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# BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

1978/87

## GEOLOGY OF THE OBAN 1:100 000 SHEET AREA, NORTHWESTERN QUEENSLAND: PROGRESS REPORT

by

Colleen M. Mock

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Note The Oban 1:100 000 geological map is available from BMR.

# ABSTRACT

The Oban 1:100 000 Sheet area is in northwestern Queensland between latitudes 21°00'S and 21°30'S and longitudes 139°00'E and 139°30'E. The eastern third of the area is occupied by a north-trending, generally westward-younging section of the Carpentarian western succession of the Mount Isa Geosyncline.

The oldest rocks exposed are sediments and volcanics of the Haslingden Group. Near the base is the 'Malbon Vale Formation', a series of conglomerate, greywacke, and sublabile sandstone shed when the crystalline Tewinga Group basement block to the east was uplifted between about 1870 m.y. and 1785 m.y. The sedimentary environment eventually matured and stabilised, and the labile and sub-labile sediments of the Malbon Vale Formation were overlain by orthoquartzite of the Mount Guide Quartzite. The sequence was interrupted by the outpouring of tholeiitic basalts now forming the overlying Eastern Creek Volcanics. The basalt flows are interlayered with sedimentary intercalations which increase in abundance up-sequence. These three formations of the Haslingden Group were extensively intruded by dolerite dykes. Cessation of igneous activity was followed by accumulation of the orthoquartzite and siltstone of the Myally Subgroup.

Subsequent folding and low-grade regional metamorphism of the Haslingden Group resulted in the formation of a series of north-trending fold belts offset by west-northwest transverse faults. The metamorphism was broadly contemporaneous with intrusion at about 1650 m.y. of the Sybella Granite, a composite, medium to high-level batholith with associated pegmatites and possible comagmatic volcanics, the Carters Bore Rhyolite. The granitoid rocks were deformed after their emplacement, indicating at least two periods of metamorphism.

After uplift and erosion, shale and dolomitic siltstone of the Mount Isa and McNamara Groups were deposited in a narrow, north-trending trough. Basin-and-dome folding and local compression of the Mount Isa Group are evidence of a later stage of deformation.

Flat-lying siltstone, chert, shale, and phosphorite deposited in the Cambrian Georgina Basin during a much younger transgression onlap the Precambrian rocks.

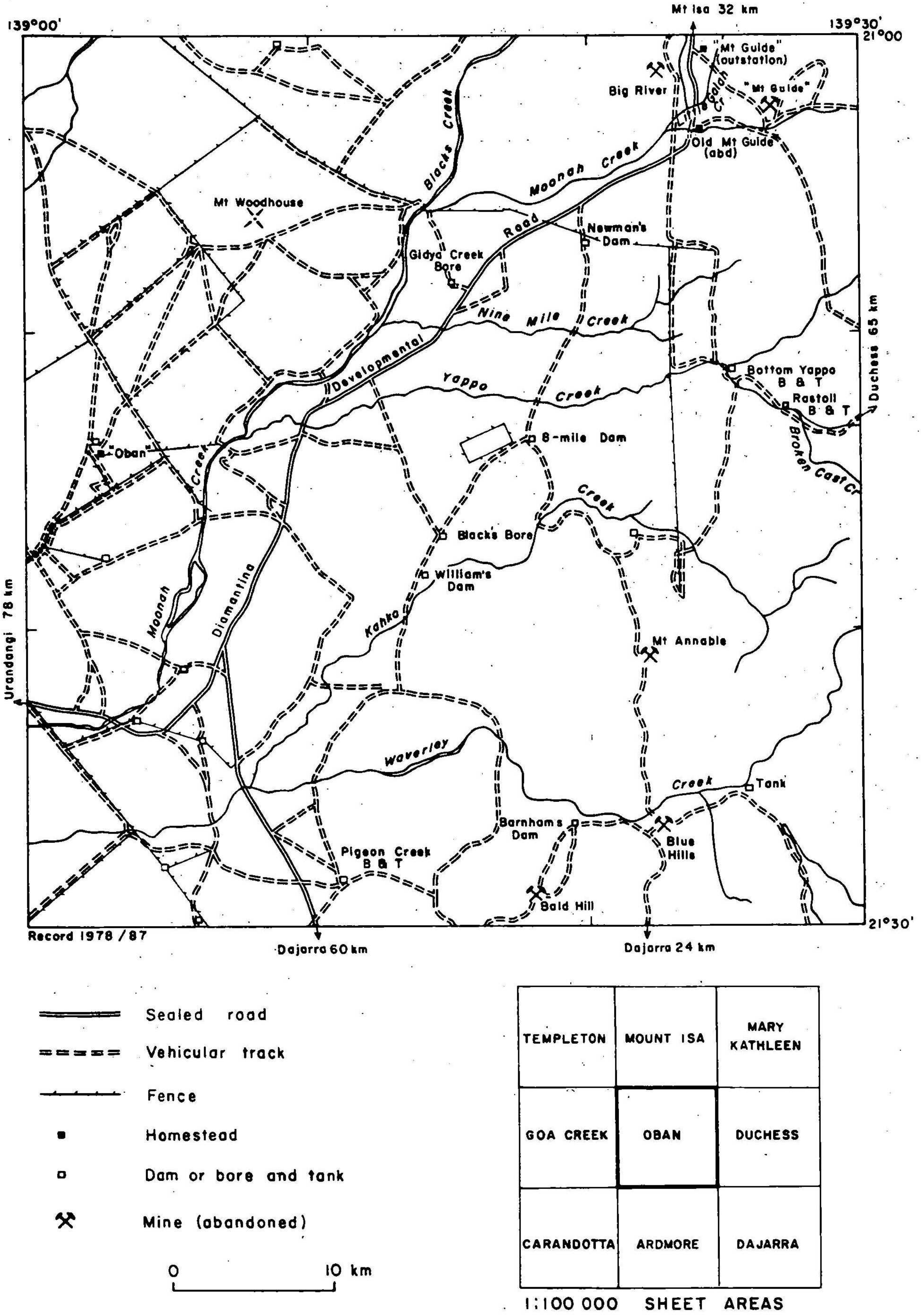

Fig. 1 Topographic and cultural features of the Oban Sheet area

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# INTRODUCTION

## Location

The Oban 1:100 000 Sheet area (Sheet no. 6755) lies in northwestern Queensland between latitudes 21°00'S and 21°30'S and longitudes 139°00'E and 139°30'E. It forms the northeastern sextant of the Urandangi 1:250 000 Sheet area (SF/54-5). Mount Isa is 32 km north of the northeastern corner of the Oban Sheet area, and the southeastern corner of the Sheet area is 10 km north of Dajarra, an important transport centre for stock at the terminus of a branch from the Mount Isa-Townsville railway line. Dajarra is 900 km west-southwest of Townsville.

## Access

Principal access is via the sealed Diamantina Developmental Road, which crosses the Sheet area diagonally from northeast to southwest (see Figure 1). More direct access to the Precambrian rocks occupying the eastern third of the Sheet area is provided by a graded track from Duchess to Mount Guide (via Bottom Yappo Bore), and a mining company track from Dajarra through to Blue Hills and Mount Annable. Several station and mining company tracks branch north and south from the Duchess-Urandangi road and provide adequate access to the exposed Precambrian rocks.

The western and central parts of the Sheet area, with extensive black-soil plains formed on flat-lying to gently dipping Phanerozoic sediments of the Georgina Basin succession, are well-served by a network of station tracks.

## Population and industry

One homestead, Oban, and one outstation, Mount Guide, accommodate the permanent population of the Oban Sheet area. The sole industry is cattle-raising, which is carried out chiefly on the Mitchell grass plains of the western two-thirds of the Sheet area. All mining operations in the area, eg. at Mount Guide, Mount Annable, Bald Hill and Blue Hills, are now abandoned.

## Object

The aims of the survey were to:

(1) present a geological map at 1:100 000 scale of the Precambrian rocks;

(2) reassess the stratigraphy, structure, petrology, and economic potential of the Precambrian rocks, and present an interpretation of the geological history of the region;

(3) undertake a geochemical examination of selected rock units.

