# DEPARTMENT OF ~~NATIONAL RESOURCES~~ NATIONAL DEVELOPMENT

# BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record 1980/16

PRECAMBRIAN GEOLOGY OF THE ARDMORE 1:100 000 SHEET AREA, NORTHWESTERN QUEENSLAND - PRELIMINARY DATA



by

R.J. Bultitude

Record 1980/16

# PRECAMBRIAN GEOLOGY OF THE ARDMORE 1:100 000 SHEET AREA, NORTHWESTERN QUEENSLAND - PRELIMINARY DATA

by

R.J. Bultitude

# CONTENTS

CONTENTS

# CONTENTS

## ABSTRACT

The Precambrian rocks in the Ardmore 1:100 000 Sheet area can be divided into three northerly-trending belts, each containing abundant metabasalt. The oldest rocks of the eastern belt are inferred to be poorly exposed recrystallised felsic volcanics and interlayered metagreywacke and meta-arenite, exposed in the northeast. These have been assigned to the Bottletree formation. They are overlain, apparently conformably by the Yappo formation consisting mainly of regionally metamorphosed quartz-poor pebbly greywacke and greywacke conglomerate. The Yappo formation is conformably overlain by meta-arenites of the Mount Guide Quartzite, a unit that has been folded about northerly-trending axes and intruded by numerous metadolerite dykes. The Mount Guide Quartzite is overlain, apparently concordantly, by the Eastern Creek Volcanics, a sequence of mainly non-schistose amygdaloidal metabasalt lava flows and numerous interlayered sediments.

The Eastern Creek Volcanics are overlain to the west, apparently unconformably, by meta-arenites assigned to the Warrina Park Quartzite, the basal unit of the Mount Isa Group. The Warrina Park Quartzite grades upwards into a sequence of mainly pyritic micaceous metasiltstone and ?carbonaceous shale, mapped as Moondarra Siltstone and Breakaway Shale. These rocks are truncated to the west by the Wonomo Fault, which marks the western edge of the eastern belt.

The central belt is bounded by the Wonomo Fault in the east and the Rufus Fault Zone in the west. The unit tentatively regarded as the oldest in this belt is named Sulieman gneiss. It consists mainly of interlayered hornblende schist, quartzofeldspathic gneiss, and glassy quartzite. The transition westwards from Sulieman gneiss to a sequence of glassy quartzite and minor hornblende schist, mapped as Kallala quartzite (new name), appears abrupt but conformable. The eastern part of the belt comprises the Jayah Creek volcanics (new name), consisting mainly of amphibolitic metabasalt and numerous interlayered metasediments, some of which contain cordierite poikiloblasts. The formation appears to have concordant contacts with the Kallala quartzite and Sulieman gneiss. The western part of the belt is extensively intruded by granite.

In the western belt relatively little-metamorphosed basalt and intercalated sediments have been assigned to the Oroopo volcanics (new name). They are underlain, apparently concordantly, by the Saint Ronans metamorphics (new name) which consist mainly of quartz + muscovite + biotite ± andalusite schist, amphibolite, and recrystallised felsic volcanics, and are extensively intruded by granite and pegmatitic granite.

Granitic rocks are mapped as Sybella Granite. The main unit, a non-foliated to foliated porphyritic biotite granite, intrudes small masses of foliated hornblende-biotite granodiorite, gneissic granite, augen gneiss, and xenolithic diorite. Pegmatitic granite is common south and southeast of Ardmore homestead.

In the west the Precambrian rocks are unconformably overlain by little-deformed Cambrian sedimentary rocks of the Georgina Basin succession. There are also scattered outcrops, mainly mesa cappings, of flat-lying conglomeratic and finer-grained sedimentary rocks, and some silcrete, mapped as possible Mesozoic. Some small mesas are capped by laterite and partly lateritised Precambrian bedrock. At Oroopo Waterhole, ferruginous lateritic ?soil is capped by vuggy chalcedony of possible Late Tertiary or early Quaternary age.

# INTRODUCTION

This report presents the preliminary results of a geological survey that I carried out, as a member of a joint Bureau of Mineral Resources (BMR) and Geological Survey of Queensland (GSQ) field party, on the Precambrian rocks in the Ardmore 1:100 000 Sheet area. Fieldwork commenced in mid-June 1978 and, except for limited follow-up check - mapping in 1979, was completed in early October 1978. The survey is part of the Duchess project, the aims of which are to investigate the Precambrian rocks in the Duchess and Urandangi 1:250 000 Sheet areas and to produce maps at 1:100 000 scale of the areas.

The mapping updates the results of the BMR-GSQ regional reconnaissance survey of 1950-58 (Carter, Brooks & Walker, 1961; Noakes, Carter & Õpik, 1959). The adjacent Dajarra, Duchess, and Oban 1:100 000 Sheet areas to the east, northeast and north respectively, were mapped between 1975 and 1977, and preliminary edition maps and reports for these Sheet areas are now available (Blake, Donchak, & Bultitude, 1978; Bultitude, Blake, & Donchak, 1978; Mock, 1978).

This report is essentially a compilation of data from field notebooks, supplemented by the results of brief examinations of some thin sections.

## Terminology

In this work sandstones are classified according to Pettijohn, Potter, & Siever (1972). Distinctive grainsizes are as follows: fine, 0.125 to 0.25 mm; medium, 0.25 to 0.5 mm; coarse 0.5 to 1 mm. For plutonic and metamorphic rocks, grainsize descriptions are fine, less than 1 mm; medium, 1 to 5 mm; coarse, 5 mm to 3 cm. Terms describing metamorphic facies are as defined by Turner & Verhoogen (1960). The name 'granofels' (Goldsmith, 1959) is used for medium to coarse granoblastic metamorphic rocks which do not have a marked foliation or lineation. The term 'concordant' is used to describe contacts between strata displaying parallelism of bedding or structure, where a hiatus cannot be recognised but may exist (Gary & others, 1972). The term 'migmatite' is used to describe a composite (mixed) rock consisting of igneous or igneous-looking and metamorphic materials which are generally distinguishable megascopically (Gary & others, 1972) - injection of magma, or in situ melting, or both, may have taken place. Sample localities and reference points are given mainly as grid references.

## Map compilation

Mapping and photo-interpretation were carried out using colour aerial photographs, at about 1:25 000 scale, taken in 1976 and 1977. The field data were plotted on to transparent overlays on the colour aerial photographs and were then transferred by the field draftsman (G.A. Young) on to photoscale compilation sheets. The 1:100 000 scale preliminary edition map was drawn by G.A. Young using photographic reductions of the compilation sheets and an orthophotomap (OPM) line compilation topographic base supplied by the Division of National Mapping.

Before the 1978 field season, W.J. Perry (BMR) made a preliminary airphoto-interpretation of the Ardmore 1:100 000 Sheet area, using the colour aerial photographs and black-and-white RC9 aerial photographs, at about 1:85 000 scale.

The photoscale compilaton sheets are available for purchase from the Copy Service, Australian Government Printer (Production), P.O. Box 84, Canberra, ACT, 2600. Some amendments to the compilations are pointed out in this text. The colour (for Ardmore 1:100 000 Sheet area) and black-and-white (for Urandangi 1:250 000 Sheet area - taken in 1970) aerial photographs can be obtained from the Division of National Mapping. Enquiries regarding purchase of aerial photographs should be addressed to Air Photographs Pty Ltd., C/- Division of National Mapping, P.O. Box 548, Queanbeyan, NSW 2620.

## Location and access

The Ardmore 1:100 000 Sheet area lies between latitudes 21°30'S and 22°00'S, and between longitudes 139°00'E and 139°30'E, in the southeastern corner of the Urandangi 1:250 000 Sheet area. Dajarra township is about 1.5 km east of the eastern boundary of the Sheet area.

The Sheet area is fairly well served by roads and tracks, the northeastern, central, and central-southern parts being the most difficult of access. A single-lane sealed road, forming part of the Mount Isa-Dajarra-Boulia developmental road, crosses the central-eastern and northern parts of the Sheet area. A regularly maintained gravel road branches from this road north-northeast of Ardmore homestead and extends beyond the central-western boundary of the Sheet area to Urandangi. Poorly to well-maintained station tracks, commonly along fences, give reasonable access to the rest of the Sheet area. Most roads and tracks become impassable after heavy rain.

The old main road from Dajarra to Mount Isa extended past Sulieman Bore in a general northwesterly direction to Jayah Creek Bore, more or less parallel to, and in places along, an abandoned and never used railway track. It is not now maintained, and is negotiable only by four-wheel drive vehicles. Building of the proposed railway line from Dajarra to Camooweal commenced in about the late 1900s (the line west of Dajarra is shown on the map accompanying a report presented by Dunstan, 1920), and, according to local informants, reached about as far as Jayah Creek Bore before being abandoned, because of a lack of funds. Numerous culverts, cuttings, embankments, and bridges were built, many of which are still fairly well preserved.

A branch railway line from Duchess about 50 km to the northeast, on the Townsville to Mount Isa railway line, terminates at Dajarra, which has a regular weekly train service, and a more frequent service during the stock-trucking season. Mount Isa and Cloncurry, larger population centres to the north and northeast are linked by regular air services to Brisbane and Townsville, and Mount Isa is a port of call for commercial jet aircraft flying between Brisbane and Darwin. Airstrips suitable for landing light planes are maintained at Dajarra and Ardmore homestead, and there is also a landing ground in the far northeast of the Sheet area, although it does not appear to be regularly maintained. The area is served by the Royal Flying Doctor Base at Mount Isa.

## Population and industry

The Sheet area is sparsely populated. Probably less than 15 people live permanently at Ardmore homestead, the only population centre in the Sheet area. However, about 1.5 km east of the Sheet area, Dajarra, with a population of probably more than 100 (mainly aborigines) has a school, police station, railway station, post office, bush nursing centre, store, and hotel, and is an important strock-trucking centre.

Cattle-grazing on unimproved natural pastures is the main industry in the Sheet area, which is free of many of the diseases and pests found in the wetter areas of tropical Australia. However, in past years much of the area was stocked with large numbers of sheep instead of cattle. The succession of relatively good seasons in the 1970s has resulted in abundant plant growth and a marked increase in the population of kangaroos. These are shot in large numbers for their skins.

## Climate

(mainly from Slatyer & Christian, 1954; Slatyer, 1964; Bureau of Meteorology, 1975).

The Sheet area is semi-arid and has a tropical monsoonal climate with a short wet 'summer' season characterised by very hot days, and a long dry 'winter' season characterised by pleasant sunny days and cool to cold nights. Average annual rainfall is low - about 380 mm or less - and decreases from northeast to southwest: the mean annual rainfall at Urandangi, about 125 km west of Dajarra, is 288 mm; at Mount Isa, about 110 km north of Dajarra, it is 429 mm; at Cloncurry, about 150 km to the northeast, 470 mm; and at Boulia, about 130 km to the south-southeast, 264 mm (Bureau of Meteorology, 1975). Rainfall tends to be variable, and droughts are not uncommon. Since 1970 there has been a succession of years with above-average annual rainfalls. Most of the rain falls between November and March, although there have been years (for example, 1978) when cyclonic influences and rain depressions have brought heavy rain in May, June, and even later. Between 2 and 10 July 1978, 90.9 mm of rain fell at Dajarra (65.6 mm on 10 July). An idea of the variability in rainfall is given by the rainfall registrations at Dajarra for the first half of 1978. These are as follows: January, 120.8 mm; February 1.6 mm; March, 33.6 mm; April, 7.0 mm; May, 84.8 mm; June, 7.8 mm. The rain comes mainly in storms and is commonly localised in heavy showers, with rapid runoff.

Mean daily temperatures range from less than about 10°C (minimum) to 24°C (maximum) during July, up to about 20°C (minimum) and 38°C (maximum) during November, December and January. Diurnal variations in temperature are marked in the Ardmore Sheet area, particularly in the 'winter' months when night-time temperatures commonly fall below freezing point. Frosts occur locally between June and August. Relative humidity is generally less than 50 percent.

The steady southeast trade winds which prevail during most of the dry 'winter' season, particularly from June to August, subside in late September or October and a transitional period of calms and variable winds commences. Inflow of moisture from the northwest, with thunderstorm activity, commences in October, and showers and thunderstorms become increasingly frequent during November, December, and January, under the influences of the northwest monsoon. The monsoon generally wanes in March and a period of calms and variable winds commences and continues for about a month, after which winds tend to blow from the southeast again.

## Vegetation

(Perry & Christian, 1954; Perry & Lazarides, 1964; Horton, 1976)

The rocky ridges and hills, and the rolling to undulating terrain support a vegetation of mainly spinifex (Triodia spp.), kerosene gassses (Aristida spp.), sparse low trees and shrubs, minor low woodland, and scattered patches of dense to open scrub consisting mainly of cassias (Cassia spp.), poverty bushes (Eremophila spp.), rattle pods (Crotalaria spp.), wattles (Acacia spp.), native lavender (Stemodia viscosa), wild tomato plants (Solanum spp.), corkwood (Hakea sp.), and mulla mullas (Ptilotus spp.). Small stands of holly-leaf grevillea (Grevillea wickhamii) grow in places. Some of the more common trees are snappy gum (Eucalyptus brevifolia), bloodwood (Eucalyptus terminalis) and ghost gum (Eucalyptus papuana). Small dense stands of gidgee (Acacia georginae and Acacia cambagei) are common in places. The rare native fig (Ficus platypoda) grows sparsely on rocky hills in the northeast. Relatively tall trees, mainly eucalypts (including river red gum - Eucalyptus camaldulensis), line the main watercourses.

Treeless grasslands, in which Mitchell grasses (Astrebla spp.) predominate, occupy most of the extensive cracking-clay-soil plains underlain by mainly lower Palaeozoic sediments of the Georgina Basin succession in the northwestern and central-western parts of the Sheet area. These areas have relatively high stock carrying capacities and are the most extensively developed.

## Early history and summary of previous geological investigations

An account of the early history of the region and a summary of geological investigations up to 1960 have been presented by Noakes & others (1959) and Carter & others (1961). Mining company activity in the Urandangi 1:250 000 Sheet area has been summarised by Noon (1977). Since 1960 the Precambrian rocks have been examined by geologists from several mining companies, but no large base-metal deposits have yet been found.

In the mid-1960s the Georgina Basin was assessed to be a potential phosphogenic province (Sheldon, 1966), and in 1966 a search for phosphate deposits in the area was initiated by Mines Exploration Pty Ltd, a subsidiary of Broken Hill South Ltd. The investigation concentrated on the Middle Cambrian succession, particularly the Beetle Creek Formation, exposed around the margins of Georgina Basin. Substantial reserves of high-grade phosphate have been proved in the Ardmore Outlier and small deposits have also been found in the Quita Creek area in the southwest. These rocks of the Georgina Basin succession were examined by a BMR field party in 1969 (de Keyser & Cook, 1972).

Unlike Sheet areas to the east and northeast, (for example, Duchess 1:100 000 Sheet area), Ardmore does not have a long history of mining, and contains only a few base-metal prospects. A minor gold rush to the headwaters of Jayah Bore Creek, about 9.5 km east of Jayah Creek Bore in the late 1920s or early 1930s was reported by Shepherd (1935). No production from the field was recorded.

## Topography and drainage

The Ardmore Sheet area lies in the southeastern corner of the Barkly region, the geomorphology of which has been described by Stewart (1954). However, the geomorphological divisions generally applied to the Mount Isa region are those of Twidale (1964), who described the landforms in the adjoining Leichhardt-Gilbert area to the east. Stewart's Erosional Land Surface and Depositional Land Surface subdivisions correspond to Twidale's (1964) Isa Highlands and Inland Plains physiographic divisions, respectively.

The Precambrian rocks in the Ardmore 1:100 000 Sheet area are exposed as a highly dissected plateau of moderate relief, and form part of the Erosional Land Surface of Stewart (1954). Planated surfaces are preserved as small remnants in many places on quartzite and meta-arenite ridges, and indicate extensive erosion and peneplanation. Rock type and structure largely control the landforms. Arenaceous metasediments, being most resistant to erosion, form the areas of greatest relief. Erosion of the generally northerly-trending successions of mainly interlayered metasediments and mafic metavolcanics has produced a series of mainly northerly-trending ridges and valleys. Most areas of granitic rocks have a dense dendritic drainage pattern and sandy to coarse gravelly soils; tors and spheroidal boulders are present in many places.

A few small mesas and buttes capped by Cambrian and ?Mesozoic sediments, presumably the remnants of a formerly more extensive cover, also occur in the Sheet area - mainly in the central and southern parts. The presence of a Tertiary (Twidale, 1964) erosion surface is indicated by rare remnant cappings of laterite and extensively weathered bedrock again mainly in the central and southern parts of the Sheet area. Broad, gently undulating plains with little relief have formed on the mainly flat-lying or gently dipping Phanerozoic sediments in the northwest and, to a lesser extent, in the central west. These form part of Stewart's (1954) Depositional Land Surface.

The area lies within the Georgina-Diamantina drainage system. Watercourses in the western part of the Sheet area trend mainly southwestwards, and are tributaries of the Georgina River. The eastern part of the Sheet area is drained mainly by the southerly to southeasterly-trending Sulieman Creek and its tributaries. Southeast of the Sheet area, Sulieman Creek joins Wills Creek, a tributary of the Burke River which joins the Georgina River south-southwest of Boulia. A low, mainly northeast-trending divide extending across the central and eastern parts of the Sheet area separates the two catchments.

## OUTLINE OF GEOLOGY

The Precambrian rocks in the Ardmore 1:100 000 Sheet area form part of the Cloncurry Complex (Carter & others, 1961) of the Mount Isa Inlier (Geological Survey of Queensland, 1976). The Precambrian stratigraphy of the sheet area is summarised in Table 1. Previously, the rocks had been mapped mainly as Mount Guide Quartzite, Eastern Creek Volcanics, Mount Isa Shale, and Sybella Granite (Noakes & others, 1959).

The Precambrian rocks in the Ardmore 1:100 000 Sheet area can be broadly divided into three northerly trending belts, each containing abundant metabasalt. The eastern belt contains units that extend from the adjoining Dajarra and Duchess 1:100 000 Sheet areas to the east and northeast, but the central and western belts are characterised by a lack of distinctive marker units that can be correlated unequivocally with units mapped elsewhere in the Mount Isa region. Sequences in the central and western belts consisting mainly of metabasalt were tentatively assigned to the Eastern Creek Volcanics on the released photoscale field compilation sheets. Many of the rocks exposed in the central belt appear to be similar to those described west of the Mount Isa Fault in the Mount Isa 1:100 000 Sheet area to the north (Hill & others, 1975). There they have been mapped mainly as Haslingden Group (May Downs Gneiss, Mount Guide Quartzite and Eastern Creek Volcanics). However, because of some uncertain stratigraphic relations, a lack of distinctive marker units, an absence of reliable isotopic age dates, and the consequent possibility that the rocks are not equivalent to the Haslingden Group, most sequences in the central and western belts are now referred to new formations.

The oldest rocks of the eastern belt are poorly exposed recrystallised felsic volcanics, interpreted to be mainly finely banded tuffs, and interlayered metagreywacke, and sericitic and feldspathic meta-arenite, in the northeastern part of the Sheet area. These have been assigned to the Bottletree formation. They are overlain, apparently conformably by, and are possibly partly diachronous with, the Yappo formation, which consists mainly of regionally metamorphosed greywacke and greywacke conglomerate. Most of the pebbles in this formation are of extensively recrystallised felsic volcanics. The Yappo formation is broadly equivalent to the lower Mount Guide Quartzite mapped in the Mount Isa and Mary Kathleen 1:100 000 Sheet areas (Hill & others, 1975; Derrick & others, 1977). It is conformably overlain by pebbly quartzose, feldspathic, and sericitic meta-arenites of the Mount Guide Quartzite, a unit that has been folded about northerly-trending axes, and is intruded by numerous metadolerite dykes.

The Mount Guide Quartzite is overlain, apparently concordantly, by the Eastern Creek Volcanics, a sequence of mainly non-schistose, commonly epidotised amygdaloidal metabasalt lava flows and numerous interlayered lenses of epidotic quartzite, pebbly meta-arkose and quartzose and feldspathic meta-arenite, metamorphosed labile greywacke conglomerate and pebbly greywacke, and grey to pink quartzitic rocks which may represent recrystallised felsic tuffs or tuffaceous metasediments. Most clasts in the conglomeratic rocks are of non-schistose metabasalt (amygdaloidal and massive), similar to that of adjacent lava flows, and little-altered 'cherty' felsic volcanics. The formation also includes rare andesitic lava flows or small high-level intrusions. It is intruded by numerous amphibolitic metadolerite dykes, and is overlain apparently concordantly in most places examined, by the basal unit of the Mount Isa Group, the Warrina Park Quartzite - a sequence consisting mainly of sericitic, feldspathic, and quartzose meta-arenite containing scattered pyrite casts. However, about 9 km northwest of Dajarra, aerial photographs show an angular discordance of about 30° between the trends of the Warrina Park Quartzite and metasediments (mainly meta-arenites with minor greywacke conglomerate) tentatively assigned to the Mount Guide Quartzite. Consequently the Haslingden Group is regarded as being unconformably overlain by the Warrina Park Quartzite.

The meta-arenites assigned to the Warrina Park Quartzite appear to grade up into poorly exposed pyritic, micaceous metasiltstone and minor interbedded dolomite and pyritic shale, mapped as Moondarra Siltstone. The Moondarra Siltstone is conformably overlain by the Breakaway Shale consisting mainly of blue-grey to dark grey ?carbonaceous shales containing numerous pyrite casts. The Mount Isa Group is truncated to the west by the Wonomo Fault, which is regarded as an extension of the Mount Isa Fault.

In the southwestern part of the eastern belt a sequence of uncertain affinities consists mainly of quartzose, feldspathic, and sericitic meta-arenites containing some pyrite casts and minor basal conglomerate overlain by metasiltstone and shale, commonly containing pyrite casts. I have tentatively mapped the sequence as Warrina Park Quartzite and Moondarra Siltstone; however, the meta-arenites extend into the adjacent Dajarra 1:100 000 Sheet area, where they have been tentatively assigned to the Myally Subgroup because they have been interpreted as conformably overlying mafic metavolcanics and interlayered meta-sediments mapped as Eastern Creek Volcanics (Blake & others, 1978).

The central belt is bounded to the east and west by faults. The Sulieman gneiss, most extensively exposed in the southwest, is tentatively regarded as the oldest unit in the belt. It consists mainly of interlayered hornblende schist, quartz + biotite + feldspar ± garnet ± muscovite gneiss and augen gneiss, and recrystallised glassy medium to coarse-grained quartzite, muscovite quartzite, and feldspathic quartzite; also present are some banded calc-silicate gneiss or granofels (commonly garnetiferous), para-amphibolite, and numerous extensively deformed pegmatite veins that are generally concordant with the foliation. The sequence is intruded by granite, undeformed pegmatite veins, and rare dykes and pods of little-altered dolerite containing primary biotite. The transition from Sulieman gneiss westwards to a sequence of mainly medium to coarse-grained glassy recrystallised quartzite, muscovite quartzite, feldspathic quartzite and minor hornblende schist - mapped as Kallala quartzite - appears gradational over a distance of a few metres; thin lenses of glassy recrystallised quartzite and muscovite quartzite occur in the Sulieman gneiss adjacent to the contact. However, it is not certain which of the two formations is the older. In the south, lithological layering and quartzite lenses in the Sulieman gneiss dip mainly to the west, and consequently it is tentatively regarded as underlying the Kallala quartzite.

The eastern part of the central belt consists of the Jayah Creek volcanics, a sequence of mainly schistose amygdaloidal and massive amphibolitic metabasalt containing numerous sedimentary lenses, some of which are relatively thick and extensive (for example, the Timothy Creek meta-arenite member). The interlayered metasediments consist of sericitic, feldspathic, and quartzose meta-arenite, quartz + muscovite + biotite ± feldsapr schist and gneiss, quartzite, muscovite quartzite, and minor para-amphibolite, calc-silicate rocks, recrystallised impure limestone, and quartz-biotite-muscovite schist containing cordierite poikiloblasts. The Jayah Creek volcanics are intruded by granite, numerous metadolerite dykes and pegmatite veins, and rare quartz-feldspar porphyry dykes, and appear to have concordant contacts with the Kallala quartzite and Sulieman gneiss.

A poorly exposed sequence of mainly cross-bedded quartzose meta-arenite and laminated to thin-bedded metasiltstone and shale preserved in the keel of a syncline in the southern part of the central belt is tentatively assigned to the Mount Isa Group. Contacts with the adjacent metabasalts of the Jayah Creek volcanics were not observed, but the two units appear to be separated by faults and a possible metamorphic unconformity - the sediments in the ?Mount Isa Group appear to be relatively little metamorphosed compared with the metabasalt sequence.

The metamorphic grade in this central belt appears to increase westwards from about middle greenschist facies to about middle amphibolite facies. The highest-grade rocks appear to be those exposed in the southwest and mapped mainly as Sulieman gneiss and Kallala quartzite. The western part of the belt is extensively intruded by the Sybella Granite. However, the metamorphism does not appear to be directly related to intrusion of the main granite type, which appears to be post-tectonic. The main granite type is only strongly foliated locally, mainly adjacent to contacts with country rocks, and it generally cuts across the foliation in the country rocks at high angles. However, the regional metamorphism and intrusion of the granite may have taken place during the same tectonic episode.

In the western belt in the far south, little-metamorphosed non-schistose basalt contains intercalated meta-arenite and metasiltstone, and is similar to that in the eastern belt. It is overlain in one place, and elsewhere (in the Rufus Fault Zone) apparently interlayered with pebbly quartzose meta-arenite, meta-arkose, calcareous meta-arenite, and recrystallised limestone. The sequence has been assigned to the Oroopo volcanics. The metamorphic grade increases northwards towards the centre of the western belt - from about lower to middle greenschist facies to about lower or middle amphibolite facies - where the Oroopo volcanics are underlain, apparently concordantly, by the Saint Ronans metamorphics. What is interpreted to be the upper part of the Saint Ronans metamorphics in this central western belt consists mainly of interlayered recrystallised felsic volcanics (mainly ?tuffs), fine-grained schistose amphibolitic and amygdaloidal metabasalt, and fine-grained quartz-muscovite-biotite schist. The Saint Ronans metamorphics south of Ardmore homestead consist mainly of fine-grained quartz + muscovite + biotite $\pm$ andalusite schist. In the northern part of the belt, the formation comprises mainly schistose amphibolite and minor recrystallised felsic volcanics. The formation is extensively intruded by granite, pegmatite veins, and amphibolitic metadolerite dykes.

Granitic rocks are restricted to the central and western belts and are mapped as Sybella Granite. Several types are present. The main type - a non-foliated to foliated coarse-grained, xenolithic, porphyritic biotite granite - intrudes small masses of intensely foliated medium-grained hornblende-biotite granodiorite, intensely foliated gneissic granite and augen gneiss, and minor xenolithic diorite. All these types are cut by veins and small bodies of non-foliated medium-grained biotite granite and biotite leucogranite. Another granite type, exposed south and southeast of Ardmore homestead, consists of non-foliated, medium to coarse-grained and pegmatitic, biotite-muscovite and muscovite leucogranite. Most of these types are cut by undeformed quartz-feldspar pegmatite veins that commonly contain muscovite, and more rarely tourmaline. In most places, bedding and foliation in adjacent country rocks show little apparent disruption by intrusion of granite; hornfelses are poorly developed and are generally restricted to within about 5 m or so of granite contacts.

The youngest intrusion in the area is probably a little-metamorphosed ?chalcopyrite or ?pyrrhotite-bearing dolerite dyke which cuts the Sybella Granite about 20 km west of Dajarra.

In the west the Precambrian rocks are unconformably overlain by flat-lying to gently dipping, mainly Middle Cambrian rocks of the Georgina Basin succession. Several outliers of flat-lying Cambrian rocks occur east of the Rufus Fault Zone, where they form mainly small remnant cappings. However, the most extensive outcrops of Cambrian rocks in the central belt are in the Ardmore Outlier, essentially a small graben in the Rufus Fault Zone. The Beetle Creek Formation within the succession is phosphatic and there are significant deposits of rock phosphate in the Ardmore Outlier.

Scattered outcrops of flat-lying, poorly consolidated, conglomeratic and finer-grained sedimentary rocks, with some silcrete in places, are mapped as possible Mesozoic. They form mainly thin remnant cappings on mesas. Other small mesas are capped by laterite and partly lateritised, but still identifiable Precambrian bedrock; these cappings are remnants of probable Tertiary weathering profiles. At Oroopo Waterhole, ferruginous, ?lateritic ?soil is capped by a thin flat-lying layer of vuggy chalcedony of possible Late Tertiary or early Quaternary age. Unconsolidated residual and alluvial sand, silt, gravel, and clay of Quaternary and probably Tertiary age are mapped as Czs, Czr, Czb, and Qa. Residual sand, silt, and clay also form an impersistent cover on weathered outcrops of Precambrian, Cambrian, or ?Mesozoic rocks.

## DESCRIPTIVE NOTES ON PRECAMBRIAN STRATIGRAPHIC UNITS OF THE CLONCURRY COMPLEX

### EASTERN BELT

#### Bottletree formation
(name not yet approved)

Map symbols. Ꝑht, Ꝑht?

Nomenclature. Named after Bottletree Hummock in the northwest of the Duchess 1:250 000 Sheet area (Bultitude & others, 1978). Previously mapped in the Ardmore Sheet area as Eastern Creek Volcanics, Mount Guide Quartzite, and Cainozoic deposits (Noakes & others, 1959).

Distribution. Exposed in far northeast of Sheet area, south and north of Black Mount Tank (GR 429141).

Reference area. About 3 km north-northwest of Black Mount Tank, from GR 407165 to GR 415167.

Thickness. Maximum thickness unknown, because of poor exposure and structural complexities; appears to be at least 570 m thick 3 km north-northwest of Black Mount Tank.

Topographic expression and airphoto characteristics. Forms very subdued, flat to undulating terrain with few trend lines visible. Mainly medium tones on aerial photographs.

