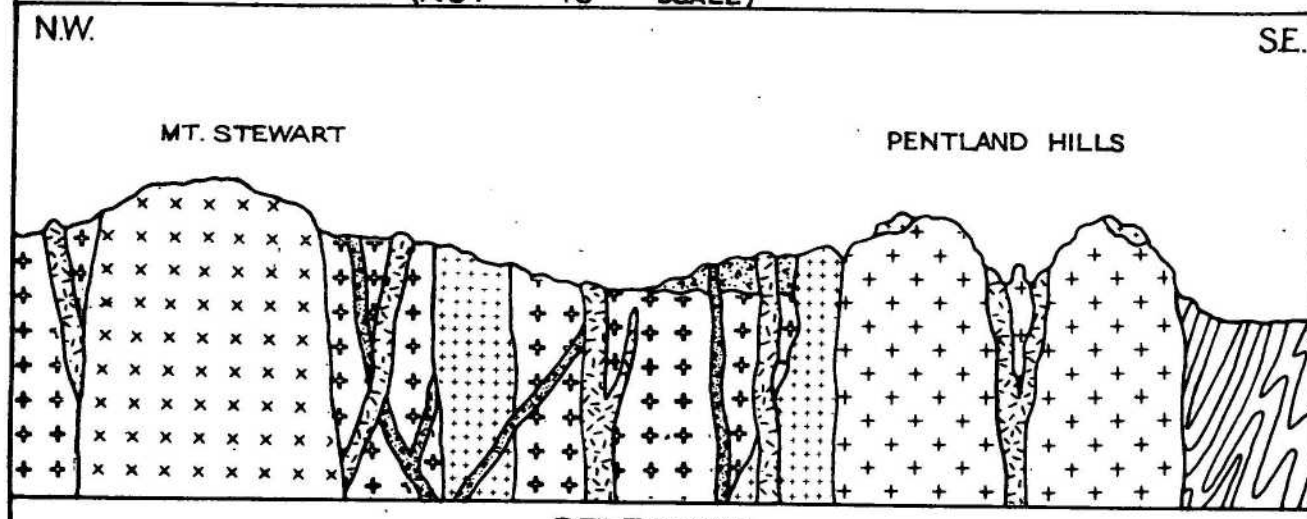
Fig. 4.

(UPPER PERMIAN)

CHARTERS TOWERS & HUGHENDEN 1:250,000 SHEET AREAS

Diagrammatic sketch section illustrating probable order of emplacement of the rocks of the Complex.

(NOT TO SCALE)



REFERENCE

1. Volcanic breccia (Pue)
2. Microadamellite, hornblende microdiorite, dolerite, granite and other minor intrusives (Pud)
   Dolerite/microdiorite dykes.
3. Drusy leucogranite (Pug)
4. Felsite dykes.
5. Porphyritic microgranite (Pum).

Lolworth Igneous Complex

Cape River Beds

} Country rocks

To accompany Record 1967/104

F55/A/15

The southern end of the range is the more rugged and higher part, for here it rises abruptly to about 1800 feet above the level of the surrounding country. The summit is 3,000 feet above sea-level. The northern and north-eastern edge of the range is not so precipitous. These topographic differences are closely related to the rocks of the Complex and to the adjoining rock types e.g. to the south the Cape River Beds are of comparatively low relief and are covered by the superficial Campaspe Beds while to the north the Lolworth Igneous Complex is of moderate relief.

In plan, the outline of the stock (Pug) which forms the Pentland Hills is roughly oval, measuring some $5\frac{3}{4}$ miles long by $3\frac{1}{2}$ miles wide, the longer axis trending north-east.

Five major units have been distinguished in the Complex, of which four appear on CHARTERS TOWERS. The four units are:

Unit		Map symbol
Volcanics		Pue
Minor Intrusives		Pud
Leucogranite		Pug
Dykes	Felsite	f
	Dolerite/microdiorite	d

The fifth unit, a leucocratic microgranite stock, forms Mount Stewart on HUGHENDEN.

Volcanics (Pue)

The volcanics form a narrow belt along the north-eastern and northern margins of the Complex. The best outcrops are at the western end of the northern margin. Here the volcanics consist of a breccia composed of fragments of granite from the Lolworth Igneous Complex, pale, aphanitic igneous rock, probably a rhyolite, and broken quartz and feldspar grains, all in a greenish-grey aphanitic matrix. The rock fragments range in size from 60 cm. to 1mm. across.

Viewed from a distance of several miles this unit appears to have a crude layering which dips to the north at about 10°. However, neither in hand specimen nor in the actual outcrop can any evidence of layering be distinguished.

The unit has been extended by photo-interpretation farther to the east along the northern flank of the Pentland Hills.

Along the north-eastern flank of the Hills an area with a different air-photo pattern to the adjoining country apparently belongs to the Complex. The area is a smooth slope on which floaters only have been found. Two floaters, which were sectioned, consist of an altered porphyritic dacite and a porphyritic microadamellite respectively. Other floaters determined in hand specimen consist of: dark brown, slightly porphyritic aphanitic rhyolite with quartz, white and red feldspar and rare mafic phenocrysts; a variety of this rock in which the groundmass is coarser, the phenocrysts more abundant and the colour redder; a pale grey glomeroporphyritic andesite with euhedral crystals of white feldspar and mafics: fine-grained blue dacite, and red-brown rhyolite with scattered red spherulites and vague flow banding. They have all been mapped in the volcanic unit although some may be intrusive.

A vertical sheet of pink microgranite, 100 feet thick, separates these rocks from the Cape River Beds to the east. This microgranite passes, to the south-west, into leucogranite of the main Pentland Hills stock.

Minor Intrusives (Pud)

Heterogeneous fine-grained plutonic rocks crop out on the north-western and north-eastern flanks of the Pentland Hills, where they appear to form minor intrusions, satellitic to the main stocks. The rocks are distinctly richer in mafic minerals than those in the main stocks.

In the north-west these rocks form a narrow belt between volcanic breccia (Pue) in the north and the main stock of leucogranite (pug) in the south; the leucogranite intrudes them. The rock types range from dolerite through microdiorite and micromonzonite to microadamellite to microgranite; all contain acicular amphibole and have been deuterically altered. The predominant rock type is a porphyritic microadamellite which consists of zoned plagioclase phenocrysts in a groundmass of red (potash?) feldspar, acicular amphibole, quartz, and deuteric alteration products. The more basic rock types commonly form xenoliths within the more acid types. In texture and composition some of the rocks resemble those which form the summit of Mount Stuart, near Townsville (Wyatt et al., 1965, and in prep.).

Fine-grained diorite and biotite adamellite or granite form the low north-eastern shoulder of the Pentland Hills, 1 to 2 miles south-west of Oaky Yard. The fine-grained diorite is strikingly porphyritic in hornblende up to one cm. long; the rock has not been deuterically altered. The mutual relations of the two rock types were not determined, nor were their relationships to the other rocks of the complex. They appear to intrude the Lolworth Igneous Complex.

High up in the south-western spurs of the Pentland Hills a small area of porphyritic microadamellite appears to form a roof pendant on the leucogranite of the Pentland Hills stock. Rocks with a similar photo-pattern also cap the north-eastern peak of the Pentland Hills. In both instances the rocks have been included with the minor intrusives.

Two separate minor intrusions occur several miles north-west of the Pentland Hills. The southernmost is a boss, one third of a mile in diameter, which intrudes coarse muscovite granite of the Lolworth Igneous Complex. The boss forms a high, rugged ridge encircling a shallow central depression. It is composed of pale pink porphyritic biotite-hornblende microadamellite very similar to that predominating in the minor intrusives which form part of the north-western shoulders of the Pentland Hills. About 1 mile further north a similar depression with encircling ridge, has been photo-interpreted as another small boss of the Mundic Igneous Complex.

Leucogranite (Pug)

The stock which forms the greater part of the Pentland Hills is composed of medium-grained, pink and red, drusy leucogranite. The druses average 5mm. in diameter and are commonly lined with a pale yellow to pale turquoise earthy mineral or, in places, are filled with very small flakes of a bright yellow mineral. Neither of these minerals has, as yet, been determined. The stock intrudes the minor intrusives along its north-western margin.

A marginal zone of porphyritic graphic microgranite occurs along the eastern margin, next to rocks tentatively assigned to the volcanic unit (Pue). The microgranite consists of microperthite 55%, quartz 25%, oligoclase 15%, and minor biotite.

The stock is bisected by a sinistral wrench fault trending north-west, which has been the locus of felsite dyke intrusions.

Dykes

Felsite and dolerite/microdiorite dykes are genetically associated with the Mundic Igneous Complex. The felsite dykes have not been found in contact with the dolerite/microdiorite dykes on CHARTERS TOWERS, but on HUGHENDEN the acid dykes are invariably later than the more basic ones.