## Present investigation

This report presents the results of semidetailed mapping of the Precambrian rocks in the Oban 1:100 000 Sheet area, mainly by the author while a member of joint Bureau of Mineral Resources (BMR) and Geological Survey of Queensland (GSQ) field parties in 1975 and 1976. Reconnaissance traverses were made by C.M. Mock in 1975 and a series of closely spaced vehicle and foot traverses with some helicopter 'spot-checking' saw the completion of mapping of the Precambrian rocks in 1976. The 1976 work was carried out by C.M. Mock with significant contributions by R.M. Hill (especially on the Mount Isa Group), R.J. Bultitude (BMR), and T.A. Noon (GSQ). The summary descriptions of the Cambrian and Mesozoic rocks in the Sheet area are based on the work of de Keyser & Cook (1972), de Keyser (1972), and Smith (1972), with additional information from Rogers (1976), and Offenberg (1976).

Colour aerial photographs at a scale of about 1:25 000 were used for the detailed mapping. Black and white photographs at scales of 1:50 000 and 1:85 000 were used for the detection of large-scale structures. Soil boundaries in the western part of the Sheet area were determined by colour airphoto-interpretation. The geological overlays were compiled by P.L. Blythe on photo-scale bases enlarged from 1:100 000 topographic sheets.

About 200 thin sections have been examined, of which 50 were modally analysed. XRD determinations were done by G.W.R. Barnes (BMR), using a Philips PW 1010 diffractometer with graphite monochromator, and chemical analyses were done by AMDEL by XRF, using a Philips PW 1220.

Progress reports on the geology of the adjoining 1:100 000 Sheet areas to the east and southeast (Duchess and Dajarra respectively) have been written (Bultitude, Blake, & Donchak, 1978; Blake, Donchak, & Bultitude, 1978). The geology of the Mount Isa 1:100 000 Sheet area, to the north, and that of the Mary Kathleen 1:100 000 Sheet area, to the northeast, have been described by Hill, Wilson & Derrick (1975), and Derrick & others (1974, 1977).

## References

Carter, Brooks, & Walker (1961) have compiled a comprehensive bibliography of work done to 1960 on the geology of the Precambrian belt of northwestern Queensland. Reports relevant to the Oban Sheet area are listed in the bibliography of this Record, together with reports of work done from 1960 to 1976. The aerial photographs, photomosaics, and maps available for the Sheet area are listed in Table 1.

TABLE 1. MAPS AND AERIAL PHOTOGRAPHS COVERING THE OBAN SHEET AREA

1. Urandangi 1:250 000 topographic map, SF/54-5, Series R502, Division of National Mapping, 1964.
2. Mount Isa-Cloncurry 1:500 000 Regional Series Map, Department of Mines, Queensland.
3. Urandangi 4-mile (1:253 440) Geological Series SF/54-5, 2nd edition, Bureau of Mineral Resources, 1958.
4. RC8 colour airphotos, 1:25 000, 1975.
5. RC8 colour airphotos, 1:25 000, (eastern half of Oban only) 1971.
6. RC9 black and white airphotos, 1:83 000, 1970.
7. K17 black and white airphotos, 1:50 000, 1947.
8. Oban orthophotomap, 1:100 000, compiled from RC9 airphotos, 1970.
9. Oban photo-index, 1:100 000, compiled from RC9 airphotos, 1970.

## Drainage and water resources

The Oban Sheet area lies entirely within the Georgina Basin drainage system (Stewart, 1954), which drains inland into Lake Eyre. The southwesterly flowing Moonah, Yappo, Kahko, and Waverley Creeks, tributaries of the Georgina

River, rise in the eastern highlands, which are well-drained by an intensive trellis pattern of small streams. A dense dendritic stream pattern characterises the low hills of the sandy granite country west of the highlands. In the west, large streams crossing the Mitchell grass plains, eg. Moonah Creek, follow mature braided or deeply cut single channels.

Most of the watercourses contain water only during and for a few weeks after the main wet season. Permanent or semipermanent surface water can be found in a few waterholes on Moonah Creek, e.g. Widgewarra, and in rockholes in the eastern ridges. Earth dams, and tanks fed with bore water constitute the main source of water in the Sheet area; in the western part the bores tap subartesian water in the sedimentary rocks of the Georgina Basin.

## Climate

The following climatic details are taken from Slatyer & Christian (1954). The area has an arid, subtropical monsoonal climate, in which the seasons consist of a long dry winter and a short wet summer separated by brief transition periods. Of the average annual rainfall of about 380 mm, more than two-thirds falls between November and March, with the highest falls being in January and February. Light rain is commonly received in early winter. The winter season is characterised by southeasterly winds and relatively large diurnal temperature variations. The annual average maximum daily temperature is about 32°C, with November-February being the hottest months, and the annual average daily minimum is about 16°C. June-August are distinctly cooler than the rest of the year. Although the climate is monsoonal, the area is far enough inland to enjoy relatively low humidities; mean relative humidity ranges from 24% to 45%.

## Geomorphology and land systems

The following account is condensed from Stewart (1954) and Stewart, Christian & Perry (1954). Three north-trending topographic zones cross the Oban Sheet area: a series of planated ridges along the eastern boundary of the area, the hilly country, is separated from grassy plains in the western third of the area, the Mitchell grass country, by a transitional zone of low rounded foothills and undulating sandy plains, the southern desert country. The eastern highland zone is part of a major range that extends north and northwest from the Oban Sheet area and forms the watershed between the Gulf of Carpentaria drainage system to the northeast and Lake Eyre drainage system to the southwest.

The three topographic zones include six land systems (Stewart, Christian & Perry, 1954), shown in Figure 2. Each land system is an area of unified topography, soil, and vegetation. The characteristics of the land systems, including their relations to the topography and underlying geology, are described briefly below and summarised in Table 2.

Resistant Precambrian rocks form the eastern hilly country of steep-sloped, immaturely-dissected ridges and plateaux separated by narrow V-shaped valleys (Mount Isa land system). The ridges rise to 470 m, although local relief is usually less than 100 m. The Cambrian and Mesozoic rocks within the hilly country are characterised by dissected mesa topography (Yelvertoft land system) somewhat lower than the ridges. Their lateritised surfaces are remnants of a Tertiary land surface (Grimes, 1972). The transititional southern desert country is partly erosional and partly depositional - low, rounded granite hills (Waverley land system) rise from undulating plains (Bundella Land System) that are covered with granite sand and post-Miocene coarse-textured alluvia derived from the highlands. Finer-grained sediments have been deposited farther west, where a thick black soil profile of post-Miocene fine-textured alluvia has developed on flat low-lying plains (Kallala and Moonah land systems).

## Vegetation

The interplay of geology, topography, soil, and drainage has produced a variety of plant communities in the area. Perry & Christian (1954) described ten major communities that are represented in the Oban Sheet area. The dominant members and habitats of the ten communities as described by Perry & Christian are given below.