Table 1. SUMMARY OF PRECAMBRIAN STRATIGRAPHY, ARDMORE 1:100 000 SHEET AREA

| Rock unit (max. thickness in metres) | Main rock types (and map symbols) | Relations |
|---|---|---|
| MOUNT ISA GROUP | EASTERN BELT | |
| Breakaway shale (1150) | Pyritic shale; minor sericitic siltstone or metasiltstone (Ƀib, Ƀib?) | Conformable on Moondarra Siltstone; truncated by Wonomo Fault |
| Moondarra Siltstone (1000) | Pyritic, ?dolomitic, and micaceous metasiltstone; minor ?dolomite, limestone, pyritic shale (Ƀim, Ƀim?) | Conformable on Warrina Park Quartzite |
| Warrina Park Quartzite (700) | Quartzose, feldspathic, and sericitic meta-arenite and quartzite; minor metasiltstone, silty meta-arenite, metaconglomerate (Ƀiw, Ƀiw?) | Inferred to unconformably overlie Eastern Creek Volcanics; faulted against Jayah Creek volcanics (central belt) |
| | MAJOR UNCONFORMITY | |
| HASLINGDEN GROUP | | |
| Eastern Creek Volcanics (?2000) | Non-schistose to schistose amygdaloidal and massive metabasalt, flow-margin breccia, epidotic quartzite, pebbly quartzose and feldspathic meta-arenite, meta-arkose, metagreywacke conglomerate, pebbly metagreywacke, ?meta-andesite (Ƀhe, Ƀhe?, $Ƀhe_q$, $Ƀhe_q$?, $Ƀhe_{cg}$ $Ƀhe_a$) | Overlies Mount Guide Quartzite apparently concordantly; cut by numerous metadolerite dykes and quartz veins |
| Mount Guide Quartzite (1000) | Sericitic, feldspathic, and quartzose meta-arenites, quartzite; minor meta-arkose (Ƀhg, Ƀhg?) | Conformable on Yappo Formation; cut by numerous amphibolitic metadolerite dykes and quartz veins |
| Yappo formation (?1800) | Regionally metamorphosed greywacke, greywacke conglomerate; minor meta-arenite, meta-arkose, quartzite, amphibolite, limestone, calc-silicate rocks, ?para-amphibolite (Ƀhy, Ƀhy?) | Apparently conformably overlies and possibly partly diachronous with Bottletree formation; gradational boundary with overlying Mount Guide Quartzite. Cut by quartz veins and amphibolitic meta-dolerite dykes |
| Bottletree formation (>570) | Recrystallised felsic volcanics, metagreywacke, sericitic and feldspathic meta-arenite (Ƀht, Ƀht?) | Base not exposed; cut by amphibolitic metadolerite dykes |
| | CENTRAL BELT | |
| undivided ?Mount Isa Group (280) | Quartzose and sericitic meta-arenite, ?carbonaceous metasiltstone, metasiltstone, shale, quartzite, quartz-mica schist (Ƀi?) | Uncertain - tentatively regarded as unconformable on Jayah Creek volcanics |
| | ?UNCONFORMITY | |

Table 1. SUMMARY OF PRECAMBRIAN STRATIGRAPHY, ARDMORE 1:100 000 SHEET AREA (continued)

| Rock unit (max. thickness in metres) | Main rock types (and map symbols) | Relations |
|---|---|---|
| Sybella Granite | Medium to coarse-grained, foliated to non-foliated, porphyritic biotite granite; minor pegmatite, pegmatitic granite, biotite-muscovite leucogranite, gneissic biotite-hornblende granodiorite and biotite granite, augen gneiss, biotite-?hornblende diorite (Ꞓgs, Ꞓgs?, $Ꞓgs_f$, $Ꞓgs_f$?, $Ꞓgs_p$, $Ꞓgs_p$?, $Ꞓgs_g$) | Intrudes Jayah Creek volcanics, Kallala quartzite, and Sulieman gneiss. Cut by rare dykes of amphibolitic metadolerite and unmetamorphosed dolerite. Unconformably overlain by Cambrian and ?Mesozoic strata |
| Jayah Creek volcanics (?15000) | Schistose amygdaloidal and massive metabasalt, amphibole schist, quartz + muscovite + biotite + feldspar ± cordierite schist and gneiss, quartzite, muscovite quartzite, and quartzose, sericitic, and feldspathic meta-arenite; minor para-amphibolite, labile meta-arenite and quartzite, recrystallised limestone, calcareous meta-arenite (Ꞓjv, Ꞓjv?, $Ꞓjv_q$, $Ꞓjv_q$?) | Faulted against rocks assigned to Mount Isa Group, Saint Ronans metamorphics. Unconformably overlain by Middle Cambrian and ?Mesozoic sediments. Intruded by Sybella Granite, veins of quartz, pegmatite and several types of granite, and amphibolitic metadolerite dykes; also cut by rare quartz-feldsapr porphyry dykes |
| Timothy Creek meta-arenite member (2000) | Sericitic, quartzose and feldspathic meta-arenite; minor quartzite, labile meta-arenite (Ꞓjt, Ꞓjt?) | Overlain and underlain, apparently concordantly, by mafic metavolcanics and interlayered metasediments of the Jayah Creek volcanics. Cut by numerous amphibolitic metadolerite dykes |
| Kallala quartzite (?350) | Glassy recrystallised quartzite, feldspathic quartzite, and muscovite quartzite; minor hornblende schist, hornblende-biotite schist and gneiss (Ꞓkq) | Apparently conformable with Sulieman gneiss and apparently has concordant, possibly conformable contacts with Jayah Creek volcanics; uncertain whether unit underlies or overlies Sulieman gneiss |
| Sulieman gneiss | Quartz + biotite + feldspar ± garnet ± muscovite gneiss, augen gneiss, hornblende schist, quartzite, muscovite quartzite, ?feldspathic quartzite; minor calc-silicate rocks, para-amphibolite, pegmatite, feldspar metaporphyry (Ꞓsg, Ꞓsg?, $Ꞓsg_q$, $Ꞓsg_q$?) | Gradational contact with the Kallala quartzite; apparently concordant with rocks mapped as Jayah Creek volcanics. Intruded by Sybella Granite |
| | WESTERN BELT | |
| Sybella Granite | Described above | Extensively intrudes Saint Ronans metamorphics |
| Oroopo volcanics | Amygdaloidal and massive metabasalt, quartzose meta-arenite, quartzite, metasiltstone, recrystallised limestone, calcareous meta-arenite, chlorite schist (Ꞓov, Ꞓov?, $Ꞓov_q$, $Ꞓov_s$, $Ꞓov_l$) | Apparently concordantly overlie Saint Ronans metamorphics. Unconformably overlain by Middle Cambrian and ?Mesozoic sediments. Cut by quartz veins and amphibolitic meta-dolerite dykes; also apparently intruded by rare pegmatite and granite veins |
| Saint Ronans metamorphics | Quartz + biotite + muscovite ± andalusite schist and gneiss, quartzite, recrystallised felsic volcanics, schistose amphibolite and amygdaloidal metabasalt, quartzose meta-arenite (Ꞓs, Ꞓs?, $Ꞓs_a$, $Ꞓs_b$, $Ꞓs_b$?) | Extensively intruded by Sybella Granite; also cut by numerous amphibolitic metadolerite dykes. Unconformably overlain by Middle Cambrian sediments of Georgina Basin succession. |

General lithology. Recrystallised felsic metavolcanics and minor interbedded medium-grained sericitic and feldspathic meta-arenite and schistose ?tuffaceous metagreywacke.

Details of lightlogy. Felsic volcanics. Dark grey to red-brown; finely laminated to massive; fine to medium-grained; non-porphyritic to porphyritic with small remnant quartz and feldspar phenocrysts; generally fairly intensely foliated and extensively recrystallised to quartzitic rocks containing abundant biotite; small clots and lenticles rich in fine biotite flakes common; feldspar phenocrysts recrystallised in some places to aggregates of smaller feldspar grains. Mainly ?tuffs.

Metagreywackes. Dark grey, biotite-rich, medium to coarse-grained, ?tuffaceous. Some metagreywackes contain sparse scattered rounded clasts (up to about 8 cm across) of granite and felsic volcanics in a ?tuffaceous matrix containing abundant quartz and feldspar grains.

Structure and metamorphism. Trends mainly north to northwest and dips are moderately steep to steep. The rocks are extensively recrystallised and contain abundant metamorphic biotite, probably indicating about middle to ?upper greenschist grades of regional metamorphism.

Stratigraphic relations. Base not exposed. Apparently conformably overlain by, and possibly partly diachronous with, labile metasediments of the Yappo formation. Cut by schistose amphibolitic metadolerite dykes.

Age. Precambrian - probably Early Proterozoic. Preliminary studies of a felsic volcanic unit in the Bottletree formation in the Duchess 1:100 000 Sheet area have yielded an age of about 1810 m.y. using the U-Pb-zircon method (Bultitude & others, 1978).

Correlations. Correlated with the Bottletree formation exposed at the base of the Haslingden Group in the adjoining Dajarra and Duchess 1:100 000 Sheet areas. Regarded as equivalent to felsic volcanics mapped as Argylla Formation in the southwest of the Mary Kathleen 1:100 000 Sheet area.

Mineralisation. No significant mineralisation known.

Remarks. The common occurrence of fine lamination and banding and of alternating non-porphyritic and porphyritic layers suggest that many of the felsic volcanics may be tuffs. Boundary with Yappo formation commonly difficult to delineate accurately. Not formally included in the Haslingden Group, because not defined as part of the group by Derrick & others (1976a).

HASLINGDEN GROUP

Three formations of the Haslingden Group have been recognised in the eastern belt. These are, from oldest to youngest, the Yappo formation, Mount Guide Quartzite, and Eastern Creek Volcanics. The group is interpreted to be conformable on the Bottletree formation and unconformably overlain by the Mount Isa Group.

Yappo formation

(name not yet approved)

Map symbols. Ehy, Ehy?

Nomenclature. Named after Yappo Creek in the northwest of the Duchess 1:250 000 Sheet area; described by Bultitude & others (1978). Previously mapped in Ardmore Sheet area as Mount Guide Quartzite, Eastern Creek Volcanics, and Cainozoic deposits (Noakes & others, 1959).

Distribution. North-trending belt in northeast. Extends north and northeast into the Oban and Duchess Sheet areas; shown as the Malbon Vale Formation on the Oban Preliminary map (Mock, 1978).

Reference area. In northeast, about 8 km north-northwest of Black Mount Tank from GR 377200 to GR 397209.

Thickness. Difficult to estimate accurately because of structural complexities and presence of numerous metadolerite dykes. Appears to be about 1750-1800 m thick in reference area.

Topographic expression and airphoto characteristics. Forms fairly subdued undulating to hilly terrain and low strike ridges. Medium to dark brown tones on colour aerial photographs, generally darker than those of adjacent Mount Guide Quartzite.

<u>General lithology</u>. Mainly poorly sorted metamorphosed greywacke and conglomerate; minor quartzose, sericitic, and feldspathic meta-arenite, epidotic quartzite, meta-arkose and gritty meta-arkose, fine to medium-grained schistose amphibolite; rare laminated and thinly banded recrystallised limestone, calc-silicate rocks, and ?para-amphibolite.

<u>Details of lithology</u>. <u>Metagreywackes</u>. Pale to dark grey; fine to medium-grained; cross-bedded but cross-stratification commonly poorly developed; mainly medium to thick-bedded, with numerous thin heavy-mineral-rich layers; some laminated to thin-banded beds; gritty, pebbly, and conglomeratic lenses very common; grits contain abundant coarse quartz and white to pale pink feldspar fragments up to about 1 cm long; abundant metamorphic biotite.

<u>Metaconglomerates</u>. Rounded to subangular pebbles, cobbles, and boulders up to about 1 m in greywacke or, more rarely, arkose matrix. Clasts undeformed to fairly intensely deformed locally, consisting of extensively recrystallised porphyritic and non-porphyritic felsic volcanics, generally subordinate vein quartz, quartzite, pink leucogranite, fine to coarse-grained pale pink non-porphyritic to porphyritic biotite granite, medium to coarse-grained biotite leucogranite, fine-grained mafic schist, and rare aplite; granite clasts predominate locally.

<u>Sericitic and feldspathic meta-arenite, metamorphosed arkose and arkosic grit</u>. Occur mainly at top of formation; friable, schistose; medium to coarse-grained, gritty, and pebbly; white to red-brown; medium to thick-bedded; cross-bedded; thin heavy-mineral-rich layers common; meta-arkoses contain abundant coarse feldspar and quartz grains (?granite debris) and scattered subrounded to rounded pebbles (up to about 5 cm) of medium-grained quartzite, vein quartz, and recrystallised felsic volcanics. Also some interlayered medium to coarse-grained pebbly meta-greywacke containing numerous felsic volcanic clasts.

Structure and metamorphism. Beds mainly north-trending with moderate to steep dips; overturned in northwest below contact with Mount Guide Quartzite. Cut by northeast-trending and northwest-trending faults. Structure uncertain because of general massive nature of the outcrops and lack of distinctive marker units. Calcareous rocks show complex small-scale folds and crenulations.

Regionally metamorphosed probably to ?middle greenschist facies; some beds are completely recrystallised, others are only partly recrystallised; abundant metamorphic biotite and rare chlorite present.

Stratigraphic relations. Gradational boundary with overlying Mount Guide Quartzite; appears to conformably overlie, and is possibly partly diachronous with, Bottletree formation. Cut by quartz veins and numerous fine to coarse-grained schistose and non-schistose amphibolitic metadolerite dykes. Sequence also cut by rare, thin (generally less than 30-cm wide), irregular, commonly ptygmatically folded pegmatite veins consisting mainly of coarse quartz and pale pink feldspar with minor biotite and opaque oxide.

Age. Precambrian - probably Carpentarian or late Early Proterozoic.

Correlations. Equivalent to Yappo formation in adjacent Oban, Dajarra, and Duchess 1:100 000 Sheet areas; also corresponds to most of the lower Mount Guide Quartzite mapped in the Mary Kathleen and Mount Isa 1:100 000 Sheet areas.

Mineralisation. None known in sheet area.

Remarks. May represent partly fluvial and partly shallow-marine outwash fan deposits. Metagreywackes appear to contain abundant volcaniclastic debris, probably largely locally derived from the Bottletree formation. Meta-arkoses and feldspathic meta-arenites in upper part of formation consist mainly of coarse granitic debris, possibly derived from a granitic landmass to east.

The upwards gradation from the immature volcaniclastic metasediments of the Yappo formation to the more mature sericitic, feldspathic, and quartzose meta-arenites of the Mount Guide Quartzite may reflect the gradual exposure of a granitic terrain stripped of its volcanic cover and the development of a subdued topography in the source area.

The boundary between the Yappo formation and Mount Guide Quartzite has been placed at the pronounced break in slope between the lower undulating terrain formed on the former and the upstanding ridges formed on the latter.

## Mount Guide Quartzite

Map symbols. Ehg, Ehg?

Nomenclature. Named after Mount Guide in the northwest of the Duchess 1:250 000 Sheet area (Carter & others, 1961). Subdivided by Derrick & others (1976a) into a lower unit (largely corresponding to the Yappo formation of this work) and an upper unit (corresponding largely to the Mount Guide Quartzite of this work). Previously mapped in Ardmore Sheet area mainly as Mount Guide Quartzite (Noakes & others, 1959).

Distribution. Restricted to eastern part of Sheet area - mainly in northern and central parts. Extends east, north, and south into adjoining Sheet areas.

Reference area. About 7 km northwest of Black Mount Tank, from GR 368184 to GR 382191.

Thickness. Difficult to estimate accurately because unit has been extensively folded, faulted, and intruded by amphibolitic metadolerite. Appears to be about 900-1000 m thick in north.

Topographic expression and airphoto characteristics. Forms prominent ranges and hills of closely spaced planated strike ridges. Generally characterised by pale tones on aerial photographs.

General lithology. Mainly sericitic, feldspathic, and quartzose meta-arenite and white to pale brown, medium-grained glassy quartzite and ?feldspathic quartzite. Minor pebbly and gritty beds and some gritty meta-arkose, and meta-greywacke.

Basal part of formation consists mainly of highly friable, thin to medium-bedded, fine to medium-grained, sericitic and feldspathic meta-arenites containing scattered pebbles of granite, vein quartz, felsic volcanics, and quartzite; also minor thin beds of dark grey fine-grained biotite-rich meta-greywacke. Overlying sequence contains medium to thick beds of white medium-grained indurated, in places glassy, pebbly quartzose meta-arenite and quartzite, interlayered with more friable meta-arenite units.

Details of lithology. Meta-arenites and quartzites. Pale brown to red-brown, buff, white; fine to medium-grained; mainly moderately to well sorted; cross-bedded and ripple-marked; generally low-angle large-scale cross-beds; thin to thick-bedded; sericitic meta-arenites commonly friable; many beds contain heavy mineral-rich bands; rare ?pyrite casts. Scattered rounded pebbles (up to about 15 cm) and thin pebbly units occur throughout sequence - pebbles mainly of medium-grained quartzite. Arenites extensively ferruginised and ironstained in places, especially in south, as a result of lateritic weathering.

Structure and metamorphism. Beds trend generally north, are moderately to steeply dipping, and have been folded about northerly trending axes into several open to tight anticlines and synclines; bedding extensively disrupted by well-developed axial-plane fracture cleavage in hinge zones of folds. Some beds in north are overturned. The formation is cut by numerous faults with mainly small displacements - an early set of northerly-trending, commonly dolerite-filled strike faults, and a later set of commonly quartz-filled northwest-trending sinistral faults. Adjacent to faults, beds are extensively disrupted, brecciated, and quartz-veined, and quartz-muscovite (or sericite) schists have been formed locally; west and southwest of Dajarra bedding has been largely obliterated.

The formation has been regionally metamorphosed probably to lower or middle greenschist facies. The rocks are locally schistose, but, in most places, primary sedimentary structures are well preserved. Thermal metamorphic aureoles up to about 30 cm wide, consisting of dark grey medium-grained quartzite, are developed locally adjacent to some metadolerite dykes.

Stratigraphic relations. The Mount Guide Quartzite is conformable on the Yappo formation and is overlain, apparently concordantly, by mafic volcanics mapped as Eastern Creek Volcanics. The formation is cut by numerous mainly northerly-trending schistose to non-foliated amphibolitic metadolerite dykes, some of which may be feeders to the overlying mafic volcanics. However, no folded dykes have been found, and it appears that most dykes postdate the Haslingden Group (see Glikson & others, 1976). There are some rare remnant cappings of Tertiary laterite and ferruginous rubble.

Age. Proterozoic - probably Carpentarian (Derrick & others, 1976a).

Correlations. Equivalent to Mount Guide Quartzite mapped in adjacent Duchess and Dajarra 1:100 000 Sheet areas (Bultitude & others, 1978; Blake & others, 1978), and to the upper unit and upper part of the lower unit of the Mount Guide Quartzite mapped in the Mount Isa and Mary Kathleen 1:100 000 Sheet areas to the north (Hill & others, 1975; Derrick & others, 1977). Ꝑhg and Ꝑhg? extend north into Oban 1:100 000 Sheet area, where they are mapped as Myally Subgroup and Malbon Vale Formation (= Yappo formation), respectively (Mock, 1978).

Mineralisation. None known in Sheet area.

Remarks. Consists of mainly mature clastic sediments probably deposited in a shallow-water nearshore environment. The detritus may have been derived, at least partly, from the Kalkadoon Granite-Leichhardt Metamorphics basement complex to the east.

## Eastern Creek Volcanics

Map symbols. Ꝑhe, Ꝑhe?, Ꝑhe$_q$, Ꝑhe$_q$?, Ꝑhe$_{cg}$, Ꝑhe$_a$.

Nomenclature. Named after Eastern Creek, a tributary of Gunpowder Creek, in the Camooweal 1:250 000 Sheet area; defined by Carter & others (1961). The formation was subdivided into four members by Robinson (1968), but a three-fold division, comprising two mainly basaltic members separated by a predominantly quartzitic member, was later defined by Derrick & others (1976a). Previously mapped as Eastern Creek Volcanics in the Ardmore Sheet area (Noakes & others, 1959).

Distribution. Exposed mainly as north-northwest-trending belt in the northeast and central-east of Sheet area. Also some small scattered outcrops in the far southeast of Sheet area. Formation extends north into the Oban 1:100 000 Sheet area and east into the Dajarra 1:100 000 Sheet area.

Reference area. About 9 km northwest of Dajarra, from GR 379035 to GR 396051.

Thickness. Ꝑhe, unknown; structure very difficult to determine owing to general lack of marker beds that can be traced on aerial photographs; may be about 2000 m thick in north. Ꝑhe$_q$ has maximum thickness of about 250 m, Ꝑhe$_q$? about 350 m, Ꝑhe$_{cg}$ about 200 m, and Ꝑhe$_a$ less than 100 m.

Topographic expression and airphoto characteristics. Form valleys and low undulating terrain, characterised by dark tones on aerial photographs (Ɇhe, Ɇhe$_{cg}$), and upstanding strike ridges with pale to medium tones (Ɇhe$_{q}$).

General lithology. Metabasalt lava flows, commonly with well-developed flow margin breccias; generally form rubbly outcrops. Numerous interlayered lenses of epidotic quartzite, pebbly meta-arkose and quartzose and feldspathic meta-arenite, metagreywacke conglomerate and pebbly metagreywacke; rare possible meta-andesite in north.

Details of lithology. Ɇhe, Ɇhe? Metabasalts. Mainly fine-grained; grey-green to black; central parts of some flows contain plagioclase phenocrysts; flows generally have amygdaloidal, scoriaceous, and brecciated flow margins that are commonly extensively epidotised, and locally contain traces of chalcopyrite and malachite. Scoriaceous or rubbly flow tops consist of angular to rounded clasts of highly vesicular basalt and minor massive basalt cemented by calcite, epidote, quartz, fine-grained dark grey quartzite and epidotic quartzite, and altered finely comminuted basalt lava debris; commonly overlain by thin (less than 3 m) lenses of locally cross-bedded fine to medium-grained glassy quartzite and quartzose meta-arenite.

Metabasalt is generally non-schistose, but zones of chlorite and amphibole schist are developed locally adjacent to faults and to contacts with Mount Guide Quartzite and interbedded meta-arenite units. Cut by rare thin veinlets of coarse white calcite. Most flows range from about 15 to 40 m thick. Amygdales undeformed in most places; filled with quartz, epidote, and minor calcite, biotite, and chlorite.

Sequence contains numerous interlayered lenses of metasediments, generally less than 10 m thick; some relatively thick units of mostly metagreywacke conglomerate and pebbly metagreywacke, exposed mainly about 5 km southwest of Dajarra, are also included because boundaries with enclosing metabasalts could not be accurately delineated on aerial photographs. At about GR 408963, 6.5 km southwest of Dajarra, the metasediments overlie fine-grained massive metabasalt, the amygdaloidal top of the flow presumably having been eroded away.

Meta-arenites and quartzites. Fine to coarse-grained; pale green and epidotic, but also white to pale brown and brownish grey to dark grey (?tuffaceous); commonly cross-bedded; quartzites are commonly glassy; thin layers and laminae rich in heavy minerals are common; contain cubes of altered ?pyrite and euhedral ?pyrite casts in places; commonly contain scattered angular to rounded pebbles up to about 15 cm of little recrystallised felsic volcanics, metabasalt, vein quartz, and glassy quartzite; well sorted to poorly sorted - some units characterised by bimodal grainsize distributions; locally friable, containing fine sericite, biotite, or chlorite flakes. Some dark grey pebbly metagreywacke and metagreywacke conglomerate commonly associated with the meta-arenites, especially southwest of Dajarra. Meta-arenites are extensively brecciated and schistose adjacent to many faults, especially in southwest.

Metagreywacke conglomerates and pebbly metagreywackes. Well exposed between 4 and 6 km southwest of Dajarra. Clasts well-rounded and unsorted; up to about 60 cm; mainly of fine-grained, little-recrystallised felsic volcanics and fine-grained non-schistose amygdaloidal and massive metabasalt similar to that of enclosing metabasalt lavas, together with some vein quartz, white medium-grained glassy quartzite, and rare coarse-grained non-foliated biotite granite; locally, for example, about 9.5 km northwest of Dajarra, basalt and epidodic quartzite clasts predominate. Matrix is banded, fine to medium-grained, dark grey, labile, quartz-poor; commonly contains abundant fine biotite, rarely amphibole needles; epidotised in places; ?tuffaceous.

Contain interlayered lenses of pale brown to grey fine to medium-grained glassy quartzitic rocks (silicified or recrystallised felsic tuffs?) and feldspathic meta-arenite; commonly contain scattered small clasts of basalt and felsic volcanics.

$Phe_q$, $Phe_q$? Quartzose and feldspathic meta-arenites, some sericitic meta-arenite, meta-arkose, glassy quartzite. Medium-grained; white, pale brown to dark red-brown, grey; mainly thin to medium-bedded; cross-beds common; contain fine bands rich in heavy minerals; commonly friable; fairly well sorted to poorly sorted - poorly sorted meta-arenites contain brown, fine-grained quartzose to quartz-poor labile matrix separating larger grains (of mainly quartz); contain scattered small (up to about 8 cm) subangular to rounded pebbles of mainly quartzite and felsic volcanics, together with minor vein quartz. Beds highly sheared and extensively brecciated and disrupted adjacent to some faults - also cut by quartz veins.

Some interlayered dark brown schistose fine-grained labile meta-arenite or metasiltstone; dark grey metagreywacke conglomerate containing numerous clasts of non-schistose amygdaloidal and massive metabasalt and felsic volcanics; and minor medium-grained quartzite.

Beds mapped as Ehe$_q$? tend to be glassy and more highly deformed and indurated than those mapped as Ehe$_q$; pebbly beds are also less common in Ehe$_q$?, and metagreywacke conglomerate lenses and felsic volcanic clasts have been found only at GR 381059, about 10 km northwest of Dajarra.

<u>Ehe$_{cg}$</u>. Mainly interlayered metagreywacke conglomerate, pebbly and gritty metagreywacke, pebbly meta-arkose, and quartzose, feldspathic, and sericitic meta-arenite. <u>Clasts</u>. Generally well rounded, but some clasts are subangular; up to about 60 cm; mainly several types of little-recrystallised porphyritic to non-porphyritic felsic volcanics, amygdaloidal and massive metabasalt, medium-grained quartzose meta-arenite and glassy quartzite, vein quartz, and rare fine-grained biotite leucogranite. In a few places the felsic volcanic clasts are extensively altered, but generally they are very fresh and little altered. Some felsic volcanic clasts in conglomerate exposed about 2.5 km west-northwest of Dajarra appear to have been flattened. <u>Matrix</u>. Mainly dark grey to red-brown (ferruginised) fine to coarse-grained labile arenite and greywacke; contains scattered, coarse quartz and feldspar grains, and abundant fine biotite flakes.

Interlayered lenses of <u>quartzose, feldspathic and sericitic meta-arenite, metagreywacke, gritty metagreywacke and meta-arkose</u> common; red-brown, pink brownish grey to dark grey; fine to medium-grained; mainly thin to medium-bedded; cross-bedded; extensively ferruginised (lateritised) in places; commonly contain abundant feldspar or pink ?altered feldspar grains and angular to rounded clasts up to about 15 cm; also contain numerous fine bands rich in heavy minerals, and zones relatively rich in coarse quartz and feldspar grains; extensively silicified and indurated; commonly form massive outcrops in which bedding is difficult to detect.

Minor pale grey fine-grained labile meta-arenite, ?silicified metasiltstone, and pale grey pebbly metasiltstone. Rare dark grey fine-grained siliceous quartzitic rocks (?recrystallised felsic tuffs).

<u>Ehe$_a$</u>. <u>Possible andesitic metavolcanics</u>. Two small outcrops in northern part of Sheet area (about GR 337186), about 23 km north-northwest of Dajarra. The easternmost outcrop consists of large boulders of black biotite-rich ?meta-andesite containing numerous angular inclusions (mainly lithic freagments up to about 8 cm long), and what appear to be quartz phenocrysts in a fine-grained extensively recrystallised groundmass containing scattered chalcopyrite grains. The lithic fragments are mainly fine-grained biotite-rich porphyritic ?meta-andesite similar to the enclosing rock, but also include scarce rounded pebbles of medium-grained quartzite and porphyritic felsic volcanics. The rocks are characterised by numerous irregular holes up to about 8 cm across that may represent weathered out clasts of pumiceous andesite.

Unit shows slight decrease in grainsize at western contact with country rocks. Interlayered with grey to pale brown, partly epidotic, quartzitic rocks containing what appear to be quartz phenocrysts and angular to rounded inclusions of ?meta-andesite and more leucocratic felsic volcanics, and with minor pebbly metagreywacke containing numerous rounded clasts of amygdaloidal and massive metabasalt up to about 15 cm and scattered glassy quartzite clasts. Sequence is cut by medium-grained massive non-schistose amphibolitic metadolerite dykes and quartz veins. Sequence tentatively regarded as representing a metamorphosed volcanic breccia (?agglomerate) with associated tuffaceous metasediments.

The westernmost outcrop comprises a thin (15 m) flow of amygdaloidal ?andesite (- appears to be too siliceous for basalt) containing numerous coarse clots of ?actinolite. Amygdales occur throughout the flow but are most abundant in the upper, western part.

<ins>Structure and Metamorphism</ins>. Trends in the Eastern Creek Volcanics are mainly northerly to northwesterly; units generally moderately to steeply dipping, and right way up. Large-scale structures are very difficult to detect because of lack of marker units that can be traced on aerial photographs. Appear to be folded about northerly-trending axes into upright anticlines and synclines. Cut by northwest-trending faults with horizontal displacements of up to about 1 km, also by northeasterly-trending, and difficult to detect northerly-trending strike, faults. Sequence extensively sheared and deformed west and southwest of Dajarra. Rocks schistose and brecciated adjacent to many faults; rarely (for example, at GR 400765) angular fragments of brecciated meta-arenite are cemented by ?hematite.

The common occurrence of chlorite and biotite indicate mainly low greenschist grades of regional metamorphism.

<ins>Stratigraphic relations</ins>. Overlie Mount Guide Quartzite apparently concordantly and, in most places examined, are overlain apparently concordantly by sediments assigned to the Warrina Park Quartzite (see <ins>Stratigraphic relations</ins> and <ins>Remarks</ins> under <ins>Warrina Park Quartzite</ins>). Cut by numerous medium-grained non-schistose amphibolitic metadolerite dykes with doleritic textures preserved in places. Also cut by quartz veins, especially adjacent to faults.

<ins>Age</ins>. Precambrian - probably Carpentarian (Derrick & others, 1976a).

Correlation. Equivalent to Eastern Creek Volcanics mapped east of the Mount Isa Fault and its extensions in Sheet areas to the north and northeast. Belt extends north into the Oban Sheet area where mapped as Cromwell Metabasalt Member and Lena Quartzite (Mock, 1978). However, no attempt has been made to subdivide the formation in the Ardmore Sheet area into the formally defined units of Derrick & others (1976a).

Mineralisation. Traces of chalcopyrite and malachite occur in some amygdales. One small pit, about 1.5 m deep, was found in dark grey metagreywacke conglomerate at GR 413968, about 6 km southwest of Dajarra; mineralisation consists of malachite in thin (less than 1 m thick) vuggy quartz vein cutting sequence.

In 1978 an exploration company initiated an airborne scintillometer survey of an area north of Sulieman Bore, in the northeastern part of the Sheet area. Several anomalies were found in areas underlain by mafic rocks mapped as part of the Eastern Creek Volcanics. Ground traverses were then carried out to map the anomalous areas in detail, and in late September 1979 diamond drilling was about to commence to test for uranium mineralisation at about GR 372089.

Remarks. The formation crops out extensively in the western part of the Cloncurry Complex, and, to the north, has been interpreted as a possible continental flood basalt sequence (Glikson & others, 1976; Glikson & Derrick, 1978). The metabasalts mapped as Eastern Creek Volcanics in the Ardmore Sheet area crop out east of the Wonomo Fault and are mainly non-schistose and little-deformed; they contrast markedly with the schistose metabasalts and metasediments mapped as Jayah Creek volcanics west of the Wonomo Fault. Also, the Eastern Creek Volcanics include numerous lenses of pebbly meta-arenite and labile conglomerate containing abundant 'cherty' felsic volcanic and non-schistose metabasalt clasts; similar metasediments are very rare in the Jayah Creek volcanics.

Despite the abundance of interlayered metasediments, no structures such as lava pillows, or rock types such as altered palagonite breccias, have been recognised in the sequence to indicate subaqueous eruption of basalt. In places metagreywacke conglomerate lenses directly overlie massive metabasalt, the vesicular upper parts of the flows apparently having been eroded away. Furthermore, the metabasalt clasts in the conglomerates are mainly non-schistose, and they closely resemble metabasalt from the enclosing lava flows. Consequently, most of the lavas are regarded as having been erupted subaerially and extensively eroded in places. The interbedded metasediments were probably deposited in a fluviatile or shallow-water environment. Clasts in the conglomeratic metasediments may have been derived mainly from an elevated terrain to the east. The rocks exposed in the source area(s) apparently consisted mainly of felsic volcanics with minor granite (which supplied the relatively scarce granite and more common vein quartz clasts - probably also the coarse feldspar grains in the feldspathic meta-arenites and meta-arkoses). Most of the basalt clasts appear to have been eroded locally. Much of the finer detritus in the labile metasediments may have also been derived by erosion of the felsic and mafic volcanics, although some of it may be tuffaceous.

Most of the felsic volcanic clasts in the conglomeratic metasedimentary lenses are characterised by fine-grained recrystallised siliceous groundmasses. They are not as coarsely or extensively recrystallised, for example, as the felsic volcanic clasts in the Bottletree and Yappo formations. In degree of recrystallisation the clasts most closely resemble the Standish Volcanics, mapped in the adjacent Dajarra 1:100 000 Sheet area to the east and in the southern part of the Duchess 1:100 000 Sheet area (to the northeast), and some of the volcanics tentatively mapped as Leichhardt Metamorphics in the northern part of the Duchess Sheet area. The Standish Volcanics were interpreted as being younger than the Eastern Creek Volcanics in these areas (Blake & others, 1978; Bultitude & others, 1978), although they have not been found in contact with Haslingden Group rocks and they have not been isotopically dated. However, this interpretation has been modified since the 1979 field season, and it is now generally accepted that felsic volcanics mapped in the Duchess and Dajarra Sheet areas as Standish Volcanics are most probably equivalent to units mapped as Argylla Formation or Leichhardt Metamorphics elsewhere.

The abundance of immature pebbly and conglomeratic sediments containing numerous felsic volcanic clasts in the Eastern Creek Volcanics, and the relative scarcity of pebbles and absence of 'cherty' felsic volcanic clasts in the more mature sediments forming the upper part of the underlying Mount Guide Quartzite, suggest that there may have been a significant time break between the deposition of the Mount Guide Quartzite and commencement of basaltic volcanism. This hypothesis is also supported by the apparent absence of metabasalt lava flows interlayered with sediments of the upper Mount Guide Quartzite in the Ardmore Sheet area. The abundance of conglomeratic sediments in the Eastern Creek Volcanics suggests that basaltic volcanism was preceded or accompanied by, or both, tectonism and uplift. Furthermore, the possibility that there was pene-contemporaneous volcanic activity to the east and northeast cannot be ruled out on evidence available in the Ardmore Sheet area. A felsic volcanic unit in the Bottletree formation at the base of the Haslingden Group in the Duchess 1:100 000 Sheet area to the northeast has yielded a preliminary U-Pb zircon age of about 1810 m.y. (Page, personal communication, 1978), and felsic volcanics mapped as part of the Argylla Formation in the Mary Kathleen 1:100 000 Sheet area have yielded a U-Pb zircon age of about 1777 m.y. (Page, 1978). It is therefore possible that some felsic volcanic units mapped as part of the Standish Volcanics or Tewinga Group in Sheet areas to the east and northeast may have been erupted at about the same time as basalts of the Eastern Creek Volcanics.

The sequence immediately west and southwest of Dajarra has been extensively deformed and at least some of the metasediments tentatively mapped as $Phe_q$ may be equivalent to the Mount Guide Quartzite.

MOUNT ISA GROUP

The Mount Isa Group was first defined by Bennett (1965) who described seven formations within the group. An eighth formation, the basal Warrina Park Quartzite, was added to the group by Derrick & others (1976b), who reported that the Mount Isa Group unconformably overlies the Haslingden Group.