The felsite dykes are abundant in the Lolworth Igneous Complex north of the Pentland Hills, where they form ridges readily identifiable on air photographs. They also intrude the Cape River Beds east of the Pentland Hills. Flow-banded, leucocratic rhyolite is the commonest rock type. Some rocks are porphyritic in feldspar, and a few contain biotite. The dykes are between 5 feet and 50 feet wide and some have been recognised to extend for 3 or 4 miles. Besides intruding the country surrounding the Mundic Igneous Complex they have also been emplaced within and parallel with the fault zone which bisects the Pentland Hills stock.

The dolerite/microdiorite dykes intrude the Lolworth Igneous Complex 4 miles north of the Pentland Hills where they are parallel to a swarm of felsite dykes. These more basic dykes average 2 to 3 feet wide, but their length is unknown because they have no significant topographic expression. On the whole they do not appear to be as abundant as the felsite dykes, but this may be a reflection of their less conspicuous outcrop and their non-appearance on air photographs.

In the north-west of the Pentland Hills, a dyke of altered, porphyritic hornblende andesite intrudes the Lolworth Igneous Complex. This dyke contains rare, rounded xenoliths of dolerite.

Order of Emplacement

The form and order of emplacement of the units comprising the Mundic Igneous Complex are summarised in Table 2 and illustrated diagrammatically in Figure 4.

TABLE 2: Summary of Mundic Igneous Complex

Order of emplacement	Symbol	Rock Types	Mode of occurrence	1:250,000 Sheet area: Hughenden	1:250,000 Sheet area: Charters Towers
1	Pue	Volcanic breccia (and possibly other extrusive rocks)	Extrusive. Crudely bedded		X
2	Pud	Microgranite, microadamellite, micromonzonite, microdiorite, diorite and dolerite	Minor intrusives. Small bosses and bodies of unknown shape. Roof pendants	X	X
	d	Dolerite/microdiorite	Dykes	X	X
3	Pug	Drusy leucogranite (Pentland Hills)	Stock		X
4	f	Felsite (including rhyolite and other acidic rocks)	Dykes (some cone-sheets(?) near Mount Stewart)	X	X
5	Pum	Leucocratic microgranite (Mount Stewart)	Stock	X	
		Granitic intrusion-breccia	Boss	X	

Age

The age of the Mundic Igneous Complex can only be firmly established between wide limits; it intrudes the Cape River Beds (early Palaeozoic) and the Lolworth Igneous Complex (early Devonian), but ante-dates the Tertiary Campaspe Beds. The Complex may be coeval with rhyolite dykes which intrude probable Upper Permian sediments on HUGHENDEN (Paine et al., 1965). Also,

the upper Permian Betts Creek Beds contain some contemporaneous volcanics. For these reasons the Complex is tentatively assigned to the Upper Permian.

LOWER TRIASSIC

At the beginning of the Mesozoic the craton to the west of the Drummond Axis (Hill, 1951) was a great, almost perfect peneplain (Whitehouse, 1955). It was on this surface in the Hughenden-Cape River area that the Lower Triassic Warang Sandstone was deposited unconformably over the underlying rocks.

Warang Sandstone (Rlw)

On CHARTERS TOWERS the Warang Sandstone occurs as scattered inliers in Cainozoic sediments south-west of the Cape River, and as an outlier which forms the Just Range near the centre of the Sheet area. The Just Range is the most north-easterly outcrop of this unit. Each inlier covers an area of several square miles and the best exposures are in scarps on the north-eastern margin of a tableland, named the Alice Tableland on HUGHENDEN (Vine et al., 1964). In most places, however, no scarp is formed and the tableland merges with the lowlands of the Cape River valley to the north-east.

The Warang Sandstone is predominantly a white, poorly sorted, kaolinitic quartz sandstone with minor interbeds of red or white siltstone. The measured section, X22, in the valley of Crooked Creek (see location on map) is typical of the formation in this area although it does not represent the total thickness occurring in the Sheet area.

Section X22

TOP (at hilltop)

76'	Kaolinitic quartz sandstone; brown to white, poorly sorted, mainly fine-grained but varying to coarse-grained and gritty in bands and cross-strata; strong trough cross-stratification; friable except where case-hardened; massive.
27'	Mainly concealed, scattered poor exposures of kaolinitic quartz sandstone.

76' Kaolinitic quartz sandstone; white, poorly sorted, mainly fine-grained but varying to coarse-grained and gritty in bands and cross-strata; strong trough cross-stratification with indicated current directions from 020° to 190°; massive, friable except where case-hardened.

3' Quartz siltstone; red and white; blocky.

44' Kaolinitic quartz sandstone; white, poorly sorted, mainly fine-grained, but varying to coarse-grained and gritty in bands and cross-strata; strong trough cross-stratification, with indicated current direction 145°; massive; friable except where case-hardened.

2' Micaceous quartz siltstone; red and white, with patchy colouration; thick bedded.

10' Kaolinitic quartz sandstone; white, poorly sorted, mainly fine-grained but varying to coarse-grained and gritty in bands and cross-strata; strong trough cross-stratification, with indicated current direction 035°.

Total 238'

A characteristic feature of the Warang Sandstone is the presence of large-scale, trough cross-stratification. Although measurements in section X22 indicate a general easterly current direction, too few observations were made to establish a general current pattern.

Only part of the Warang Sandstone occurs within the Sheet area and nowhere is a complete sequence exposed. Near Pentland to the north-west on HUGHENDEN, the formation is about 800 feet thick. Near Lake Buchanan to the south on BUCHANAN an incomplete section is at least 400 feet thick. On CHARTERS TOWERS, the sandstone is probably over 500 feet thick. It dips very gently to the south-west.

The Warang Sandstone rests with regional unconformity on the Upper Permian Betts Creek Beds. To the west and south of CHARTERS TOWERS, it is overlain with regional unconformity by sandstone sequences of presumed Upper Jurassic

age (Vine et al., 1964). No fossil remains have been found in the Warang Sandstone on CHARTERS TOWERS. The nearest authenticated remains are at Galah Gorge, approximately 30 miles north-west of Pentland, where Evans (1964) identified spores of Lower Triassic age.

The large-scale, trough cross-stratification in the Warang Sandstone suggests that it was deposited in a fluviatile environment, possibly under torrential conditions. Deposition probably took place on extensive flood plains. Such an oxidising environment is further suggested by the presence of minor red beds and the almost complete absence of organic remains. The source of the sandstone on CHARTERS TOWERS was no doubt the granitic and metamorphic rocks in the western part of the Sheet area.

CAINOZOIC

On CHARTERS TOWERS the Cainozoic era is represented mainly by lacustrine and fluviatile deposits. Small areas of olivine basalt in the north-west represent the southernmost extension of the large basalt plateau which lies to the north (Twidale, 1956; White, 1962; Wyatt, et al., 1965, and in prep.). A further characteristic of the Cainozoic era is the widespread development of laterite and/or ferricrete. The Cainozoic stratigraphy is summarised below:

Recent	Sand, soil, colluvium, and alluvium (Qs, Qa)
Recent	Toomba Basalt (Qt)
	Undifferentiated Cainozoic Sediments (Czg)
Pleistocene	Sellheim Formation (Cze)
Pleistocene - Pliocene	Nulla Basalt (Czn) Ferruginization (Tf) Campaspe Beds (Tc)
Miocene	Lateritisation (Tl)
Miocene or older	Unnamed Tertiary sediments (Tu)

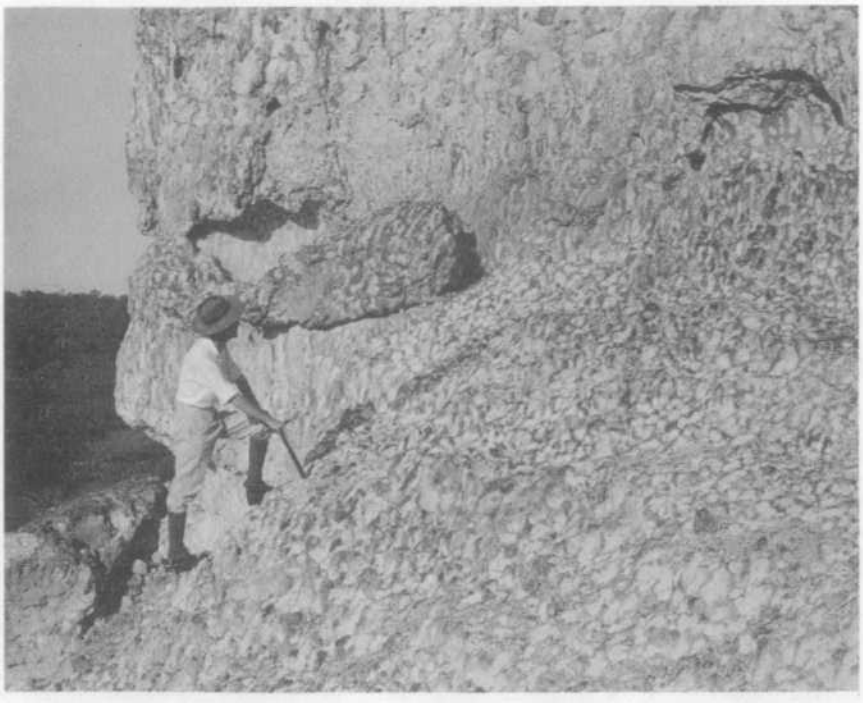


Photo Plate 8

Mottled zone of laterite profile developed in Tertiary argillaceous gritty sandstone (Tu) overlying Ravenswood Granodiorite. Little Red Bluff, four miles south-east of Charters Towers.