TABLE 2. CHARACTERISTICS OF THE LAND SYSTEMS REPRESENTED IN THE OBAN SHEET AREA

| Land system | Mount Isa | Yelvertoft | Waverley | Bundella | Kallala | Moonah |
|---|---|---|---|---|---|---|
| Symbol | M | Y | WV | BN | KL | MN |
| Geological association | PC except Pgs | C | Pgs, M | Czs | Qf | Czr swamps |
| Topographic group | Hilly country | Hilly country | Sourthern desert country | Southern desert country | Mitchell grass country | Mitchell grass country |
| Geomorphological unit | Dissected country without lateritic remnants | Dissected country with lateritic remnants | Dissected country without lateritic remnants | Post-Miocene coarse-textured alluvia | Post-Miocene fine-textured alluvia | Post-Miocene fine-textured alluvia |
| Geomorphological subdivision | Erosional | Erosional | Erosional | Depositional | Depositional | Depositional |
| Description | Rugged hilly country with N-S ridges; mostly rock outcrops or skeletal soils; | Undulating, some rock outcrops, but mostly skeletal soils or truncated lateritic red earths; | Undulating to low hilly country with some rock outcrops; mostly light-textured skeletal soils with low scrub spinifex, *E. brevifolia* woodland; | Undulating with some rock outcrops; mostly light-textured 'Bundella' soils with low scrub and spinifex, *Eucalyptus argillacea* - *E. terminalis* shrub woodland; | Very large, very gently undulating heavy black-soil plains; heavy brown pedocals; | 'red soil' rises with Georgina alluvial red-brown earths; |
| | some small alluvial valleys; mostly lightly timbered *E. brevifolia* (+ *E. dichromophloia*) woodlands; much spinifex, some pastures in valleys; rainfall 250-750 mm; high ridges served by rock springs and water-holes | | Small depressions with alluvial soils and better pastures; average rainfall 250-410 mm; surface water very poor, sub-artesian water generally available | | *Astrebla pectinata* grassland or *Acacia cambagei-A. pectinata* woodland, | and *A. cambagei* shrub woodland |
| | | | | | but mostly treeless Barley Mitchell grass pastures; boggy when wet; average annual rainfall 250-430 mm; widely spaced non-permanent streams, few permanent water-holes, adequate sub-artesian water at less than 150 m depth | |

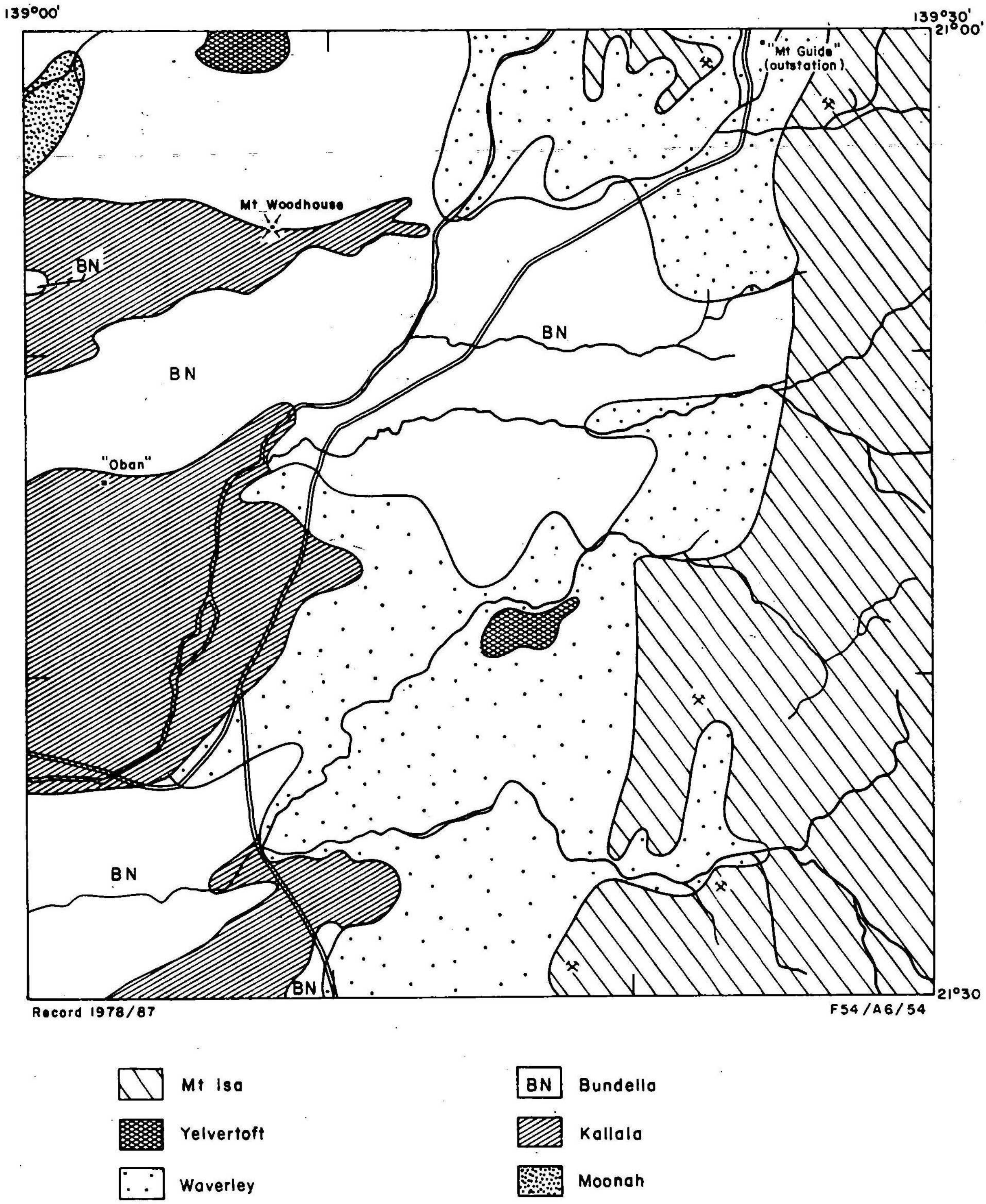

Fig.2 Distribution of land systems of the Oban Sheet area

The skeletal soils of the quartzite ridges and granite hills support a sparse ground cover of soft and hard spinifex tussocks (Triodia pungens and T. molesta) and scattered short grasses such as kerosene grass (Aristida arenaria), interspersed with low acacias, such as turpentine (Acacia lysiphloia), and eucalypts, mainly snappy gum (Eucalyptus brevifolia). The tree layer is denser on the lower slopes, where silverleaf box (Eucalyptus pruinosa) is associated with Hakea aborescens, corkwood (H. lorea), vine tree (Ventilago viminalis), mulga (Acacia aneura), beefwood (Grevillea striata), and whitewood Atalaya hemiglauca). The shallow stony soil is colonised by a sparse grass dominated by Aristida pruinosa and kangaroo grass (Themeda australis). Creek beds, valley floors, and alluvial flats throughout the Sheet area are delineated by clumps of dark-leafed gidyea (Acacia cambagei), with scattered low eucalypts and shrubs. A shrub-woodland community of low eucalypts, such as western box (E. argillacea) and bloodwood (E. terminalis), together with shrubby acacias and spinifex, grows on the sandy plains west of the highlands. The poorly drained black-soil plains in the western part of the Sheet area are covered by a thick mat of Mitchell grass (Astrebla pectinata and A. elymoides) interspersed with Flinders grass (Iseilema spp.). Near major watercourses, eg, Moonah Creek, the flat grassland horizon is broken by an occasional spreading coolibah (Eucalyptus microtheca), or a stately red river gum.

## Nomenclature

Igneous rocks in the Oban Sheet area are classified according to their modal compositions, using the terminology of Streckeisen (1973). Acid intrusive rocks are classified according to their relative modal proportions of quartz (Q), albite + orthoclase (Ab + Or), and anorthite (An) (see Fig. 6). Alkali-feldspar prefixes are applied in order of increasing abundance towards the root-name (eg. 'granite', 'granodiorite', etc) to indicate whether sodic or potassic alkali-feldspar predominates. Commonly, granitic rocks that fall in the same field using Streckeisen's scheme show marked differences with respect to abundance and relative proportions of mafic minerals. Where the abundance of non-essential minerals is greater than about 10 percent, descriptive qualifiers are added to the root-name - eg. 'biotite-albite-microcline granite' describes an alkali feldspar granite with more microcline than albite, and between about 10 and 20 percent biotite.

Sedimantary rocks are classified according to their modal compositions and grainsizes, using the terminology of Packham (1954) and Crook (1960) as modified by Folk (1968). Thus, psammites with less than about 10 percent labiles (feldspars, rock fragments, ferromagnesian minerals and chlorite) are orthoquartzites; those with between 10 and 25 percent labiles are sublabile sandstones, or, where appropriate, feldspathic sandstones; and those with more than 25 percent labiles are arkoses if rock fragments are mainly felspathic, or greywackes if rock fragments are mainly ferromagnesian. The term 'quartzite' has been used as a field name for recrystallised sandstones (that have not been modally analysed).