The Mount Isa Group crops out as a narrow north-northwesterly trending belt in the eastern part of the Ardmore 1:100 000 Sheet area, and is more extensive than shown on the Urandangi 1:250 000 map (Noakes & others, 1959). It extends into the Oban 1:100 000 Sheet area to the north and, in the southeast, meta-arenite and quartzite tentatively assigned to the Warrina Park Quartzite extend into the Dajarra 1:100 000 Sheet area to the east. Only the lower part of the group is exposed in the Ardmore 1:100 000 Sheet area, namely (from youngest to oldest) the Breakaway Shale, Moondarra Siltstone, and Warrina Park Quartzite. The Urquhart Shale, host to Mount Isa Cu and Pb-Zn deposits, has not been recognised. The group is truncated to the west by the Wonomo Fault.

Small scattered deposits of copper ores occur in the Moondarra Siltstone and Breakaway Shale in the Mount Isa 1:100 000 Sheet area (Hill & others, 1975), and in sediments mapped as Moondarra Siltstone in the southern part of the Oban 1:100 000 Sheet area (for example, the Blue Hills and Mount Annable prospects; Mock, 1978), but no significant base-metal deposits have been found in the Mount Isa Group in the Ardmore 1:100 000 Sheet area. Secondary, commonly ?silicified, iron oxide-rich gossans are fairly common in the Breakaway Shale and Moondarra Siltstone, but are thought to have resulted mainly from the oxidation of pyrite in the sediments.

The Mount Isa Group sediments display features that suggest deposition in a relatively shallow lacustrine or ?intracratonic marine environment.

## Warrina Park Quartzite

Map symbols. Piw, Piw?

Nomenclature. Named after Warrina Park recreation reserve, below the spillway at Lake Moondarra, about 20 km northeast of Mount Isa, Cloncurry 1:250 000 Sheet area. Defined by Derrick & others (1976b). Previously mapped in the Ardmore Sheet area as Eastern Creek Volcanics (Noakes & others, 1959).

Distribution. Narrow north to north-northwest-trending belt in east; extends north into the Oban Sheet area, and east into the Dajarra Sheet area, where sequence has been tentatively mapped as Myally Subgroup (Blake & others, 1978).

Reference area. About 23 km north-northwest of Dajarra, from GR 322183 to GR 327184.

Thickness. Maximum of about 470 m in north, and apparent maximum of about 700 m in south.

Topographic expression and airphoto characteristics. Typically forms prominent, steep-sided, commonly planated strike ridges with trend lines generally conspicuous. Mainly pale to dark brown tones on colour aerial photographs.

General lithology. Quartzose, feldspathic, sericitic, and ferruginous meta-arenite and quartzite; minor metasiltstone, silty meta-arenite, metaconglomerate.

Details of lithology. Meta-arenites and quartzites. White, pale to dark grey, buff, pale brown to dark red-brown; commonly ferruginous and ironstained; fine to medium-grained; thin to medium-bedded; friable to indurated and glassy;

generally cross-bedded; rare ripple marks; many beds contain scattered grains of opaque oxide, fine black bands rich in heavy minerals, or white to pale pink clay (?altered feldspar) grains. White to brown and red-brown clay matrix fairly common.

Subhedral to euhedral pyrite casts up to about 1 cm long are widespread, and are abundant in some beds in the upper part of the formation in the north; more rarely, beds contain altered pyrite grains surrounded by purple haloes of ?secondary iron oxide-stained meta-arenite or quartzite.

Beds are commonly pebbly, and gritty and conglomeratic in places; pebbles are mainly rounded, rarely flattened, up to about 15 cm, and consist mainly of vein quartz and medium-grained quartzose meta-arenite and quartzite; rare clasts of granite and fine-grained quartzitic rocks (recrystallised felsic volcanics?) occur in pebbly and conglomeratic beds exposed west of Brumby Dam (GR 448783) in the southeast, and flattened clasts of extensively weathered possible felsic volcanics containing what appear to be remnant quartz phenocrysts were also found at GR 372042. Pebbles and pebbly beds are less common in the upper part of the formation. Beds adjacent to some faults contain flattened pebbles.

Beds tend to be thinner, finer-grained, and more pyritic in upper part of unit; grade upwards into thin-bedded, grey to red-brown (oxidised and ferruginised) micaceous metasiltstone mapped as Moondarra Siltstone.

Metaconglomerates and grits. Observed mainly in southeast (for example, at GR 403771 and GR 424831) at, or near, base of unit; up to about 5 m thick; contain generally well-rounded, unsorted clasts (up to about 1 m) of mainly pale grey, white, and pale brown fine to medium-grained quartzose meta-arenite, white to brown glassy quartzite, and vein quartz. Matrix: poorly sorted, fine to coarse-grained, in places gritty, meta-arenite or relatively well-sorted meta-arenite; commonly slightly friable, and generally contains abundant white clay or fine sericite flakes, or both. Clasts in conglomerate at GR 403771 also include subangular pebbles of white to pale brown fine to medium-grained sericitic meta-arenite. Conglomerate exposed at GR 424831 consists mainly of unsorted angular clasts, up to about 30 cm across, of white to brown fine to medium-grained quartzose meta-arenite in a matrix of brown, fine to medium-grained sericitic meta-arenite. Many of these subangular to angular clasts are similar to underlying meta-arenites tentatively assigned to the Eastern Creek Volcanics, and may be locally derived. Clasts in conglomerate in north at GR 358095 appear flattened. There the conglomerate consists of clasts of white to grey glassy quartzite in a medium-grained gritty, quartzose meta-arenite matrix; it forms a unit about 5 m thick in a sequence of mainly brown fine-grained friable sericitic and ferruginous meta-arenite containing small pyrite casts.

The conglomerates contain lenses of pebbly cross-bedded, ripple-marked pale grey sericitic meta-arenite with fine layers rich in heavy minerals.

Structure and metamorphism. In the northern and central parts of the Sheet area the formation appears to be exposed on the moderately to steeply dipping limbs of an extensively faulted syncline with a north-northwesterly-trending fold axis. In the southeast, east-northeast of Wonomo Waterhole, meta-sediments tentatively assigned to this unit have been folded about northerly-trending axes into a series of upright anticlines and synclines; a fairly major syncline well exposed about 2 km east-northeast of Wonomo Waterhole plunges gently northwards at about 20°. A northerly-trending axial-plane fracture cleavage, subparallel to bedding (on the limbs of the folds) and generally vertical to steeply east-dipping, is commonly well developed in the hinge zones of folds; bedding is generally obliterated in these zones.

The formation is truncated to the west by the north-northwest-trending Wonomo Fault; it is also cut by northeasterly and northwesterly-trending minor or subsidiary faults, and by quartz veins. Unit is extensively contorted, brecciated, and sheared adjacent to many of the faults, and a schistosity is commonly developed.

The presence of generally well-preserved sedimentary structures, of recrystallised quartzites as well as partly recrystallised meta-arenites, and of a schistosity (commonly poorly developed) indicates low greenschist grades of regional metamorphism.

Stratigraphic relations. Faulted against metabasalts and metasediments mapped as Jayah Creek volcanics in the west. In the north the formation overlies basaltic lavas and associated sediments, mapped as Eastern Creek Volcanics, apparently concordantly in most places. However, at about GR 373052 there is an angular discordance of about 30° between the trends of the Warrina Park Quartzite and metasediments tentatively assigned to the Mount Guide Quartzite, and also sedimentary lenses in the adjacent Eastern Creek Volcanics. Consequently the Haslingden Group is regarded as being unconformably overlain by the Warrina Park Quartzite. In the southeast (northeast of Wonomo Waterhole) metasediments tentatively assigned to the Warrina Park Quartzite are interpreted as being unconformable on metasediments tentatively assigned to the Eastern Creek Volcanics. The two units appear concordant and similar lithologically, but there is a polymictic conglomerate up to about 5 m thick at the base of the ?Warrina Park Quartzite. The conglomerate, very well exposed at GR 403771, contains angular and subangular clasts of quartzose and sericitic meta-arenite, similar to the underlying meta-arenites, that may have been derived locally. However, basaltic clasts have not been recognised.

The formation grades upwards into micaceous metasiltstone assigned to the Moondarra Siltstone.

Age. Precambrian - probably Carpentarian (Derrick & others, 1976b).

Correlations. Extends north into the Oban 1:100 000 Sheet area, where it has been mapped mainly as Warrina Park Quartzite and partly as Myally Subgroup (Mock, 1978). In southeast, unit extends into the Dajarra 1:100 000 Sheet area where it is tentatively assigned to the Myally Subgroup because it is reported to be conformable on the Eastern Creek Volcanics (Blake & others, 1978). I have mapped the sequence in north of the Ardmore Sheet area as Warrina Park Quartzite because it conformably underlies and grades upwards into a sequence consisting mainly of dolomitic metasiltstone, micaceous and pyritic metasiltstone, and pyritic ?carbonaceous shale that can be fairly confidently correlated with the Moondarra Siltstone and Breakaway Shale mapped in Sheet areas to the north. Sequence in the southeast is tentatively assigned to the Warrina Park Quartzite, because it is similar lithologically to that mapped as Warrina Park Quartzite in the north, because it grades up into micaceous metasiltstone similar to the Moondarra Siltstone, and because I have interpreted it to be unconformable on the Eastern Creek Volcanics.

Mineralisation. No economic concentrations of ore minerals known. Gossany outcrops confined mainly to certain beds are common in the upper part of the sequence, northeast of Wonomo Waterhole. These were examined by geologists from Pechiney Queensland Pty Ltd in the late 1960s for base-metal mineralisation and an angled hole was drilled at 139°27'46"E, 21°54'42"S to a depth of 44.2 m. However, no significant base-metal concentrations were found.

Remarks. May represent shallow-water marine or lacustrine sediments. The pyrite grains probably formed at about the same time as the sediments were deposited, in a reducing environment. Beds originally containing abundant pyrite are extensively ferruginised as a result of oxidation of the pyrite.

The Warrina Park Quartzite forms discontinuous outcrops that can be traced on aerial phtotographs from south of the Mount Annable Fault in the central part of the Oban Sheet area through the eastern part of the Ardmore Sheet area, into the southwestern part of the Dajarra Sheet area. In different places, the unit overlies metabasalts of the Eastern Creek Volcanics, metasediments assigned to the Eastern Creek Volcanics and Mount Guide Quartzite, and metasediments mapped as Myally Subgroup.

In many places in Sheet areas to the north the Warrina Park Quartzite appears concordant on underlying arenites and the boundary is difficult to delineate (see Bennett, 1965; Hill & others, 1975; Derrick & others, 1976b).

## Moondarra Siltstone

Map symbols. Ⓟim, Ⓟim?

Nomenclature. Described by Bennett (1965) and more recently by Mathias & Clark (1975). Type section is southeast of Lake Moondarra, Cloncurry 1:250 000 Sheet area (Derrick & others, 1976b). Previously mapped in the Ardmore Sheet area as Eastern Creek Volcanics and Mount Isa Shale (Noakes & others, 1959).

Distribution. Narrow north-northeast-trending discontinuous belt in the central-east and northeast.

Reference area. Far north of Sheet area, from GR 318208 to GR 325208.

Thicknesses. Apparent maximum thickness of about 1000 m in far north of Sheet area; thickness decreases to south - in places to less than 100 m.

Topographic and airphoto characteristics. Typically forms flat valleys in which exposures are very poor and scarce. Brown to red-brown tones on colour aerial photographs.

<u>General lithology</u>. Pyritic, ?dolomitic, and micaceous metasiltstone; minor ?dolomite, limestone, and dark grey siliceous pyritic shale.

<u>Details of lithology</u>. <u>Metasiltstones</u>. Laminated to thin-bedded; blue-grey to pale grey, black, white, pale brown; commonly red-brown and ferruginised (due to oxidation of pyrite grains); non-fissile and commonly characterised by conchoidal fracture; some beds are probably dolomitic; fine muscovite or sericite flakes are common; some beds and zones contain abundant fine anhedral pyrite, pyrite casts, or altered pyrite grains; graded bedding displayed in places, with pyrite grains concentrated in the coarser-grained basal parts of beds; rare cross-bedding in a few coarser-grained units; some convolute bedding.

<u>?Dolomites and limestones</u>. White to dark grey; finely crystalline, characterised by fine, highly contorted laminations and small-scale karst-type weathering surfaces; cut by thin veins (less than 10 cm wide) of coarse white calcite; interlayered with black to dark red-brown micaceous and ?dolomitic metasiltstone.

Sequences assigned to the Moondarra Siltstone west of The Gap and east of Timothy Tank consist mainly of pyritic, ?dolomitic, and micaceous metasiltstones similar to those described above, but they also contain some meta-arenite and blue-grey to dark grey and black ?carbonaceous shale. The <u>meta-arenites</u> are brown to red-brown or white to pale grey; fine-grained; thin to medium-bedded; quartzose, feldspathic, sericitic, pyritic; commonly friable.

<u>Structure and metamorphism</u>. Beds steeply west-dipping to vertical in northern and central parts of Sheet area, and vertical to east-dipping east of Timothy Tank in south; commonly buckled and contorted, especially adjacent to faults; cut by quartz veins; vertical foliation developed west of The Gap near contact with meta-arenites tentatively assigned to the Warrina Park Quartzite. ?Dolomite in north shows small isoclinal folds with northerly trending axes.

Regionally metamorphosed to ?lower greenschist facies.

<u>Relations</u>. Overlies meta-arenites assigned to the Warrina Park Quartzite conformably, and is conformably overlain by the Breakaway Shale.

<u>Age</u>. Precambrian - most probably Carpentarian (Derrick & others, 1976b).

Correlations. Correlated with similar sediments mapped as Moondarra Siltstone in Sheet areas to the north.

Mineralisation. No economic ore deposits known in Sheet area.

Remarks. Probably deposited in a low-energy environment in a slowly subsiding trough or elongate basin (Derrick & others, 1976b). Bennett (1965) reported that siltstones mapped as Moondarra Siltstone in the Mount Isa area are dolomitic.

## Breakaway Shale

Map symbol. Ēib.

Nomenclature. The Breakaway Shale near Mount Isa was described by Bennett (1965) and Mathias & Clark (1975). The type section is about 4 km north-northeast of Mount Isa, and extends from the Mount Isa 1:250 000 Sheet area into the adjoining Cloncurry 1:250 000 Sheet area (Derrick & others, 1976b). Previously mapped in the Ardmore Sheet area as Mount Isa Shale and Eastern Creek Volcanics (Noakes & others, 1959).

Distribution. Exposed in two small areas, in the far northeast and in the central-east.

Reference area. In far north from GR 306205 to GR 318207.

Thickness. Maximum thickness of about 1150 m in far north.

Topographic expression and airphoto characteristics. Typically forms low rounded hills and strike ridges. Pale to dark tones on aerial photographs with trend lines commonly prominent.

General lithology. Mainly pyritic shale; minor brown to dark red-brown sericitic siltstone and shale. Some secondary iron oxide-rich gossany outcrops.

Details of lithology. Shales. Blue-grey to dark grey; siliceous; ?carbonaceous; extensively weathered to pale grey, or oxidised to dark red-brown or purple; laminated to thin-bedded; fissile; pyrite casts up to about 1 cm are very common - also contain some pyrite grains completely replaced by secondary iron oxides.

Structure and metamorphism. Beds are mainly steeply west-dipping to vertical. Truncated by the Wonomo Fault to the west and cut by thin quartz veins. Regional metamorphic effects relatively slight - probably mainly lower greenschist grade.

Stratigraphic relations. Conformably overlies Moondarra Siltstone.

Age. Precambrian - probably Carpentarian (Derrick & others, 1976b).

Correlations. Correlated with the Breakaway Shale mapped in the Oban and Mount Isa 1:100 000 Sheet areas to the north (Hill & others, 1975; Mock, 1978).

Mineralisation. No economic concentrations of ore minerals are known.

Remarks. The Breakaway Shale was probably deposited in a deeper-water or lower-energy environment than the Moondarra Siltstone because it is finer-grained, less calcareous or dolomitic, and more pyritic.

## CENTRAL BELT

### Sulieman gneiss
(name not yet approved)

Map symbols. Psg, Psg?, $Psg_q$, $Psg_q$?

Nomenclature. Named after Sulieman Creek, whose tributaries drain much of the area in which the formation is exposed. Previously mapped mainly as Eastern Creek Volcanics, and also partly as Sybella Granite (Noakes & others, 1959).

Distribution. Forms narrow northerly-trending belt in central part of Sheet area. Most extensive and best exposures are in far south, north of Pinnacles Dam. Formation extends south into the Glenormiston 1:250 000 Sheet area.

Type area. About 39.5 km southwest of Dajarra, from GR 197707 to GR 222695.

Thickness. Unknown - formation has been extensively deformed and base apparently not exposed. Subunit Ꝑsg$_q$ appears to have maximum thickness of about 850 m.

Topographic expression and airphoto characteristics. Outcrop area ranges from extensively alluviated terrain, with scattered low rubbly outcrops, to rough hilly country with numerous strike ridges. Medium tones on aerial photographs, on which trends are commonly clearly visible in hilly terrain.

General lithology. Mainly interlayered medium-grained quartz + biotite + feldspar ± garnet ± muscovite gneiss and augen gneiss, hornblende schist, recrystallised medium to coarse-grained quartzite, muscovite quartzite, and ?feldspathic quartzite; also some banded calc-silicate gneiss or granofels (commonly garnetiferous), para-amphibolite, quartz-feldspar pegmatite, feldspar metaporphyry, and intensely foliated to non-foliated porphyritic to non-porphyritic biotite-rich to leucocratic fine to coarse-grained granite.

Details of lithology. Ꝑsg, Ꝑsg? Quartz + biotite + feldspar ± garnet gneiss and augen gneiss. Mainly medium-grained; commonly thin to medium-banded; contain mafic and leucocratic layers or zones. Some layers are rich in feldspar augen, some contain only rare scattered augen, and some are even-grained. Feldspar augen are white to pale pink; up to about 4 cm across, but generally less than 2 cm; not recrystallised to completely recrystallised to aggregates of small feldspar grains. Some units of augen gneiss interlayered with amphibolite (hornblende schist) are 30 cm or less thick and show no apparent decrease in grainsize (chilled margins) adjacent to contacts with the amphibolite. The gneisses also commonly contain abundant to rare small grains and poikiloblasts and porphyroblasts (up to about 3 cm) of garnet.

Hornblende schist. Black; extensively weathered to red-brown in places; medium-grained; generally foliated; commonly forms massive outcrops. Rarely, units are extensively epidotised and contain zones rich in stretched quartz and/or epidote-rich lenticles that may have originally been amygdales.

Minor white to pale grey and brown, medium to coarse-grained, recrystallised glassy quartzite, muscovite quartzite and ?feldspathic quartzite, laminated to thin-banded para-amphibolite, amphibolitic calc-silicate rocks (commonly containing abundant epidote and/or garnet) and finely banded siliceous calc-silicate granofels (the banding may represent original lithological layering).

In western part of type area, there is also: (1) Thin-banded ?para-amphibolite containing what appear to be lensoidal blocks (up to about 60 cm long) of epidotised amygdaloidal and massive metabasalt (?possible pillow lava). Thin (1 cm) leucocratic layers in the ?para-amphibolite show very intricate small-scale folds. (2) Large slabby outcrops of thin-banded, medium-grained calc-silicate granofels and para-amphibolite. Sphene and epidote are common in some units. Euhedral garnet poikiloblasts up to about 1 cm across are also very abundant in some layers. Rare epidote-rich veinlets cut across the foliation. (3) Quartz + muscovite + garnet (as small porphyroblasts up to about 2 cm across) + ?hornblende + ?feldspar schist. (4) A small lens or pod of feldspar metaporphyry exposed at GR 198701, about 3.5 km north of Pinnacles Dam; contains numerous euhedral to subhedral tabular colourless to pale pink feldspar grains up to about 6 cm long in a fine to medium-grained groundmass of mainly quartz, feldspar, and biotite. The large feldspar grains show a well-developed preferred orientation parallel to the foliation in the enclosing rocks; some have recrystallised to aggregates of much smaller feldspar grains. The feldspar grains are interpreted as relict phenocrysts, and the rock as an intrusive granitic porphyry, rather than an extrusive felsic metavolcanic - it appears to grade into more extensively recrystallised quartzo-feldspathic and augen gneisses to the east.

Ꝑsg$_q$ . Mainly white to pale brown, medium to coarse-grained, recrystallised glassy quartzite, muscovite quartzite, and ?feldspathic quartzite; ?feldspathic quartzite contains numerous clots of pale pink clay and small elongate holes that may represent altered and weathered out feldspar grains; mainly thin to medium-bedded; intensely foliated in places. Minor epidotic quartzite and medium-grained hornblende schist. Cut by thin veins of quartz and quartz + feldspar ± muscovite ± hematite pegmatite.

Structure and metamorphism. Trends are mainly northerly and dips are fairly steep to vertical. Foliation and lithological layering commonly show small-scale folds and crenulations. Unit is cut by several, mainly north-northeasterly to northerly-trending faults, and is regionally metamorphosed to amphibolite grade - rocks are medium-grained, extensively recrystallised, with hornblende and clinopyroxene (?salite) common in the amphibolites and calc-silicate rocks, respectively. The common occurrence of minor chlorite (mainly replacing biotite, rarely amphibole) and sericite (replacing plagioclase) indicate that the formation has undergone a later low (greenschist) grade retrogressive regional metamorphism.

Stratigraphic relations. Appears to have a gradational contact with metasediments assigned to the Jayah Creek volcanics. Has a fairly abrupt but gradational contact with the Kallala quartzite - thin lenses of glassy recrystallised quartzite and muscovite quartzite occur in the Sulieman gneiss adjacent to the contact. However, uncertain whether the Sulieman gneiss is younger or older than the Kallala quartzite because no facing directions have been found in either formation.

Extensively intruded by several types of granite and numerous veins of pegmatite, all of which are tentatively regarded as forming part of the Sybella Granite batholith. Also intruded by small pods and dykes of apparently unmetamorphosed dolerite containing abundant primary biotite, and by dykes of medium-grained non-schistose amphibolitic metadolerite with doleritic textures preserved.

The pegmatite veins intruding the formation are of at least two different ages and the granite veins are probably of several different ages. Early pegmatite and granite veins are mainly thin (commonly less than 20 cm thick) and are generally grossly concordant with the foliation in the enclosing rocks. These veins have been extensively boudinaged, and generally have irregular contacts and in places show small-scale ptygmatic folds; large feldspar augen up to about 10 cm are also common in the pegmatites. The extensively deformed pegmatites consist of quartz + pink to white feldspar $\pm$ muscovite $\pm$ sparse ?hematite.

Undeformed or little-deformed, commonly tabular pegmatite veins that cut the formation are regarded as being younger than those described above. Relatively thick veins commonly show very coarse centres and finer-grained chilled margins of medium-grained aplite or leucogranite. They commonly cut across the foliation in the country rocks at high angles, and tend to be thicker than the extensively deformed pegmatite veins. They consist mainly of quartz + white to pink feldspar, and generally contain muscovite and, very rarely, tourmaline or biotite. Formation cut in north (at GR 219060) by thick vein of graphic quartz + pink feldspar + muscovite + tourmaline pegmatite.

Granite types found cutting the formation include: (1) Intensely foliated to non-foliated, medium to coarse-grained, even-grained to patchily porphyritic (in small pale pink feldspar phenocrysts up to about 1 cm long) biotite granite and leucogranite. (2) Intensely foliated, medium to coarse-grained, extensively recrystallised gneissic biotite granite containing scattered small pink feldspar phenocrysts. Foliation in the gneissic granite is commonly wavy and crenulated, and shows small-scale ptygmatic folds in places: (3) Intensely foliated, extensively recrystallised medium to coarse-grained porphyritic biotite-rich gneissic granodiorite containing numerous 'streaked out' and recrystallised pale pink feldspar phenocrysts.

Formation is also intruded by main mass of Sybella Granite, west of Oroopo Waterhole in central part of sheet area - granite adjacent to contact contains numerous large angular blocks of mainly medium-grained quartz-biotite-feldspar gneiss. Formation adjacent to contact is cut by numerous veins of quartz + white feldspar + muscovite pegmatite and medium-grained foliated biotite granite.

Age. Precambrian.

Correlations. May be equivalent, at least partly, to the May Downs Gneiss mapped west of the Mount Isa Fault in the Mount Isa 1:100 000 Sheet area to the north. However, hornblende schist, garnet-bearing gneiss and schist, para-amphibolite and calc-silicate rocks have not been reported in the May Downs Gneiss by Hill & others (1975), who described the gneiss as consisting of (p. 14) 'banded feldspathic quartz gneiss with some potash feldspar porphyroblasts and biotite clots, muscovite and muscovite-biotite schist, sillimanite-muscovite schist, and minor fine to medium quartzite'.

The augen gneisses and calc-silicate rocks are similar, at least superficially, to rocks mapped as part of the Tewinga Group and Corella Formation in the Duchess 1:100 000 Sheet area. However, scapolite is very common in the calc-silicate rocks of the Corella Formation in the Duchess Sheet area, whereas it has not been identified in the calc-silicate rocks of the Sulieman gneiss.

<u>Mineralisation</u>. No economic concentrations of ore minerals known in formation in Ardmore Sheet area. Formation was investigated in the south by geologists from Pechiney Queensland Pty Ltd in the late 1960s and 1970 for uranium mineralisation thought to be associated with pegmatite veins.

<u>Remarks</u>. In places, for example, the area around Rufus Tank (GR 202785), the formation is deeply weathered and extensively ferruginised (lateritised).

In the central and northern parts of the Sheet area metamorphic rocks tentatively mapped as Sulieman gneiss are truncated by the Rufus Fault Zone to the west and extensively intruded by Sybella Granite to the east. Garnet is very rare in the rocks in these areas, and at least some of the rocks may be equivalent to metasediments mapped as part of the Jayah Creek volcanics. To the south, at about GR 255873, the sequence contains pods and lenses of aggregates of very coarse chlorite, associated with northerly trending pegmatite veins.

The intensely foliated gneissic granites (which form small satellitic bodies adjacent to the larger main bodies of Sybella Granite), and the extensively deformed pegmatite and granite veins which cut the formation, are tentatively regarded as syntectonic intrusions, emplaced during the regional metamorphism that gave rise to the Sulieman gneiss and associated metamorphic rocks in the central belt. The larger outcrops of Sybella Granite and the undeformed or little-deformed pegmatite (generally muscovite and, rarely, tourmaline-bearing) and granite veins, all of which cut across the foliation in the country rocks, are regarded as mainly post-tectonic intrusions.

The origin of the augen gneisses is equivocal. In the Mount Isa 1:100 000 Sheet area to the north, Hill & others (1975) interpreted (p. 14) 'banded feldspathic quartz gneiss with some potash feldspar porphyroblasts and biotite clots' as regionally metamorphosed arkosic sands. At least some of the augen gneisses in the Sulieman gneiss may be extensively deformed and recrystallised, syntectonic, intrusive feldspar porphyries and porphyritic granite. At about GR 198701, probable feldspar porphyry containing large euhedral recrystallised feldspar phenocrysts, appears to grade into more extensively recrystallised and deformed augen gneiss.

Symbol 'P̲hs' used instead of P̲sg on original field compilation sheets.

## Kallala quartzite

(name not yet approved)

Map symbol. Ꝑkq.

Nomenclature. Named after QT Kallala Bore, located about 36 km south-southeast of Ardmore homestead. Previously mapped as Eastern Creek Volcanics by Noakes & others (1959).

Distribution. Narrow northerly-trending belt in far south of central part of Sheet area. Extends south into the Glenormiston 1:250 000 Sheet area.

Type area. From GR 172681 to GR 189672, in south of Sheet area.

Thickness. Probably at least 350 m; formation has been tightly folded and dips are steep to vertical.

Topographic expression and airphoto characteristics. Forms rugged hilly terrain with numerous closely spaced, mainly northerly-trending strike ridges and valleys. Characterised by pale to medium brown tones on colour aerial photographs.

General lithology. Mainly quartzite, feldspathic quartzite, and muscovite quartzite; some interlayered hornblende schist and hornblende-biotite schist and gneiss.

Details of lithology. Quartzites. Medium to coarse-grained; white, pale brown, and brown; mainly thin to medium-bedded; generally glassy and recrystallised; some muscovite quartzites are friable; in places extensively sheared and bedding largely obliterated.

Hornblende + biotite schists and gneisses. Mainly medium-grained; biotite fairly common in some units, rare or absent in others; commonly form massive, intensely foliated slabby outcrops in areas adjacent to Sybella Granite - generally very poorly exposed elsewhere; some units contain what appear to be thin interlayered lenses of quartzite and epidotic quartzite; possible amygdales in spotty amphibolite adjacent to Sybella Granite at GR 174715 and in schistose amphibolite and associated 'epidotic quartzite' at GR 170716. Unit extensively lateritised in places.

Structure and metamorphism. Bedding trends are mainly northerly, and dips are moderately steep to vertical. Trend lines and variations in the direction of dip indicate unit has been tightly folded about mainly north to northeast-trending axes. Beds commonly show warps and flexures, and fold noses were found in places. A northerly-trending axial-plane fracture cleavage is well developed in hinge zones of folds. Truncated to the north by a north-northeast-trending splay of the Rufus Fault Zone. Regionally metamorphosed to amphibolite grade - the quartzites are completely recrystallised and the sequence contains interlayered hornblende schist.

Stratigraphic relations. Formation appears to have a conformable contact with Sulieman gneiss and is tentatively regarded as being younger than the gneisses. To west it has an apparently concordant, possibly conformable, contact with sequence of schistose amphibolite (metabasalt) and interlayered metasediments tentatively mapped as Jayah Creek volcanics. Formation is intruded by Sybella Granite - medium to coarse-grained non-foliated to foliated porphyritic biotite granite (regarded as a mainly post-tectonic granite) and veins of fine to coarse-grained biotite leucogranite, fine to medium-grained foliated to non-foliated patchily porphyritic biotite granite, and quartz + white to pink feldspar pegmatite (with chilled margins in places). Some of the thin (less than about 30 cm thick) granitic veins show well-developed small-scale folds and crenulations, indicating a later period of deformation. Small remnant cappings of laterite and laterite rubble preserved in places.

Age. ?Proterozoic.

Correlations. Possibly equivalent to quartzite, mapped as Mount Guide Quartzite, exposed west of the Mount Isa Fault in the Mount Isa 1:100 000 Sheet area.

Mineralisation. No economic concentrations of ore minerals known in formation in Ardmore 1:100 000 Sheet area.

Remarks. Difficult to determine order of superposition between the Sulieman gneiss, Kallala quartzite, and Jayah Creek volcanics. These sequences have been regionally metamorphosed to mainly amphibolite grade, tightly folded in places, extensively recrystallised, and intruded by granite; no facing directions have been determined in the Sulieman gneiss or Kallala quartzite, or in the Jayah Creek volcanics adjacent to contacts with these formation. Dips are generally very steep to vertical in lithological layers adjacent to contacts between units, and the intrusion of the Sybella Granite may have resulted in some overturning of beds. There is a general lack of marker beds that could outline structural trends displayed by the units.

The interlayered lenses of hornblende ± biotite schist in the Kallala quartzite are probably mainly regionally metamorphosed and ?metasomatically altered dolerite dykes; however, some contain what appear to be thin quartzite lenses, and may be metabasalts. The hornblende-biotite gneisses may represent regionally metamorphosed labile ?tuffaceous sediments.

## Jayah Creek volcanics

(name not yet approved)

Map symbols. Ꝑjv, Ꝑjv?, Ꝑjv$_q$, Ꝑjv$_q$?; also includes Timothy Creek meta-arenite member (Ꝑjt, Ꝑjt?), which is described separately.

Nomenclature. Named after Jayah Creek, whose tributaries (including Jayah Bore and Jayah Rocky Creeks) drain part of the northern outcrop area. Previously mapped as Eastern Creek Volcanics by Noakes & others (1959). Described briefly by Joplin (1955) as an older metamorphic complex.

Distribution. Exposed as north-northwest-trending belt in central part of Sheet area. Extends into Oban 1:100 000 Sheet area to north. Covered by ?Mesozoic and Cainozoic deposits in far south.

Reference area. General area from about 8 km southwest of Dajarra to about 16 km west-southwest of Dajarra; no complete section from base to top of formation exposed in Sheet area.

Thickness. Uncertain. Sequence appears to be about 8200 m thick in reference area, and has an apparent maximum thickness of about 15 000 m, 20.5 km southwest of Dajarra.

Topographic expression and airphoto characteristics. Forms gently undulating to hilly terrain with dark tones (Ꝑjv), and closely spaced strike ridges (commonly planated) and steep-sided valleys with mainly pale to medium tones (Ꝑjv$_q$), but dark where Ꝑjv$_q$ extensively ferruginised (lateritised).

General lithology. Mainly foliated to schistose fine-grained amygdaloidal and massive metabasalt, fine to medium-grained amphibole schist, quartz + muscovite + biotite ± feldspar ± cordierite schist and gneiss, quartzite, muscovite quartzite, and quartzose, sericitic, and feldspathic meta-arenite. Minor rock types include para-amphibolite, labile meta-arenite and quartzite, recrystallised limestone, and calcareous meta-arenite.