B.M.R.Neg.No.M/281.

Tertiary

Unnamed sediments (Tu)

Flat-lying sandstones and conglomerates cover a large part of the south-east of the Sheet area. They have been designated on the map as undifferentiated Tertiary sediments. The sequence is much dissected and the remnants form mesas and plateaux which overlie pre-Cainozoic rock units. The main outcrop of the unit is south of the Seventy Mile Range, but isolated outcrops occur north of the range in the Barrabas Scrub area, at the head of Scrubby Creek south of Rishton, at Little Red Bluff south of Charters Towers (Photo Plate 8), and at the Featherby Range south-west of Charters Towers.

The most extensive area is The Tableland west of Cranbourne Homestead where the sediments are coarse, white to buff, argillaceous sandstone, feldspathic sandstone and argillaceous pebbly sandstone with lenses of pebble or cobble conglomerate. The rocks have been strongly lateritized, but the laterite cap has been stripped off most of The Tableland, except along its north-western edge where 25 feet of ferruginous and mottled material remain. The pebbles in the conglomerates are well rounded but quartz grains in the matrix range from very angular to moderately rounded. Locally the sandstones are strongly cross-bedded but in these instances they are not normally argillaceous. In places, beds immediately beneath the pallid zone of the laterite profile are somewhat silicified. Much of The Tableland is covered by deep red, sandy soil, containing rare pisolitic ferruginous concretions, which is probably derived from the eroded ferruginous capping.

Most of the laterite in the Seventy Mile Range is developed on sandstones similar to those described above, but it is also developed on older rocks. Only laterite has been shown on the map in this area because, without field observations at closely spaced points, it is generally not possible to distinguish lateritized sandstone from lateritized basement rocks. Much of the sand-covered areas of the valley of the Rollston River and its tributaries are probably underlain by sandstone of this unit.

West of the Suttor River and south of the Cape River, the sequence consists of lateritized silicified quartz sandstone which forms cliffs up to 100 feet high. West of here the unit occurs as isolated mesas or low rises

and the thickness decreases westwards to near Nosnillor Homestead, where the unit is only a foot or so thick.

Morton (1945) described the sequence at Little Red Bluff south of Charters Towers. Similar argillaceous and gritty sandstones occur at the southern end of the Featherby Range near the Flinders Highway and, according to Rands (1891), at The Bluff,9 miles south-east of Charters Towers.

The thickness of the sediments is variable. At Featherby Range there is probably no more than 40 feet of sediment but three quarters of a mile to the north the sediments are absent. At Little Red Bluff, Morton estimated a thickness of approximately 100 feet, but on a ridge half-a-mile to the north the laterite is developed on granite and the sediments are again absent. At The Bluff, Rands estimated a thickness of 120 feet. In the Seventy Mile Range and The Tableland the average thickness is about 60 feet, but is much greater in places. Just west of the Suttor River the thickness is probably 100 feet or more.

The sediments of this unit are older than the period of major laterite development which,in this report, is tentatively regarded as Miocene in age. Morton (1945) collected dicotyledonous plant fossils from Little Red Bluff and the Featherby Range area. Fossil dicotyledonous angiosperm wood is abundant in the sediments five miles north-west of Cranbourne Homestead. The wood cannot be identified even to generic level but a Cainozoic age is certainly indicated (See Appendix 1). This wood is different from that collected from the Sellheim Formation. For the present these sediments are regarded as Tertiary, possibly Miocene.

These sediments are probably lacustrine and fluviatile deposits laid down on an uneven land surface. The provenance of the sediments appears to have been local as their lithology is generally closely related to that of the underlying or nearby rocks. They were probably deposited during the period of peneplanation which preceded the Miocene lateritization. Following this lateritic period the peneplain was dissected and as the result of this dissection a widespread deposit of sand and gravel was laid down. This deposit comprises the Campaspe Beds.

Campaspe Beds (Tc)

The Campaspe Beds (Paine et al., 1965) cover an area of approximately 2500 square miles in the west of the Sheet area but outcrop is extensively masked by a lateritic capping. The eastern limits are not well established, but the Beds are believed to thin out and disappear some 4 to 10 miles east of the Gregory Development Road. The Beds mostly form extensive plains which are drained by the Cape and Campaspe Rivers and their tributaries. The larger creeks commonly have cut channels 20 to 30 feet deep into the plains. To the north, towards the Grasstree Ranges and Seventy Mile Range, the Beds form piedmont deposits at the foot of the higher country.

Good outcrops of the Campaspe Beds occur in the banks of most major creeks e.g. sections up to 10 feet thick occur in Balfes and Homestead Creeks where they are crossed by the Flinders Highway.

The Beds consist mainly of white to pale buff, argillaceous, gritty sandstone. The sandstone is poorly sorted and weakly cemented. Grain size varies from fine to medium and the coarser portions tend to be pebbly. Rare siltstone is interbedded with the sandstone. The sandstone is poorly-bedded and rarely cross-bedded.

The sandstone is composed of quartz and feldspar in a matrix of fine quartz sand, silt or clay. Rare flakes of randomly oriented muscovite, derived from the Lolworth Igneous Complex, are widespread throughout the unit. Small calcareous nodules occur in some of the fine-grained sandstone e.g. at Rocky Bar Homestead.

In interfluvial areas the Campaspe Beds are capped by a poorly preserved layer of nodular to pisolitic ferricrete (Tf) which commonly weathers to buckshot gravel. Where dissected by stream, the ferricrete generally forms a sharp step at the top of the uneven slope bordering the stream courses. The iron-rich zone reaches a maximum thickness of three to four feet. A zone of weak mottling underlies the ferricrete, commonly with an abrupt transition. This mottled zone is between two and five feet thick and passes down gradually into the white or pale buff sediments. These sediments perhaps represent a pallid zone. In some areas, notably north of the Flinders Highway and west of Thalanga Homestead, the ferricrete appears to have been

removed entirely by erosion.

The maximum thickness seen in outcrop in creek banks on the plains, well away from the source area, is about 30 feet, but the base of the unit has nowhere been observed. Near the source area, where the base can be seen, greater thicknesses occur. Water bores drilled in the Campaspe Beds in the south-western part of the Sheet area have encountered up to 200 feet of sediments, all of a sandy nature, but it is not known if all of the section can be assigned to the Campaspe Beds.

The structure of the Campaspe Beds is simple - the strata form a horizontal blanket deposit, with a comparatively narrow zone characterized by depositional dips of up to 10 degrees, adjacent to the source areas of the Grasstree Ranges and the Seventy Mile Range. In the general area of Dillon's Creek, a few, rather straight, dark lines on the aerial photographs are found to be scarp-like ridges, up to 10 feet high, of Campaspe Beds and ferricrete trending north-west and west. They are interpreted as normal faults of small displacement.

The source rocks of the Campaspe Beds have been chiefly granite (Lolworth Igneous Complex) and to a lesser extent metamorphics and volcanics (Mount Windsor Volcanics), older Tertiary sediments (Tu), and the Warang Sandstone. The marked lack of sorting in the Beds, the virtual absence of bedding, the random orientation of muscovite and the persistance of the coarse fraction for long distances from the source, all suggest that the Beds were laid down under torrential conditions. The preservation of feldspar suggests that little chemical erosion occurred in the source area, and that transport and burial were rapid in an environment which was not conducive to chemical weathering. An arid climate with intermittent torrential rainfall, in conjunction with a sparse cover of vegetation, would provide such conditions.