Metamorphic rocks are named for their metamorphic textures and facies-diagnostic minerals, following the terminology of Joplin (1968) and Spry (1969).

All mineral qualifiers are ordered in increasing abundance towards the root-name.

Textural terms for igneous and metamorphic rocks are applied in the sense used by Joplin (1968, 1971) or by Spry (1969).

Grainsizes are determined from the following scheme:

| | |
|---|---|
| coarse-grained: | >3 mm average grain diameter |
| medium-grained: | 1-3 mm average grain diameter |
| medium to fine-grained: | 0.3-1 mm average grain diameter |
| fine-grained: | 0.05-0.3 mm average grain diameter |

## STRATIGRAPHY

The Precambrian rocks of the Oban Sheet area are part of the Cloncurry Complex (Carter & others, 1961) of Carpentarian or older age, and belong to the Mount Isa Orogenic Domain (GSA, 1971). The domain consists of two north-trending basins - the Eastern and Western Geosynclines of Carter & others (1961), containing the eastern and western successions of Derrick, Wilson & Hill (1976a) - separated by an elevated basement block of granitic and acid volcanic rocks (Plumb & Derrick, 1975). The metamorphosed sedimentary and volcanic rocks exposed in the Oban Sheet area form part of the western succession. Some of the younger units known from the western succession in the Mount Isa Sheet area to the north were either not deposited in the Oban Sheet area or have been eroded. The stratigraphy of the Oban 1:100 000 Sheet area is summarised in Table 3.

A north-trending metamorphic unconformity, which in the Mount Isa Sheet area coincides with the Mount Isa Fault (Hill & others, 1975), divides the western succession in the northern part of the Oban Sheet area into two similar sequences. The westerly sequence has been metamorphosed to a higher grade than has the easterly sequence; therefore a separate system of nomenclature has been applied to the westerly sequence (see map legend). The difference in metamorphic grade between the sequences decreases southwards, however; for this reason a single system of nomenclature has been used throughout the southern part of the Oban Sheet area, that of the sequence east of the Mount Isa Fault in the northern part of the Sheet area.

Stratigraphic nomenclature follows that of Carter & others (1961), as modified by Hill & others (1975), Derrick & others (1974, 1976a, b), and Cavaney (1975) in their mapping to the north and northeast of Oban. The modifications to the nomenclature of Carter & others (1961) that are relevant to Oban are summarised below.

(a) The Mount Guide Quartzite has been subdivided into two informal members (Derrick & others, 1974, 1967a), both of which are extensive on Oban. The lower member has since been mapped as a separate formation in the easterly adjoining Duchess Sheet area (Bultitude, Blake, & Donchak, 1978) and is informally referred to here and shown on the accompanying map as the Malbon Vale Formation*. Some outcrops shown as Eastern Creek Volcanics by Noakes, Carter, & Opik (1959) have been remapped as part of this formation.

(b) The Eastern Creek Volcanics east of the Mount Isa Fault have been divided into three formal members, the Cromwell Metabasalt Member, the Lena Quartzite Member, and the Pickwick Metabasalt Member (Derrick & others, 1976a).

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* This unit has been formally named the Yappo Formation (Bultitude & others, 1978) as the name 'Malbon Vale Formation' has not been approved, because of its similarity to 'Malbon Group'.

TABLE 3. SUMMARY OF THE STRATIGRAPHY OF THE OBAN SHEET AREA

| Age | Group | Rock unit | Symbol | Lithology | Stratigraphic relations | Topography | Remarks |
|---|---|---|---|---|---|---|---|
| CAINOZOIC | | | Qra | river bed gravel and sand | | unconsolidated present-day river bed deposits | distinguished on mappably wide stream beds |
| | | | Qf | black soil; fine alluvium | | Mitchell and Flinders grass black-soil plains | extensive in western half of Sheet area |
| | | | Czs | residual sand and silt; quartz and feldspar rich | | unconsolidated cover on plains and foothills | best developed on graniti terrains |
| | | | Czr | medium-grained alluvium; quartz sand and silt | | flood plain and former stream channel alluvium | |
| MESOZOIC | | | M | pebble conglomerate, siltstone, claystone, ferruginous quartzose sandstone, chert; silcrete, ferricrete cappings | | mesa cappings | almost exclusively caps Cambrian sediments; Cambrian commonly exposed on slopes of Mesozoic capped mesas |
| CAMBRIAN | | INCA FORMATION | Cmi | shale, siltstone, chert | conformable on Beetle Creek Formation; laterally equivalent to Georgina Limestone and other formations | low flat-topped hills | represents silt-shale-chert lithosome |
| | | BEETLE CREEK FORMATION | Cme | lower member of black and white banded algal and vuggy quartzitic chert, siltstone, coquinite, spiculite; upper member of brown, locally phosphatic quartzose siltstone, chert, shale | transitional upwards into Inca Fm; lower member laterally equivalent to Thorntonia Ls; upper member conformable on Thorntonia Ls; unconformable on Precambrian | " | represents chert-siltstone-limestone-phosphate lithosome (Cambrian shown on map is subsurface to a thin capping of Mesozoic). |
| | | THORNTONIA LIMESTONE | Cmt | grey platy dolomite, dolomitic limestone with chert nodules and layers | transitional upwards into Beetle Creek Fm; unconformable on Precambrian | " | represents dolomite-limestone-chert-coquinite lithosome |
| | | RIVERSDALE FORMATION | Cmh | pebble conglomerate, red conglomeratic sandstone, red micaceous siltstone, porcellanite | unconformably overlain by Thorntonia Ls; unconformable on Precambrian | " | represents basal sandstone-conglomerate-siltstone lithosome |

TABLE 3 (continued)

| Age | Group | Rock unit | Symbol | Lithology | Stratigraphic relations | Topography | Remarks |
|---|---|---|---|---|---|---|---|
| CARPENTARIAN | | | do | dolerite, metadolerite, amphibolite | | bouldery rises in granite terrains; valleys in sedimentary rock terrain | includes products of minor basic igneous activity that accompanied deformation of Mount Isa Group |
| | MOUNT ISA GROUP | NATIVE BEE SILTSTONE | Ꝑin | bedded carbonaceous sericitic siltstone, minor chert | conformable on or faulted against Breakaway Shale; | poor outcrop; broad gentle valleys between shale ridges | small area of outcrop on boundary of Oban Sheet area identified as Pin because of continuity with adjacent Mt Isa Sheet area, and presence of possible chert marker |
| | | BREAKAWAY SHALE | Ꝑib | brown, purple & grey laminated carbonaceous sericitic siliceous shale | conformable on Moondarra Siltstone; faulted against Eastern Creek Volcanics and Myally Subgroup | low sharp ridges | |
| | | MOONDARRA SILTSTONE | Ꝑim | dolomitic siltstone, quartzitic siltstone, ferruginous siltstone, calcareous shale | conformable on Warrina Park Quartzite | broad valleys covered with kerosene grass | |
| | | WARRINA PARK QUARTZITE | Ꝑiw | conglomeratic quartzite, quartzose arenite, micaceous quartzite, ferruginous quartzone sandstone | unconformable on Myally Subgroup; unconformable on or faulted against Eastern Creek Volcanics | sharp, jagged ridges | |
| | McNAMARA GROUP | GUNPOWDER CREEK FORMATION | Ꝑrw$_{3f}$ | ferruginous siltstone, sandstone, conglomerate | top not exposed; conformable on Ꝑrw$_{3}$ | low hills | |
| | | | Ꝑrw$_{3}$ | cleaved black carbonaceous shale, laminated silty and micaceous shale | disconformable on Ꝑrw$_{1}$ | valleys | |
| | | | Ꝑrw$_{1}$ | feldspathic sandstone, orange micaceous quartzite schist with basal pebble beds, grey pelitic schist | unconformable on Carters Bore Rhyolite, Myally Subgroup, and Phe | low jagged rises | |