Sequence characterised by numerous interlayered metasedimentary units ranging in thickness from less than 1 m up to about 2000 m (Timothy Creek meta-arenite member). In the northwest argillaceous metasediments are very common, whereas in the central and southern parts of the belt arenaceous and ?tuffaceous metasediments predominate.

Details of lithology. Ꝑjv, Ꝑjv?. Mainly black schistose fine to medium-grained amygdaloidal and massive metabasalt and numerous interlayered metasediments. Some black fine-grained, essentially non-schistose (in hand specimen), relatively little-deformed amygdaloidal and massive metabasalt and flow-margin breccia (for example, at GR 319166, GR 360050, GR 398939, GR 330849), mainly in eastern part of belt. Metabasalts extensively epidotised in places, and amygdales commonly filled with mainly epidote or quartz. Also some relatively coarse-grained non-foliated to schistose amphibolite, probably representing metamorphosed dolerite, and possibly some metabasalt. Mafic rocks generally intensely schistose and relatively coarse-grained in western part of belt near intrusions of Sybella Granite. Zones of chlorite schist common in east adjacent to faults.

At GR 285867 individual metabasalt lava flows are about 20 m thick. A few metabasalt flows contain small white plagioclase phenocrysts (for example, at GR 126665).

Interlayered metasediments include:

(1) White, grey, and brown fine to medium-grained quartz + muscovite + biotite ± feldspar schist and gneiss. The schists commonly contain muscovite porphyroblasts oblique to the schistosity and aggregates of fine to coarse, randomly oriented muscovite flakes that appear to have replaced an earlier porphyroblast - probably cordierite, possibly andalusite.

(2) White, brown, and grey, mainly thin to medium-bedded fine to medium-grained, commonly glassy recrystallised quartzite and muscovite quartzite; extensively epidotised in places.

(3) White, brown, and pale grey thin to medium-bedded fine to medium-grained sericitic, quartzose, and feldspathic meta-arenite and quartzite; ripple-marked in places; sericite-rich units commonly schistose and friable. Some beds contain thin layers rich in heavy minerals. Muscovite flakes common along partings in western part of belt near Sybella Granite. Minor sericite schist, fine to medium-grained ?tuffaceous meta-arenite containing numerous amphibole needles, and brown schistose medium-grained micaceous labile meta-arenite.

(4) Pale green to dark grey-green fine-grained epidotised quartzite. Some of it may be extensively altered basalt where it contains what appear to be well-preserved amygdales (for example, at GR 343007), comprising an outer zone of radiating epidote crystals and an inner zone of quartz grains. Commonly present as lenses (less than 1 m thick) between metabasalt lava flows. Pale green fine-grained epidotised quartzite at GR 393946 contains what appear to be fragments of extensively altered amygdaloidal metabasalt.

(5) Quartz-biotite schist; mainly laminated to thin-banded, fine-grained; contains thin layers rich in clinozoisite/epidote. Some medium to coarse-grained quartz-biotite schist (altered mafic rocks) in fault zones in far southwest.

(6) Medium to coarse-grained muscovite schist and biotite-muscovite schist.

(7) Fine to medium-grained para-amphibolite; common, particularly in southern part of belt, south and south-southwest of Steeles Tank. Laminated to thin-banded and characterised by fine regular compositional banding or layering; generally schistose; extensively epidotised in places; interlayered with white to dark grey fine-grained ?tuffaceous quartzite and ?tuffaceous labile metasediments containing sparse to abundant amphibole grains and small grains and

rare porphyroblasts of opaque oxide, pale grey fine-grained quartz-biotite schist, thinly banded amphibolitic and siliceous calc-silicate rocks commonly containing abundant epidote and small aggregates of coarse amphibole grains, and brown fine to medium-grained epidotic quartzite.

(8) Quartz-muscovite-biotite rock (at GR 299858) containing numerous small anhedral dark grey to black poikiloblasts of cordierite (characterised by a waxy lustre). Mainly thinly banded, and interlayered with fine-grained laminated to thinly banded para-amphibolite and labile ?tuffaceous metasediments.

(9) Thin-bedded pale grey fine-grained recrystallised limestone and impure limestone, and red-brown calcareous meta-arenite about 5 m thick; exposed at GR 270179; limestone contains thin layers rich in amphibole grains.

(10) Rare, highly sheared dark grey to dark brown fine-grained siliceous metasiltstone; poorly exposed at GR 125666 and GR 126665. Some possible sheared brown fine-grained micaceous metasiltstone at GR 128665.

$\underline{\text{Ejv}}_q$ , $\underline{\text{Ejv}}_q$ ? Rock types include:

(1) Pale brown to brown and pale grey fine to medium-grained commonly friable quartz-muscovite schist, muscovite schist, and quartz + biotite ± muscovite ± feldspar schist and gneiss; some schists contain small porphyroblasts (of ?cordierite) completely replaced by aggregates of muscovite flakes; cordierite poikiloblasts up to about 1 cm across present in quartz-muscovite-biotite schist at GR 254170. Schists commonly contain scattered small muscovite and biotite porphyroblasts, many of which are aligned oblique to the dominant foliation. Schistosity not well developed in units relatively poor in micas - textures in these rocks mainly gneissic. Most specimens contain small sparse scattered tourmaline grains, but specimen U72A exposed at GR 282098 has abundant tourmaline, probably resulting from boron metasomatism

associated with the intrusion of the nearby Sybella Granite. Similarly, medium-grained gneiss adjacent to a relatively thick (6 m) tourmaline-muscovite pegmatite dyke at GR 265100 contains scattered tourmaline crystals up to about 3 cm long and coarse muscovite flakes.

Minor interlayered black schistose fine to medium-grained amphibolite, and dark grey-green fine-grained quartz-chlorite and chlorite schist.

(2) Brown to grey, medium-grained, commonly glassy quartzite and muscovite quartzite from adjacent to contacts with Sybella Granite; minor intercalated medium-grained hornblende schist.

(3) Fine to medium-grained sericitic, ?feldspathic, and quartzose meta-arenite and quartzite; white, grey and pale brown to red-brown; ?feldspathic meta-arenites contain pink clay grains; mainly thin to medium-bedded; sericitic rocks commonly friable and schistose; quartzose meta-arenites partly epidotised in places. Meta-arenites in east and far southwest cross-bedded and, more rarely, ripple-marked; contain sparse, small (generally less than 3 cm but up to about 10 cm in far southwest) rounded pebbles of mainly quartzite and vein quartz, and fine black layers rich in heavy minerals. Some units east of the Pinnacles Dam in for southwest contain abundant biotite. Minor pale to dark grey fine-grained, partly epidotised quartzite and pale to dark grey schistose micaceous metasiltstone. Sequence exposed about 3 km southwest of Steeles Tank consists mainly of vertical to west-dipping beds of medium-grained pebbly sericitic, quartzose, and feldspathic meta-arenite and quartzite; white to brown and pale grey; commonly schistose and friable; thin to medium-bedded; vague, poorly preserved possible cross-beds in places; small cubes of altered ?pyrite and ?pyrite casts common in beds at GR 264874. Pebbly units contain scattered to locally abundant rounded clasts up to about 15 cm of mainly glassy recrystallised quartzite and vein quartz; many of the clasts are extensively deformed and flattened. Meta-arenites commonly contain muscovite and, more rarely, biotite flakes, particularly in west. Rare metaconglomerate, metagreywacke, deeply weathered and extensively altered possible amygdaloidal metabasalt, and medium-grained quartz-muscovite schist. Some grey medium-grained quartz-biotite-?muscovite-feldspar gneiss in west, showing small-scale isoclinal folds and crenulations.

(4) White to pale brown thin to medium-bedded medium to coarse-grained, commonly glassy quartzite and muscovite quartzite; foliated in places. Exposed east of the Pinnacles Dam in far southwest of the central belt.

(5) Fairly highly metamorphosed conglomerate and pebbly meta-arenite forming large massive bouldery outcrop at GR 260685; outlines of rounded clasts up to about 15 cm fairly readily discernible; many of the larger clasts appear to have been flattened; most of the readily identified clasts consist of medium to coarse-grained glassy quartzite and vein quartz (commonly recrystallised); matrix is medium to coarse-grained glassy quartzite, commonly containing abundant amphibole or epidote grains.

(6) Minor medium-grained hornblende schist, east of the Pinnacles Dam in far southwest.

(7) Dark grey fine-grained quartz-biotite schist.

(8) Minor medium-grained labile ?tuffaceous meta-arenite containing abundant amphibole needles.

(9) Thin to medium-bedded, commonly schistose pale grey labile meta-arenite with biotite flakes common; exposed at GR 318951.

(10) Coarse chlorite rock with scattered angular fragments of vein quartz up to above 3 cm; crops out near contact with Sybella Granite, at GR 310953.

(11) Rare black medium-grained meta-arenite, apparently consisting mainly of ?hematite and rounded glassy quartz grains; forms bed about 1 m thick at GR 255838.

Structure and metamorphism. Beds and lithological layers have a general northerly trend and moderate to steep dips, almost invariably to the west. No major folds and few major faults have been recognised. Bedding, cross-bedding, and ripple marks are commonly preserved in metasediments in eastern and far southwestern part of belt, but are largely obliterated in west, where a northerly-trending foliation or schistosity is extensively developed. A pronounced northerly-trending cleavage is developed adjacent to the Rufus Fault Zone.

The formation is truncated by the north to north-northwest-trending Wonomo Fault in east and the north-northeast-trending Rufus Fault Zone in west. It is also cut by northeasterly and northwesterly-trending, commonly quartz-filled faults (mainly dextral and sinistral strike-slip types, respectively) with mainly small lateral displacements. It is extensively sheared and recrystallised adjacent to many faults and cut by veins of quartz and, more rarely, coarse actinolite and white calcite, especially adjacent to the Wonomo Fault and in far northwest adjacent to the Rufus Fault Zone; metabasalts and fine to medium-grained amphibolites are converted to zones of fine to coarse-grained chlorite schist and, more rarely, coarse chlorite rock (for example, at GR 403944) and a schistosity is commonly developed in sericitic meta-arenites; more competent quartzite beds are extensively disrupted, buckled, brecciated, and in some places (for example, GR 378005 and GR 364051) foliated. Small chevron folds are developed in chlorite schist in far southwest (at GR 154665); pegmatite and quartz veins adjacent to northerly-trending fault zone in this area are extensively deformed and sheared.

Sequence north and south of Dinner Creek hut in southern part of belt is extensively sheared and quartz-veined, and there are zones of fine to medium-grained quartz schist, and phyllite developed in interlayered metasediments - also some fine-grained quartz-sericite or muscovite schist with altered porphyroblasts (at GR 344829); the foliation is crenulated in places (for example, at GR 339759).

Small-scale isoclinal folds and crenulations are developed in quartzose and sericitic meta-arenites and quartz-biotite-?muscovite-feldspar gneiss at GR 258864 and GR 262876, 4.5 km west of Steeles Tank. Thin pegmatite veins grossly concordant with the foliation in these rocks are commonly extensively deformed and boudinaged.

The regional metamorphic grade appears to increase from east to west - there is a general increase in grainsize westwards where the rocks are generally more highly schistose or foliated than those in the east. Amygdales in metabasalts in the west are commonly extensively deformed, flattened, and 'streaked out'. However, it has not been established whether the apparent increase in metamorphic grade westwards is due to the intrusion of the Sybella

Granite, or to an earlier unrelated metamorphism. Metamorphism of a similar lithological sequence west of the Mount Isa Fault, in the Mount Isa 1:100 000 Sheet area to the north is attributed to relatively low-pressure high-temperature metamorphism (to the upper amphibolite facies) associated with the intrusion of the Sybella Granite (Hill & others, 1975).

The presence of cordierite in metapelites in the western part of the belt indicates (lower to ?middle) amphibolite facies of regional metamorphism (Winkler, 1967). The metamorphic grade in the east is about middle to upper greenschist facies.

Biotite flakes and feldspar grains in many of the schists and gneisses are partly to completely replaced by chlorite and sericite respectively, indicating that the rocks have undergone a later, low-grade (retrogressive) metamorphism.

Obvious thermal contact-metamorphic effects, such as hornfelsing, associated with the intrusion of the Sybella Granite appear insignificant. In some places (for example, GR 301078 and GR 295076) interbedded quartzites in sequence exposed near the granite plutons have saccharoidal textures. At GR 312980 glassy quartzite and muscovite quartzite have been converted to medium-grained saccharoidal quartzite adjacent to contacts with cross-cutting pegmatite veins. At GR 277836 and GR 279837 the main phase of the Sybella Granite truncates the sequence with very little dislocation of the lithological layering. Obvious contact metamorphic effects comprising patchily developed hornfelses are confined in most places to a zone less than 5 m wide.

Stratigraphic relations. The unit is faulted against Mount Isa Group rocks in the east, and is faulted against Saint Ronans metamorphics and Sulieman gneiss in far northwest and southwest, respectively. Contact between Jayah Creek volcanics and Sulieman gneiss about 4.5 km west of Steeles Tank appears to be gradational with little evidence for any major faults. Coarse chlorite rock is developed in the Sulieman gneiss in places adjacent to this contact, but is generally associated with northerly trending pegmatite veins; its formation appears to be related to the intrusion of the pegmatites.

The unit is tentatively regarded as being unconformably overlain by a sequence of meta-arenite, metasiltstone, and shale tentatively assigned to the Mount Isa Group about 6 km west of Rundle Bore. It is also unconformably overlain by flat-lying to gently dipping Middle Cambrian and ?Mesozoic sediments in far south. Some small remnant cappings of laterite and planated, deeply weathered, extensively kaolinised and ferruginised (lateritised) bedrock occur locally.

The formation is cut by an amphibolitic metadolerite dyke swarm about 8 km southwest of Dajarra and by numerous dykes and small irregular pods of amphibolitic metadolerite in north. The metadolerites are difficult to distinguish from the metabasalts on aerial photographs, and are more abundant than shown on map. Many layers of generally non-amygdaloidal amphibolite, mapped as metabasalt, may be metadolerite intrusives. Rarely, doleritic textures are well preserved (for example, at GR 370000 and GR 379004).

The sequence is extensively intruded in the west by Sybella Granite and is also cut by numerous veins of quartz and quartz + feldspar + muscovite ± tourmaline pegmatite near to granite contacts, and at GR 275181 by rare veins of coarse white calcite. Most pegmatite veins appear undeformed; they range up to about 6 m thick, commonly contain small books of muscovite up to about 8 cm and tourmaline crystals up to about 15 cm long, have fine-grained margins in places, and some are cut by quartz veins. They appear to postdate some and possibly all the amphibolitic metadolerite dykes - units tentatively identified as metadolerite are cut by pegmatite veins in places. Sequence also intruded by rare thin, extensively deformed and boudinaged, earlier pegmatite veins (for example, at GR 324859).

The formation is also cut by veins, pods, and small bodies of leucogranite, aplite, pegmatitic granite, and porphyritic biotite granite, and by rare thin (less than 20 m) dykes and ?sills of quartz porphyry, quartz-feldspar porphyry, and even-grained quartzitic rock.

Age. Precambrian.

Correlations. Uncertain. Similar to rocks assigned to the Eastern Creek Volcanics west of the Mount Isa Fault in the Mount Isa 1:100 000 Sheet area to the north (Hill & others, 1975).

Mineralisation. Sequence cut by veins of quartz (for example at GR 248161) and pegmatite (for example, at GR 324859 and GR 291074) containing traces of malachite. In far southwest there are several small pits and trenches up to about 10 m deep in mainly medium to coarse-grained quartz + biotite ± ?hornblende schist containing abundant ?tourmaline in places. Mineralisation consists mainly of malachite and some chrysocolla, azurite, and secondary iron oxide; it appears to be associated with quartz veins in northerly to north-westerly-trending shear zones.

Minor copper deposits, consisting mainly of malachite, chrysocolla and chalcopyrite, and probably associated with thin (<10 m) quartz veins cutting sheared mafic rocks (most of which appear to be altered dolerite), were found in the far north near GR 276162. The copper mineralisation occurs in both the quartz veins and enclosing fine to medium-grained chlorite schist. Several shallow pits were found, but no significant amounts of ore appear to have been mined.

A minor gold rush to the headwaters of Jayah Creek, about 9.5 km east of Jayah Creek Bore and 25.5 km northwest of Dajarra, in the late 1920s or early 1930s was reported by Shepherd (1935). No production from the field was recorded. Shepherd (1935) described the country rocks as consisting mainly of northwesterly-trending hornblende schists and mica schists intruded by numerous quartz veins, and the gold mineralisation appears to have been associated with these veins. Shepherd also reported minor malachite and chalcocite in some of the rocks.

Remarks. Many of the schistose and gneissic metasediments interlayered with the amphibolitic schists are similar petrographically to those in the Saint Ronans metamorphics. Joplin (1955) described cordierite-andalusite-sillimanite-biotite gneiss collected a few metres west of the old Dajarra-Mount Isa road about 10.5 km northwest of Sulieman Bore. She assigned these rocks to her (p. 38) 'older metamorphic complex'. Sillimanite is fairly common in what appear to be equivalent rocks (mapped as Eastern Creek Volcanics) in the Mount Isa Sheet area to the north (Hill & others, 1975).

The unit was mapped as Eastern Creek Volcanics on the photoscale field compilations because it appears to be similar lithologically to regionally metamorphosed rocks mapped as part of the Haslingden Group west of the Mount Isa Fault in the Mount Isa Sheet area to the north. However, it is shown as a separate formation on the Ardmore preliminary map because it has several characteristics not shared with rocks mapped as Eastern Creek Volcanics in the eastern part of the Sheet area - for example, conglomerate is very rare, and no pebbles of felsic volcanics have been positively identified. Metapelites, para-amphibolite, and ?tuffaceous metasediments are abundant in places in the Jayah Creek volcanics, but are scarce or absent in the Eastern Creek Volcanics to the east.

## Timothy Creek meta-arenite member (of the Jayah Creek volcanics)

(name not yet approved)

Map symbols. Ɛjt, Ɛjt?

Nomenclature. Named after Timothy Creek in central east. Previously mapped as Eastern Creek Volcanics (Noakes & others, 1959).

Distribution. North-northeast-trending belt in eastern part of Sheet area. Extends north into Oban 1:100 000 Sheet area, where it has been mapped mainly as Myally Subgroup and partly as Mount Isa Group and Eastern Creek Volcanics (Mock, 1978).

Type area. From GR 392946 to GR 371936, about 9 km southwest of Dajarra.

Thickness. About 2000 m thick in type area. Appears to be significantly thicker in far north, but it is extensively faulted, sheared, and deformed there, and may be partly repeated by faulting, or possibly folded.

Topographic expression and airphoto characteristics. Forms prominent north-northwest-trending range of closely spaced planated strike ridges. Generally characterised by pale to medium tones on aerial photographs, but dark where extensively ferruginised (lateritised).

General lithology. Mainly sericitic meta-arenite in lower part, grading up into quartzose and feldspathic meta-arenites and glassy quartzite; minor pebbly beds. Some labile meta-arenite containing abundant chlorite in lower part of unit.

Details of lithology. Meta-arenites. Mainly white to pale brown, brown, red-brown, buff; fine to medium-grained; thin to medium-bedded, minor thicker beds; cross-bedded, ripple marks present in places (for example, at GR 318089); commonly friable, especially where sericitic; numerous fine layers rich in heavy minerals in lower part of unit; abundant white clay in matrix in some places; ?pyrite casts up to about 1 cm present locally (for example, at GR 304201 and GR 288203). Also some white to pale brown glassy, in places saccharoidal, medium-grained quartzite.

Scattered rounded pebbles (up to about 15 cm) and thin pebbly units occur throughout the sequence: clasts are mainly of vein quartz, white to pale brown glassy medium-grained quartzite, and quartzose and feldspathic meta-arenite or quartzite; some tabular clasts of white to pale grey micaceous metasiltstone are present in south (for example, at GR 408841).

Minor rock types include: (1) pale to dark grey fine to coarse-grained micaceous metasiltstone and chlorite schist (?schistose metasiltstone); (2) dark grey fine-grained quartzite; (3) grey fine to medium-grained vuggy (?calcareous) quartzitic rocks; (4) black fine-grained schistose amygdaloidal and massive metabasalt and dark green fine-grained chlorite schist, with thin interlayered lenses of extensively sheared and brecciated fine-grained quartzite and pale brown fine-grained quartz-muscovite schist; these crop out in far north in an extensively faulted and sheared zone, and most probably represent in-faulted blocks of overlying Jayah Creek volcanics; (5) pale grey to buff friable fine-grained quartz sericite schist and grey fine to medium-grained labile sericitic meta-arenite; (6) brown to grey fine to medium-grained quartz-biotite-muscovite schist.

The rocks are extensively ferruginised and lateritised in places; especially in south. Feldspathic meta-arenites commonly contain small clots of pink clay, probably after feldspar.

Structure and metamorphism. Beds trend mainly north-northwest, face and dip moderately steeply (generally between 50° and 70°) to west, and are not folded on a large scale, except possibly in far north adjacent to the Wonomo Fault. Small-scale folds, crenulations, and chevron folds have developed in beds adjacent to some faults and shear zones. The member is cut by quartz-filled, northeasterly and northwesterly trending faults (mainly dextral and sinistral strike-slip types, respectively), most of which have lateral displacements of less than 1 km. As mapped, the member is truncated in far north and far south by the Wonomo Fault, and also in far north by a major northerly-trending shear zone. Beds are commonly schistose and brecciated along faults.

The member has been regionally metamorphosed to about ?middle greenschist facies. The rocks are only locally schistose, and primary sedimentary structures are generally well preserved. No thin sections have been examined and whether the chlorite identified in some hand specimens of labile meta-arenite resulted from prograde or retrograde metamorphism has not been determined. Chlorite schist (mainly altered metabasalt) is developed in far north in and adjacent to shear zone marking western boundary of unit.

Narrow (up to about 30 cm wide) thermal metamorphic aureoles consisting of white to pale brown and dark grey medium-grained quartzite are exposed in places adjacent to some metadolerite intrusions.

Stratigraphic relations. Overlain and underlain, apparently concordantly, by mafic metavolcanics and interlayered metasediments mapped as Jayah Creek volcanics; cut by numerous, mainly northerly-trending dykes and pods of metadolerite - metadolerite at GR 322087 contains small white remnant feldspar phenocrysts. Locally, the metadolerites contain scattered irregular cavities that are probably vesicles and thin (30 cm) amygdaloidal zones. Some of the metadolerite intrusions may represent feeders to the overlying mafic metavolcanics, but several metadolerite bodies in far north (for example at GR 274186 and GR 290202) do not appear to have intruded beyond the basal part of the unit. Rare remnant cappings of Tertiary (Twidale, 1964) laterite and ferruginous rubble are present at a few localities.

Age. Precambrian.

Correlations. Uncertain. Sequence mapped west of the Mount Isa Fault and its extensions in Sheet areas to the north have been assigned mainly to the Haslingden Group (Hill & others, 1975; Mock, 1978). If that correlation is correct, the Timothy Creek meta-arenite member may be correlated with the Lena Quartzite Member of the Eastern Creek Volcanics. However, the Timothy Creek meta-arenite member is about twice as thick as the maximum thickness recorded for the Lena Quartzite to the north (see Derrick & others, 1977).

Another possibility is that the member is equivalent to the Mount Guide Quartzite - the predominant rock types in the two units are very similar. The Mount Guide Quartzite has a reported maximum thickness of more than 6000 m in the Mary Kathleen Sheet area to the northeast (Derrick & others, 1977) and about 1560 m in the Duchess 1:100 000 Sheet area (Bultitude & others 1978).

Mineralisation. No mineralisation of economic significance is known.

Remarks. Forms continuous, relatively thick, in most places little deformed unit. Consists of mainly mature clastic sediments probably deposited in a shallow-water, nearshore environment.

Unit is labelled 'Pht' on photoscale compilation sheets.

## Undivided ?Mount Isa Group

Map symbol. Pi?

Nomenclature. Mapped as Eastern Creek Volcanics by Noakes & others (1959).

Distribution. Small outcrops in southeastern part of Sheet area about 6.5 km west of Rundle Bore (GR 390830).

Reference area. At GR 327831, about 6.5 km west of Rundle Bore.

Thickness. About 280 m.

Topographic expression and airphoto characteristics. Forms two low, prominent, north to north-northeasterly trending ridges, with trend lines commonly visible, in a fairly flat, extensively soil-covered terrain. Characterised by dark tones on aerial photographs.

General lithology. Quartzose and sericitic meta-arenite, quartzite, ?carbonaceous metasiltstone, metasiltstone, and shale; minor grey to brown fine-grained quartz-mica schist.

Details of lithology. Meta-arenites and quartzites. Thin to thick-bedded and cross-bedded; pale brown, pale to dark grey, white; fine to medium-grained; meta-arenites are commonly friable and characterised by honeycomb weathering; minor glassy quartzite; low-angle cross-beds well developed in places; ripple marks present locally.

Metasiltstones and shales. Dark grey to black, pale grey, yellow-brown to red-brown; partly ?carbonaceous; laminated to thin-bedded; partly silicified; finely banded; some micaceous metasiltstone; contain small pyrite casts and altered pyrite grains and there are some gossany outcrops.

Structure and metamorphism. Beds form keel of syncline partly fault-bounded against Jayah Creek volcanics; they also show broad open cross-folding or warping, indicated by trends ranging from northerly to northeasterly, and have mainly steep dips. They are cut by quartz veins in the southwest and northeast. Metasiltstone and shale adjacent to quartz veins are buckled and contorted, and minor folds have developed. The sediments have been converted to fine-grained quartz-mica schist in northeast, adjacent to what is probably an unmapped major fault separating the unit from the Jayah Creek volcanics. Most of the sediments appear little deformed and are regionally metamorphosed to only very low greenschist grade.

Stratigraphic relations. Uncertain, because contacts with adjacent rocks either faulted or not observed. Tentatively regarded as unconformably overlying the Jayah Creek volcanics, because the sediments appear to be much less metamorphosed than the adjacent metabasalts and interlayered metasediments.

Age. Most probably Proterozoic.

Correlations. Uncertain. Similar lithologically and in metamorphic grade to metasediments in the eastern belt assigned to the lower Mount Isa Group. May also be equivalent to Gunpowder Creek Formation mapped in the western part of the Mount Isa Sheet area.

Mineralisation. None known.

## WESTERN BELT

### Saint Ronans metamorphics

(name not yet approved)

Map symbols. Ps, Ps?, $Ps_a$, $Ps_b$, $Ps_b$?

Nomenclature. Named after Saint Ronans Creek in the southern part of the Sheet area. Mapped as Eastern Creek Volcanics by Noakes & others (1959).

<u>Distribution</u>. Crops out mainly in central-west, south, and east of Ardmore homestead. A small outcrop in far north has also been tentatively assigned to this formation.

<u>Reference area</u>. About 20 km south-southeast of Ardmore homestead, from GR 209857 to GR 171860, where most of the constituent rock types are represented.

<u>Thicknesses</u>. Difficult to estimate accurately because of metamorphism, granite and dolerite intrusion, and obliteration of bedding. Ps - thickness unknown; rough estimates of range in thicknesses for $Ps_a$ and $Ps_b$ are: $Ps_a$ 85-2000 m; $Ps_b$ 85-1600 m.

<u>Topographic expression and airphoto characteristics</u>. Forms hilly to gently undulating terrain with closely spaced foliation or schistosity trend lines commonly visible on aerial photographs. Mainly pale to dark brown and red-brown tones on colour aerial photographs; mafic rocks are characterised by dark tones.

<u>General lithology</u>. Mainly regionally metamorphosed pelitic and psammitic sediments, felsic and mafic volcanics, and ?tuffaceous sediments; extensively intruded by granite, pegmatite, and dolerite.

<u>Details of lithology</u>. <u>Ps</u>. Mainly dark grey to red-brown, fine-grained quartz + muscovite + biotite ± andalusite schist, quartz + biotite + feldspar ± muscovite gneiss, and extensively recrystallised, intensely foliated to schistose even-grained to porphyritic felsic metavolcanics. Andalusite porphyroblasts (commonly replaced by sericite or muscovite) up to about 2.5 cm long are common in some of the schists (metapelites).

The felsic metavolcanics are dark grey, finely recrystallised, and commonly form intensely foliated 'slabby' outcrops. They are generally finely banded, with abundant fine metamorphic biotite concentrated in thin layers and lenticles. Remnant quartz and feldspar phenocrysts tend to be concentrated in certain units or zones. At least some of the metavolcanics appear to be tuffs; these generally show very fine banding and are commonly even-grained, although some consist of alternating thin (less than 30 cm) phenocryst-rich and phenocryst-poor or even-grained layers. Agglomeratic felsic metavolcanics at about GR 064896 contain abundant small (up to about 8 cm) rounded to elongate lithic fragments of mainly fine-grained mafic rocks and some ?felsic metavolcanics, together with euhedral quartz and scattered, relatively large, dark pink feldspar phenocrysts, in a fine-grained, dark grey, siliceous groundmass. They are interlayered with dark grey, fine to medium-grained quartz-biotite schist and schistose, fine to medium-grained quartzitic rocks (?mainly recrystallised felsic tuffs or tuffaceous metasediments) commonly containing abundant fine biotite, scattered muscovite flakes, and possible remnant quartz phenocrysts. The felsic metavolcanics appear to be most abundant in what is regarded as the upper part of the unit.

Minor rock types include: fine to medium-grained biotite schist; pale grey fine to medium-grained quartz-biotite schist with small scattered muscovite porphyroblasts; black fine to medium-grained schistose amphibolite and hornblende schist; fine-grained metabasalt, in places containing abundant biotite; grey to brown micaceous quartzite (commonly friable) with abundant biotite; white, pale grey, and pale brown fine to medium-grained quartzite and muscovite quartzite; fine-grained epidotic quartzite; grey to brown thin to medium-bedded schistose micaceous medium-grained quartz-poor labile meta-arenite; grey to brown medium-grained quartzose and sericitic meta-arenite; pale grey ?chlorite schist.

$\underline{Ps}_a$. Mainly dark grey fine-grained quartzitic recrystallised felsic metavolcanics and interlayered quartz-muscovite-biotite schist and quartz-sericite schist. Felsic metavolcanics are intensely foliated to schistose; siliceous groundmass commonly contains abundant fine biotite flakes; laminated to thin-banded (?bedding); generally non-magnetic; contain small remnant quartz and feldspar phenocrysts; some units or zones are relatively rich in phenocrysts, other units or zones contain few or no phenocrysts; probably mainly tuffs; commonly extensively epidotised; form slabby outcrops; deeply weathered in places to pale grey crumbly rocks with scattered flakes of muscovite. Schists are fine to medium-grained; brown to red-brown and pale to dark grey; commonly friable; laminated in places; contain sparse small porphyroblasts completely replaced by chlorite or aggregates of muscovite flakes.

Minor white to pale grey medium-grained quartzose meta-arenite; grey fine to medium-grained quartzite; pale grey medium-grained feldspathic meta-arenite with scattered flakes of muscovite; grey to brown laminated to thin-bedded fine to medium-grained labile micaceous meta-arenite; schistose micaceous metasiltstone commonly containing ?pyrite casts; fine-grained epidotic quartzite; fine to medium-grained schistose amphibolite; fine to medium-grained grey quartz + biotite + feldspar ± muscovite gneiss; quartz-?chlorite schist (in south). Small-scale cross-beds preserved in some meta-arenite units.

$Ps_b$, $Ps_b$? Mainly black, fine-grained schistose amphibolite with some amygdaloidal zones (e.g., at GR 177919, GR 169945, GR 211060). Sequence contains numerous thin lenses of pale to dark grey, grey-green to green, brown, and white fine to medium-grained quartzose meta-arenite, quartzite, glassy quartzite, and epidotic quartzite. Also some mica schist, quartz-mica schist, and friable sericitic meta-arenite; schistose labile meta-arenite; para-amphibolite; medium to coarse-grained massive to locally schistose amphibolite (?metadolerite), especially in far north (e.g., at GR 190192). Rare fine-grained chlorite schist and at GR 228198 fine-grained massive amphibolite (?metadolerite) with scattered plagioclase phenocrysts.

In far north, east of Jayah Creek Bore (GR 183195), $Ps_b$? contains relatively well-exposed, intensely foliated to schistose dark grey fine-grained quartzitic rocks, interpreted as extensively recrystallised felsic meta-volcanics. Some units contain scattered small pink feldspar ?phenocrysts in a dark grey fine-grained siliceous groundmass containing abundant biotite; other units are even-grained and laminated to thin-banded (?bedded), and are probably metamorphosed felsic tuffs. Sequence is fairly strongly sheared adjacent to contact with Sybella Granite.

Farther south, at GR 211057 and GR 196055, low rubbly outcrops of grey to red-brown, intensely foliated fine-grained micaceous (mainly muscovite-bearing) quartzitic rocks may also be recrystallised felsic volcanics (or micaceous quartzites or tuffaceous metasediments); some rocks contain possible remnant quartz phenocrysts.

The presence of amygdaloidal zones and numerous interlayered lenses of metasediments suggests that the schistose amphibolites are probably mainly metamorphosed basalt lava flows. Some units of fine-grained schistose amphibolite at GR 169945 are finely laminated and may represent metamorphosed mafic tuffs or tuffaceous sediments. No amygdaloidal zones have been found in $Ps_b$? in far north of Sheet area, and the amphibolites in this area may be mainly metadolerites. Fine to medium-grained quartz-mica schists, some containing altered ?pyrite cubes and ?pyrite casts, and quartzose, sericitic, and labile meta-arenites are relatively common in $Ps_b$ in far south (at GR 154820); some grey, fine-grained quartz-biotite-feldspar rocks intercalated with the labile meta-arenites may be metamorphosed tuffs.