The age of the Campaspe Beds is unknown. No fossils have been found in them; even fossil wood, which occurs in the undifferentiated Tertiary sediments and the Sellheim Formation, is absent. At Red Falls on TOWNSVILLE the Campaspe Beds disconformably overlie the Miocene(?) laterite. In the northern bank of Hann Creek, at the track crossing 6 miles south-east of Myola Homestead, white, gritty sandstone of the Campaspe Beds, from which the ferricrete has

presumably been removed by erosion, is overlain by the Nulla Basalt. Other exposures further east in Hann Creek suggest that the Campaspe Beds and Nulla Basalt may in places abut against each other, as penecontemporaneous units. The presence of a lateritic profile on the Campaspe Beds suggests a Tertiary rather than a Quaternary age. In the absence of more positive evidence, their age is regarded as Pliocene.

Undivided

Nulla Basalt (Czn)

The Nulla Basalt (Twidale, 1956) covers large areas of TOWNSVILLE, HUGHENDEN and CLARKE RIVER and extends southwards for about 45 square miles into the north-west corner of CHARTERS TOWERS.

The Nulla Basalt is a blue-grey porphyritic, olivine basalt, vesicular in places. The abundant olivine phenocrysts have been altered to iddingsite; the groundmass is composed of titanaugite and plagioclase. The basalt is extensively weathered and forms large tracts of red soil covered with rounded basalt boulders. The best exposures are in creek banks.

On HUGHENDEN local residents report that water bores drilled in the basalt have intersected lenses of "running" sand. The extent of these interbedded sands is unknown.

The basalt is essentially horizontal. A low west-trending ridge of basalt boulders about five miles long is prominant on aerial photographs just south of the Myola-Toomba track. The ridge has a maximum height of five feet and like similar ridges in the Campaspe Beds is interpreted as a Quaternary(?) fault scarp.

The thickness of the Nulla Basalt in this area is probably less than 20 feet. The thickness varies according to the dissection of the pre-basalt land surface. It is greatest along stream channels and thins out to probably only a few feet over interfluves. The basalt was erupted from centres on HUGHENDEN and CLARKE RIVER where the thickness is much greater.

A sample from the northern bank of Hann Creek at the Myola track crossing was dated at 1.32 ± 0.1 m. yrs by the potassium-argon method on the total rock (Determination by A.W. Webb at the Department of Geophysics and Geochemistry, Australian National University). A sample from one mile west of Hann Creek Mill, dated by the same method, gave a result of 4.0 ± 2 million years. Webb (pers. comm.) states that these results are probably unreliable, and that no significance should be attached to the difference between them. However, they suggest a Pliocene-Pleistocene age.

On TOWNSVILLE some flows appear to have been lateritized, so that eruption may possibly have commenced in the Miocene.

Sellheim Formation (Cze)

The Sellheim Formation was first noted by Jack (1879) and later named and mapped on TOWNSVILLE by Wyatt (1963). It was formally described under that name by Wyatt et al. (1965).

The type area is on CHARTERS TOWERS south of Sellheim railway station. The unit forms low, almost flat-topped, rises bordered by very low, poorly developed scarps. These rises occur discontinuously on both sides of the Burdekin River from Sellheim south-east to the Upper Burdekin Falls. The boundary scarps are not as strong as those of the better consolidated Tertiary sandstones.

The formation consists of poorly consolidated, coarse argillaceous sandstone, ferruginous sandstone and pebble conglomerate. Unconsolidated sand or weathered sandstone forms much of the unit in the Rishton Scrub area. A maroon, strongly cemented ferruginous sandstone, often pebbly, occurs near the base of the sequence.

The sediments are flat-lying. Bedding is not conspicuous but it can be recognised in most outcrops. Cross-beds are present but are not common. The average thickness is 10-15 feet but may be up to 30 feet in the southerly outcrops. The distribution of the unit suggests that it is an old high-level alluvial deposit of the Burdekin River.

The unit contains numerous fragments of fossil wood. Specimens from Rishton Scrub have been identified as Pataloxylon sp. (Appendix 1), which

indicates a Cainozoic age. R.L. Jack (1879) records Diprotodon australis from sediments which are now mapped with the Sellheim Formation at Rishton; this indicates a Pleistocene age. The formation occurs at a lower topographic level than the Tertiary sandstones and although mottled has no ferricrete developed at its upper surface. The mottling is associated with leaching adjacent to plant roots and not apparently to any lateritic process. The formation is therefore regarded as being younger than either of the ferricrete-forming periods which affected the Tertiary sediments and the Campaspe Beds. It is probably Pleistocene in age.

Unnamed sediments (Czg)

Three areas of semi-consolidated sediments cannot be correlated confidently with any of the Cainozoic units already mentioned.

South-east of Ravenswood, well bedded gravel, sand and silt cap the interfluvial areas of the southern tributaries of Connolly Creek. The tops of the cappings are up to 40 feet above the bed of Connolly Creek.

Along the southern margin of First Pocket about 10 miles south-east of Ravenswood, a four-foot bed of semi-consolidated conglomerate overlies up to 20 feet of coarse, unsorted sand and silt. These sediments have a slight primary dip to the north.

In the south-eastern part of the Sheet remnants of a broad terrace border the Suttor River. The remnants consist of unconsolidated, slightly ferruginous gravel. The terrace is thirty to forty feet above the river bed.

The sediments near Connolly Creek and in First Pocket are outwash deposits associated with fault scarps, their relationship being quite evident from the present day geomorphology. The sediments along the Suttor River are old alluvial deposits.

These sediments are regarded as being roughly equivalent to the Sellheim Formation i.e. probably Pleistocene.

Grey and brown soils (Czo)

Heavy-textured grey and brown soils cover an area between Slogan Downs Homestead and Egera Homestead. The area appears to lack rock outcrops and the origin of the soils is unknown. Lime nodules up to 3 inches in diameter are common, scattered on the ground surface and in gullies. Lime nodules have also been encountered in water bores in the area north-east of Old Victoria Downs Homestead.

It is thought that this soil may have developed on concealed Cainozoic calcareous deposits.

Quaternary

Toomba Basalt (Qt)

The Toomba Basalt (Twidale, 1956) covers an area of about 4 square miles in the extreme north-western corner of the Sheet area. It occurs mainly on CLARKE RIVER (White, 1962), TOWNSVILLE (Wyatt et al., 1965) and HUGHENDEN (Paine et al., 1965).

The Toomba Basalt is a porphyritic olivine basalt flow of very young aspect; its southern edge is known locally as the Great Basalt Wall - a low, but impassable barrier formed by the extremely uneven surface of the basalt. Only one vent has been recognised; it is on HUGHENDEN approximately 25 miles west of Myola Homestead.

On CHARTERS TOWERS, the Toomba Basalt overlies the Nulla Basalt. Twidale (1956) regarded it as late Pleistocene but Rands (1891) and Morton (1932a) both remarked on its very young aspect and White (1962) mapped it as Recent.

Superficial sand (Qs)

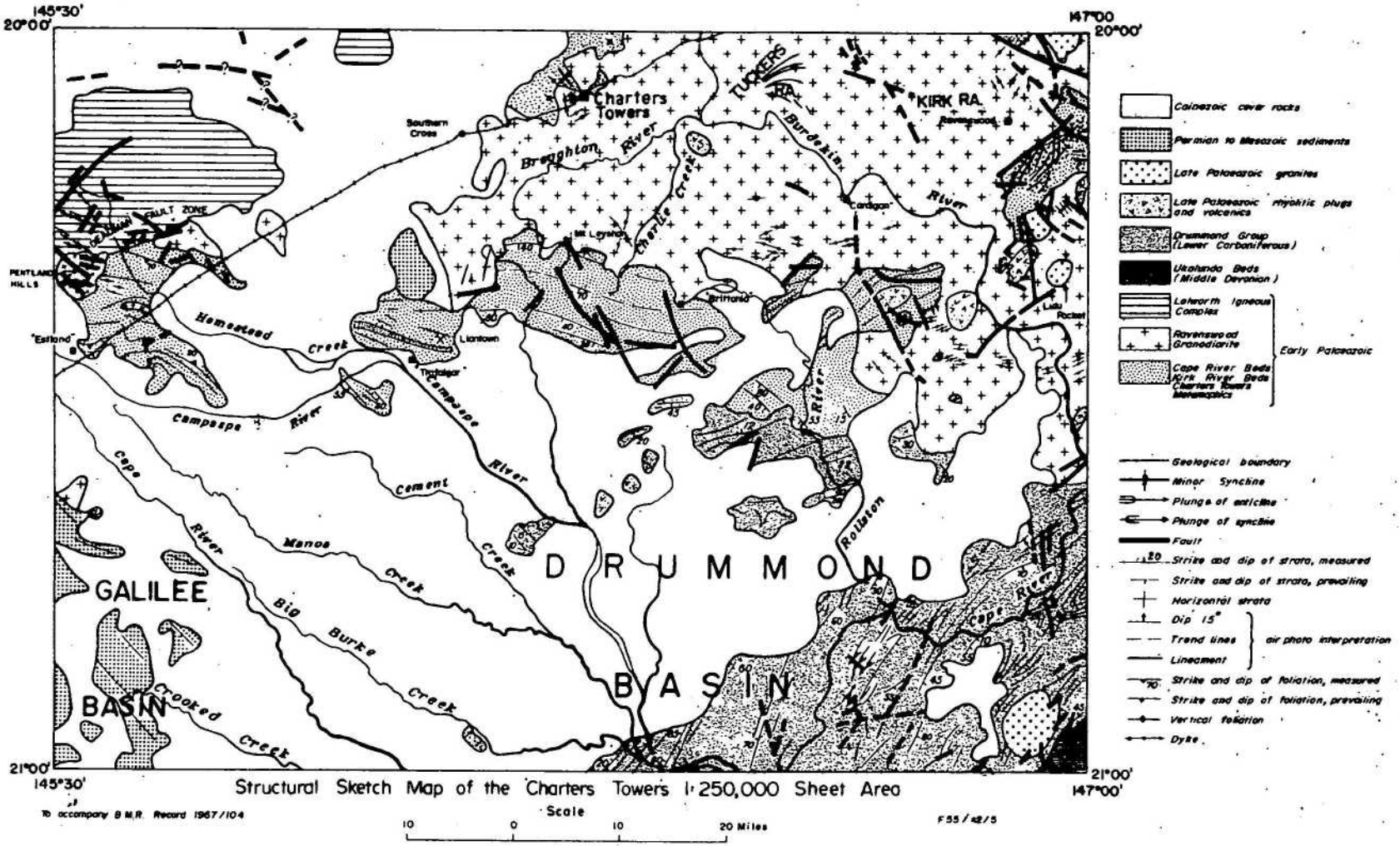
Low, broad rises of clayey grit and coarse, white or buff sand cover much of the catchment area of the Rollston River and Bligh and Kangaroo Creeks. The rises are noticeably higher than the recent stream alluvium. The sands and grits are outwash deposits resulting from the erosion of the Tertiary sediments and laterites of The Tableland and the Seventy Mile Range.