TABLE 3 (continued)

| Age | Group | Rock unit | Symbol | Lithology | Stratigraphic relations | Topography | Remarks |
|---|---|---|---|---|---|---|---|
| | | SYBELLA GRANITE | Ꞓgs$_4$ | feldspar-muscovite-quartz-beryl pegmatite | intrudes Ꞓgs$_1$ | | shown by screen on map |
| | | | Ꞓgs$_3$ | massive or foliated fine to medium even-grained biotite granite | intrudes Ꞓhe, Ꞓgs$_1$ | | shown by screen on map; distinguished from microgranite dykes as being larger and stock-like |
| | | | Ꞓgs$_1$ | massive or foliated coarse porphyritic biotite granite | intrudes Ꞓhg, Ꞓhe, and probably Ꞓhj | tors, low hills set in undulating sandy plains | |
| | | | do | metadolerite, amphibolite | | valleys between quartzite ridges | |
| | | CARTERS BORE RHYOLITE | Ꞓhr | foliated, kaolinized pink porphyritic rhyolite | probably unconformable on Judenan Beds; unconformably overlain by Gunpowder Creek Fm; possibly comagmatic with Sybella Granite | jagged hills | |
| CARPENTARIAN | | JUDENAN BEDS | Ꞓhj | silicified quartzite, quartz-sericite schist, feldspathic quartzite | conformable on Eastern Creek Volcanics | poor outcrop; low rubbly rises | |
| | | | Ꞓhj$_1$ | sandstone, quartzite, pelitic schist, quartz-sericite schist, actinolite schist, mica schist, gneiss | conformable on Eastern Creek Volcanics; top not exposed in Oban Sheet area | low sharp-peaked ridges | identified as Ꞓhj$_1$ on basis of continuity with Mt Isa Sheet, lithology, & relation with underlying Ꞓhe |
| | HASLINGDEN GROUP | MYALLY SUBGROUP | Ꞓhm | quartzite, feldspathic quartzite, siltstone, feldspathic arenite | disconformable on Eastern Creek Volcanics; unconformably overlain by Mt Isa Group; faulted against Ꞓhv, Ꞓhg | moderately rugged ridges | not subdivided because section is thin & cannot be directly correlated with type section |
| | | EASTERN CREEK VOLCANICS | Ꞓhe | metabasalt, amphibolite, mica schist, hornblende schist | conformable on Ꞓhg; conformably overlain by Ꞓhj, Ꞓhm | undulating | undivided, high-grade sequence west of Mt Isa Fault |
| | | | Ꞓhe$_q$ | quartzite, epidote quartzite, pelitic schist, cordierite schist | lenses in Ꞓhe | as for Ꞓhe | shown by screen on map |
| | | | Ꞓhe$_s$ | quartzite | interbed in Ꞓhe | prominent ridge | marker quartzite in Ꞓhe |

TABLE 3 (continued)

| Age | Group | Rock unit | Symbol | Lithology | Stratigraphic relations | Topography | Remarks |
|---|---|---|---|---|---|---|---|
| CARPENTARIAN | HASLINGDEN GROUP<br>EASTERN CREEK VOLCANICS | PICKWICK METABASALT MEMBER | P̲hp | basalt, metabasalt, amygdaloidal metabasalt | conformably overlain by P̲hm, conformable on P̲hl | undulating | |
| | | | P̲hp$_q$ | feldspathic sandstone, shaly siltstone, calcareous quartzite, pebble beds, limestone, quartzite, micaceous quartzite | lenses in P̲hp | as for P̲hp | shown by screen on map |
| | | LENA QUARTZITE MEMBER | P̲hl | variable; maroon feldspathic quartzite, shaly sandstone, brown pebbly micaceous sandstone, white quartzite | conformable on P̲hc; conformably overlain by P̲hp | distinctive ridges | |
| | | CROMWELL METABASALT MEMBER | P̲hc | metabasalt, amygdaloidal metabasalt, flow-top breccia | conformable on Mount Guide Quartzite | undulating | |
| | | | P̲hc$_q$ | quartzite, epidote quartzite, micaceous quartzite | lenses in P̲hc | as for Phc | shown by screen on map |
| | | MOUNT GUIDE QUARTZITE | P̲hg | feldspathic quartzite, orthoquartzite | conformable between P̲he and P̲hv | rugged ridges, with planated tops, moderate ridges | |
| | | MALBON VALE | P̲hv | feldspathic micaceous sandstone, greywacke, subabile arkose, conglomerate, micaceous siltstone, minor basalt | base not exposed | undulating country | |

(c) The Myally Subgroup (Derrick & others, 1976a), previously the Myally Beds, has not been subdivided in the Oban Sheet area; areas in the south previously mapped as Mount Guide Quartzite are mapped in this study as Myally Subgroup.

(d) The Malbon Vale Formation, the Mount Guide Quartzite, the Eastern Creek Volcanics, the Myally Subgroup, and their equivalents make up the Haslingden Group of Derrick & others (1976a).

(e) A formation defined by Hill & others (1975), the Carters Bore Rhyolite, is present in the northern part of the Sheet area.

(f) The Mount Isa Shale (Carter & others, 1961), redefined as the Mount Isa Group by Bennett (1965), is now taken to include the Warrina Park Quartzite as its basal formation (Derrick & others, 1976b). This formation was formerly referred to as the Quartzite Marker of the Myally Beds (Bennett, 1965). Only the three basal formations of the Mount Isa Group crop out in the Oban Sheet area. The extent of outcrop of the group is greater than was shown by Noakes & others (159).

(g) A small area in the north previously mapped as Judenan Beds is now mapped as Gunpowder Creek Formation, a unit of the McNamara Group (Cavaney, 1975).

The rocks of the Cloncurry Complex were assigned to the Lower Proterozoic by Carter & others (1961), but subsequent isotopic age determinations (Richards, 1966; Farquharson & Wilson, 1971; Page & Derrick, 1973) have shown that the western succession belongs to the Carpentarian System (1800-1400 m.y.) as defined by Dunn, Plumb, & Roberts (1966).

## CARPENTARIAN

### Haslingden Group

In the Oban Sheet area, the Haslingden Group is overlain unconformably by the Mount Isa Group east of the Mount Isa Fault and by the Gunpowder Creek Formation west of the fault. The Carters Bore Rhyolite may also be unconformable on the Haslingden Group (Cavaney, 1975). The group comprises, from the base, the Malbon Vale Formation, the Mount Guide Quartzite, the Eastern Creek Volcanics, and the Myally Subgroup and laterally equivalent Judenan Beds.

The Sybella Granite intrudes the group, thereby setting for it a minimum age of 1650 m.y. (Page & Derrick, 1973); the Haslingden Group is younger than granite and metavolcanics of the Leichhardt-Kalkadoon basement block to the east, dated at about 1860-1780 m.y. (Page, 1976).

## Malbon Vale Formation (Ꝑhv)

The Malbon Vale Formation (informal name) is equivalent to the lower Mount Guide Quartzite of Carter & others (1961) and Derrick & others (1974, 1976a, 1977), but it has been delineated as a separate formation (formally defined by Bultitude & others (1978) as 'the 'Yappo Formation') in the Oban, Duchess, and Dajarra Sheet areas. The 'Mount Guide Quartzite' corresponds to the upper Mount Guide Quartzite, using the terminology of Derrick & others (1974, 1969a, 1977). The Malbon Vale Formation is most extensive in the southeastern corner of the Oban Sheet area, where immature sandstone, greywacke, and conglomerate of the formation cover about 120 km$^2$ of low, hilly country. It also crops out in the northeast.

The belt of Malbon Vale Formation in the southeast was mapped by Carter & others (1961) as part of the Eastern Creek Volcanics. The abundance of dolerite dykes, the presence of intercalated basalt flows, and the gentle topography associated with Ꝑhv produce an airphoto-pattern very similar to that of the volcanics.