<u>Structure and metamorphism</u>. The Saint Ronans metamorphics have a generally steeply dipping foliation trending mainly north to northwest, more or less parallel to the lithological layering; small crenulations and kink bands are common, but few major folds have been positively identified. In the south, about 6 km north-northwest of Rufus Tank (GR 202786), foliation and rare bedding in $Ps_a$ and $Ps_b$ have easterly trends, dip generally steeply southwards, and are cut by a prominent northerly-trending cleavage. Most quartz veins in this area also have easterly trends.

Andalusite schist, quartz-feldspar porphyry, and schistose amphibolite similar lithologically to units mapped in the east (west of the Rufus Fault Zone) have also been mapped in the western part of the Ps outcrop, and may form part of the same stratigraphic succession that has been broadly folded.

The foliation in metamorphic rocks mapped as $Ps_a$ and $Ps_b$ dip steeply away from the margins of the granite intrusion exposed about 13 km north of Rufus Tank. Just to the south of this pluton, the metamorphics together with an extensive metadolerite intrusion (?sill) have been folded about a north-westerly-trending axis.

The metamorphics are highly sheared and extensively deformed adjacent to many faults.

The general obliteration of bedding, the widespread development of schistose rocks, the presence of andalusite porphyroblasts in some metapelites, and the extensive recrystallisation of the felsic and mafic volcanic rocks are interpreted as indicating mainly upper greenschist to possibly lower or middle amphibolite grades of regional metamorphism. Metamorphic grade appears to decrease to south.

Retrograde metamorphism and deformation, perhaps associated with the intrusion of the Sybella Granite, are indicated by the very extensive replacement of andalusite by mainly fine sericite and quartz, by the partial replacement of biotite by chlorite, and by the presence of deformed and bent mica flakes in some of the schists.

Rocks from adjacent to the contacts with some of the granite bodies are coarser-grained than those from farther from the contacts, and the micas tend to be more randomly oriented and the schistosity not as well defined. These features may be due to thermal metamorphism of the country rocks by the granite.

Stratigraphic relations. Ꝑs is extensively intruded by veins, pods, and larger masses of granite and pegmatitic granite and by swarms of pegmatite dykes; these intrusions are mapped as part of the Sybella Granite batholith; most of the granite is leucocratic; the pegmatites commonly contain muscovite and some are also tourmaline-bearing. Granite and pegmatite bodies are less common in units Ꝑs$_a$ and Ꝑs$_b$ than in Ꝑs. The formation is also cut by many quartz veins, and by numerous non-schistose to schistose amphibolitic metadolerite dykes and ?sills, some of which are extensive and apparently grossly concordant with foliation in the enclosing schists. Most, possibly all, of the metadolerites were intruded before the granitic rocks because many are cut by granite and pegmatite veins.

Ꝑs, Ꝑs$_a$, and Ꝑs$_b$ appear to be concordant and to locally interfinger. Ꝑs$_a$ and Ꝑs$_b$ are tentatively regarded as forming the upper part of the formation.

Relations with the Oroopo Volcanics are uncertain; the two formations appear concordant and no major break has been recognised between them, - cross-beds in a south-dipping meta-arenite unit in the volcanics at GR 126763, indicate beds are right way up and younging southwards. Rare cross-beds in the Saint Ronans metamorphics adjacent to the contact indicate that this sequence is right way up, and underlies the Oroopo volcanics.

Formation is unconformably overlain by flat-lying to gently dipping Middle Cambrian sediments of the Georgina Basin succession.

Age. Precambrian.

Correlations. Uncertain. May be equivalent to the Yaringa Metamorphics in the western part of the Mount Isa Sheet area (Hill & others, 1975), which consist mainly of quartz-muscovite and quartz-sericite schist and phyllite, minor quartz-muscovite-biotite gneiss, migmatitic rocks, and quartz-feldspar porphyry, and rare conglomerate (reported by Carter & others, 1961). However, the cleavage in the Yaringa Metamorphics has a well-defined easterly trend (Carter & others, 1961; Hill & others, 1975) whereas that in the Saint Ronans metamorphics has mainly northerly to northwesterly trends.

Other possible correlatives to the east and northeast are the Bottletree formation (exposed at the base of the Haslingden Group, mainly in the Duchess 1:100 000 Sheet area) and units in what is interpreted as the upper part of the Tewinga Group (Magna Lynn Metabasalt and Argylla Formation, exposed mainly in the Duchess, Mary Kathleen, and Prospector 1:100 000 Sheet areas). Both these sequences contain felsic and mafic metavolcanics and interlayered lenses of metasediments.

Mineralisation. None known.

Remarks. Many of the smaller granite bodies intruding Ᵽs are not shown on the map because they could not be distinguished from the country rocks on the aerial photographs and their boundaries could not be accurately photo-interpreted.

The presence of andalusite, and the absence of garnet, staurolite, kyanite, sillimanite, and orthoclase in metapelites, indicate low-pressure Abukuma-type regional metamorphism (Miyashiro, 1961), which reached about lower or middle amphibolite facies grade.

## Oroopo volcanics
(name yet to be approved)

Map symbols. Ᵽov, Ᵽov?, Ᵽov$_q$, Ᵽov$_s$, Ᵽov$_1$.

Nomenclature. Named after Oroopo Waterhole (GR 319892) on Sulieman Creek. Previously mapped as Eastern Creek Volcanics and Sybella Granite (Noakes & others, 1959).

Distribution. Exposed mainly in southwest; small outcrops in central-north also tentatively regarded as forming part of this unit. Extends south into the Glenormiston 1:250 000 Sheet area.

Reference area. In southwest, about 20 km southwest of Oroopo Waterhole, between GR 158793 and GR 055670.

Thicknesses. Ᵽov, unknown - sequence has been folded and extensively faulted. Ᵽov$_q$ has maximum thickness of about 400 m, Ᵽov$_s$ about 1300 m, and Ᵽov$_1$ about 100 m.

Topographic expression and airphoto characteristics. Smooth low undulating terrain with dark red-brown to dark grey tones on colour aerial photographs (metabasalts); steep-sided, commonly planated strike ridges with mainly pale to medium tones on aerial photographs (meta-arenites), but dark where lateritised; low undulating terrain characterised by dark blue-grey tones(limestone lenses); and plains and low hills with dark red-brown tones(metasiltstones).

General lithology. Amygdaloidal and massive metabasalt, and lenses of meta-arenite, quartzite, and metasiltstone; minor limestone, chlorite schist, calcareous meta-arenite, metadolerite.

Details of lithology. Pov, Pov? Mainly amygdaloidal and massive metabasalt with lenses (generally less than 5 m thick) of meta-arenite, quartzite, and metasiltstone. Minor chlorite schist, flow-margin breccia, scoriaceous metabasalt, dark brown fine-grained recrystallised limestone, and non-schistose to schistose amphibolitic metadolerite.

Metabasalt. Fine-grained; mainly non-foliated, but locally sheared; grey, greyish green, and black; epidote and/or ?chlorite generally abundant; scattered small ?pyrite grains present in places; amygdaloidal zones common - amygdales generally undeformed and filled with quartz, epidote, and, in places, minor pink ?feldspar; commonly schistose and chloritic (especially in southwest) adjacent to faults, adjacent to contacts with more competent, relatively thick quartzose meta-arenite interbeds, and adjacent to Saint Ronans metamorphics. Some flow-margin breccia in places; consists of fragments of amygdaloidal metabasalt in a fine-grained epidotic matrix of quartzite or altered comminuted lava debris. A possible pahoehoe lava-flow surface, consisting of coalescing elliptical bulbous bodies of metabasalt up to about 1 m across, is exposed at GR 132778; most of the ellipsoids have a thin outer selvage of dark grey-green, fine-grained, 'cherty', massive metabasalt characterised by concentric banding, and a non-banded core of highly amygdaloidal, rarely massive, metabasalt; radial structures characteristic of pillow lavas were not identified (see Macdonald, 1972).

Meta-arenites and quartzites. White to dark grey, grey-green and brown; commonly epidotic; thin to medium-bedded; fine to medium-grained; quartzose, feldspathic, and sericitic, with fine bands rich in heavy minerals. Sericitic meta-arenites are commonly schistose and friable. Minor grey fine-grained sericitic labile meta-arenite containing small (3 cm) rounded pebbles of fine-grained ?metabasalt occur in the south.

Metasiltstone. Extensively weathered dark grey to black and pale brown to red-brown, micaceous, medium-bedded, commonly banded; some interlayered fine grained meta-arenite.

$Pov_q$. Mainly quartzose and feldspathic meta-arenite and quartzite. White to pale brown, more rarely grey; commonly ironstained; mainly thin to medium-bedded; medium to coarse-grained; cross-bedded; local ripple marks. Quartzites are commonly glassy. Minor sericitic meta-arenite. Some friable beds. Rarely, beds show a bimodal distribution of grains. Zones of pebbly meta-arenite, and metamorphosed conglomerate and grit are common: clasts are angular to rounded, up to about 15 cm, and consist of mainly vein quartz and glassy quartzite. Some beds in north contain small scattered altered ?pyrite grains and ?pyrite casts.

Minor highly sheared dark grey to pale brown metasiltstone and micaceous metasiltstone, pale brown to buff fine-grained thin-bedded micaceous meta-arenite, and fine to medium-grained quartz-chlorite schist (developed in Rufus Fault Zone).

$Pov_1$. Mainly recrystallised limestone, calcareous meta-arenite, and fine-grained, red-brown ?calcareous metasiltstone. Limestone. White, pale to dark grey, black, buff, brown to red-brown, ochreous yellow; fine-grained, recrystallised; mainly laminated to medium-bedded with thin irregular, closely spaced wavy bands common; chert nodules commonly present; some beds have pitted and grooved weathered surfaces and circular structures up to 30 cm across; thin interbeds of pink to brown medium-grained calcareous meta-arenite also commonly present. Beds are commonly extensively buckled and contorted and show many small-scale open 'wavy' to tight folds.

Calcareous meta-arenite at base of unit near GR 124742 is dark red-brown, ferruginous, laminated to thin-bedded, and shows gradational contacts with underlying quartzose meta-arenite and overlying limestone.

North of Rufus Tank, at GR 217867, ?basal part of sequence mapped as $Pov_1$ consists of extensively chloritised and epidotised amygdaloidal and massive metabasalt, dark brown medium to coarse-grained meta-arkose and gritty meta-arkose, and white to brown fine to medium-grained cross-bedded quartzose and feldspathic meta-arenite with fine bands rich in heavy minerals.

$Pov_s$. Dark grey or weathered and ferruginised to brown or dark red-brown; micaceous and siliceous; laminated to thin-bedded; fine-grained; bedding commonly wavy and crenulated; beds highly sheared and buckled adjacent to faults with kink bands or chevron folds well developed. Minor quartzose and sericitic meta-arenite: brown to grey; extensively sheared, weathered and ferruginised, medium-grained; contains thin interbeds of grey metasiltstone.

Sequence cut by thin quartz veins and by fine to medium-grained, non-schistose amphibolite metadolerite (doleritic texture preserved) dyke with chilled margins.

Structure and metamorphism. Bedding attitudes are generally difficult to determine because the sequence consists mainly of metabasalt in which trends are rarely obvious. In the southwest, west of the Rufus Fault Zone, interbedded sediments trend generally northwest and dip steeply southwest. In the Rufus Fault Zone, trends are mainly north-northeast and dips are steep to vertical.

$Pov_q$ and $Pov_1$ are exposed at about GR 125735 in what appears to be the core of a small structural basin truncated by a fault to the north, and form a small anticline in the Rufus Fault Zone at GR 161730.

The formation is cut by several faults, adjacent to which it is commonly buckled and contorted. It is bounded to the east by the northerly trending Rufus Fault Zone, along which the final movements appear to postdate those on the northwest and northeast-trending faults which cut the formation. Adjacent to major faults, especially in the Rufus Fault Zone, the metabasalts are extensively altered to fine-grained chlorite schist, and kink bands and chevron folds are well developed; bedding in meta-arenites and quartzites is extensively buckled and crenulated, and in many places the metasediments have been converted to quartz schist and quartz-muscovite schist. In places within the Rufus Fault Zone, quartz veins cutting chlorite schist (metabasalt) are extensively deformed and boudinaged.

The general lack of a well-developed schistosity away from faults, the presence of chlorite and probable actinolite in most of the metabasalts, and the general preservation of primary igneous and sedimentary structures indicate mainly greenschist grades of regional metamorphism. The metamorphic grade appears to increase towards a highly sheared contact with Sybella Granite in the far north, where lower amphibolite-grade rocks may be present, and it may also increase towards the contact with the Saint Ronans metamorphics in the southwest.

Stratigraphic relations. The Oroopo volcanics appear to concordantly overlie $Ps_a$ of the Saint Ronans metamorphics; however, the contact between the two units is very poorly exposed and the formations are extensively intruded by metadolerite adjacent to the contact. The formation is unconformably overlain by Middle Cambrian and ?Mesozoic sediments; contacts with other formations are either faulted or covered by superficial deposits; It is cut by numerous quartz veins and metadolerite dykes. The formation is apparently intruded by veins of muscovite-pink feldspar-quartz pegmatite and non-foliated to foliated porphyritic to non-porphyritic biotite granite at GR 217867, similar to Sybella Granite elsewhere in the Sheet area.

Age. Precambrian; considered to be older than Sybella Granite.

Mineralisation. Minor malachite and chrysocolla occur along partings and in amygdales in metabasalt.

Carrelations. May be equivalent to the Eastern Creek Volcanics mapped in the eastern part of the Sheet area.

Remarks. The Oroopo volcanics resemble the Eastern Creek Volcanics to the east; for example, (1) both sequences consist mainly of basaltic lava flows that have been regionally metamorphosed to mainly greenschist grade; (2) both sequences are cut by numerous, metadolerite dykes; (3) granitic rocks are rare in the Oroopo Volcanics and have not been found in the Eastern Creek Volcanics, although farther east and northeast in the adjoining Dajarra and Duchess 1:100 000 Sheet areas the Eastern Creek Volcanics are cut by the Garden Creek Porphyry of unknown affinities. However, there are also several differences between the Oroopo volcanics and Eastern Creek Volcanics in the Ardmore Sheet area. One of the most noteworthy differences is the presence in the Eastern Creek Volcanics of abundant conglomerate containing pebbles of finely-recrystallised felsic volcanics. Also, the Eastern Creek volcanics apparently concordantly overlie the Mount Guide Quartzite, a thick sequence of quartzose, feldspathic, and sericitic meta-arenite, whereas the Oroopo volcanics appear to be concordant on a sequence of mainly pelitic metasediments and felsic metavolcanics (Saint Ronans metamorphics). Such differences may be the result of facies variations from east to west, or they may indicate that the two formations are not equivalent.

The Oroopo volcanics are shown as Eastern Creek Volcanics on released field compilation sheets.

## NOTES ON PHANEROZOIC SEDIMENTS

### Cambrian rocks of the Georgina Basin succession

Sedimentary rocks of the Georgina Basin succession crop out mainly in the southwest and in the Ardmore Outlier (about 13 km southeast of Ardmore homestead). Small isolated remnants, mainly cappings, also occur in the far south and central part of the Sheet area. The rocks are mainly flat-lying to gently dipping, and rest with marked unconformity on the folded and regionally metamorphosed rocks and granites of the Precambrian Cloncurry Complex. The Cambrian succession was mapped by F. de Keyser and P.J. Cook in 1969 (de Keyser & Cook, 1972) following the discovery, in the mid to late 1960s, of phosphate deposits in lower Middle Cambrian rocks exposed in the Ardmore Outlier and Quita Creek area, as well as in Sheet areas to the north and east (Russell, 1967; Thomson & Russell, 1971). The Cambrian rocks in the Ardmore Sheet area have been examined within the last ten years by many geologists mainly from mining companies and universities, but most of the results of their work are unpublished and not readily available.

I did not examine the Cambrian rocks in any detail. The boundaries and subdivisions of the Cambrian units shown on the photoscale compilations and the Preliminary-edition 1:100 000 map were photo-interpreted from colour aerial photographs at about 1:25 000 scale, using unpublished photoscale compilations (worksheets) at about 1:50 000 scale prepared by de Keyser & Cook, and figures 15 and 16 in BMR Bulletin 138 (de Keyser & Cook, 1972) as guides.

### Riversdale Formation, Thorntonia Limestone, Beetle Creek Formation, Blazan Shale, Quita Formation, Steamboat Sandstone, undivided Cambrian

Map symbols. Cml, Cml?, Cmt, Cmt?, Cme, Cme?, Cmb, Cmb?, Cmq, Cmq?, Cms, Cms?, Cm, Cm?

Nomenclature. Units described by Opik (1957, 1960), Noakes & others (1959), de Keyser & Cook (1972), and de Keyser (1973).

Distribution. Mainly in southwest, west of the Rufus Fault Zone, and in Ardmore Outlier in the central part of Sheet area; some small scattered remnants in far north, central-west, and far south (east of Rufus Fault Zone); present in subsurface in central-west and northwest.

Thickness (reported maximum). Cml = 30 m; Cmt = 20 m; Cme = 15 m; Cmb = 60 m; Cmq = 70 m; Cms = 100 m, Cm in far south has a maximum thickness of about 30 m, and is probably less than 30 m elsewhere.

Topographic expression and airphoto characteristics. Main landforms are plains, subdued undulating terrain commonly with terraces and benches, low terraced hills, and mesas; these have pale to dark tones on aerial photographs.

General lithology. Conglomerate, quartz arenite, sandy siltstone, siltstone, shale, claystone, silty phosphorite, phosphatic siltstone, pelletal phosphorite, dolomite, dolomitic limestone, marl, chert (commonly convolute or vuggy), silicified chert breccia. Calcareous and dolomitic units commonly contain chert nodules, and are bituminous in places. Sediments of the Riversdale Formation are generally brown to red-brown, ferruginous.

Details of lithology. Remnant cappings in far central-south mapped as Cm consist of units apparently equivalent to the Riversdale Formation, the Chert Member (also referred to as the Ardmore Chert Member) of the Thorntonia Limestone (de Keyser & Cook, 1972; de Keyser, 1973), and the Beetle Creek Formation. The sequence here has not been subdivided because individual units are generally too small to be delineated on the 1:100 000-scale map. A similar sequence adjacent to the Rufus Fault Zone in the far south of the western belt has been subdivided into Riversdale and Beetle Creek Formations; here chert and chert breccia at the top of the Riversdale Formation have been included in the Beetle Creek Formation for convenience, although the unit is probably equivalent to the Chert Member (not delineated on the preliminary map) mapped by de Keyser & Cook (1972) and de Keyser (1973) as part of the Thorntonia Limestone.

The parts of the Riversdale Formation and basal part of undivided Cambrian (Cm) that I examined consist of mainly white to dark brown ferruginous fine to medium-grained and pebbly to gritty quartzose and feldspathic arenite, and minor dark brown pebbly ferruginous siltstone. Minor conglomerate is also present in the basal parts of the units, and fine to medium-grained white to brown and red-brown laminated to thin-bedded ferruginous quartz arenite (commonly containing scattered sericite flakes), micaceous siltstone, and shale are present in the upper parts. Ripple-marks occur in places. Pebbles in the conglomeratic beds are unsorted, angular to rounded, up to about 15 cm (but generally less than 3 cm), and consist mainly of vein quartz with some quartzite and chert; they show a general decrease in size and abundance with height in sections.

The basal, mainly arenaceous sediments are overlain by white to dark grey and pale brown to yellow-brown vuggy banded chert and chert breccia (generally silicified), probably equivalent to the Chert Member of the Thorntonia Limestone (de Keyser & Cook, 1972; de Keyser, 1973). However, in the far south and far north (immediately east of main Mount Isa-Boulia road) the chert has been included within the Beetle Creek Formation because the outcrops are too small to be shown separately on the map. East-northeast of Split Creek Tank (GR 201036) in central part of Sheet area, the chert unit appears to directly overlie Saint Ronans metamorphics.

The chert unit is overlain by white to pale grey and pale brown to red-brown, commonly massive and banded silicified siltstone which generally has a conchoidal fracture, and also by some white fine-grained micaceous siltstone, red-brown to ochreous yellow ferruginous siltstone, and white to pale brown thin to medium-bedded and locally finely banded fine-grained quartz arenite which commonly contains scattered flakes of sericite. This sequence is probably equivalent to part of the Beetle Creek Formation.

Structure and metamorphism. Beds are mainly flat-lying to gently dipping; dips generally less than 10°, except near some faults. Not metamorphosed. Cut by the Rufus Fault Zone and subsidiary faults but vertical displacements are estimated to be less than 100 m and there is no evidence of any significant lateral fault movement. There is no change in rock type or in thickness of Cambrian formations across the fault bounding the western margin of the Ardmore Outlier, and no significant offsetting of beds (de Keyser & Cook, 1972). The Ardmore Outlier is graben bounded by normal faults (de Keyser & Cook, 1972).

Poorly exposed Cambrian sediments north of Cement Springs in the north of the Sheet area are shown as overlapping the Rufus Fault Zone, but relations between sediments and faulting in this area are not known.

Stratigraphic relations. The Cambrian units form a concordant, and in places interfingering, sequence, and contacts between units are commonly gradational. However, succession contains several unconformities or disconformities and hiatuses in deposition (diastems) (Öpik, 1957, 1960; de Keyser & Cook, 1972; de Keyser, 1973; Druce, 1978). They are unconformable on Precambrian rocks of the Cloncurry Complex and are unconformably overlain by pebbly and conglomeratic arenites of probable Mesozoic age. Beds are extensively ferruginised in places and there are some small remnant cappings of laterite.

<u>Age</u>. Mainly Middle Cambrian; the Steamboat Sandstone may be partly Upper Cambrian (Druce, 1978).

<u>Correlations</u>. Correlated with Cambrian units exposed elsewhere around the margins of the Georgina Basin (Öpik, 1957, 1960; de Keyser & Cook 1972; de Keyser, 1973; Druce, 1978).

<u>Mineralisation</u>. The Beetle Creek Formation exposed in the Ardmore Outlier and Quita Creek area contains phosphate deposits concentrated mainly in the upper part of the formation (Thomson & Russell, 1971; de Keyser & Cook, 1972). The richest and most extensive deposits found are in the Ardmore Outlier, where the phosphatic sediments in the upper part of the Beetle Creek Formation have an average thickness of about 7 m, a maximum thickness of about 12 m, and consist mainly of pelletal phosphorites interbedded with grey and black cherts and siliceous shales (Thomson & Russell, 1971).

<u>Remarks</u>. The Riversdale Formation, at the base of the succession, was originally thought to be Late Proterozoic or Early Cambrian (Noakes & others, 1959; Carter & others, 1961), but is now regarded as probably mainly Ordian (lowermost Middle Cambrian, J.H. Shergold, BMR, personal communication, 1979). The symbol representing the formation has consequently been changed from Pur to Cml. It is interpreted as a transgressive, littoral-marine, in places perhaps fluvial, deposit forming the basal part of the sedimentary Cambrian succession (de Keyser, 1973).

Rubbly black-and-white banded and convoluted chert and chert breccia forming a layer up to about 15 m thick is well developed in the Quita Creek area, and also crops out in the Ardmore Outlier, and is referred to by de Keyser & Cook (1972) as the Chert Member and by de Keyser (1973, fig. 6) as the Ardmore Chert Member of the Thorntonia Limestone. De Keyser & Cook observed that the Chert Member generally overlies calcareous and dolomitic beds of the Thorntonia Limestone and underlies the Beetle Creek Formation, but noted, however, that in places the chert layer rested directly on Precambrian basement rocks. Southgate & Henderson (1978) regarded the chert layer as forming the basal unit of the Beetle Creek Formation. Outcrops of the Ardmore Chert Member have also been mapped in the Glenormiston 1:250 000 Sheet area to the south (de Keyser & Cook, 1972, fig. 19). The origin of the chert is conjectural (see de Keyser & Cook, 1972) and some recent workers have suggested that the chert represents a silicified evaporite deposit.

Environments of deposition appear to have ranged from very shallow-water, evaporitic, to deeper marine; during deposition there was relatively little influx of clastic detritus from the adjacent, presumably subdued, Precambrian landmass. The Steamboat Sandstone represents a phase of clastic sedimentation.

## ?Mesozoic sediments

Map symbol. M.

Distribution. Small scattered outcrops in west, south and north.

Topographic expression and airphoto characteristics. Forms mainly thin remnant cappings on mesas; some low rubbly rises in far west and southeast. Medium tones on aerial photographs.

Thickness. Commonly variable owing to deposition on an irregular surface; maximum of about 10 m.

General lithology. Conglomerate, grit, arenite; minor silcrete.

Details of lithology. Mainly pebble and boulder conglomerate and grit at base overlain by and interlayered with quartz arenite. In most places the conglomerate contains unsorted, rounded to angular clasts up to about 1 m of mainly vein quartz, chert, quartzite, glassy quartzite, muscovite quartzite, quartzose and sericitic meta-arenite, and pebbly quartzose meta-arenite; some arenite lenses are also commonly present.

Coarse conglomerate is generally confined to basal parts of succession. At GR 221885, conglomerate contains rounded to subangular clasts up to about 2 m of mainly deeply weathered crumbly medium-grained granite, fresh non-foliated medium-grained biotite granite with scattered small (1 cm) pink feldspar phenocrysts, pale brown to grey medium-grained feldspathic meta-arenite, meta-arkose, and white to grey banded chert and chert breccia. Most of the clasts, particularly the larger ones, appear to have been locally derived from Precambrian units. In far south (GR 208666) conglomerate contains medium to coarse-grained recrystallised quartzite and muscovite quartzite similar to quartzites in the Kallala quartzite exposed about 2.5 km to the west. Similarly, conglomerate at about GR 135699 contains clasts of fairly distinctive medium to coarse-grained quartzose meta-arenite in which angular vein quartz clasts are evident. These pebbly quartzose meta-arenite clasts closely resemble pebbly quartzose meta-arenite of the Oroopo volcanics exposed about 3 km to the northwest. The clasts of banded chert and chert breccia were most probably derived from Middle Cambrian units.

Arenite overlying, interlayered with, and forming the matrix of the conglomerate is friable to extensively silicified, white to brown and dark-brown, ferruginous (lateritised) to bleached, and medium to coarse and partly gritty and pebbly; it commonly contains abundant clay.

Sequence commonly extensively silicified and in a few places (for example, GR 757115 and GR 158936) an irregular layer of silcrete up to about 3 m thick has developed in the upper part of the succession. At GR 158936 the silcrete appears to have extensively replaced the matrix between clasts in conglomerate.

In far southeast, unit is represented mainly by rubble of generally well-rounded pebbles and boulders up to about 1 m (interpreted as a disaggregated conglomerate), and rare low scattered outcrops of white gritty and pebbly claystone - manganese-stained and silified in places - and brown coarse-grained gritty and pebbly arenite.

Structure and metamorphism. Essentially flat-lying and unmetamorphosed.

Stratigraphic relations. Unconformable on underlying units; deposited on an irregular eroded surface, and in places now preserved in depressions at a lower level than surrounding older rocks (for example, at GR 123735). Overlies deeply weathered, extensively ferruginised and kaolinised granite in far south.

Age. Probably mainly Mesozoic.

Correlations. Skwarko (1966) included the ?Mesozoic sediments of the Urandangi 1:250 000 Sheet area with the Cretaceous Mullaman beds, which are reported to consist of a non-marine sequence overlain by marine beds.

Remarks. Sequence has been extensively ferruginised (lateritised) and silicified in places. It is commonly capped by a thin veneer of laterite, or more rarely, silcrete has extensively developed in the upper part of the unit. The laterite is generally regarded as having formed in the Tertiary, but the age of the formation of the silcrete is unknown, probably Cainozoic. The silcrete has been included as part of the probable Mesozoic succession, mainly because the outcrops are generally too small to be shown on the 1:100 000 map.

Mesozoic? sediments in the Ardmore 1:100 000 Sheet area may be largely fluviatile. Plant fossils were found in the sequence in the far north of the sheet area by de Keyser & Cook (1972).

## Laterite

Map symbols. Tl, Tl?

Distribution. Mainly in southern half of Sheet area; most extensive in far southeast; some small areas in northeast.

Topographic expression and airphoto characteristics. Forms remnant cappings on mesas of ?Mesozoic, Cambrian, and Precambrian rocks; characterised by dark tones on aerial photographs.

Thickness. Generally about 3 m or less - in many places preserved as thin rubble layer; however, in far southeast, at GR 289674, it is at least 10 m thick.

Lithology. Massive, layered and pisolitic lateritic ironstone; no structures or textures of original bedrock preserved. At GR 289674 laterite has a conglomeratic appearance on weathered surfaces and consists mainly or rounded to angular fragments of laterite in a fine-grained laterite matrix. Minor silcrete (GR 334906).

Age. Probably Tertiary (Twidale, 1964).

Remarks. Relation between silcrete and laterite not known; at GR 334906 silcrete crops out at lower level than adjacent laterite.

## Weathered bedrock

Map symbols. Tc, Tc?

Distribution. Small outcrops in central and southern parts of Sheet area.

Topographic expression and airphoto characteristics. Forms cappings on small mesas; medium to dark tones, paler than those of laterite, on aerial photographs.

Thickness. Up to about 10 m.

Lithology. Bleached to ironstained kaolinised bedrock in which some original textures and structures are clearly visible.

Stratigraphic relations. Locally capped by laterite.

Age. Probably Tertiary.

Remarks. Probably represents lower parts of lateritic weathering profiles formed in situ under relatively stable conditions during the Tertiary (Twidale, 1964).

## Chalcedony and ?soil

Map symbol. Ty.

Distribution. Small outcrop at Oroopo Waterhole, 18 km southwest of Dajarra.

Topographic expression and airphoto characteristics. Small low mesa; characterised by medium tones on aerial photographs.

Thickness. About 15 m exposed in southern bank of Sulieman Creek at Oroopo Waterhole.

Lithology. Dark red ferruginous crumbly ?lateritic ?soil capped by flat-lying layer of white, grey, and brown, commonly highly vuggy chalcedony with a waxy lustre.

Age. Probably Late Tertiary or early Quaternary (see Paten, 1960).

Correlations. May be equivalent to the Austral Downs and Noranside Limestones (Paten, 1960).

Remarks. The vuggy chalcedony may be of lacustrine origin. White, vuggy, opaline chalcedony ( 6 m thick) exposed in the bank of Carbine Creek at GR 441823, and vuggy chalcedony blocks forming rubble at Rufus Creek Bore (GR 328729) in far southeast, are probably part of this unit but are not distinguished on the map. The deposits appear to have formed in old creek valleys.

## Mainly unconsolidated sediments

Map symbols. Czs, Czr, Czb, Qa.

Distribution. Widespread in Sheet area, especially in northwest and southeast; most widespread in valley of Sulieman Creek, and overlying Middle Cambrian sediments in the northeast.

Topographic expression and airphoto characteristics. Present on plains and footslopes, and in depressions and creek beds; pale to moderately dark tones on aerial photographs.

Thickness. Probably up to about 15 m.

Lithology. Mainly unconsolidated sand, silt, gravel, clay, and grey to black cracking-clay soils ('black soil'); alluvial, colluvial, and residual. Also included are small outcrops in beds of some of the larger creeks (for example, Sulieman Creek at GR 309898) of conglomerate containing mainly unsorted cobbles, pebbles, and sand in a pale grey fine-grained ?calcareous matrix (cemented river bed deposits); the matrix is commonly crumbly.

Age. Probably partly Tertiary and partly Quaternary.

Remarks. Form a thin and impersistent cover on many areas shown as bedrock on the 1:100 000-scale geological map.

## DESCRIPTIVE NOTES ON INTRUSIVE ROCK UNITS

### Sybella Granite

Map symbols. Pgs, Pgs?, $Pgs_f$, $Pgs_f$?, $Pgs_p$, $Pgs_p$?, $Pgs_g$.

Nomenclature. Named after Sybella Creek in the Mount Isa 1:100 000 Sheet area; defined by Carter & others (1961); subdivided by Hill & others (1975) into four main types. Previously described by Joplin (1955), Joplin & Walker (1961), and Wilson (1972). Mapped as Sybella Granite and Eastern Creek Volcanics in the Ardmore 1:100 000 Sheet area by Noakes & others (1959).

Distribution. Main outcrops are in a northerly trending belt in the central part of the Sheet area; there are also scattered small outcrops in west, south and southwest of Ardmore homestead. Main belt extends north into the Oban 1:100 000 Sheet area and south into the Glenormiston 1:250 000 Sheet area.

Reference area. From about 15.5 to 24 km west of Dajarra, in area traversed by the Mount Isa-Dajarra and the old Dajarra-Ardmore roads. Most of the main granite types are well exposed in this area and easily accessible.

Topographic expression and airphoto characteristics. Landforms range from moderately rugged boulder-strewn hills and low ranges (mainly in north) to gently undulating coarse sand plains with scattered spheroidal boulders. Mainly medium tones on aerial photographs. Outcrops in south and west commonly extensively ferruginised (lateritised), deeply weathered, and characterised by darker tones.