Photo Plate 9.

Pahoehoe structures preserved on surface of Toomba Basalt (late Pleistocene or Recent) 0.3 miles north-west of Myola Homestead.

B.M.R.Neg.No.G/8023.

Fig. 5.



Structural Sketch Map of the Charters Towers 1:250,000 Sheet Area

To accompany B.M.R. Record 1967/104

Scale

10 0 10 20 Miles

F55/42/5

The thickness of the sand varies greatly depending on the amount of erosion of the underlying Tertiary sediments. Where it overlies partly eroded Tertiary sediments the thickness is of the order of 10 to 20 feet. In a bore 4 miles north-north-west of Harvest Home Homestead, 200 feet of sandy material was encountered, but some of this may represent Tertiary sediments.

The sand is being dissected by present-day streams. It has been assigned a Quaternary age but is regarded as older than the alluvium bordering the major streams of the region.

In the south-west of the Sheet area an extensive sheet of red sand which overlies the lateritic profile developed on the Warang Sandstone is also mapped with this unit. In Red Gorge Creek (just west of the Sheet area) it is at least 30 feet thick, but it is generally much thinner.

Alluvium (Qa)

All the major streams are bordered by alluvial terraces composed mainly of sand and silt. The widest terraces border the braided stream channels of the Cape River in the south-west.

Generally there are at least two terraces along most streams, and the higher terraces are rarely covered by stream waters except in the largest floods. Some of the deposits in these higher terraces may be as old as Pleistocene.

STRUCTURE

The major structural elements of CHARTERS TOWERS are shown in Figure 5. The area contains part of four major structural units. The oldest unit is in the north and consists of fractured and sheared early Palaeozoic sediments and volcanics intruded by large early Palaeozoic granite batholiths. The sediments and volcanics trend across the Sheet area from west to east. This early Palaeozoic "basement" unit forms the northern margin of the late Devonian to Lower Carboniferous Drummond Basin. The Drummond Basin occupies the south-east part of the Sheet area and extends well to the south; it is bounded on the east by the Anakie High (Malone et al., 1966) which is represented by the Ukalunda Beds on CHARTERS TOWERS. A small part of the

Permian-Triassic Galilee Basin (Vine et al., 1965) overlaps both the early Palaeozoic units and the Drummond Basin in the south-west of the Sheet area.

The early Palaeozoic rocks and rocks of the Drummond Basin have been intruded by small late Palaeozoic plutons and volcanic plugs. Essentially flat-lying Cainozoic sediments and basalt form a thin cover over parts of all structural units.

Folding. The pattern of folding in the early Palaeozoic rocks is obscure. The Charters Towers Metamorphics dip uniformly to the north-east at between 45 and 70 degrees, with minor local folding and reverse dips (Reid 1917).

The Cape River Beds trend from north-west near Homestead to north-east south of Ravenswood. West of Homestead the trend directions are easterly and north-easterly. However the trends do not always represent bedding trends. To the west and south of Homestead cleavage and foliation have masked the bedding; converging trends in the foliation near Estland Homestead suggest the presence of a tight overturned fold. Between Liontown and Brittania Homestead the trends follow the bedding which dips generally southwards. South-east of Ravenswood bedding was not detected in the volcanics, but south-easterly dips have been recorded in sedimentary interbeds exposed in Fish Creek. In general, where the bedding can be recognised, for example between Trafalgar Homestead and the Burdekin River, the degree of folding is moderate, and the rocks have yielded to stress by jointing and, in places, severe shearing.

In the Ukalunda Beds and Drummond Basin folding is much more conspicuous and jointing and shearing less marked. In the Drummond Group in the south-eastern part of the Sheet area the trend of the major fold axes is north-east. The folds are isoclinal in places, with some reversals in plunge. Near the northern basement, folding is more in the form of small basins and domes rather than elongate anticlines and synclines. The trend of the major structures of the Drummond Group was evidently not controlled by the structures of the Cape River Beds.

In the Galilee Basin the strata have a very slight but uniform regional dip to the south-west.

The Cainozoic sediments east of about Southern Cross, were possibly tilted westward by the uplift which formed coastal scarps in late Tertiary(?) times. No coastal scarps occur on CHARTERS TOWERS but the north-west trending faults west of Hillsborough Homestead may have been rejuvenated during the coastal movements. Rejuvenation of streams following the uplift has stripped off most of the Cainozoic cover east of the Burdekin River.

Faulting. Two main sets of faults can be recognised. The first set generally trends north-eastward although some faults trend between east-north-east and east-south-east. The second set trends between south-south-west and south-east. The pattern is similar to that developed on TOWNSVILLE to the north.

Although it is possible to date the movements on individual faults within certain limits, in general our knowledge is insufficiently comprehensive to allow an historical account of the faulting. The main north-west fault which bisects and displaces the Pentland Hills granite is filled by dykes which are believed to be Upper Permian. North-east striking faults have displaced the late Palaeozoic granite of the St Annes Cross Range. Shearing in the east-north-east striking Deadman Fault Zone is older than the Lolworth Igneous Complex. No faults have been recognised in the Mesozoic sediments but possible faults in the Campaspe Beds and Nulla Basalt trend between north-east and south-east; the most persistent faults trend nearly east-west.

Igneous structures. The Ravenswood Granodiorite is commonly foliated, but the intensity of the foliation is variable and its origin uncertain. On TOWNSVILLE (Wyatt et al., 1965) the foliation is considered to be of two types - one developed in the later stages of crystallization and related to the configuration of the country rocks and a second developed after crystallization and related to intense shearing and fracturing. It is possible that a similar relationship holds for CHARTERS TOWERS.

The curvilinear trends in the Tuckers and Kirk Ranges are formed, in part at least, by dyke-like bodies of basic rocks and adamellite respectively. Where observed, banding in the gabbro masses south of Charters Towers strikes east-west and dips steeply north.

Most of the late Palaeozoic granitic bodies are stocks which are circular or sub-circular in cross-section.

The late Palaeozoic rhyolite intrusions all show steeply dipping flow-banding which appears to be developed essentially parallel to the margins of the intrusion.

ECONOMIC GEOLOGY

Mineralization is widespread over the northern half of the Sheet area but little has been recorded from the southern half which is occupied mainly by the Drummond Group and Cainozoic sediments. Most mineralization appears to occur within or be related to the Ravenswood Granodiorite or the Lolworth Igneous Complex. Deposits occur within these granitic rocks or in the Cape River Beds not far from their contact with the granites. A few occurrences are related to later volcanic foci e.g. at Mount Leyshon and Mount Wright.

No mining operations are at present being carried out on CHARTERS TOWERS. The last mines to produce ore in any quantity were the New Queen silver-lead mine at Liontown, which closed in 1962, and, before that, the Black Jack gold mine which ceased mining operations in 1959. In 1964 the Great Extended shaft at Kings (silver) was reopened but no developmental work was done.