Stratigraphic relations: The base of Ꝑhv is not exposed in the Oban Sheet area, where, as elsewhere, the formation is conformably overlain by the Mount Guide Quartzite. In places the contact is transitional, but it is generally marked by a sharp lithological change from friable micaceous sandstone to feldspathic quartzite and by a correpsonding change in topography from low hills to upstanding ridges. Ꝑhv is intruded by numerous dolerite dykes and sills, and by rare porphyry dykes that may be equivalent to the Garden Creek Porphyry mapped in the adjoining Duchess and Dajarra Sheet areas.

Field occurrence and lithology: Ꝑhv is exposed in the core of a broad north-trending anticlinorium in the southeastern part of the Sheet area. The anticlinorial core is broken into large blocks by northwest-trending transverse faults with sinistral displacement and southerly downthrow. The transverse faults and associated shear zone cut across tight north-northeast-trending fold axes, along which dolerite dykes have been intruded. As the base of Phv is not seen, its thickness cannot be estimated, but at least 1500 m of section are exposed. Dips throughout the Ehv block are shallow to moderately steep (30°-60°).

The Malbon Vale Formation can be subdivided into four parts, each consisting of a dominant lithological type interbedded with the other typees. From the base, the main lithologies of each part are:

sublabile sandstone and arkose;
greywacke and conglomerate;
sublabile sandstone and siltstone;
quartzose sandstone and siltstone.

The two lower parts predominate in the southern blocks of the Ehv belt; the two upper parts predominate in the northern block. In all units, individual beds are between 20 cm and 1 m thick.

The first (basal) part consists of saccharoidal brown to buff medium-grained micaceous pebbly to conglomeratic sublabile sandstone, in which high-angle cross-beds are defined by trails of opaque oxides or mica, and interbeds of friable white to grey chloritic, micaceous conglomeratic arkose; black siltstone; metabasalt; schistose sublabile sandstone; and mica schist. The pebbles in the conglomeratic beds are of blue quartzite, white quartzite, sandstone, epidotised sandstone, aplite, biotite schist, and granite.

The second part consists of greywacke and conglomerate, with minor sandstone interbeds. The greywacke is well bedded, well sorted, and graded, with some pebble beds; high-angle cross-beds are defined by trails of mica and opaque oxides. The conglomerate consists of pebbles of granite, acid volcanics, biotite-amphibole schist, quartzite, and sandstone in a dark blue matrix of possibly partly volcaniclastic origin.

The third part consists of interbeds of friable brown to buff medium-grained micaceous, ferruginous sublabile sandstone and white siltstone; the sandstone is similar to the sandstone of the first part except that it is finely parallel-laminated, the laminations being defined by bands of opaque oxides. Pebbles occur sporadically.

The fourth (top) part, which grades up from the third part, consists mainly of interbeds of siltstone and massive ferruginous quartzose sandstone with negligible micaceous content; it also contains interbedded basalt and greywacke. Interbeds of white quartzite and siltstone increase in abundance upwards in both the third and fourth parts.

Along shear zones, bedding is destroyed, and rocks become schistose and quartz-veined; crenulation cleavage is commonly developed.

Dolerite dykes intruding P̲hv are bordered by aureoles of contact-metamorphosed blue quartzite.

Petrography: The volume percent compositions of samples of P̲hv are shown in Table 4 and plotted in Figure 3. Sublabile muscovite-bearing sandstone of the lowermost unit consists of a mosaic of medium, even-grained irregularly-shaped, polygonal quartz grains (50-70%, 0.05 to 0.1 mm diameter) whose boundaries and boundary junctions are marked by muscovite flakes. Biotite and opaque oxides are local accessories.

Chloritic quartzite shows a polygonal mosaic of quartz grains (80%) in two size groups: grains less than 0.01 mm diameter are interstitial to grains of 0.05-1 mm diameter. Elongate flakes of pale green chlorite are randomly scattered through the quartz grain aggregate.

The blue greywackes consist of rock fragments in a well-packed and mostly recrystallised matrix of quartz, muscovite, biotite, microcline, epidote, opaque oxides, sphene, zircon, and apatite. The quartz grains in the matrix fall into two size groups: small grains (0.05 mm) are angular in shape but with rounded corners and large grains (1 mm) are more irregularly shaped and sharp-cornered. The pebbles in the greywacke include some euhedral microcline crystals and aggregates, and quartzite. The granite pebbles have generally retained an allotriomorphic granular texture which can be distinguished from the recrystallised sedimentary texture of the matrix.

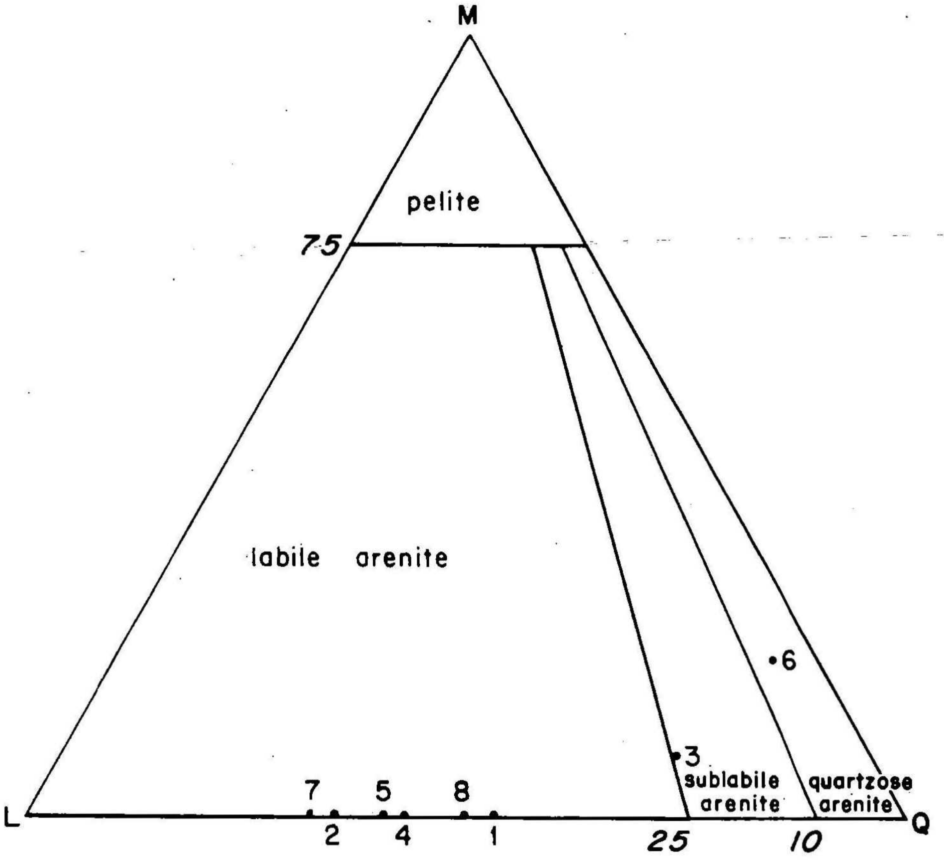
The overall texture and mineralogical and chemical composition of the conglomerate (see Table 5) are similar to those of a granite. Pebbles consisting of quartz and euhedral twinned microcline form up to 25 percent of the rock and are set in a matrix of recrystallised polygonal quartz, microcline, opaque oxides, biotite, apatite, zircon, epidote, and clinozoisite. The matrix is parallel-foliated and locally segregated into mafic-rich bands. The quartz grains are irregularly shaped and sharp-cornered. These appears to have been minimal reworking of a granitic source to produce the matrix of the conglomerate.