General Lithology. Pgs. Porphyritic biotite granite; minor pegmatite, pegmatitic granite, non-porphyritic biotite granite, biotite leucogranite, biotite-muscovite leucogranite, muscovite leucogranite, strongly foliated to gneissic biotite-hornblende granodiorite, gneissic biotite granite, and augen gneiss; rare biotite-?hornblende diorite.

$Pgs_g$. Grey, intensely foliated to gneissic, xenolithic, porphyritic biotite-hornblende granodiorite, extensively intruded by veins, pods, and small masses of several types of granite. The granodiorite is characterised by a relatively dark tone on aerial photographs.

<u>Pgs</u>$_f$. Intensely foliated to gneissic, even-grained to richly porphyritic biotite granite; some augen gneiss, muscovite leucogranite, biotite-muscovite granite. Intruded by veins and pods of foliated to non-foliated biotite leucogranite, pegmatitic and megacrystic leucogranite, and pegmatite.

<u>Pgs</u>$_p$. Medium-grained to pegmatitic, non-foliated to foliated biotite granite and muscovite-biotite granite.

<u>Details of lithology</u>. <u>Pgs</u>. <u>Mainly medium to coarse-grained, porphyritic biotite granite</u>; <u>some even-grained granite</u>; non-foliated to foliated, in places gneissic (for example, at GR 156679 and GR 224131); foliation generally defined by thin discontinuous layers of biotite flakes, rarely by alignment of feldspar phenocrysts; the central parts of most plutons are non-foliated. Generally contains sparse to abundant euhedral to subhedral phenocrysts (up to about 4 cm long) and, in places, megacrysts up to about 8 cm long of white to pink feldspar; rapakivi textures, characterised by overgrowths of white feldspar (?albite) on rounded to subhedral pink feldspar (microcline) phenocrysts, are common in places (for example at GR 253013 and GR 280872, where the overgrowths appear to be confined to certain zones). Rarely, small glassy quartz phenocrysts are present, for example, at GR 280872. Groundmass consists mainly of quartz, white feldspar, and biotite; minor interstitial purple fluorite was observed in specimen W456 from GR 292835. Some ?contaminated granite typically with 'swirly' biotite-rich layers, and zones of pegmatitic granite occur in places, mainly west of the Rufus Fault Zone.

The granite contains sparse to abundant mafic, biotite-rich clots and inclusions up to about 60 cm in diameter; these are generally less than 15 cm in diameter away from marginal zones of plutons. Xenoliths up to 5 m long, and also larger pendants of country rocks, mainly quartzite and amphibolite (extensively converted to biotite schist), are common close to the margins of plutons, and migmatite is developed in a few places - for example, at GR 290069. The granite also contains numerous xenoliths of medium-grained, intensely foliated to gneissic biotite-hornblende granodiorite containing scattered pale pink feldspar phenocrysts up to about 1 cm long; the granodiorite inclusions tend to be concentrated in zones and are particularly common in the pluton exposed 20 km west of Dajarra. Also locally present are: (1) sparse, rounded to angular inclusions, up to about 1 m, of non-foliated even-grained to slightly porphyritic medium to coarse-grained biotite granite (at GR 261985 and GR 280873); (2) xenoliths up to about 1 m of quartz-feldspar porphyry or porphyritic microgranite (at GR 280873) and pegmatite (at GR 280873); and (3) irregular segregations or pods of pegmatitic granite, at least some of which (for example, at GR 274683) appears to have gradational contacts with the enclosing finer-grained granite.

The granite plutons generally show a narrow (generally less than 1 m wide) 'chilled' zone at contacts, consisting of fine to medium-grained generally foliated porphyritic to even-grained biotite granite.

The granite is cut by veins, pods, and small masses of quartz; quartz + feldspar ± muscovite pegmatite (rarely biotite-bearing); fine to coarse-grained, intensely foliated to non-foliated, rarely xenolithic, patchily porphyritic biotite granite and leucogranite; and rare pegmatitic granite. Veins and pods of porphyritic biotite microgranite at GR 216204 contain small anhedral quartz phenocrysts as well as larger feldspar phenocrysts.

Country rocks adjacent to the coarse-grained porphyritic biotite granite plutons are extensively intruded by graphic quartz + feldspar ± muscovite ± tourmaline pegmatite veins up to about 6 m thick.

The granite is extensively kaolinised and partly lateritised, particularly in the south, where scattered small mesa cappings, up to about 7 m thick, in which mafic minerals and feldspar have been replaced by chlorite and clay minerals respectively, are common.

Minor rock types mapped as Pgs include: (1) Grey foliated to gneissic, sparsely porphyritic, medium-grained biotite-hornblende granodiorite, well exposed 20 to 22 km west-southwest of Dajarra. Granodiorite extensively intruded by veins of: (a) foliated coarse-grained, porphyritic biotite granite, (b) foliated, commonly ptygmatically folded fine to coarse-grained, patchily porphyritic biotite granite, biotite leucogranite, and leucogranite containing scattered opaque oxide grains, and (c) quartz-pink feldspar pegmatite. (2) Augen gneiss containing sparse to abundant xenoliths (up to about 30 cm) of mainly rounded biotite-rich mafic rocks and sparse relatively large (up to about 1 m) angular to rounded inclusions of medium to coarse-grained glassy recrystallised quartzite, amphibolite, and foliated coarse-grained patchily porphyritic biotite granite. (3) Fine to medium-grained non-porphyritic granite with glassy quartz grains; appears to form small pendant in coarse-grained porphyritic biotite granite at GR 282872. (4) Medium-grained biotite-rich diorite containing abundant small (generally less than 3 cm but up to about 15 cm in diameter) mafic xenoliths - now mainly biotite-rich clots. The diorite forms small pods (?remnants) exposed at about GR 258006 and GR 258009; the pods are strongly foliated along their margins but their central parts are weakly foliated to massive. They are intruded by coarse porphyritic biotite granite and veins of graphic quartz-pink feldspar pegmatite. At GR 258009 the adjacent granite appears locally chilled against the diorite, which crops out as a northerly-trending dyke-like body about 10 m wide. (5) Intensely sheared medium to coarse-grained gneissic quartzofeldspathic rocks and augen gneiss; some of the gneisses have thin quartz-rich and feldspar-rich layers. The rocks are tentatively regarded as extensively sheared and recrystallised granite. Most extensive outcrops are in the Cement Springs area, about 26.5 km northwest of Dajarra, adjacent to the Rufus Fault Zone. Here the rocks commonly contain secondary chlorite and feldspar phenocrysts which are augen-shaped but generally not recrystallised; the gneiss is intruded by thin quartz-pink feldspar pegmatite veins, grossly concordant with the foliation. North from the fault zone the gneissic rocks appear to grade into intensely foliated porphyritic to non-porphyritic biotite granite which is cut by thin aplite and pegmatite veins and by numerous shear zones.

Pgs$_p$ . Mainly relatively leucocratic medium-grained to pegmatitic even-grained to porphyritic non-foliated to foliated biotite granite, muscovite-biotite granite, and muscovite leucogranite commonly containing numerous segregations, pods, and zones of pegmatite and pegmatitic granite. The pegmatitic zones grade imperceptibly into enclosing finer-grained granite and consist mainly of graphically intergrown quartz and feldspar. The granites commonly contain scattered white feldspar megacrysts up to about 15 cm (for example, at GR 165861); some of the megacrysts are graphically intergrown with quartz. The granites also contain numerous, mainly mafic biotite-rich xenoliths (up to about 1 m).

Pgs$_p$ forms small masses intruding Saint Ronans metamorphics west of the Rufus Fault Zone. Some bodies contain numerous white to pale pink feldspar phenocrysts up to about 1 cm long in marginal contact zones and have slightly coarser, more even-grained central parts. The largest mass, exposed about 27 km west-southwest of Dajarra, appears to be a marginal phase of the main porphyritic biotite granite phase (Pgs). Pgs$_p$ is extensively intruded in places by veins and pods of quartz + white to pale pink feldspar + muscovite ± tourmaline pegmatite.

Pgs$_g$ . Grey, strongly foliated to gneissic medium to coarse-grained biotite-hornblende granodiorite and minor augen gneiss; exposed about 22 to 24 km west-southwest of Dajarra; foliation commonly wavy and crenulated;

contains scattered pale pink feldspar phenocrysts up to about 1 cm long and rare feldspar megacrysts up to about 5 cm; phenocrysts commonly extensively recrystallised and 'smeared' or 'streaked' out - many are augen-shaped. The granodiorite contains abundant xenoliths up to about 2 m in diameter and sparse larger remnants of country rocks, including glassy quartzite, schistose amphibolite, and medium grained quartz-biotite-feldspar gneiss; also contains scattered pegmatitic segregations consisting mainly of pink feldspar.

The granodiorite is extensively intruded by a variety of granitic veins and pods, including: (1) Mainly coarse-grained, intensely foliated to gneissic porphyritic biotite granite containing numerous pale pink feldspar phenocrysts up to about 1 cm long; foliation commonly wavy and crenulated; many of the feldspar phenocrysts are augen-shaped and have recrystallised to aggregates of smaller grains; granite contains larger xenoliths of medium-grained granodiorite in places. Some veins are less than 30 cm wide, but show no significant chilling along contacts with granodiorite. (2) Coarse-grained non-foliated biotite granite containing pale pink feldspar phenocrysts up to about 3 cm long and sparse small lensoid mafic xenoliths. (3) Foliated to non-foliated medium to coarse-grained, patchily porphyritic to even-grained biotite granite and leucogranite; these veins postdate (1) and at least some antedate (2); some veins contain small (1 cm) scattered pink feldspar phenocrysts or angular to rounded xenoliths (of mainly ?microgranodiorite) up to about 30 cm across. (4) Tourmaline-bearing pegmatite, which postdates (1).

The granodiorite is cut by a non-schistose amphibolitic metadolerite dyke at GR 230028.

$Pgs_f$. Mainly medium to coarse-grained, intensely foliated to gneissic even-grained to richly porphyritic biotite granite; also some foliated medium-grained biotite-muscovite granite, augen gneiss, quartzofeldspathic gneiss, even-grained leucogranite, highly sheared white muscovite leucogranite, biotite-rich foliated granodiorite with scattered small feldspar phenocrysts. Granitic rocks extensively recrystallised in places (for example, GR 243902). Feldspar phenocrysts, up to about 3 cm long are commonly augen-shaped and recrystallised to aggregates of smaller grains. Granite contains scattered rounded xenoliths (up to about 15 cm) of mafic rocks and larger, more angular inclusions and pendants of hornblende schist, quartzite, and quartz-biotite-feldspar gneiss.

Cut by veins, commonly less than 3 cm wide, and small pods of: (1) fine to coarse-grained foliated to non-foliated biotite leucogranite; (2) coarse-grained pegmatitic leucogranite containing feldspar megacrysts up to 4 cm long;

(3) quartz + feldspar ± muscovite pegmatite; and (4) medium-grained non-foliated biotite granite, commonly pegmatitic in central parts, which in places cuts pegmatite (3) veins.

Thin veins are mainly grossly concordant with foliation, which, in places (for example, at GR 247703, GR 242704, GR 255016) shows small-scale folds and crenulations; thin pegmatite veins at GR 228131 are boundinaged.

The granitic rocks are commonly highly sheared and in places form chloritic mylonites adjacent to Rufus Fault Zone in the north.

Structure and metamorphism. The Sybella Granite forms mainly elongate (in a northerly direction) plutons, almost invariably characterised by sharp contacts with adjacent country rocks. Hornfelsing of adjacent country rocks is generally very slight and, in most places, restricted to within 5 m or less of the contact. Tourmaline in schistose metasediments near granite contacts is attributed to boron metasomatism by the granite.

The oldest phases (including $Pgs_g$ and at least some $Pgs_f$) are intensely foliated (the foliation roughly paralleling the regional foliation in the adjacent Jayah Creek volcanics and Sulieman gneiss), commonly extensively recrystallised, and generally preserved as narrow elongate bodies concordant with the regional foliation. These bodies are probably syntectonic intrusions. The widespread recrystallisation indicates moderate-grade regional metamorphism.

The main granite phase - medium to coarse-grained porphyritic biotite granite (Pgs) - forms the largest plutons. These generally have foliated margins and non-foliated to slightly foliated central parts. The relation between the massive and foliated phases appears to be gradational. The granite generally shows some deformational effects in thin sections, even where it appears massive in outcrop. The eastern and western contacts of most plutons are concordant with the foliation in the adjacent regionally metamorphosed country rocks, but the southern and northern contacts generally truncate the foliation at high angles. In most places the granite appears to have been emplaced with little deformation of the adjacent country rocks; for example, at GR 277836 and GR 279837, amphibolitic and quartzitic country rocks truncated by coarsely porphyritic biotite granite show only slight buckling within about a metre or so of the granite; immediately adjacent to the contact epidotic quartzite has been thermally metamorphosed to medium to coarse-grained, glassy, granoblastic quartzite.

The Sybella Granite is cut by numerous northwest to northeast-trending faults and shear zones, many of which form part or are splays of the Rufus Fault Zone. North and south-southeast of Cement Springs (GR 223131) the granite is cut by numerous, commonly closely spaced shear zones ranging from about 1 m to 10 m wide, along which porphyritic biotite granite is converted to mylonite and schistose rocks consisting mainly of small quartz augen, abundant fine muscovite, and finely recrystallised ?feldspar; no feldspar phenocrysts are preserved. Quartz veins and some biotite schist also occur in the shear zones. Epidote and epidote-rich veinlets are common in sheared granite in south of Sheet area.

All granite specimens examined in thin section show some evidence of strain: alkali feldspar and quartz grains generally show undulose extinction, and partial to complete comminution or recrystallisation of large alkali feldspar and quartz grains to fine-grained aggregates is common. The deformation appears to have been accompanied by partial sericitisation of the original plagioclase feldspar grains.

<u>Stratigraphic relations</u>. Unconformably overlain by flat-lying to gently dipping Middle Cambrian and ?Mesozoic sediments; granite and overlying sediments are generally extensively weathered, kaolinised, and ferruginised at contact. Intrudes Jayah Creek volcanics, Saint Ronans metamorphics, Kallala quartzite, Sulieman gneiss, and probably Oroopo volcanics: in the Rufus Fault Zone (at GR 217867) rocks assigned to the Oroopo volcanics appear to be cut by pegmatite and granite veins regarded as being related to the Sybella Granite. The granitic rocks are not seen in contact with the Mount Isa Group or Haslingden Group rocks mapped in the eastern part of the Sheet area.

The country rocks adjacent to outcrops of Sybella Granite are cut by numerous pegmatite veins assumed to be related to the Sybella Granite; in places (for example, GR 175715) there is a thin zone, ranging from about 1 m to less than 3 cm thick, of pegmatite separating the country rocks from the granite. Some pegmatite veins cut both granite and country rocks, but some appear to merge into the granite.

Most pegmatite veins intruding the Jayah Creek volcanics are tabular, apparently undeformed cross-cutting dykes or veins, commonly with chilled margins and generally bearing muscovite and tourmaline. These are assumed to be late intrusions related to the main porphyritic biotite granite phase (Pgs).

Pegmatite veins of at least two different ages cut the Sulieman gneiss - an early deformed set and a later essentially undeformed set.

Some plutons of intensely foliated granite and granodiorite are intruded by rare metadolerite dykes, and porphyritic biotite granite at GR 256006 is cut by a northeast-trending dyke of dolerite containing scattered grains of ?pyrrhotite or ?chalcopyrite (Lakeview Dolerite type, Derrick & others, 1978).

Age. Precambrian - probably Carpentarian. None of the granitic rocks in the Ardmore Sheet area have been isotopically dated, and the age range of the Sybella Granite is yet to be satisfactorily resolved (also see Hill & others, 1975; Derrick & others, 1978).

Correlations. Correlated with the Sybella Granite mapped in the Oban and Mount Isa 1:100 000 Sheet areas to the north (Hill & others, 1975; Mock, 1978). However, some plutons, particularly those west of the Rufus Fault Zone may be equivalent to the Big Toby Granite mapped in the Mount Isa 1:100 000 Sheet area, the age of which is uncertain (Derrick & others, 1978).

Mineralisation. No economic concentrations of ore deposits known in formation. In the late 1960s, an exploration company examined pegmatite dyke swarms and the adjacent intruded country rocks (mainly Sulieman gneiss) in far central-south of Sheet area for uranium minerals thought to be related to the intrusion of the pegmatites.

Remarks. The name 'Sybella Granite' is used in a geographical sense to include all granitic rocks exposed west of the Wonomo Fault in the Ardmore Sheet area. As such the Sybella Granite is a complex of several plutons comprising several main and minor granite types, the general order of emplacement apparently being form relatively mafic to relatively felsic.

The relatively young plutons consisting mainly of non-foliated to foliated porphyritic biotite granite, show many of the characteristics of mesozonal intrusions listed by Buddington (1959), including: (1) the plutons are generally of composite character, being made up of two or more units; (2) the plutons have complex emplacement relations with the country rocks - in part discordant, in part grossly concordant; (3) planar foliation is generally well developed in the outer parts of the plutons, but is commonly only weakly developed in the central parts; (4) younger units crosscut the foliation of older units; (5) highly chilled, aphanitic rocks are absent from the contact zones of the plutons, which do, however, generally show some chilling restricted to narrow zones adjacent to contacts; (6) migmatitic (mixed) rocks are generally absent; (7) pegmatites are abundant; and (8) a schistosity in the country rock bordering the plutons is widespread. Buddington (1959, p. 697) noted that 'in the larger or relatively deep mesozonal batholiths regional metamorphism is associated. Phyllites and slates are changed to high-grade crystalline schists, and hornfels may form from metavolcanic rocks or metalimestones in the vicinity of contacts'. The widespread presence of mainly amphibolite-grade regional metamorphic rocks in the belts intruded by the Sybella Granite, therefore, suggests that the plutons were emplaced at relatively deep levels in the mesozone.

Pods of augen gneiss and plutons of biotite-hornblende granodiorite and more leucocratic biotite granite, which are characterised by a gneissic foliation and commonly extensively intruded by the main, porphyritic biotite granite phase, may have been emplaced in the catazone. There is a general conformity between country rock and intrusive, and the intrusives are interpreted as syntectonic. The augen gneisses and some of the quartzofeldspathic gneisses mapped as part of the Sulieman gneiss may also represent syntectonic catazonal intrusives. The associated country rocks have been regionally metamorphosed to amphibolite grade and appear to be the highest-grade rocks exposed in the Sheet area.

## Mafic intrusives (mainly dykes)

Map symbols. Largest bodies labelled 'dl', '$dl_a$' or '$dl_d$'; otherwise shown as unlabelled dyke symbol.

Distribution. Found throughout most of the Precambrian part of the Sheet area; many more present than shown on 1:100 000-scale map.

Thicknesses. Commonly less than 10 m thick, but range up to more than 1 000 m.

Topographic expression and airphoto characteristics. Tend to form depressions and narrow linear valleys. Form low bouldery hills and ridges in southwest where more resistant to erosion than adjacent quartz-mica schists and recrystallised felsic volcanics of the Saint Ronans metamorphics. Characterised by dark tones on aerial photographs.

General lithology. Mainly amphibolitic metadolerite; minor chlorite schist, biotite schist, apparently unmetamorphosed dolerite and biotite dolerite. Some lenses of medium-grained hornblende ± biotite schist in the Sulieman gneiss and Kallala quartzite are probably metamorphosed and ?metasomatically altered dolerite dykes.

Details of lithology. $dl_a$. Fine to coarse-grained schistose to non-schistose amphibolitic metadolerite. Well-exposed relatively thick dykes show fine-grained schistose margins and coarser-grained non-foliated centres with doleritic textures commonly preserved; centres non-porphyritic to porphyritic with remnant phenocrysts of white plagioclase. Some dykes in the Jayah Creek volcanics and Timothy Creek meta-arenite member are characterised by zones containing sparse to abundant vesicles.

At GR 403942 fine-grained, schistose amygdaloidal and massive metabasalt of the Jayah Creek volcanics is extensively intruded by metadolerite dykes forming large massive outcrops characterised by numerous fine bands or layers (?compositional layering), and zones containing vesicles up to about 1 cm wide. At GR 397943, GR 398939, GR 399939, and GR 274186, banded metadolerite contains sparse to numerous vesicles up to about 5 cm in diameter, generally concentrated in marginal zones. These vesicular units are interpreted as relatively high-level intrusives.

$dl_d$. Relatively rare. Sulieman gneiss is cut by small pods and dykes of apparently unmetamorphosed dolerite containing abundant primary biotite, and the main phase of the Sybella Granite is cut by a northeast-trending dyke of apparently unmetamorphosed medium-grained dolerite containing primary biotite and scattered grains of ?pyrrhotite or ?chalcopyrite.

dl. Undivided dolerite and schistose to non-foliated amphibolitic metadolerite; minor chlorite schist, biotite schist, and hornblende schist. Symbol used to label mafic intrusives delineated by airphoto-interpretation but not examined in the field.

Structure and metamorphism. Steeply dipping to vertical, and mainly concordant with bedding or foliation. Some of the mafic intrusives have been regionally metamorphosed to greenschist grade, and some to amphibolite grade; youngest intrusives, such as the dyke intruding Sybella Granite about 19.5 km west of Dajarra, do not appear to have been regionally metamorphosed.

Stratigraphic relations. Intrude all formations except Mount Isa Group metasediments. Early granites of the Sybella Granite are intruded by rare non-schistose amphibolitic metadolerite dykes. However, most, possibly all, of the amphibolitic metadolerites were intruded before the main granite type; those examined in areas adjacent to the granite plutons are commonly cut by granite and pegmatite veins assumed to be related to the main Sybella Granite phase.

Age. Proterozoic. At least two ages of mafic intrusives are present - those intruded before the main Sybella Granite type and those intruded after it, the former being by far the more abundant.

Correlations. May include intrusive equivalents of basalt lavas in the Saint Ronans metamorphics, Oroopo volcanics, Jayah Creek volcanics, and Eastern Creek Volcanics. The apparently unmetamorphosed dolerite dyke intruding Sybella Granite has no known extrusive equivalent, but may be equivalent to the Lakeview Dolerite mapped in the Mary Kathleen 1:100 000 Sheet area (Derrick & others, 1977) and to the unmetamorphosed dolerite dyke intruding Burstall Granite in Duchess 1:100 000 Sheet area (Bultitude & others, 1978).

Mineralisation. Unmetamorphosed dolerite dyke intruding Sybella Granite contains scattered specks of ?pyrrhotite or ?chalcopyrite.

## Minor felsic intrusives

The Jayah Creek volcanics are intruded by rare thin (less than 20 m) dykes and ?sills of quartz porphyry, quartz-feldspar porphyry, and even-grained quartzitic rock, generally concordant with, but locally cross-cutting, the regional foliation. At about GR 298858 (about 1 to 1.5 km south-southwest of Steeles Tank) and GR 309833 (about 3.5 km south of Steeles Tank), the unit consists of small euhedral to subhedral quartz and white to pale pink feldspar phenocrysts enclosed in a grey, fine-grained, recrystallised, siliceous groundmass; it has a very fine-grained ?flow-banded non-porphyritic ?chilled western (?upper) margin (the enclosing sequence is inferred to young westwards - it generally dips west and in places faces west), and may be a sill. Another thin (5 m) unit of quartz-feldspar porphyry is exposed about 3.5 km south of Steeles Tank at about GR 307834; it contains numerous small euhedral quartz and feldspar phenocrysts in a fine-grained recrystallised siliceous groundmass.

The porphyry at GR 307851 contains sparse small quartz phenocrysts and numerous mafic inclusions (up to about 5 cm across) in a fine-grained dark grey recrystallised siliceous groundmass. At GR 307851 one of the porphyry units cuts across the foliation in the enclosing metabasalts.

Sheared feldspar porphyry (not shown on map) poorly exposed at GR 124666 forms what appears to be a thin dyke intruding mafic rocks mapped as Jayah Creek volcanics adjacent to the Rufus Fault Zone. The porphyry contains white to pink feldspar phenocrysts, up to about 3 cm long, in a highly sheared micaceous fine-grained groundmass.

## STRUCTURE AND METAMORPHISM

Structural elements in the Ardmore 1:100 000 Sheet area and mineral assemblages in the regionally metamorphosed Precambrian rocks of the area have yet to be investigated in detail and are only briefly discussed below. Faults and large-scale folds are commonly difficult to detect in the mafic rocks, schists, and gneisses because of a lack of distinctive marker units that can be traced on aerial photographs.

### FOLDING

#### Eastern belt

The structure is shown best by meta-arenites of the Mount Guide Quartzite in the north and those tentatively assigned to the Warrina Park Quartzite in the south. These have been folded about northerly-trending axes into mainly open to tight synclines and anticlines characterised by steeply dipping to vertical axial planes and horizontal to moderately steeply plunging axes. Some beds in the north are overturned. Fold axes in the ?Mount Guide Quartzite in the far north (at GR 363188 and GR 355184) plunge northwards at between 0 and 40°, and at GR 365139 they plunge southwards at about 60°. In the central part of the Sheet area, just north of the main Mount Isa-Boulia road, meta-arenites of the Mount Guide Quartzite appear to plunge southwards at about 20° to 30°. A major syncline well exposed in meta-arenites of ?Warrina Park Quartzite, about 2 km east-northeast of Wonomo Waterhole plunges northwards at about 20°. A northerly-trending, steeply dipping to vertical axial-plane fracture cleavage subparallel to bedding (on the limbs of the folds) is commonly well developed in the hinge zones of folds, especially in the south; beds are generally extensively brecciated and disrupted, and bedding is largely obliterated in these areas.

Bedding in thin calcareous units interlayered with regionally metamorphosed massive pebbly greywacke and greywacke conglomerate of the Yappo formation shows small-scale folds and crenulations in places.

Mount Isa Group metasediments exposed in the northern and central parts of the eastern belt trend north-northwest and are mainly west-dipping to vertical. However, scattered thin slivers of metasediments, in places dipping to the east, exposed adjacent to the Wonomo Fault and tentatively assigned to the Warrina Park Quartzite may indicate that the Mount Isa Group rocks have been synclinally folded about a north-northwest-trending axis rather than simply tilted and faulted. Poorly exposed ?dolomitic metasediments assigned to the Moondarra Siltstone in the far north show small-scale isoclinal folds with northerly-trending axes.

## Central belt

The Jayah Creek volcanics making up the bulk of the eastern part of the central belt form an apparently ordered succession in which no major folds and few major faults have been recognised. The degree of deformation increases westwards; in the western part of the belt, bedding is largely obliterated, and a northerly-trending foliation or schistosity is extensively developed, together with some small-scale isoclinal folds and crenulations with axes trending north-northwest to north-northeast and plunging north at between 30 and 60°. Small-scale folds, crenulations and chevron folds have also formed in beds adjacent to some faults and shear zones in the eastern part of the belt.

The most extensively deformed and highly metamorphosed rocks, mainly those of the Sulieman gneiss and Kallala quartzite, crop out in the western part of the central belt where they are intruded by the Sybella Granite. Foliation and lithological layering in the Sulieman gneiss commonly show small-scale folds and crenulations. Some reversals in dip directions suggest that the Sulieman gneiss may be tightly folded in places.

Bedding trends in the Kallala quartzite are mainly northerly, and dips are moderately steep to vertical. Variations in trend and dip directions indicate that the unit has been tightly folded about mainly vertical north to northeast-trending axial planes. Photo-interpretation suggests that fold axes plunge to the northeast, north-northeast, and southwest.

Small outcrops of meta-arenite and metasiltstone, tentatively assigned to the Mount Isa Group, west of Rundle Bore in the south show broad open flexures or warps indicated by trends ranging from northerly to northeasterly. Variations in dip directions indicate that the outcrops form the keel of a small, at least partly fault-bounded syncline.

Primary igneous foliation is fairly rare in the Sybella Granite except near contacts with country rocks. However, a weak metamorphic foliation is commonly developed even in the central parts of plutons. All specimens, including those from massive, apparently non-foliated outcrops, of Sybella Granite examined in thin section, showed some evidence of deformation, such as undulose extinction in quartz grains.

## Western belt

The Saint Ronans metamorphics have a generally steeply dipping foliation trending mainly north to northwest, more or less parallel to the predominant trend of the lithological layering. Small crenulations and chevron folds are common, but few major folds have been identified. In the south, about 6 km north-northwest of Rufus Tank, foliation and rare bedding in the metamorphics have easterly trends, dip steeply southwards, and are cut by a prominent northerly-trending cleavage or schistosity. The variations in trend directions and the disposition of units in the metamorphics and overlying Oroopo volcanics appear to outline part of a large anticline truncated by the Rufus Fault Zone to the east and extensively covered by Cambrian and superficial deposits to the west.

The metamorphic rocks have been domed outwards by the emplacement of granite mapped as Sybella Granite about 13 km north of Rufus Tank, and, in most places around the margins of the pluton, the foliation dips steeply away from the granite. Just to the south of this pluton, the metamorphics together with an extensive metadolerite intrusion have been folded about a northwesterly-trending axis. This folding was probably associated with the emplacement of the pluton.

Attitudes in the Oroopo volcanics are generally difficult to determine because the sequence consists mainly of metabasalt in which trends are rarely obvious. In the southwest (west of the Rufus Fault Zone) interbedded meta-sediments indicate a general northwesterly bedding trend with steep dips to the southwest. Adjacent to the Rufus Fault Zone, some of these interbedded sediments show minor flexures and folds with northerly to northeasterly-trending axes. Meta-arenite with some recrystallised limestone mapped as part of the Oroopo volcanics outline what appears to be a small, partly fault-bounded structural basin at GR 125735.

The Oroopo volcanics have been extensively deformed in and adjacent to the Rufus Fault Zone where trends are mainly north-northeast and dips are steep to vertical. In places, beds have been folded about northerly-trending axes to form small anticlines and synclines. The calcareous metasediments commonly show small-scale folds and crenulations.

Adjacent to major faults - mainly in the Rufus Fault Zone - the metabasalts in the Oroopo volcanics are extensively altered to fine-grained chlorite schist in which chevron folds are commonly well developed. Bedding in the meta-arenites or quartzites is extensively buckled and crenulated, and in many places the metasediments have been converted to quartz schist and quartz-muscovite (or sericite) schist. In places in the Rufus Fault Zone, quartz veins cutting chlorite schist are extensively deformed and boudinaged.

FAULTING

The faults in the area consist mainly of a obscure northerly-trending set, a conjugate set trending northeasterly and northwesterly with relatively small displacements, and the north to north-northwest-trending Wonomo Fault and the north-northeast-trending Rufus Fault Zone which traverse virtually the entire Sheet area.

A few faults trending between north-northeast and north-northwest have been mapped, mainly in the eastern and central belts. Quartz and pegmatite veins with similar trends in the Saint Ronans metamorphics may be filling pre-existing fractures. Most of these appear to be normal or high-angle reverse faults developed along lithological boundaries parallel to bedding and foliation trends. Such faults are most evident within outcrops of Mount Guide Quartzite and Yappo formation of the Haslingden Group in the eastern belt, where they are commonly filled by metadolerite dykes. Metadolerite dykes intruded parallel to bedding and foliation trends in the Timothy Creek meta-arenite member and Kallala quartzite of the central belt may also have been largely emplaced along faults.

In general the northerly-trending faults are the oldest faults mapped in the area; they (and the metadolerite-dyke fillings) are displaced by faults of the conjugate set. Possible exceptions are the faults of the Rufus Fault Zone and Wonomo Fault which may have been initiated during a period of meridional faulting, and were probably controlled by deep-seated crustal discontinuities. The Wonomo Fault truncates the Mount Isa Group, one of the youngest Proterozoic units recognised in the region, and some movement along faults in the Rufus Fault Zone occurred in the Phanerozoic after the deposition of the Cambrian Georgina Basin succession. The Ardmore Outlier is essentially a down-faulted graben in the Rufus Fault Zone (de Keyser & Cook, 1972).

Northwesterly-trending faults of the conjugate set are well developed in the eastern belt; northeast-trending faults of the set tend to be more prominent in the central belt; and both types are about equally represented in the western belt. Some are quartz-filled and form steep-sided narrow ridges. The faults are more or less vertical, and movement along them appears to have been mainly dextral strike-slip along those trending northeast, and sinistral strike-slip along those trending northwest; lateral displacements are up to about 1 km. The movements along the conjugate set of faults indicate an overall east-west compression (see Anderson, 1951).

Most faults of the conjugate set are probably more or less of similar age. Northeast and northwest-trending faults which cut Cambrian sediments in the far southwest parallel faults of the conjugate set and probably resulted from movements along pre-existing fractures in the underlying Precambrian basement rocks.

The Rufus Fault Zone is interpreted as an extension of the Mount Annable Fault mapped in the adjoining Oban 1:100 000 Sheet area to the north; the Mount Annable Fault is regarded as an extension of the Mount Isa Fault by Mock (1978), but is regarded as part of the right-lateral Mount Remarkable Fault System to the north by G. Derrick, BMR, (personal communication 1979). The Wonomo Fault is truncated by the Mount Annable Fault in the far south of the Oban 1:100 000 Sheet area, and is probably an extension of the Mount Isa Fault. Displacements accompanying faulting have not been established because of the complexities of the structures and the lack of readily correlatable units across the faults.