Gold

By far the most important mining centre in the area was Charters Towers - principal centre of the Charters Towers Gold and Mineral Field. Although production from Charters Towers has been very small since the 1920's, its total production since its discovery in 1871 to the end of 1964, except for a small quantity from the Cape River area, was 6,805,510 fine ozs of gold.

The geology of the Charters Towers field has been fully described by Reid (1917). All mines of any importance were in the Ravenswood Granodiorite. The lodes were tabular bodies, wholly or partly within fissures. The fissures belong to two sets of faults which dip either to the east-north-east at between 60 and 70 degrees or to the north or north-west at between 30 and 50 degrees. The fissure walls are well defined and are commonly slickensided.

The lodes are formed by one or more quartz veins separated by crushed and altered country rock. The occurrence of two or more veins in a fissure is common and in the major fissures separate lodes formed in parallel or branching channels are often sufficiently far apart to be separated by unaltered country rock and to require mining as independent bodies. Such bodies occurred in the Day Dawn and Brilliant systems.

Ore-shoots were irregular in shape and no consistent pitch direction is apparent. A crude en echelon arrangement of the shoots is, in places, discernible between parallel veins.

The ore-bodies show a simple, mesothermal mineral assemblage; the normal primary constituents, in addition to native gold, are quartz, pyrite, galena and sphalerite. Other, less common minerals are calcite, chalcopyrite, gypsum, barytes, arsenopyrite, native arsenic and an unidientified telluride. Galena was important as an indicator of gold values.

The deepest workings were on the Brilliant lode (3000 feet) and on the Day Dawn lode (2700 feet). Only a few of the other lodes were worked below 1,000 feet. In all cases values became poorer with depth.

Little is known concerning ore localization. It does not appear to be related to country rock or to intersection of the lodes by dykes, early barren quartz veins or faults except, in the last case, for minor local enrichment. Blatchford (1953) indicated that the ore-shoots of the Day Dawn lode conform to the flatter portions of the lode where, he said, it was drag-folded - the axis of the drag fold being parallel to the fold axis of the Charters Towers Metamorphics north-west of Charters Towers city. However numerous other lodes cannot be explained by this, or any similar, theory.

The next most important mining centre was Ravenswood on the Ravenswood Gold and Mineral Field. This also was one of the major gold producing areas of Queensland, the total yield to the end of 1963 being some 900,000 fine ozs. The field was discovered in 1868 but early development was slow and it was not until between 1898 and 1912 that annual production was consistently high and more than half the total yield was produced.

The main lodes, comprising quartz-sulphide ore-bodies in fissures in the Ravenswood Granodiorite, were situated in the town area and at Sandy Creek. The Ravenswood Field is characterised by a number of outside centres, each of which had its own village around which was grouped several mines. None of these centres was a great producer, except maybe Brookville, but they are worthy of mention. They include Kirk, The Four Mile, Donnybrook, The One Mile (or Totley) (Ag), Trieste and the farthest removed and quite isolated centre of Hillsborough or The Eight Mile.

The lodes at Ravenswood itself trend in two principal directions; some strike between north-north-west and north-north-east and dip to the east and the others strike between north-east and east and dip to the south. The north-trending lodes are the more numerous and the more important. The lodes do not form a network but rather several groups of north-trending lodes are separated from each other by a few east-trending lodes.

At Sandy Creek, a few miles south-east of Ravenswood, the lodes again trend in two directions. The more important lodes strike north-west and dip south-west, the less important strike north-east and dip north-west.

In many of the outlying centres lodes generally conform to either a north to north-west trend or an east to east-north-east trend. These trends correspond with the major structural lineaments of the Sheet area.

Payable ore was obtained to a depth of 700 feet but only a few of the many lodes were worked to below 400 feet. The sulphide ores, which were highly refractory, were not amenable to normal battery treatment and this factor retarded early development. Primary minerals other than native gold included galena, chalcopyrite, sphalerite, pyrite, quartz and possibly calcite.

Although the north-east trending lodes are the least important of the field, the Buck Reef at Ravenswood is worthy of special mention. It is unlike any other lode on the field as it has the appearance, in both hand specimen and thin section, of a quartzite. It is composed essentially of sub-angular to sub-rounded grains of quartz in a quartz matrix. In addition it contains very fine needles of, (?)apatite, very rare zircon and a little iron oxide, probably limonite. Slightly mineralized itself, it appears to have induced enrichment in lodes which intersect it.

The details of various mines on the field have been described by Maclaren (1900), Cameron (1901, 1903) and Reid (1934).

Other gold occurrences in the Ravenswood Granodiorite occur south-east, south and south-west of Charters Towers. None were very big producers but among the more important are Broughton, Rishton, Dreghorn, Saint Paul's, Lighthouse, Windsor and Southern Cross. Many of these were described by Maitland (1911).

A little gold has also been produced from the Old Homestead Diggings, 7 to 12 miles north of Homestead (Rands, 1891) and at Fern Springs (Morton, 1939a, b). In both cases mineralization is probably related to the Lolworth Igneous Complex.

Gold has also been found in the Cape River Beds and the Mount Windsor Volcanics. For example gold was worked at the New Homestead Diggings south-east of Thalanga Siding last century (Rands, 1891); at Liontown in the early 1900's (Morton, 1937); and at the Highway Mine in the 1950's (Connah, 1960). Numerous old, usually shallow, workings, about which little is known, occur between Brittania Homestead and the Gregory Developmental Road. They are the result of gold mining and prospecting activites earlier this century; some may be the result of prospecting activities during the depression years of the 1930's. None of the deposits in the Cape River Beds has been a large producer.

Gold has also been mined in volcanic rocks which post-date the Ravenswood Granodiorite at Mount Leyshon (Jack, 1885; Rands, 1891; Morton, 1932b) and Mount Wright (Connah, 1956). At Mount Leyshon the gold occurs throughout rhyolitic and dacitic agglomerate representing an old volcanic vent which was intruded at the contact of the Ravenswood Granodiorite and the Cape River Beds. The gold is disseminated throughout the rock or associated with thin limonitic veins and stringers which ramify the country rock. Values are erratic. Other primary minerals include pyrite and chalcopyrite. Production from 1887 to 1946 is about 38,000 fine ozs gold from about 208,000 tons of ore.

At Mount Wright deposits occur in hydrothermally altered granite. Dykes of rhyolite which radiate from Mount Wright and small areas of intrusion breccia suggest the alteration was produced by an acid intrusion some distance below the surface. The lode consists of an ill defined zone within the altered granite irregularly impregnated with pyrite and sphalerite, with some traces of copper and arsenic. Siderite also occurs in both auriferous and non-auriferous sections. Production figures are incomplete but approximately 1300 fine ounces of gold were produced.

Small quantities of gold have also been worked from deep leads at the base of Tertiary sediments forming Little Red Bluff (Morton, 1945), Millchester Bluff and the Puzzler Walls.

Silver-Lead

Silver and lead rank as the second most important metals mined on CHARTERS TOWERS. Two centres only are of importance: the Totley area (King's) near Ravenswood (Connah, 1953) and the Liontown area (Levingston, 1952, 1956, 1960).

At Totley the main lode is King's Lode which consists of altered and crushed granitic material in a medium, reddish quartz diorite of the Ravenswood Granodiorite. The lode strikes north-west and dips north-east at 30 to 35 degrees in the shallower workings but steepens to 50 to 60 degrees in the deeper workings. The footwall is well defined and slickensided but the hangingwall is often poorly defined. The lode varies from a few inches to 25 feet in width. Two main shoots were worked and these are possibly related to the change in dip of the lode. The ore occurs as stringers, bands or lenses of massive sulphides in the altered quartz diorite. High silver values are associated with the wider galena veins which were rich in tetrahedrite. Other minerals recorded are pyrite, sphalerite, arsenopyrite, pyrargyrite, chalcopyrite, proustite, argentite, lead antimony sulphide, a little gold and stephanite. Although several attempts have been made to reopen the mine, it virtually ceased operations in 1891. Early production figures are very scant, but to 1891 more than 22,600 tons of ore were raised, valued at more than £112,000.

At Liontown the deposits occur in sheared volcanics and sediments of the Cape River Beds, which are intruded by acid porphyries probably representing apophyses of the Ravenswood Granodiorite. The schistosity strikes east-north-east and dips steeply north and south. The bedding possibly has a general southerly dip, but it is not readily recognisable.

The lodes consist of veins of cerussite, limonite, quartz and kaolin in sheared country rock. Lead also occurs in schistose material outside the veins as well as in a white gouge commonly present alongside the veins. Normal width of the lode is 8 to 24 inches. Deposition was probably controlled principally by two series of fractures, both striking 80° but one dipping 60 degrees south and the other vertically.