## TABLE 4. VOLUME PERCENT COMPOSITION OF THE MALBON VALE FORMATION

| Mineral Grouping | | Sample No | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Mineral | 1017B[3] | 1017D | 1018 | 1263A | 1263B | 1275A | 1267A | 1277 |
| Q | Q | Quartz | 52.8 | 35.2 | 68.4 | 42.7 | 41.4 | 72.7 | 32.1 | 50.6 |
| L | F | K-feldspar | 9.5 | 36.7 | | 31.1 | 19.3 | | 48.2 | 24.6 |
| | | Plagioclase | 8.1 | 9.7 | 2.3 | 3.0 | | 5.6 | 6.0 | 6.0 |
| | R | Biotite | 14.7 | 12.6 | 4.5 | 9.9 | 23.5 | | 12.0 | 4.0 |
| | | Muscovite | 2.0 | 4.4 | 5.0 | 2.0 | 0.4 | | 1.7 | 6.4 |
| | | Opaques | 3.7 | 0.4 | 1.4 | 3.6 | 6.2 | | | 6.6 |
| | | Epidote | 8.8 | | 5.1 | 6.8 | 8.4 | | | 1.8 |
| | | Sphene | | 1.0 | | 0.4 | | | | |
| | | Zircon | | | | | 0.2 | | | |
| | | Apatite | 0.4 | | 0.2 | 0.3 | | | | |
| | | Calcite | | | | 0.2 | | | | |
| | | Stilpnomelane | | | 1.5 | | | | | |
| | | Chlorite | | | 1.6 | | 0.6 | | | |
| | M | Muscovite | | | 5.5 | | | 21.7 | | |
| | | Biotite | | | 4.5 | | | | | |

Key:
1. 1017B: dark feldspathic greywacke
2. 1017D: dark conglomeratic arkose
3. 1018 : micaceous arenite
4. 1263A: volcanic arkose
5. 1263B: dark feldspatholithic greywacke
6. 1275A: micaceous quartzose arenite
7. 1276A: feldspathic arenite
8. 1277 : lithofeldspathic arenite

1. Minerals are grouped in order to plot samples in QLM and QFR diagrams (Folk, 1968) (Figures 3 & 4); apices in the QLM diagram are: Q - quartz, including chert and quartzite pebbles; L - labiles, including feldspar, rock fragments, ferromagnesian minerals, etc: M- Apices in the QFR diagram are: Q - quartz, including chert and quartzite pebbles; F- feldspar, granite and gneiss gragments; R - all other rock fragments, ferromagnesian minerals, etc.
2. Sample numbers 1. to 8. refer to Figure 3.
3. Sample numbers are second half of BMR registered numbers.



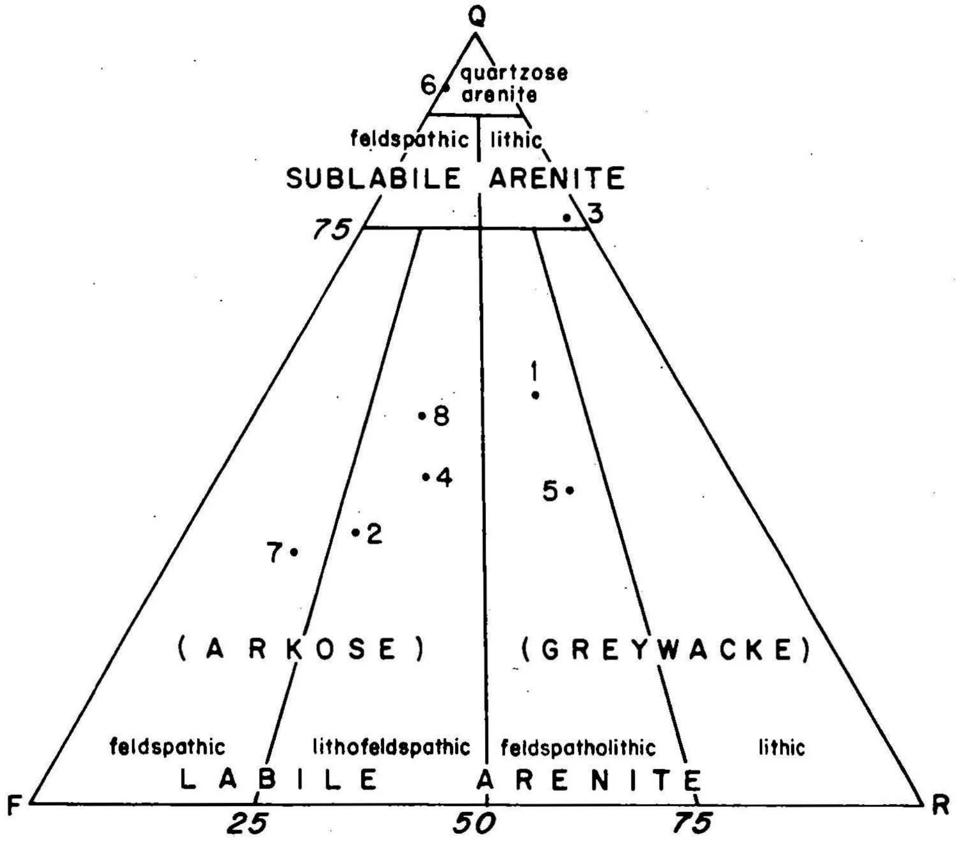


Fig. 3 Classification of the Malbon Vale Formation in MLR and QFR diagrams (Folk, 1968). For explanation of diagram apices and sample numbers see Table 4

TABLE 5. CHEMICAL ANALYSES OF THE MALBON VALE FORMATION

| Sample No. | 1.<br>1017A | 2.<br>1263B | 3.<br>1263C |
|---|---|---|---|
| $SiO_2$ | 68.06 | 66.48 | 68.41 |
| $TiO_2$ | 1.52 | .97 | .74 |
| $Al_2O_3$ | 12.48 | 12.77 | 13.08 |
| $Fe_2O_3$ | 5.63 | 5.62 | 3.93 |
| $FeO$ | 1.17 | 1.36 | 1.21 |
| $MnO$ | .09 | .08 | .06 |
| $MgO$ | 1.26 | 1.74 | 1.49 |
| $CaO$ | 3.81 | 2.62 | 2.77 |
| $Na_2O$ | 2.30 | 2.42 | 2.50 |
| $K_2O$ | 3.10 | 4.47 | 4.38 |
| $P_2O_5$ | .12 | .17 | .13 |
| $CO_2$ | .10 | .05 | .05 |
| $H_2O^+$ | .81 | .64 | .64 |
| $H_2O^-$ | .02 | .06 | .03 |
| Total | 100.47 | 99.40 | 99.42 |

Key:
1. 1017A; Єhv, feldspathic greywacke
2. 1263B; Єhv, feldspatholithic greywacke
3. 1263C; Єhv, feldspatholithic greywacke

Discussion: The sediments of Ehv are extremely immature, as they contain a high proportion of feldspar, mica, and rock fragments, and the mineralogical composition of the feldspathic greywackes is almost identical to that of a granite. The immaturity of the sediments, the nature of the rock fragments, and the occurrence of high-angle cross-bedding point to rapid deposition in a high-energy environment close to a rapidly eroding source area of acid igneous rocks - the Kalkadoon-Leichhardt basement block to the east. That the depositional regime was subject to rapid lateral and vertical variations is evident from the variations in sediment type, and lateral thickness variations. Sporadic basic volcanic activity occurred concomitantly with sedimentation.

The environment inferred from the nature of Ehv in the Oban Sheet area agrees with that of Derrick & others (1974, 1977) and Glikson, Derrick, Wilson, & Hill (1976), who concluded from mapping in the Mary Kathleen 1:100 000 Sheet area that Ehv was deposited in a tectonically active area adjacent to a rising tectonic welt to the east.

## Mount Guide Quartzite (Ehg)

The Mount Guide Quartzite was defined by Carter & others (1961) and subdivided into two units by Derrick & others (1974, 1976a, 1977). The two units have since been given separate formation status in the Duchess and Oban Sheet areas, the lower unit being the Malbon Vale Formation and the upper unit the (new) Mount Guide Quartzite. The Mount Guide Quartzite forms north-trending ridges of resistant orthoquartzite and feldspathic quartzite, and covers about 180 $km^2$ along the eastern margin of the Sheet area. Probable Mount Guide Quartzite is also exposed in the north along the western edge of the Precambrian.