Some faulting probably took place during the emplacement of the Sybella Granite. The Saint Ronans metamorphics are cut by easterly-trending quartz and pegmatite veins that may have been emplaced along fractures during this period.

## METAMORPHISM

### Eastern belt

The highest-grade regional metamorphic rocks in the eastern belt appear to be those of the Bottletree and Yappo formations, the two oldest units exposed in the belt. Felsic volcanics in the Bottletree formation are extensively recrystallised and contain abundant metamorphic biotite, probably indicating mainly middle to ?upper greenschist grade of regional metamorphism. Some beds in the Yappo formation are completely recrystallised, whereas others appear only partly recrystallised; the formation contains abundant metamorphic biotite and rare chlorite.

Meta-arenites of the Mount Guide Quartzite and Eastern Creek Volcanics are schistose and recrystallised only locally, mainly adjacent to faults or dolerite dykes, and primary sedimentary structures are generally well preserved. The presence of relict primary igneous textures, the lack of a regional foliation, and the common occurrence of biotite and chlorite in metabasalts from the upper part of the Eastern Creek Volcanics indicate a low greenschist grade of regional metamorphism. The regional metamorphic grade of the Mount Isa Group rocks appears similar to that of the upper Eastern Creek Volcanics.

## Central belt

The regional metamorphic grade in the central belt appears to show a general increase from east to west. The Jayah Creek volcanics in the east appear to consist of middle to upper greenschist facies rocks. Non-schistose amygdaloidal metabasalt is present in a few places, and primary sedimentary structures are generally well preserved in the Timothy Creek meta-arenite member. The presence of cordierite porphyroblasts in metapelites of the Jayah Creek volcanics in the west indicate (?lower) amphibolite grades of regional metamorphism (Winkler, 1967). Rocks of slightly higher (middle to upper amphibolite) grade may also be present locally. Joplin (1955) reported sillimanite (as well as cordierite and andalusite) in metasediments that I have mapped as part of the Jayah Creek volcanics.

The Sulieman gneiss and Kallala quartzite have been metamorphosed to amphibolite grade. Rocks are medium to coarse-grained and recrystallised, and hornblende and clinopyroxene (?salite) are common in amphibolites and calc-silicate rocks respectively.

The increase in metamorphic grade westwards may be due to emplacement of the main unit (Egs) of the Sybella Granite, to a regional metamorphic event or tectonic episode that culminated with the emplacement of the Sybella Granite, or to an earlier regional metamorphism unrelated to the intrusion of the main unit of the Sybella Granite. The evidence overall appears to indicate that there is no direct relation between grade of regional metamorphism and the intrusion of the main unit of the Sybella Granite. The Sulieman gneiss and Kallala quartzite, for example, contain the most coarsely recrystallised and probably some of the highest grade rocks in the central belt, but are not extensively intruded by the main unit of the Sybella Granite. Meta-arenites of the Jayah Creek volcanics adjacent to the Sybella Granite have not been extensively converted to coarse-grained glassy quartzites, whereas arenites in the Sulieman gneiss and Kallala quartzite to the west have been completely recrystallised to medium to coarse-grained glassy quartzites which commonly show triple-point-type junctions between grains and contain relatively coarse flakes of muscovite. However, metamorphism of a similar lithological sequence west of the Mount Isa Fault, in the Mount Isa 1:100 000 Sheet area to the north, is attributed to relatively low-pressure high-temperature metamorphism (to the upper amphibolite facies) associated with the intrusion of the Sybella Granite (Hill & others, 1975).

In the Ardmore 1:100 000 Sheet area the oldest granite units are intensely foliated and commonly extensively recrystallised, and are generally preserved as narrow elongate bodies concordant with the regional foliation. The Sulieman gneiss contains numerous thin pegmatite veins that are commonly boudinaged and deformed, and lenses of augen gneiss that may represent extensively deformed and recrystallised intrusive feldspar porphyry and porphyritic granite. These bodies are probably syntectonic intrusions. The widespread recrystallisation indicates moderate-grade regional metamorphism of the quartzofeldspathic rocks.

The main granite unit, Pgs, forms plutons characterised by foliated contact zones and non-foliated to slightly foliated central parts, and appears to be mainly a post-tectonic type. In most places it appears to have been emplaced with little disruption of the adjacent country rocks, and it commonly sharply truncates the foliation and lithological layering in the adjacent country rocks. It also extensively intrudes the earlier foliated granites. Therefore, the possibility that the regional metamorphism was associated with the intrusion of the foliated early granite bodies, which may or may not be genetically related to the main granite unit, cannot be ruled out on available evidence. The main granite unit may have been emplaced during the waning period of the same tectonic episode that caused the regional metamorphism, or during a later event in which metamorphic grades similar to those of the earlier event were attained.

### Western belt

The general obliteration of bedding, the widespread development of schistose rocks, the presence of andalusite porphyroblasts in some metapelites, and the extensive recrystallisation of the felsic and mafic volcanic rocks, are interpreted as indicating mainly upper greenschist to possibly lower amphibolite grades of regional metamorphism in the Saint Ronans metamorphics. Rocks in contact with some granite plutons are coarser-grained than those away from the contact zones, and mica flakes tend to be more randomly oriented and the schistosity not as well defined; these features may be due to thermal metamorphism of the country rocks by the adjacent granite intrusions.

The grade of metamorphism decreases southwards. In the far southwest, the general lack of a well-developed schistosity in the Oroopo volcanics away from faults, the presence of chlorite and probable actinolite in the metabasalts, and the preservation of primary sedimentary structures in interbedded sediments, indicate mainly low greenschist metamorphic grade. Some amphibolite-grade rocks may be present in rocks mapped as Oroopo volcanics in the far north, adjacent to the highly sheared contact with the Sybella Granite; here the metamorphic grade appears to decrease westwards away from the granite contact.

### Retrogression

A later low-grade retrograde regional metamorphic event, probably associated with deformation of the Mount Isa Group, is indicated by the extensive replacement of andalusite porphyroblasts in the Saint Ronans metamorphics by mainly fine sericite and quartz and by the partial replacement of biotite (and rarely amphibole) by chlorite, and plagioclase by sericite, in amphibolite-grade rocks in the Sulieman gneiss and Kallala quartzite.

## SUMMARY OF GEOLOGICAL HISTORY

The main problem with compiling a realistic geological history for the Ardmore 1:100 000 Sheet area is the lack in the central and western belts of marker units that can be unequivocally correlated with units in the eastern belt. The stratigraphic positions of the rocks in the eastern belt are fairly well established.

The earliest events recorded in the Sheet area may have been sedimentation, and possibly minor volcanism and plutonism, of the Sulieman gneiss and Kallala quartzite, precursors. The sediments probably consisted mainly of shallow-water quartzose, feldspathic, and micaceous sands - represented mainly by the Kallala quartzite - and labile, relatively quartz-poor, ?partly tuffaceous sands - represented mainly by the Sulieman gneiss. These units may have been deposited at about the same time as units in the Tewinga Group mapped in Sheet areas to the east and northeast. In places the Sulieman gneiss contains numerous lenses of quartzofeldspathic and augen gneiss similar to units in the Tewinga Group in the Duchess and Dajarra 1:100 000 Sheet areas (Bultitude & others, 1978; Blake & others, 1978), where they were tentatively interpreted as mainly recrystallised felsic volcanics. However, at least some of the lenses in the Sulieman gneiss probably represent intrusive feldspar porphyry and porphyritic granite.

Another possiblity is that the Sulieman gneiss and Kallala quartzite were deposited contemporaneously with the Bottletree formation and lower Haslingden Group; in the western parts of the Duchess and Dajarra 1:100 000 Sheet areas, rocks of this age unconformably overlie undivided Tewinga Group rocks (mainly schists and gneisses) and Kalkadoon Granite. Many of the rock types in the Sulieman gneiss appear similar to those described from the May Downs Gneiss mapped west of the Mount Isa Fault in the Mount Isa Sheet area to the north (Hill & others, 1975). Hill & others interpreted the May Downs Gneiss as being equivalent to the lower Haslingden Group - that is, broadly equivalent to the Yappo formation of this work.

It is not known whether or not there was a period of non-deposition and erosion at the end of Kallala quartzite - Sulieman gneiss time, before the Jayah Creek volcanics were deposited as an apparently thick sequence of basaltic lava flows with numerous interlayered lenses of arenites, finer-grained argillaceous and ?volcaniclastic sediments, and minor limestone and calcareous muds. Despite the abundance of intercalated sediments no structures such as pillow lavas have been positively identified. However, the abundance of sediments does suggest that the lavas were extruded in a low area subject to intermittent fluvial or marine inundation. The Timothy Creek meta-arenite member is a relatively thick unit that was probably deposited in a shallow-water near-shore environment during a major lull in volcanic activity.

Part or all of the Saint Ronans metamorphics may have been deposited contemporaneously with the Sulieman gneiss and Jayah Creek volcanics. Schists and gneisses in the Saint Ronans metamorphics are similar lithologically to those in the Jayah Creek volcanics, and to a much lesser extent to those in the Sulieman gneiss.

Sediments in the Saint Ronans metamorphics appear to have been mainly fine-grained argillites and labile (?tuffaceous) arenites. Towards the end of Saint Ronans metamorphics time there were episodes of mafic and felsic volcanism, and basaltic lava flows and felsic volcanic units (probably mainly tuffs) were interlayered with labile ?tuffaceous, argillaceous, and arenaceous sediments. These felsic and mafic volcanic units may have been erupted at about the same time as similar units in the Bottletree formation. Though no basaltic lava flows have been found in the Bottletree formation in the Ardmore Sheet area, they have been mapped in the upper and lower parts of the formation in the Duchess 1:100 000 Sheet area to the northeast (Bultitude & others, 1978).

After the deposition of the units in the Saint Ronans metamorphics there was a period of extensive basaltic volcanism in the west, and mafic lava flows mapped as the Oroopo volcanics were extruded. However, whether or not there was a major period of non-deposition and possible erosion between the deposition of the Saint Ronans metamorphics and the overlying Oroopo volcanics has not been ascertained.

The Oroopo volcanics may have been deposited at about the same time as the Eastern Creek Volcanics in the east. However, the clastic sediments in the Oroopo volcanics are rarely conglomeratic and tend to be more mature than those in the Eastern Creek Volcanics. Felsic and mafic volcanic clasts and beds of pebbly greywacke and greywacke conglomerate, common in the Eastern Creek Volcanics, have not been found in the Oroopo volcanics. These differences may be due to the Eastern Creek Volcanics in the east being much closer to the source of the coarse detritus, inferred to be the Kalkadoon Granite-Leichhardt Metamorphics basement block exposed in Sheet areas to the east and northeast.

In the eastern belt, sedimentation, initially accompanied by felsic volcanism, resulted in the deposition of the Bottletree and Yappo formations. Much of the detritus in the basal Yappo formation was probably derived locally from the Bottletree formation. The upper part of the Yappo formation contains abundant coarse granitic debris possibly derived from a nearby granitic landmass to the east.

The upwards gradation from the immature sediments of the Yappo formation to the more mature arenites of the Mount Guide Quartzite may reflect the development of a subdued topography in the source area resulting from prolonged erosion. Most of the Haslingden Group sediments appear to be shallow-water deposits.

Extensive basaltic volcanism after Mount Guide Quartzite time is represented by the Eastern Creek Volcanics. The volcanism appears to have been accompanied by some tectonic activity and uplift, implied by the numerous coarse and pebbly sedimentary lenses deposited in the intervals between lava extrusion. No structures have been recognised to indicate subaqueous extrusion, and the lavas are considered to have been probably erupted subaerially.

Some time after the deposition of the Haslingden Group, there was probably a period of tectonism during which the rocks in the area were tightly to isoclinally folded, and regionally metamorphosed to grades ranging from greenschist to amphibolite facies. Rocks mapped as Sulieman gneiss, Kallala quartzite, and Jayah Creek volcanics were regionally metamorphosed mainly to amphibolite grades, tightly folded in places, and extensively recrystallised. This tectonism may have been accompanied and closely followed by the emplacement of granites mapped as Sybella Granite. The main granite unit was probably emplaced after the main folding and deformation, but earlier units have a gneissic foliation parallel to the foliation in the enclosing country rocks, and may therefore be syntectonic.

Numerous dolerite dykes appear to have been intruded at about this time; rarely they cut the gneissic granites and they are cut by pegmatite and granite veins assumed to be related to the main unit of the Sybella Granite. Most doleritic intrusives do not appear to be folded, and so were probably emplaced after the main period of deformation. Many of the faults in the area may have also been initiated during this tectonic episode.

This episode of folding, regional metamorphism, and emplacement of the Sybella Granite batholith represents a major orogenic event during which the area was probably uplifted. This uplift may have been followed by a period of subaerial erosion, after which rocks of the Mount Isa Group were deposited, possibly in elongate north-northwest-trending trough-like depressions or basins. An initial moderate relief in the source area for the sediments is inferred from the presence locally of pebbly arenites and conglomerates in the basal part of the sequence. The arenites are overlain by finely laminated shales and siltstones, together with some ?dolomite, indicating a low-energy environment and a more subdued source area. The small outcrops of meta-arenite and meta-siltstone in the southern part of the central belt are tentatively regarded as also having been deposited during Mount Isa Group time.

A later period of folding and regional metamorphism in the Sheet area took place some time after the deposition of the Mount Isa Group. The Mount Isa Group sediments and possible equivalents were deformed and regionally metamorphosed to lower greenschist grade. Some of the faults mapped in the area were probably active at this time. The regional metamorphism probably also caused local retrogression in the previously metamorphosed rocks.

The youngest Precambrian rocks in the Sheet area are probably the rare dykes of Lakeview Dolerite type (Derrick & others, 1978; shown as '$dl_d$' on map), which appear to be unmetamorphosed.

After these orogenic events, subaerial erosion persisted until probably the end of the Early Cambrian, when deposition of the more or less flat-lying mainly Middle Cambrian Georgina Basin succession commenced.

## MINERAL RESOURCES

There are no major mines, working or abandoned, in the Sheet area. Some small scattered uneconomic concentrations of base-metal - mainly copper - mineralisation have been found, but there has been no significant production of ore from any of the deposits. Traces of chalcopyrite, malachite, and chrysocolla occur along partings and in amygdales in metabasalts of the Oroopo volcanics and Eastern Creek Volcanics. One small pit, about 1.5 m deep, was found in metagreywacke conglomerate of the Eastern Creek Volcanics about 5.5 km southwest of Dajarra where the malachite occurs in a thin (less than 1 m thick) vuggy quartz vein.

The Jayah Creek volcanics are cut by quartz and pegmatite veins containing traces of malachite; some of the quartz veins also contain minor chrysocolla and chalcopyrite. In the far south there are several small pits and trenches up to about 10 m deep in mainly medium to coarse-grained quartz + biotite $\pm$ ?hornblende schist. Mineralisation consists mainly of malachite with minor chrysocolla, azurite and secondary iron oxide; it is generally associated with quartz veins, and appears to be localised in northerly to northwesterly trending shear zones associated with the north-trending fault about 44.5 km southwest of Dajarra.

A minor gold rush to the headwaters of Jayah Creek, about 9.5 km east of Jayah Creek Bore and 27 km northwest of Dajarra, in the late 1920s or early 1930s was reported by Shepherd (1935). No production was recorded from the field. The mineralisation appears to have been associated with quartz veins which cut a reported sequence of hornblende schist and mica schist (part of the Jayah Creek volcanics). Shepherd also reported chalcocite and malachite in some of the rocks.

Noakes & others (1959) reported the following minor mineral occurrences: (1) lead in the upper reaches of Saint Ronans Creek and in the headwaters of Jayah Creek; (2) low-grade manganese in the Steamboat Sandstone; and (3) copper in the headwaters of Quita Creek.

The Beetle Creek Formation exposed in the Ardmore Outlier and Quita Creek area contains phosphate deposits concentrated mainly in the upper part of the formation (Thomson & Russell, 1971; de Keyser & Cook, 1972). The richest and most extensive deposits found so far are in the Ardmore Outlier, where the phosphatic sediments in the upper part of the Beetle Creek Formation have an average thickness of about 7 m.

Noon (1977) has presented a summary of exploration company activity in the Urandangi 1:250 000 Sheet area, of which the Ardmore 1:100 000 Sheet area forms the southeastern corner.

## Water resources

The streams in the Ardmore Sheet area flow for only short periods after heavy rain, and there are few, if any permanent waterholes and springs. Sulieman Creek, the largest watercourse, contains Oroopo and Wonomo Waterholes, which appear to be at least semi-permanent, and are probably fed mainly by seepage water. Some waterholes such as those in the Cement Springs area are fed by springs sited on or adjacent to faults. Springs have also been reported in the Spring Creek area in the far central south (Reynolds & Pritchard, 1964). The springs probably cease to flow towards the end of the dry season or in times of drought.

Over most of the Sheet area, particularly those parts in which the Precambrian granitic and metamorphic rocks crop out, water for stock is mainly surface run-off stored behind low earthen embankments across watercourses, or in large depressions ('tanks') excavated in the watercourses. Supplies of soakage water are obtained from wells and bores sunk in thick sandy sediments along major watercourses, such as Sulieman, Dinner, and Rufus Creeks. The most reliable supplies of underground water are contained in the lower Palaeozoic sediments of the Georgina Basin succession in the west.

Water from many of the bores and springs, for example Sulieman Bore and Cement Springs, is saline, and the salinity commonly increases towards the end of the dry season.

## REFERENCES


ANDERSON, E.M., 1951 - THE DYNAMICS OF FAULTING AND DYKE FORMATION WITH APPLICATIONS TO BRITAIN. Oliver & Boyd Ltd, Edinburgh.

BENNETT, E.M., 1965 - Lead-zinc-silver and copper deposits of Mount Isa; in McAndrews, J., (Editor) - GEOLOGY OF AUSTRALIAN ORE DEPOSITS, second edition. Australasian Institute of Mining and Metallurgy, Melbourne, 1, 233-46.

BLAKE, D.H., DONCHAK, P.J.T., & BULTITUDE, R.J., 1978 - Precambrian geology of the Dajarra 1:100 000 Sheet area, northwestern Queensland - preliminary data. Bureau of Mineral Resources, Australia, Record 1978/46 (unpublished).

BUDDINGTON, A.F., 1959 - Granite emplacement with special reference to North America. Bulletin of the Geological Society of America, 70, 671-747.

BULTITUDE, R.J., BLAKE, D.H., & DONCHAK, P.J.T., 1978 - Precambrian geology of the Duchess 1:100 000 Sheet area, northwestern Queensland - preliminary data. Bureau of Mineral Resources, Australia, Record 1978/112 (unpublished).

BUREAU OF METEOROLOGY, 1975 - CLIMATIC AVERAGES - AUSTRALIA. Department of Science and Consumer Affairs, Canberra.

CARTER, E.K., BROOKS, J.H., & WALKER, K.R., 1961 - The Precambrian mineral belt of north-western Queensland. Bureau of Mineral Resources, Australia, Bulletin 51.

de KEYSER, F., 1968 - The Cambrian of the Burke River Outlier. Bureau of Mineral Resources, Australia, Record 1968/67 (unpublished).

de KEYSER, F., 1973 - A review of the Middle Cambrian stratigraphy of the Georgina Basin. Bureau of Mineral Resources, Australia, Bulletin 139, 13-27.

de DEYSER, F., & COOK, P.J., 1972 - Geology of the Middle Cambrian phosphorites and associated sediments of northwestern Queensland. Bureau of Mineral Resources, Australia, Bulletin 138.

DERRICK, G.M., WILSON, I.H., & HILL, R.M., 1976a - Revision of stratigraphic nomenclature in the Precambrian of northwestern Queensland. II. Haslingden Group. Queensland Government Mining Journal, 77, 300-6.

DERRICK, G.M., WILSON, I.H., & HILL, R.M., 1976b - Revision of stratigraphic nomenclature in the Precambrian of northwestern Queensland. III. Mount Isa Group. Queensland Government Mining Journal, 77, 402-5.

DERRICK, G.M., WILSON, I.H., & HILL, R.M., 1978 - Revision of stratigraphic nomenclature in the Precambrian of northwestern Queensland. VIII. Igneous rocks. Queensland Government Mining Journal, 79, 151-6.

DERRICK, G.M., WILSON, I.H., HILL, R.M., GLIKSON, A.Y., & MITCHELL, J.E., 1977 - Geology of the Mary Kathleen 1:100 000 Sheet area, northwest Queensland. Bureau of Mineral Resources, Australia, Bulletin 193.

DRUCE, E.C., 1978 - Georgina Basin project; in Geological Branch, Annual Summary of Activities, 1978. Bureau of Mineral Resources, Australia, Record 1978/89, 203-12 (unpublished).

DUNSTAN, B., 1920 - North-western Queensland. Geological notes on the Cloncurry-Camooweal-Burketown-Boulia area. Queensland Geological Survey, Publication 265.

GARY, M., McAFEE, R., & WOLF, C.L., (Editors), 1972 - GLOSSARY OF GEOLOGY. American Geological Institute, Washington.

GEOLOGICAL SURVEY OF QUEENSLAND, 1976 - Queensland geology, scale 1:2 000 000. Queensland Department of Mines, Brisbane.

GOLDSMITH, R., 1959 - Granofels, a new metamorphic name. Journal of Geology, 67, 109-10.

GLIKSON, A.Y., & DERRICK, G.M., 1978 - Geology and geochemistry of Middle Proterozoic basic volcanic belts, Mount Isa/Cloncurry, northwestern Queensland. Bureau of Mineral Resources, Australia, Record 1978/48 (unpublished).

GLIKSON, A.Y., DERRICK, G.M., WILSON, I.H., & HILL, R.M., 1976 - Tectonic evolution of the middle Proterozoic Leichhardt River fault trough, Mount Isa region, northwestern Queensland. BMR Journal of Australian Geology & Geophysics, 1, 115-29.

HILL, R.M., WILSON, I.H., & DERRICK, G.M., 1975 - Geology of the Mount Isa 1:100 000 Sheet area, northwest Queensland. Bureau of Mineral Resources, Australia, Record 1975/175 (unpublished).

HORTON, H., 1976 - AROUND MOUNT ISA : A GUIDE TO THE FLORA AND FAUNA. University of Queensland Press, Brisbane.

JOPLIN, G.A., 1955 - A preliminary account of the petrology of the Cloncurry Mineral Field. Proceedings of the Royal Society of Queensland, 66, 33-67.

JOPLIN, G.A., & WALKER, K.R., 1961 - The Precambrian granites of north-western Queensland. Proceedings of the Royal Society of Queensland, 72, 21-57.

MACDONALD, G.A., 1972 - VOLCANOES. Prentice-Hall Inc., New Jersey.

MATHIAS, B.V., & CLARK, G.J., 1975 - Mount Isa copper and silver-lead-zinc orebodies - Isa and Hilton mines; in Knight, C.L. (Editor) - ECONOMIC GEOLOGY OF AUSTRALIA AND PAPUA NEW GUINEA. 1. METALS. Australasian Institute of Mining and Metallurgy, Melbourne, Monograph 5, 351-72.

MIYASHIRO, A., 1961 - Evolution of metamorphic belts. Journal of Petrology, 2, 277-311.

MOCK, C.M., 1978 - Geology of the Oban 1:100 000 Sheet area, northwestern Queensland: progress report. Bureau of Mineral Resources, Australia, Record 1978/87 (unpublished).

NOAKES, L.C., CARTER, E.K., & OPIK, A.A., 1959 - Urandangi - 4-mile geological series. Bureau of Mineral Resources, Australia, Explanatory Notes SF/54-5.

NOON, T.A., 1977 - Mineral exploration surveys in the Urandangi 1:250 000 Sheet area, northwest Queensland. Queensland Government Mining Journal, 78, 316-9.

OPIK, A.A., 1957 - Cambrian geology of Queensland. Bureau of Mineral Resources, Australia, Bulletin 49, 1-24.

OPIK, A.A., 1960 - Cambrian and Ordovician geology; in Hill, D., & Denmead, A.K., (Editors) - THE GEOLOGY OF QUEENSLAND. Journal of the Geological Society of Australia, 7, 89-110.

PAGE, R.W., 1978 - Response of U-Pb zircon and Rb-Sr total-rock and mineral systems to low-grade regional metamorphism in Proterozoic igneous rocks, Mount Isa, Australia. Journal of the Geological Society of Australia, 25, 141-64.

PATEN, R.J., 1960 - Lacustrine sandstones and limestones and spring sinters of far western Queensland; in Hill, E., & Denmead, A.K., (Editors) - THE GEOLOGY OF QUEENSLAND. Journal of the Geological Society of Australia, 7, 391-3.

PERRY, R.A., & CHRISTIAN, C.S., 1954 - Vegetation of the Barkly region. CSIRO Land Research Series, 3, 78-112.

PERRY, R.A., & LAZARIDES, M., 1964 - Vegetation of the Leichhardt-Gilbert area. CSIRO Land Research Series, 11, 152-191.

PETTIJOHN, F.J., POTTER, P.E., & SIEVER, R., 1972 - SAND AND SANDSTONE. Springer-Verlag, Berlin.

REYNOLDS, M.A., & PRITCHARD, P.W., 1964 - The geology of the Glenormiston 1:250 000 Sheet area. Bureau of Mineral Resources, Australia, Record 1964/28 (unpublished).

ROBINSON, W.B., 1968 - Geology of the Eastern Creek Volcanics in the Mount Isa district. Proceedings of the Australasian Institute of Mining and Metallurgy, 226, 89-96.

RUSSELL, R.T., 1967 - Discovery of major phosphate deposits in northwest Queensland. Queensland Government Mining Journal, 68, 153-7.

SHELDON, R.P., 1966 - Preliminary appraisal of the Australian continent for sedimentary phosphate deposits. Bureau of Mineral Resources, Australia, Record 1966/16 (unpublished).

SHEPHERD, S.R.L., 1935 - Jayah workings, near Dajarra. Queensland Government Mining Journal, 36, 241.

SLATYER, R.O., 1964 - Climate of the Leichhardt-Gilbert area. CSIRO Land Research Series, 11, 90-104.

SLATYER, R.O., & CHRISTIAN, C.S., 1954 - Climate of the Barkly region. CSIRO Land Research Series, 3, 17-33.

SOUTHGATE, P.N., & HENDERSON, R.A., 1978 - Chert pseudomorphs after a carbonate-sulphate-halide sediment suite, Georgina Basin; in Orme, G.R., (Convenor) - ANCIENT AND MODERN CARBONATE DEPOSITS. Third Australian Geological Convention, Geological Society of Australia, Townsville, Abstracts, 20.

SPRY, A., 1969 - METAMORPHIC TEXTURES. Permagon Press, Sydney.

STEWART, G.A., 1954 - Geomorphology of the Barkly region. CSIRO Land Research Series, 3, 42-58.

SKWARKO, S.K., 1966 - Cretaceous stratigraphy and palaeontology of the Northern Territory. Bureau of Mineral Resources, Australia, Bulletin 73.

THOMSON, L.D., & RUSSELL, R.T., 1971 - Discovery, exploration and investigations of phosphate deposits in Queensland. Proceedings of the Australasian Institute of Mining and Metallurgy, 240, 1-14.

TURNER, F.J., & VERHOOGEN, J., 1960 - IGNEOUS AND METAMORPHIC PETROLOGY, second edition. McGraw-Hill, New York.

TWIDALE, C.R., 1964 - Geomorphology of the Leichhardt-Gilbert area. CSIRO Land Research Series, 11, 115-24.

WILSON, C.J.L., 1972 - The stratigraphic and metamorphic sequence west of Mount Isa, and associated igneous intrusions. Proceedings of the Australasian Institute of Mining and Metallurgy, 243, 27-42.

WINKLER, H.G.F., 1967 - PETROGENESIS OF METAMORPHIC ROCKS. Springer-Verlag, New York.

## APPENDIX 1
## Petrographic Descriptions

### Yappo formation

Metagreywacke and metaconglomerate (2 thin sections). Specimen 78532075 (metagreywacke) has been completely recrystallised to fine-grained (0.05-0.1 mm) granular aggregate of mainly quartz, feldspar (microcline and ?albite), biotite, ?clinozoisite (appears non-pleochroic), and minor opaque oxide. Biotite flakes are pleochroic from brown to very pale brown, and show a markedly preferred orientation. ?Albite grains extensively replaced by sericite.

Specimen 78532076 (metaconglomerate) is only partly recrystallised. It contains large (up to 1.5 mm long) remnant grains of quartz, microcline, and ?albite (2V positive), characterised by irregular, in places sutured, margins and undulose extinction. Some of the feldspar grains are partly replaced by clinozoisite or epidote and sericite. Most of these remnant grains have recrystallised around their margins to fine-grained aggregates of mainly quartz, microcline, ?albite, and clinozoisite or epidote. This specimen also contains scattered, relatively coarse (0.5 mm) flakes of muscovite, minor anhedral poikilitic calcite grains, and sparse small aggregates of fine chlorite.

### Eastern Creek Volcanics

Metabasalts (4 thin sections). Consist of fine-grained (0.1 mm) aggregates of mainly ?albite (biaxial positive), tremolite-actinolite, epidote, chlorite, calcite, quartz, opaque oxide, biotite (pleochroic from dark brownish green to very pale yellow or colourless), sericite, ?clinozoisite, and sphene. Primary igneous interstitial textures are fairly well preserved in specimens 78532580 and 78532685 from the upper part of the formation 5.5 to 6 km southwest of Dajarra. These specimens contain small (0.7 mm) scattered relict plagioclase phenocrysts and numerous smaller (0.1 mm) feldspar laths. Specimen 78532580 also contains numerous clinopyroxene grains extensively replaced and pseudomorphed by tremolite-actinolite (faintly pleochroic from pale green to colourless). Plagioclase grains are extensively replaced (or pseudomorphed) by calcite and sericite. Opaque oxide as scattered subhedral grains (0.2 mm) is common.

Amygdales are well-preserved and generally undeformed. They are filled mainly with coarse calcite and quartz, together with minor plagioclase, epidote, chlorite, and biotite; minerals commonly show concentric distribution. Amygdales in specimen 78532099 contain minor amphibole (?actinolite) and biotite (pleochroic from red-brown to very pale yellow).

Specimen 78532099 shows a well-developed foliation defined by the parallel orientation of the numerous small (0.2 mm) tabular actinolite grains (pleochroic from pale blue-green to very pale yellow). It also contains scattered, relatively large (0.6 mm) porphyroblasts of chlorite, generally forming aggregates. Most of the chlorite porphyroblasts are aligned parallel to the foliation, but some are oblique to it; a few contain scattered inclusions of groundmass grains. The larger amygdales are elliptical. This specimen was collected from outcrop adjacent to contact with the Mount Guide Quartzite in the north of the Sheet area (GR 368183), and the foliation was probably produced mainly by faulting or bedding-plane slip along the contact between the two formations.

Micaceous metasiltstones (2 thin sections). Both specimens are from outcrops adjacent to the Wonomo Fault about 3 km north-northeast of Wonomo Waterhole. They are fine-grained (0.02 mm), and consist mainly of muscovite, sericite, anhedral quartz grains, and minor opaque oxide and biotite. Biotite flakes are pleochroic from yellowish brown to colourless, and commonly show undulose extinction; many of the larger grains are bent. The white mica flakes generally show a preferred orientation. Scattered anhedral grains up to about 1 mm of opaque oxide are also present. Specimens are partly recrystallised and contain irregular zones of relatively coarse, mainly anhedral to subhedral quartz grains (0.2 mm) and aggregates of biotite flakes up to about 0.3 mm; the biotite is pleochroic from yellowish brown to colourless, partly bleached and ironstained, and extensively replaced or pseudomorphed by ?vermiculite. These zones also contain minor muscovite flakes and numerous anhedral opaque oxide grains.

Warrina Park Quartzite

Meta-arenites (3 thin sections). The fine (0.1-0.2 mm) grains - mainly subangular to subrounded and moderately well-sorted - and sparse scattered larger grains up to about 0.7 mm are of quartz and minor sericite and muscovite (mainly as flakes ranging from less than 0.05 mm to about 0.4 mm long). Some specimens, for example, 78532055, also contain subordinate feldspar (plagioclase and ?microcline) and rare lithic fragments and tourmaline grains. The lithic fragments consist of very fine-grained aggregates of mainly quartz and sericite. Quartz grains in some specimens are characterised by undulose extinction and highly angular outlines.

Quartzites (5 thin sections). Fine-grained (0.2 mm) rocks consisting mainly of a mosaic of very closely packed angular quartz grains showing undulose extinction; grain boundaries are highly irregular and in some specimens (for example, 78532588A from GR 405945) are sutured. Sericite, muscovite, and traces of tourmaline, ?sphene, and ?clinozoisite are minor constituents. Some specimens also contain subordinate feldspar or lithic fragments (for example, 78532588A), or both (for example, 78532575 from GR 405945), up to about 1 cm. The lithic fragments consist of very fine aggregates of mainly quartz and sericite. Quartz grains are generally elongate and show fairly well-defined preferred orientations. Mica flakes tend to be concentrated in thin discontinuous bands paralleling the orientations of the quartz grains.

Moondarra Siltstone

Quartzose meta-arenite or quartzite (1 thin section). Closely packed, fairly well-sorted, fine-grained, mainly angular quartz grains showing undulose extinction, and minor feldspar, sericite, muscovite, and tourmaline.