The lodes were discovered in 1951 and were worked mainly from the Liontown and New Queen mines. Work ceased at the end of 1962 because of the lack of a suitable marked for the ore.

The workings have not reached the primary ore which was intersected by subsequent diamond drilling (Levingston, 1963). The secondary ores have not been worked out so that the deposits still have potential for small-scale mining operations. Production, from 1951, to the end of 1962 was about 560 tons of lead, 3,334 fine ounces of gold and 62,000 fine ounces of silver.

Copper

Copper was mined at the Carrington mine, Liontown, between 1905 and 1911 but production was very small. This was the only mine in the Sheet area that could be regarded essentially as a copper producer, although its gold production was probably of equal importance. Some copper is recorded from other mines at Charters Towers and Ravenswood but it can only be regarded as a by-product of small parcels of smelted ore (ore concentrates) which were shipped to treatment works outside the fields. Small copper deposits occur in the Saint Paul's area but production was very small.

At Liontown, the Carrington deposit occurs in schists of the Cape River Beds. The lode channel, which is marked by fairly prominent walls, is conformable with the schists. The lode consists of varying proportions of

sulphide ore and country rock. The ore is a compact, intimate, mixture of silica, iron pyrites and chalcopyrite; the country rock has been crushed and silicified and mineralized to varying degrees. Barytes also occurs as a gangue mineral. Gold values appear to have been erratic e.g. sampling of No. 6 level of the Carrington P.C. Mine showed an average range of 6-7% copper and 4 to 5 dwt of gold per ton, but production figures from the 460 feet level show a yield of 8 tons 13 cwt of matte, from 60 tons of ore (8.3% Cu, and 31 dwt Au and 1.55 oz Ag per ton of ore); also 8 tons 18 cwt of matte, from 45 tons of calcined ore, assaying 37.2% copper and 6 oz 3 dwt gold per ton, and, again, 31 tons of matte, from 190 tons of ore (7.1% Cu and 21 dwt Au and 1.68 oz Ag per ton).

The mine ceased operations about 1911, but the No. 2W shaft was re-opened in 1956 (Levingston, 1960) to investigate a lead prospect found nearby. Trial parcels of the ore which contained gold, lead, copper and zinc minerals showed that the ore would be difficult to treat and as reserves were not known the owners lost interest.

Molybdenum and Antimony

Stibnite and molybdenite have been recorded from the Ravenswood area but little is known about the deposits. The most noteworthy is Kean's Molybdenite Prospect on which diamond drilling was recently carried out by North Broken Hill Pty Ltd. Results of this drilling indicated very low molybdenite values. As far as is known, no production has come from these deposits.

Antimony occurs in the Cape River Beds at "The Antler" prospect, 3 miles north-west of Homestead. No production is recorded from this prospect.

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APPENDIX I

Palaeontological Determinations from the Charters Towers Sheet area

by

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IDENTIFICATIONS

Drummond Group

Collection 1

Locality: One mile north of Cranbourne Homestead. Latitude 20°38'S., Longitude 146°58'E.

Determinations: Crossopterygian fish scales cf. *Strepsodus decipiens* Woodward.
Indet. palaeoniscid fish scales
Stigmaria sp.

Age: Lower Carboniferous.

Collection 2

Locality: Half mile south of Rockpool Lagoon, between Saint Anne's Cross Range and Suttor River. Latitude 20°58'S., Longitude 146°55'E.

Determinations: *Sublepidodendron* sp.
Lepidodendron sp. 'a'
Lepidodendron sp. 'b'
Stigmaria sp.

Age: Early Carboniferous

Collection 3

Locality: Approximately 6 miles N.N.W. of Harvest Home Homestead. Latitude 20°38'S., Longitude 147°6'E.

Determinations: Lepidodendron sp.
Stigmaria sp. indet.

Age: Lower Carboniferous

Collection 4

Locality: Eight miles west of Camp Oven Mountain. Latitude 20°23'S., Longitude 146°43'E.

Determination: ?Austroclepsis sp.

Age: Probably Carboniferous.

Collection 5

Locality: 1.6 miles N.W. of Cranbourne Homestead. Latitude 20°31'S., Longitude 146°57'E.

Determinations: ?Leptophloeum australe (McCoy).
Sublepidodendron sp.
Lepidodendron sp. indet.
Stigmaria aff. ficoides (Brongniart)
?Elonichthys sp.

Age: Lower Carboniferous

Collection 6

Locality: Four miles N.N.E. of junction of Suttor and Sellheim Rivers. Latitude 20°42'S., Longitude 146°58'30"E.

Determination: Lepidodendron sp. indet.

Age: Probably Lower Carboniferous.

Collection 7

Locality: 1.2 miles E. of Pallamana Homestead. Latitude 20°31'20"S., Longitude 146°32'40"E.

Determination: Indet. equisetalean plant

Age: Probably Lower Carboniferous.

Collection 8

Locality: Mount Elsie Homestead. Latitude 20°59'S., Longitude 146°34'E.

Determinations: Lepidondendron sp.
Indet. plant fragments

Age: Lower Carboniferous

Collection 9

Locality: Bumble Ginnie Waterhole, 4 miles south-east of Nosnillor Homestead. Latitude 20°59'S., Longitude 146°23'E.

Determinations: Leptophloeum australe (McCoy)
Indet. lepidodendroid plant
"Wood" of lepidodendroid plant

Age: Upper Devonian or Lower Carboniferous

Collection 10

Locality: 3.8 miles S.E. of Pallamana Homestead. Latitude 20°34'S., Longitude 146°34'E.

Determinations: Lepidodendron sp. indet.
Indet. equisetalean plant

Age: Probably Lower Carboniferous

Remarks: Collection 1 includes a quantity of large (22 x 25 mm.) plate-like cycloidal fish scales. The scales, which were originally deeply imbricate, are ornamented by fairly coarse radial striae bearing closely spaced minute tubercles, together with concentric growth lines on the exposed sector, and extremely fine striae and concentric growth lines on the attached portions. Some bone fragments are also present but are too incomplete for identification. Scales of this type are found in Crossopterygian fish of the family Osteolepidae, which are known from freshwater deposits of Devonian and Carboniferous age. The present material compares quite closely with the scales of Strepsodus decipiens described by Woodward (1906) from Lower Carboniferous strata at Mansfield, Victoria, but precise determination is impossible from scales alone. The association with Stigmaria would support a Lower Carboniferous age for the collection.

The plant referred to Sublepidodendron sp. in collection 2 is closely comparable with material collected by D.H. Wyatt from Townsville 1:250,000 sheet. Sublepidodendron is considered to be restricted to the late Devonian and early Carboniferous. Specimens of Lepidodendron sp. 'a' are deeply

decorticated, but leaf cushions are the largest I have seen in collections from Queensland - approximately 7 mm. wide x 35 mm. long. The assemblage is typical of the early Carboniferous.

Lepidodendron sp. in collection 3 is similar, particularly in the form of the leaf cushions and surface marking on the interstitial areas, to specimens from DTS 3 (L. 90) reported by Woods (1961) from beds above the Myrtlevale Beds in the Townsville Sheet area, where it is also associated with Stigmaria sp.

Collection 4 contains a number of pieces of a silicified plant in a remarkably fine state of preservation. The material comprises a great number of closely appressed, parallel root protosteles (1.5 - 3 mm. diameter) with triarch, or more frequently tetrarch protoxylem and metaxylem with scalariform thickening, surrounded by a dark endodermis and wide cortex, thickened in its outer zones. These roots are packed so closely that smaller steles become very deformed and root hair development seems to be completely lacking. Branching does occur, the offshoot arising from the endodermal layer. The material is believed to represent part of the outer adventitious root zone in the "false trunk" of an early fern-like plant. No stem or leaf trace steles are present in the samples. Only two genera of fossil fern-like plants with "false trunks" are known - Austroclepsis Sahni from the Carboniferous (Kuttung Series) of New South Wales and Tempskya Corda from the Cretaceous of Europe and North America. Precise identification is impossible without stem material, but closest affinities are probably with Austroclepsis australis (Osborn), although, like Tempskya, root protoxylem in this plant has been shown by Sahni (1929) to be uniformly diarch.

In collection 5, Leptophloeum australe is only tentatively identified, as the plant is decorticated to the Knorria condition. Fragments of a palaeoniscoid fish, possibly Elonichthys, are extremely abundant in the collection and include ridged scales, maxillae and preopercula. The association of Sublepidodendron, Lepidodendron and the Elonichthys - like fish is indicative of a Lower Carboniferous age.

Silicified "wood" in collection 9, is essentially undifferentiated cortical or peridermal tissue, in which small cells are arranged in radial

series. It is probably part of the trunk of a lepidodendroid plant. Compression prior to silicification has resulted in the collapse of the material, with virtual destruction of original structure.

Collection 10 includes the stems of a small, probably herbaceous equisetalean plant. The stems are slender, (approximately 4 mm. diameter) with closely spaced nodes, no more than 1 mm. apart; no foliage is preserved. The plant is present also in collection 7, which must have been derived from a similar horizon.

Sellheim Formation

Locality: S.E. corner of Rishton Scrub. Latitude 20°10'S., Longitude 146°33'E.

Determinations: Pataloxylon sp.

Age: Cainozoic

Remarks: The three wood samples submitted are all poorly preserved but enough can be seen of the structure to suggest generic identity at least.

In transverse section, winter wood is marked by vessels occurring singly or in pairs with their apposed surfaces flattened; in spring and summer wood they occur in groups of two and three. Vessels are characterised by simple, reticulate pitting of the walls. Xylem parenchyma cells are very small and moderately thickened; wood fibres are larger in diameter and are closely associated with the vessels. Medullary rays are 6-10 cells deep, uniseriate or biseriate, but more frequently the former, and in transverse section markedly sinuate. The wood, which is that of a dictotyledonous angiosperm, is placed in the form genus Pataloxylon described by Sahni (1920). Woods of this type are regarded as Cainozoic in age.

Tertiary Sandstone

Locality: 5 miles N.W. of Cransbourne Homestead. Latitude 20°37'S., Longitude 146°54'20"E.

Determinations: Dicotyledonous angiosperm wood

Age: Cainozoic

Remarks: Dicotyledonous angiosperm wood in the collection cannot be identified readily even to generic level, but a Cainozoic age is certainly indicated. None of the specimens appears to be identical with wood collected from the Sellheim Formation at latitude 20°10'S., longitude 146°33'E.

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APPENDIX 2(a)

The Petrography of Alkali Feldspar-Quartz Hornfelses (Mount Windsor Volcanics) from 3 miles north of Homestead, Charters Towers 1:250,000 Sheet area, North Qld

by

W.R. Morgan

The specimens were submitted by A.G.L. Paine for petrographic and mineragraphic examination. They were collected from outcrops 3 miles north of Homestead, in the Charters Towers 1:250,000 Sheet area, Queensland. All four specimens are slightly metasomatized alkali, feldspar-quartz hornfelses. The specimens bear lenticular aggregates of pyrite and magnetite. I.R. Pontifex has described their mineragraphy in a separate report (Appendix 2(b)).

R. 17493

The hand specimen is a hard, pale creamish-grey, thinly banded rock; the bands are 1 to 2 mm. thick. Small amounts of sulphide minerals are present in some bands; the rock immediately around the sulphide has been stained dark grey. Some quartz veins are present - these cut the rock roughly parallel to the banding.

In thin section the rock is seen to be composed mostly of roughly equal quantities of granoblastic quartz grains and interstitial, untwinned alkali feldspar. These minerals occur in alternating fine- and coarse-grained bands. In the more coarse bands, grainsizes range between 0.15 and 0.03 mm; in the finer, grainsizes are 0.05 to 0.03 mm. No straining or microfracturing is present in these grains.

A few tabular crystals of microfractured albite are present; these range up to 0.75 mm. diameter. Their general appearance suggests that they are relic phenocrysts. The rock is cut by veins of coarse-grained quartz and alkali feldspar.

R. 17494

The hand specimen is a thinly banded, mottled pinkish-grey rock. A few of the bands are minutely cavernous, because of the weathering out of

soft minerals.

In thin section, the rock is seen to be very similar in appearance to R. 17493, except that no relic phenocrysts are present. The alkali feldspar is slightly to moderately sericitized in some places. A few small tabular crystals, now composed of chlorite, have a preferred orientation, and possibly represent pseudomorphed amphibole.

The rock is cut by somewhat irregular, sub-parallel veins that contain quartz, chlorite, sulphide minerals and epidote.

R. 17495

The hand specimen is a hard, somewhat mottled pink, yellow and grey, thinly banded rock in which small amounts of sulphide minerals occur along some of the bands.

In thin section, the rock has a somewhat similar appearance to R. 17493, except that the alkali feldspar has been strongly altered to clay mineral in some layers and that no relic phenocrysts are present.

R. 17496

The hand specimen is a somewhat ferruginous, pale creamish-grey, fine-grained rock in which an indistinct banding is seen to be present. Small amounts of opaque minerals are present in some of the bands.

The general appearance of the specimen, in thin section, is rather similar to that of R. 17493. The quartzo-feldspathic groundmass is fine-grained and granoblastic, with grainsizes ranging between 0.03 and 0.1 mm. Elongated grains have a preferred orientation parallel to the banding; whether this is due to the metamorphism, or is a reflection of some pre-existing texture is not known. A few tabular crystals of albite are present; these range from 0.1 to 1.0 mm. in size, and probably represent relic phenocrysts.

Remarks

Two of the specimens (R. 17493 and R. 17496) contain plagioclase crystals whose form suggests that they are relic phenocrysts; the mineralogy of these specimens is roughly that of acid igneous rocks. The grainsizes in

the groundmass are fine, suggesting that they are metamorphosed acid volcanic rocks. R17494 and R17495 contain no relic phenocrysts; however, they have a fairly similar mineralogy to R17493 and R17496, so that they could also represent metamorphosed acid volcanics.

The general textural appearance of all the specimens suggests that contact, not regional metamorphism was responsible for the alteration.

APPENDIX 2(b)

Mineralgraphic examination of alkali feldspar-quartz hornfelses from 3 miles north of Homestead, near Charters Towers, North Queensland.

by

I.R. Pontifex

Four samples were submitted by A.G.L. Paine for identification of opaque minerals. (The petrography of these specimens is described by W.R. Morgan in Appendix 2(a)).

Field Number 17493:

A grey cryptocrystalline siliceous rock which contains narrow bands of pyrite. A black staining surrounds most of these bands.

Polished-section description:

Pyrite makes up about 95% of the opaque minerals in this section and hematite about 5%.

The pyrite generally occurs in subhedral grains which vary in size from sub-microscopic to 0.5 mm. The coarser grains are localised in bands and appear to be corroded on their edges.

Fine pyrite and skeletal crystals of hematite are dispersed at random through the rock.

Included in the pyrite is a pink-brown anisotropic mineral which has the appearance of pyrrhotite but the rare occurrence and small size of the inclusions rendered a positive identification impossible. Some pyrite carries inclusions of euhedral quartz.

The black staining around the pyrite bands impregnates the rock along intergranular boundaries. The precise composition of this staining was not evident from the polished-section study but it appears to be a secondary alteration product derived from pyrite.

Field Number 17494:

A laminated rock which contains bands of white and pink finely crystalline quartz and bands of granular pyrite. The bands of pyrite are about 1 mm. wide; they have an irregular distribution and form about 10% of the rock.

Description of polished-section:

Of the opaque minerals present pyrite forms 85%, limonite 10%, and hematite 5%.

Pyrite occurs mainly as anhedral grains up to 0.5 mm. long and 0.15 mm. wide, commonly elongated parallel to the bands in which they are localised. Some grains are euhedral which indicates that they crystallised in adequate space to permit perfect crystal growth. These crystals have finely pitted peripheries which appear to be the result of primary corrosion.

The distribution of pyrite in bands, the euhedral form and apparent corrosion of some grains suggests that the pyrite is a primary constituent of the rock.

Accessory amounts of finely skeletal hematite occur through the rock. The hematite is extensively replaced by limonite which impregnates the rock along intergranular boundaries. This is responsible for the pink coloration in the rock.

Field Number 17495:

A crypto-crystalline siliceous rock which contains fine, irregular white and orange-colcured bands and also bands of granular pyrite.

Polished-section description:

The opaque minerals in this section consist of pyrite 65%, hematite 25% and limonite 10%.

The pyrite occurs mainly as anhedral grains which have a highly irregular shape and these are concentrated in bands. Some pyrite grains in these bands have a corroded euhedral form. Rarely pyrite grains carry sub-

rounded exsolution bodies of pyrrhotite.

Finely skeletal grains of hematite are present in some of the pyrite-rich bands. The hematite generally shows extensive oxidation to limonite which occurs disseminated through the rock to produce the orange-brown-coloured bands.

Field Number 17496:

A grey crypto-crystalline siliceous rock which contains grains of iron-oxide, localised in bands. The rock is stained by secondary iron-oxides.

Polished-section description:

The opaque minerals consist almost entirely of magnetite grains which show various degrees of oxidation to hematite. The alteration takes place along the octahedral planes of the magnetite and around grain boundaries.

The magnetite and hematite give rise to secondary iron hydroxides; these stain the adjacent area and are responsible for the irregular brown patches and bands in the rock.