Sulieman gneiss

Quartz + microcline + plagioclase + biotite ± garnet gneiss, augen gneiss, and quartzofeldspathic gneiss (12 thin sections). Mainly medium-grained (0.1-0.4 mm, with some grains up to 1 cm long) granular aggregates of quartz (generally characterised by undulose extinction), microcline (relatively scarce in specimen 78532723A from GR 235025, and not detected in specimen 78532746 from GR 232994), plagioclase (?albite-andesine; some grains apparently biaxial negative, others apparently biaxial positive; some grains appear to have R.I.< quartz and others R.I.> quartz), and biotite. Two specimens (78532401A and 78532403 from GR 199705) also contain sparse anhedral to subhedral grains and small porphyroblasts (up to about 0.6 mm across) of brown garnet. Minor and accessory minerals (not present in every specimen) include: (1) muscovite, commonly intergrown with biotite; (2) chlorite, pleochroic from pale green to colourless, mainly as replacement of biotite; (3) hornblende (in specimen 78532361C from GR 220700)as subhedral to anhedral grains up to 1 mm long and pleochroic from brownish green to very pale yellow; (4) sphene as subhedral to anhedral grains up to about 0.2 mm long; (5) epidote (pleochroic from bright yellow to colourless) and ?clinozoisite (colourless, non-pleochroic); and (6) opaque oxide as subhedral grains. Many of the specimens also contain small lobate or cauliflower-shaped vermicular intergrownths of quartz and feldspar (myrmekite), apparently replacing microcline in places.

Specimen 78532403B (from about GR 199705), an augen gneiss, contains scattered large (up to about 1 cm long) poikilitic, irregular, partly embayed grains of microcline, commonly containing scattered inclusions of groundmass biotite, quartz, and plagioclase.

Plagioclase grains - commonly partly replaced by muscovite and sericite have a composition of about $An_{35}$ (determined by measuring maximum extinction angles of albite twins in sections cut normal to (010) in specimen 78532723A from GR 235025). Biotite ranges from scarce to abundant; the flakes generally show a distinct preferred orientation, and tend to occur concentrated in thin irregular layers, and in most rocks are pleochroic from dark red-brown to pale yellowish brown or brownish yellow; epidote/?clinozoisite are commonly intergrown along cleavages. Specimen 78532401A also contains some biotite pleochroic from green or greenish brown to pale yellowish green, commonly associated with garnet. Biotite flakes in specimen 78532406 are pleochroic mainly from brownish green to very pale yellow.

<u>Calc-silicate gneiss/granofels (4 thin sections)</u>. Medium to coarse-grained (0.2-0.8 mm) granular aggregates of mainly plagioclase, clinopyroxene (?salite), quartz, and garnet; minor sphene, epidote, ?clinozoisite and opaque oxide (opaque oxide only in specimen 78532405A). Some triple point-type junctions are developed between grains. Clinopyroxene forms large anhedral grains up to about 1 mm; faintly pleochroic from pale green or blue-green to colourless or pale yellowish green (?salite); slightly poikilitic; partly rimmed by amphibole, pleochroic from blue-green to very pale yellow in specimen 78532405A. Plagioclase is mainly ?oligoclase-andesine; some grains appear to be biaxial positive, others biaxial negative, and some have R.I.> quartz whereas others have R.I.< quartz; rarely poikilitic; commonly partly replaced by sericite. Garnet forms anhedral pink poikiloblasts up to about 2 mm long. Small rounded epidote grains are commonly mantled by overgrowths of ?clinozoisite with subhedral outlines. Most quartz grains show undulose extinction.

Amphibolite (3 thin sections). Medium to coarse-grained (0.2-1 mm). Consists of mainly oligoclase-andesine, hornblende (euhedral to anhedral), and minor sphene (0.1 mm), quartz (0.2 mm), epidote, ?clinozoisite, and opaque oxide. Plagioclase grains extensively replaced by sericite; appear to range from about $An_{45}$ to $An_{55}$ in specimen 78532477 (from GR 255872). Hornblende grains are pleochroic from brownish green to pale yellow or blue-green.

Possible amygdaloidal metabasalt or para-amphibolite (1 thin section). Medium-grained (0.4 mm); consists of layers rich in amphibole (pleochroic from blue-green to pale yellow) and plagioclase (very extensively sericitised), and interspersed lenses and lenticles (?deformed amygdales) of quartz, microcline, and plagioclase, and minor hornblende, biotite, chlorite (mainly as replacement of biotite and amphibole), and ?zoisite. Plagioclase and amphibole-rich layers also contain minor sphene, chlorite (pleochroic from pale blue-green to colourless, commonly partly replacing amphibole and biotite), epidote, muscovite, and ?biotite (pleochroic from blue-green to pale yellow).

?Para-amphibolite (1 thin section). Medium-grained (0.3 mm) aggregates of subhedral to anhedral amphibole (biaxial negative, faintly pleochroic from pale brownish green to colourless) and very extensively sericitised plagioclase (some grains biaxial negative) with minor quartz, scattered grains (0.1 mm) of opaque oxide, and rare apatite and red-brown biotite.

Quartzite (1 thin section). Coarse-grained (2 mm) granular aggregate of mainly anhedral quartz grains, with scattered flakes (0.5-1 mm) of muscovite fairly common. Quartz grains are characterised by highly irregular boundaries and undulose extinction. Muscovite flakes show a preferred orientation, and tend to be concentrated in thin discontinuous layers.

?Feldspar metaporphyry (1 thin section). Contains large (up to 2 mm long) scattered grains of mainly microcline, together with some ?orthoclase (characterised by Carlsbad twinning) and minor plagioclase (biaxial negative, R.I.> quartz) and quartz (as large aggregates of coarse grains characterised by highly irregular outlines and undulose extinction), in a medium-grained (0.3 mm) biotite-rich groundmass. Microcline grains are commonly rimmed, and apparently partly replaced by lobate intergrowths of quartz and feldspar (myrmekite). Plagioclase grains are extensively replaced by sericite, and also by small scattered flakes of muscovite. Groundmass consists of granular aggregates of microcline, quartz, plagioclase (commonly extensively sericitised), and ?orthoclase (characterised by Carlsbad twinning), together with abundant biotite as relatively coarse flakes and minor myrmekite, epidote, ?clinozoisite, sphene, and opaque oxide. Biotite flakes show a well-developed preferred orientation and are pleochroic from dark red-brown to very pale brownish yellow; some grains are partly replaced by chlorite (pleochroic from pale green to colourless); also commonly have intergrowths of elongate slender grains of ?clinozoisite and epidote along cleavage planes.

Kallala quartzite

Feldspathic quartzite (1 thin section). Coarse-grained (0.5-1mm) granular aggregate of quartz, subordinate microcline (0.2 - 0.5 mm), muscovite, biotite, and sparse grains of tourmaline, sphene, and opaque oxide. Biotite flakes are pleochroic from brownish yellow or yellowish brown to colourless; many appear bleached, because of weathering and incipient alteration.

Saint Ronans metamorphics

Quartz + muscovite + biotite ± andalusite schists (15 thin sections). Mainly fine-grained (0.05-0.2 mm) lepidoblastic aggregates of quartz, muscovite, and biotite (pleochroic from dark brown to pale yellowish brown); minor opaque oxide, tourmaline (as euhedral to rounded grains pleochroic from deep blue-green to colourless), and rare feldspar (in 78532760A); small anhedral grains of ?epidote occur in 78533212. In most specimens mica flakes show a distinct preferred orientation. Some coarser-grained (0.2-0.5 mm) rocks have textures which tend to be more granoblastic; these are generally found near or adjacent to granite bodies. Quartz grains in these rocks are commonly euhedral or subhedral and some are characterised by triple-point-type junctions with other grains, and many of the mica flakes are randomly oriented. In some sections (for example, 78532760A and 78532760B from GR 209973, adjacent to the Sybella Granite) many of the larger flakes of mica outlining the foliation are deformed and show kink bands and undulose extinction. A granoblastic texture is fairly well developed in specimen 78532757 (GR 213970) from about 0.75 km from the nearest mapped granite outcrop. The relatively coarse grainsize, deformation of mica flakes, and tendency to develop granoblastic habits may be due to disruption and thermal metamorphism associated with intrusion of granite.

Andalusite porphyroblasts up to about 15 mm long occur in five sections; they are mainly euhedral in 78533225 and 78533225A (GR 222017) and highly irregular in the remaining three sections. They are extensively replaced by fine sericite and quartz, together with minor muscovite and biotite. Unaltered andalusite was observed only in specimen 78532757, where porphyroblasts are characterised by very well-developed sieve textures. The porphyroblasts (?pre- or syntectonic) are commonly aligned oblique to the schistosity or foliation, and mica flakes appear to partly 'flow' or curve around some of them in specimens 78532225A and 78532760B, whereas in specimen 78532225 the foliation is generally abruptly truncated by them (?post-tectonic) indicating that more than one generation of andalusite porphyroblasts may be present.

Some specimens also contain scattered, randomly oriented porphyroblasts up to 4 mm long of muscovite and biotite (for example, 78532760B), or small aggregates of relatively coarse biotite flakes that show no preferred orientation (for example, 78532225). The lack of a well-developed preferred orientation is taken to indicate that these micas are post-tectonic. Quartz-mica schist (78532539) from GR 167939 contains numerous large (20 mm) euhedral poikilitic grains of tourmaline (pleochroic from dark grey-green to pale pink) probably formed during the intrusion of the nearby granite.

Biotite flakes are commonly weathered and ironstained, and pseudomorphed and extensively replaced by blue-green pleochroic chlorite (with anomalous blue birefringence colours).

Quartz-feldspar porphyries (4 thin sections) and recrystallised felsic ?tuffs (3 thin sections). Fine-grained (0.05-0.2 mm), extensively recrystallised, siliceous rocks commonly containing phenocrysts (up to 4 mm long) of quartz, feldspar, and opaque oxide. Feldspar phenocrysts: subhedral to anhedral; many with very irregular margins; appear to be mainly plagioclase - commonly show polysynthetic twinning; some are oligoclase-andesine (for example, in specimen 78532507A), and albite/oligoclase (for example, in 78533232); commonly partly replaced by fine grains of muscovite, sericite, biotite, quartz, and ?clinozoisite. Quartz phenocrysts: extensively recrystallised to aggregates of smaller anhedral grains characterised by undulose extinction, but original bipyramidal outlines commonly preserved. Opaque oxide phenocrysts generally form euhedral to subhedral grains. Recrystallised quartzofeldspathic groundmass: Fine-grained (0.05 mm) granular quartz grains, subordinate feldspar (othoclase or plagioclase, or both), minor biotite, muscovite, opaque oxide, ?clinozoisite, and rare epidote and calcite. Biotite flakes are pleochroic from dark khaki or olive green to pale greenish yellow, and show a pronounced preferred orientation. ?Clinozoisite grains appear colourless, with first-order birefringence colours; some grains show anomalous birefringence colours. Epidote grains are pleochroic from pale yellow-green to colourless; some are replaced by chlorite. Muscovite forms small porphyroblasts up to about 0.5 mm long as well as smaller groundmass grains.

Feldspathic quartzite and quartz-biotite-feldspar gneiss (2 thin sections). Relatively coarse-grained (0.4 mm) aggregates of mainly quartz (euhedral to anhedral), together with alkali feldspar, biotite, muscovite, and sparse ?clinozoisite and opaque oxide. Gneissic rocks are relatively rich in mica. Feldspar grains are generally cloudy and partly replaced by fine sericite. Triple-point junctions between grains are common in the gneiss, which also contains deformed muscovite flakes up to 5 mm long.

Amphibolite (1 thin section). Fine-grained (0.1 mm); consists of greenish amphibole and minor feldspar, ?clinozoisite, and quartz, and rare brown biotite.

Oroopo volcanics

Metabasalts (5 thin sections). Specimens are all from exposures of Pov in far central-north part of Sheet area. Amygdaloidal and massive metabasalts consisting of fine-grained (0.05-0.3 mm) granular aggregates of amphibole, quartz, plagioclase (?albite to andesine), minor opaque oxide and ?clinozoisite, and rare epidote. Specimens 78533018, 78533019, and 78533021, collected near or adjacent to intensely sheared contact with Sybella Granite to east, are coarser-grained than specimens 78533020 and 78533024, collected farther to west, and their grains tend to be more idioblastic; foliation is well developed in 78533021.

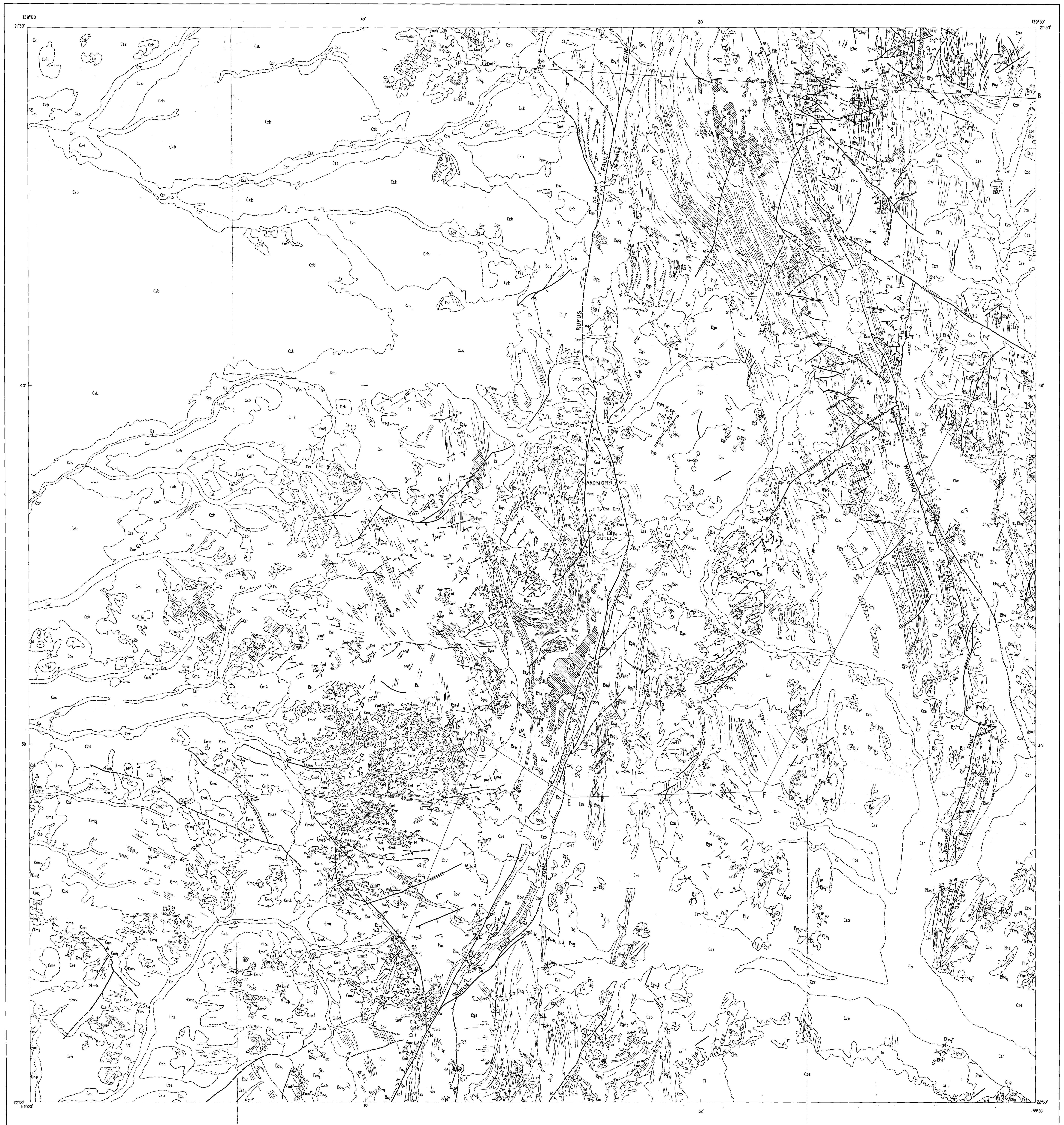
Amphibole grains are pleochroic from mainly blue-green to very pale yellow or greenish yellow; habit ranges from very fine anhedral grains in specimens from west to relatively coarse (up to 1 mm) tabular grains and sheaf-like aggregates in specimens (78533018, 78533021) near or adjacent to contact with Sybella Granite; probably mainly actinolite. Some amphibole (possibly hornblende) grains in specimens (especially 78533021) from adjacent to contact with Sybella Granite have brownish green to pale yellow pleochroism, and are associated with anhedral quartz and feldspar grains and minor opaque oxide granules. Some of the plagioclase grains have positive 2V, and R.I.> quartz (?oligoclase-andesine). However, plagioclase grains in sample 78533019 appear to have R.I.< quartz (?albite).

Amygdales are generally not deformed. They are filled with relatively coarse (0.1-0.5 mm) quartz, plagioclase, ?clinozoisite, minor amphibole (?actinolite, as tabular grains) and opaque oxide, and rare calcite. The feldspar is generally cloudy, and extensively replaced by fine ?sericite and ?clinozoisite. Some plagioclase grains in 78533018 have negative 2V and R.I.> quartz (?oligoclase-andesine).

Mineral assemblages suggest that the sequence has been regionally metamorohosed mainly to ?middle to upper greenschist grades, and possibly to lower amphibolite grade adjacent to the Sybella Granite.

# ARDMORE
QUEENSLAND






## Legend

**CAINOZOIC — QUATERNARY**

- Qa Sand, gravel: recent alluvium

**CAINOZOIC — TERTIARY?**

- Czb Sheetwash deposits, grey to black clay soils: older alluvium
- Czr Sand, silt, clay, gravel: older alluvium
- Czs Sand, silt, gravel
- Ty Vuggy chalcedony, lateritic soil?
- Tc Deeply weathered bedrock
- Tl Laterite, lateritic rubble

**MESOZOIC?**

- M Conglomerate, grit, arenite; minor silcrete

**PALAEOZOIC — CAMBRIAN**

- Ꞓms Sandstone, silty sandstone, siltstone
- Ꞓmq Bituminous limestone, marl, mudstone; minor chert, sandstone
- Ꞓmb Shaly siltstone, siliceous shale, chert, silty sandstone, bituminous limestone
- Ꞓme Chert, chert breccia, mudstone, silty phosphorite, phosphatic siltstone; minor sandstone, limestone
- Ꞓmt Dolomite: banded, vuggy, nodular and laminated chert; minor limestone
- Ꞓml Pebbly ferruginous sandstone, feldspathic and sericitic sandstone, dolomitic sandstone, sandy dolomite, siltstone or mudstone, shale, conglomerate, sedimentary breccia
- Ꞓm Undivided sediments

**PROTEROZOIC**

- di Undivided dolerite, metadolerite, schistose and massive amphibolite
- di5 Medium to coarse pyroxene dolerite, pyroxene-biotite dolerite

MOUNT ISA GROUP

- Ᵽi Meta-arenite and quartzite, carbonaceous? metasiltstone, shale; minor quartz-mica schist
- Ᵽib Grey pyritic shale; minor sericitic metasiltstone
- Ᵽim Pyritic, dolomitic? and micaceous metasiltstone; minor dolomite?, pyritic shale, limestone
- Ᵽiw Quartzose, feldspathic and sericitic meta-arenite and quartzite; minor metaconglomerate, metasiltstone ••••••• Metaconglomerate

- Ᵽgs Medium to coarse, porphyritic biotite granite; minor pegmatite, leucogranite, gneissic granite and granodiorite, diorite
- Ᵽgs Medium to coarse, mainly even-grained, relatively leucocratic pegmatitic biotite granite and muscovite-biotite granite
- Ᵽgs Medium to coarse, strongly foliated to gneissic, even-grained to porphyritic biotite granite, minor augen gneiss, leucogranite
- di4 Massive amphibolite, amphibolitic metadolerite; minor schistose amphibolite
- Ᵽgh Strongly foliated to gneissic, xenolithic, porphyritic biotite-hornblende granodiorite

HASLINGDEN GROUP

- Ᵽbv Amygdaloidal, scoriaceous and massive metabasalt, flow-margin breccia, meta-arenite, metasiltstone, minor quartzite, recrystallised limestone ••••••• Quartzose and feldspathic meta-arenite
- Ᵽbv Quartzose and feldspathic meta-arenite, quartzite; minor metasiltstone, micaceous meta-arenite
- Ᵽbv Recrystallised limestone, calcareous meta-arenite, metasiltstone
- Ᵽbv Micaceous and siliceous metasiltstone; minor meta-arenite
- Ᵽjv Schistose amygdaloidal and massive metabasalt, quartz + biotite + muscovite ± feldspar schist and gneiss, quartzite, meta-arenite, para-amphibolite, cordierite schist, recrystallised limestone and impure limestone ••••••• Quartzite, meta-arenite
- Ᵽjq Quartz-muscovite schist, quartz + muscovite + biotite + cordierite ± feldspar schist and gneiss, pebbly meta-arenite and quartzite, muscovite quartzite, minor hornblende schist; rare metaconglomerate
- Ᵽjt Pebbly meta-arenite; minor metasiltstone, quartzite, metabasalt, chlorite schist
- Ᵽhq Medium to coarse glassy quartzite, feldspathic quartzite and muscovite quartzite; minor hornblende schist, hornblende-biotite schist and gneiss
- Ᵽhe Amygdaloidal, scoriaceous and massive metabasalt, flow-margin breccia, epidotic quartzite, pebbly meta-arkose, metagreywacke and meta-arenite, metagreywacke conglomerate, pebbly metagreywacke, quartzose meta-arenite, epidotic quartzite, fine to medium quartzite rocks, flow-margin breccia, metagreywacke conglomerate, pebbly metagreywacke and meta-arenite, fine to medium quartzite rocks, metabasalt
- Ᵽhe Xenolithic porphyritic quartz-biotite meta-andesite?
- Ᵽhe Metagreywacke conglomerate and grit, pebbly metagreywacke, meta-arkose and meta-arenite
- Ᵽhp Pebbly, sericitic, feldspathic and quartzose meta-arenite; minor gritty meta-arkose, quartzite
- Ᵽhy Metagreywacke and greywacke conglomerate; minor meta-arenite, meta-arkose, metagrit, recrystallised limestone, calc-silicate rocks, para-amphibolite?, epidotic quartzite

- Ᵽs Quartz + mica ± andalusite schist, quartzite, quartzofeldspathic gneiss, amphibolite schist, felsic metavolcanics ••••••• Schistose sericitic meta-arenite
- Ᵽsb Fine schistose amphibolite and amygdaloidal metabasalt; minor felsic metavolcanics, meta-arenite, quartz-mica schist, quartzite
- Ᵽsa Felsic metavolcanics, quartz-mica schist; minor meta-arenite, quartzite, metasiltstone, amphibolite, gneiss
- Ᵽsg Medium quartz + biotite + feldspar ± garnet ± muscovite gneiss and augen gneiss, hornblende schist, glassy quartzite; minor calc-silicate rocks, para-amphibolite, quartz-feldspar pegmatite. ••••••• Quartzite
- Ᵽsgq Medium to coarse glassy quartzite, feldspathic quartzite and muscovite quartzite, minor hornblende schist
- Ᵽht Felsic metavolcanics, metagreywacke, sericitic and feldspathic meta-arenite

Facies change

Name not yet approved

## Symbols

- Geological boundary
- Anticline
- Syncline, showing trend and plunge of axis
- Inclined fault, sense of displacement not known; direction and amount of dip shown
- Fault (U, D indicate relative movement; up, down)
- Normal fault, tick on downthrow side, indicates direction of dip
- Fault showing relative horizontal displacement
- Fault containing quartz

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

- Plunge of fold axes
- Sheared zone
- Strike and dip of strata
- Strike and dip of stata, facing not known
- Vertical strata
- Strike and dip of overturned strata

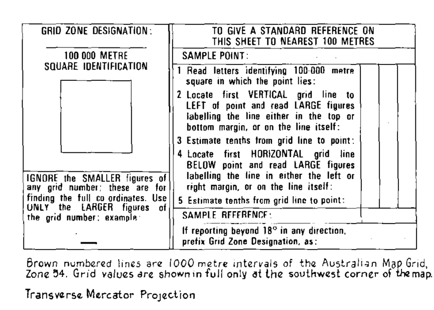
airphoto interpretation:

- Strike and dip of strata, dip 5°-15°
- Strike and dip of strata, dip 15°-45°
- Strike and dip of strata, dip greater than 45°
- Trend-line
- Joint pattern
- Lineament

- Top of bed indicated by cross-bedding, arrow shows facing
- Top of bed indicated by graded bedding, arrow shows facing
- Strike and dip of foliation
- Vertical foliation
- Strike and dip of cleavage
- Vertical cleavage
- Macrofossil locality
- Dolerite dyke
- Dyke or vein; gr - granite, peg - pegmatite, po - porphyry, q - quartz
- Abandoned prospect, no production; Cu - copper, U - uranium
- Costean
- Minor mineral occurrence; Cu - copper, Ph - phosphate

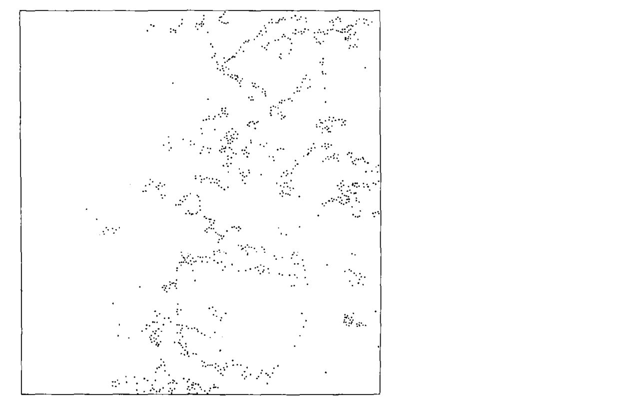
- Windpump
- Bore with windpump
- Abandoned bore
- Water tank
- Earth tank or dam
- Waterhole
- Salt spring, salinity not measured
- Secondary road
- Minor road
- Vehicle track
- Abandoned railway
- Fence
- Landing ground
- Homestead
- Building
- Yard
- Trigonometrical station
- Elevation in metres, approximate
- Elevation in metres, accurate

## UNIVERSAL GRID REFERENCE




Transverse Mercator Projection

## FIELD OBSERVATION LOCALITIES



Compiled by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development and Energy, in conjunction with the Geological Survey of Queensland. Issued under the authority of the Minister for National Development and Energy. Base map compiled by the Bureau of Mineral Resources from 1:100 000 scale orthophotomap line conversion, supplied by the Division of National Mapping

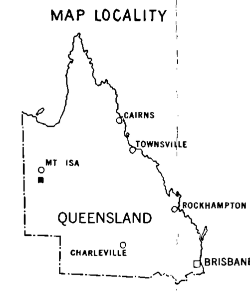
### INDEX TO 1:100 000 MAPS

| | | | | | |
|---|---|---|---|---|---|
| WOORONA 6557 | YELVERTOFT 6657 | KENNEDY GAP 6757 | PROSPECTOR 6857 | QUAMBY 6957 | CLONAGH 7057 |
| BULLECOURT 6556 | TEMPLETON 6656 | MOUNT ISA 6756 | MARY KATHLEEN 6856 | MARRABA 6956 | CLONCURRY 7056 |
| HEADINGLY 6555 | GOA CREEK 6655 | OBAN 6755 | DUCHESS 6855 | MALBON 6955 | MOUNT ANGELAY 7055 |
| URANDANGI 6554 | CARANDOTTA 6654 | ARDMORE 6754 | DAJARRA 6854 | MOUNT MERLIN 6954 | BELWYN 7054 |

SCALE 1:100000

1 0 1 2 3 4 5 6 7 8 9 10 Kilometres

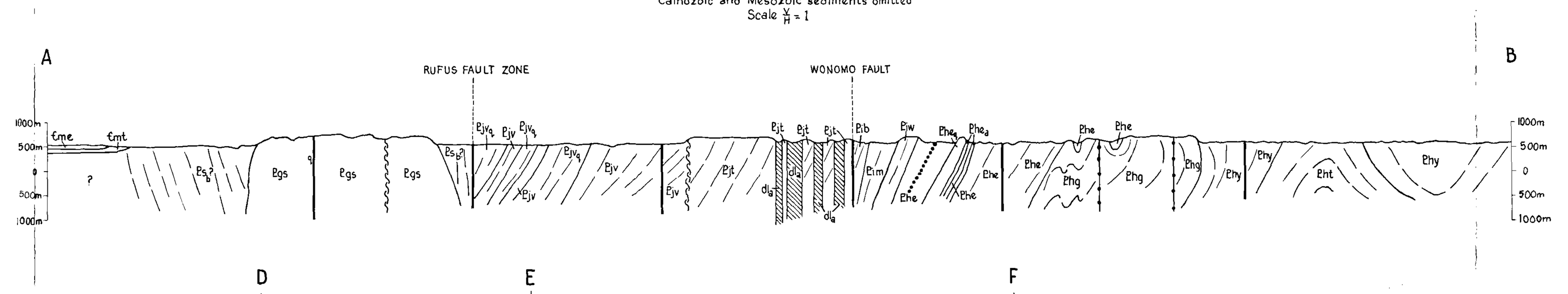
### MAP LOCALITY

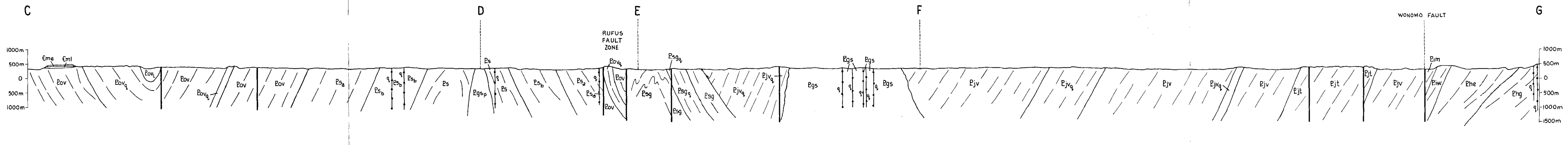



Geology 1969 by F. de Keyser, P.J. Cook
1978-79 by R.J. Bultitude
Compiled 1978-80 by R.J. Bultitude, G.A. Young
Design and drafting by Cartography Section, BMR
Drawn by G.A. Young

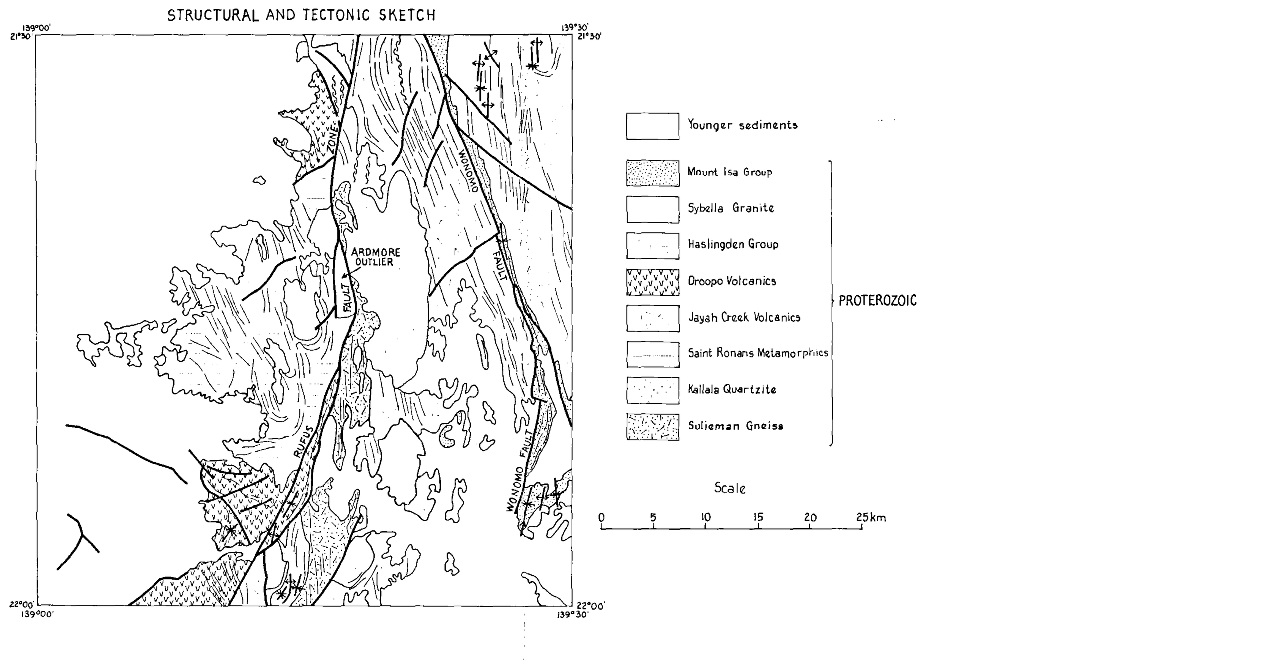
### Schematic sections

Cainozoic and Mesozoic sediments omitted




### STRUCTURAL AND TECTONIC SKETCH




PRELIMINARY EDITION
FEBRUARY 1980
SUBJECT TO AMENDMENT



ARDMORE
SHEET 6754