In the northern part of the Sheet area the formation is exposed in two north-trending anticlinoria flanking a broad synclinorium of Eastern Creek Volcanics. In the southern part of the Sheet area, Ehg is exposed as two elongate fold limbs overlying the anticlinorial zone of Malbon Vale Formation.

A belt of quartzite north and south of the Waverley Creek Tank mapped as Mount Guide Quartzite by Noakes and others (1959) has been remapped as Myally Subgroup, as it conformably overlies Eastern Creek Volcanics in this area, and is intruded by fewer basic dykes than is the Mount Guide Quartzite.

Stratigraphic relations: The Mount Guide Quartzite rests conformably on the Malbon Vale Formation, and is conformably overlain by the Eastern Creek Volcanics. P̲hg is intruded by swarms of dolerite dykes. Two stocks of grey porphyry of possible Sybella Granite affiliation intrude P̲hg at its contact with Phv in the southeast.

Field occurrence and lithology: The formation shows tight to isoclinal folding, as indicated by frequent dip reversals, along the north-northeast-trending axes; axial-plane fractures have localised most of the numerous dolerite dykes that intrude P̲hg. Blocks of P̲hg within the fold belt are locally offset along north-northwest-trending faults. Beds dip steeply but are overturned at only one locality, O 402498*, where the limbs of a tight anticline are oversteepened. The maximum thickness of P̲hg in the Sheet area is less than 1500 m, which is considerably less than in the Mary Kathleen Sheet area (Derrick & others, 1974, 1977), where up to 6200 m of Malbon Vale Formation equivalent and Mount Guide Quartzite are exposed. The Mount Guide Quartzite in the Oban Sheet area may represent a thinner sequence deposited near the edge of the depositional basin.

Although contacts between P̲hg and the overlying Eastern Creek Volcanics are faulted in many places, the faults phase out into conformable contacts along strike and apparently little or no section is missing.

The lithology of P̲hg is generally uniform but an overall upward transition from predominantly feldspathic quartzite to predominantly orthoquartzite can be traced. These two rock types are compared in Table 6. The feldspathic quartzite is buff to cream, thin to medium parallel-bedded, medium-grained, and rarely locally epidotised. In many places, and more commonly westwards, it is multiply jointed; joint planes are usually ferruginised. Intercalations of brown feldspathic sandstone, siltstone and shale occur, more commonly in the lower part of the section. The orthoquartzite is thicker bedded and is characterised by high-angle cross-beds.

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* Such grid references, shown as six digits prefixed by 'O' (Oban), refer to the accompanying map.

## TABLE 6. COMPARISON OF UNITS OF THE MOUNT GUIDE QUARTZITE

| | | |
|---|---|---|
| Classification | buff feldspathic quartzite | white orthoquartzite |
| Topography | low | high |
| | rounded ridges and broad valleys | planated ridges and sharp valleys |
| Photo pattern | buff photo pattern | white to pale green |
| Vegetation | dense, tall | sparse, short |
| Bedding | thin to medium-bedded; low angle X-bedded sets of thin parallel-laminated beds defined by heavy minerals or iron-staining | medium to thick-bedded; high-angle curved X-bedding defined by heavy minerals |
| Sedimentary features | ripple marks and mud-cracks common | mud-cracks common |
| Fracture | slabby or rubbly | spherical or blocky |
| Distribution | occupies roughly three-quarters of areal extent of Phg in Oban Sheet area | occupies roughly one-quarter of areal extent of Ᵽhg in Oban Sheet area |

Both the transition from the immature sediments of Ᵽhv to the lower unit of Ᵽhg and then to the upper unit of Ᵽhg represent increasing maturity of the source area, and stabilisation of the depositional environment. The clean quartzites of Ᵽhg probably represent shoreline sands.

### Eastern Creek Volcanics (Ᵽhe)

The Eastern Creek Volcanics (Ᵽhe) were defined by Carter & others (1961) as a sequence of metabasalt and intercalated metasediments. Robinson (1968) subdivided the sequence into four members, based on the distribution of the sedimentary intercalations. Later Derrick and others (1974, 1976a, 1977) combined the two lowermost units of Robinson's subdivision so that three members are now recognised: a relatively thick basal metabasalt unit, the Cromwell Metabasalt Member (Ᵽhc), is separated from a thinner, upper metabasalt unit, the Pickwick Metabasalt Member (Ᵽhp), by a prominent quartzite marker bed, the Lena Quartzite (Ᵽhl). This threefold subdivision is followed east of the Mount Isa Fault, where the formations are metamorphosed to greenschist grade. West of the fault Phe is metamorphosed to amphibolite grade and its stratigraphic relations are obscured. In the southern part of the Oban Sheet area, the Mount Isa Fault cannot be traced with certainty, and, as the metamorphic discontinuity across it is not evident, it is taken to have less fundamental significance in this area. The basalts have not been subdivided west of the fault or in the southern part of the Sheet area, and a prominent quartzite lens, probably equivalent to Phl, is shown on the map as $Phe_s$.

Minor quartzite lenses within Phe, Phc, and Php are shown on the map as $Phe_q$, $Phc_q$ and $Php_q$ respectively.

The Eastern Creek Volcanics cover a total of 180 $km^2$ in the Oban Sheet area, most of this being occupied by the Cromwell Metabasalt Member.

The Cromwell Metabasalt Member and undivided Phe form low undulating hills which contrast sharply with the prominent cuestas of the Lena Quartzite and $Phe_s$. The Pickwick Metabasalt Member produces topography similar to that of the Cromwell Metabasalt Member, but with slightly higher relief due to the greater proportion of interbedded sediments.

Stratigraphic relations: In the Oban Sheet area, as elsewhere (Derrick & others, 1974, 1977; Hill & others, 1975; Wilson & others, 1977), the Eastern Creek Volcanics conformably overlie the Mount Guide Quartzite. The Lena Quartzite Member conformably overlies the Cromwell Metabasalt Member and is conformably overlain by the Pickwick Metabasalt Member. The Pickwick Metabasalt Member is unconformably overlain by the basal formation of the Mount Isa Group, the Warrina Park Quartzite. The Warrina Park Quartzite and also the Myally Subgroup locally disconformably overlie the Cromwell Metabasalt Member. West of the Mount Isa Fault, the base of the Eastern Creek Volcanics is not exposed in the Oban Sheet area, but it is in the Mount Isa Sheet area, where it conformably overlies the Mount Guide Quartzite (Hill & others, 1975). The upper contact west of the fault is mostly obscured by the younger Sybella Granite, but in the northern part of the Oban Sheet area the formation is conformably overlain by the Judenan Beds and unconformably by the Carters Bore Rhyolite and the Gunpowder Creek Formation.

Field occurrence: The Eastern Creek Volcanics are exposed in the keels or limbs of broad north-trending synclinoria. Dips are variable but are usually less than 50°. Most of the Eastern Creek Volcanics show evidence of low-grade regional metamorphism and are cut by numerous narrow quartz veins.

The Cromwell Metabasalt Member is the thickest unit of the formation, reaching a possible maximum thickness of 1000 m; the thickness of Phl is everywhere about 500 m, and Php is generally less than about 500 m thick. The Eastern Creek Volcanics are thinner in the Oban Sheet area than in areas to the northeast (Derrick & others, 1974, 1977; Wilson & others, 1977), possibly because of southward decrease in volcanic activity.

Lithology: The Cromwell Metabasalt Member consists of variably altered massive actinolite-plagioclase metabasalt, schistose epidote-chlorite metabasalt, and chlorite schist. Individual flows can in places be distinguished by their densely amygdaloidal flow tops or, more rarely, by flow-top breccias. Quartz and epidote occupy the amygdales. Flows are from 10 to 30 m thick, and, in the upper part, are interlayered with blue or grey glassy quartzite, feldspathic quartzite, and epidotised sandstone; the sedimentary layers are between 5 and 20 m thick.

The Lena Quartzite Member is a lenticular unit that crops out discontinuously as three north-trending ridges. In the north a prominent ridge of resistant maroon heavy-mineral-banded quartzite overlies the Cromwell Metabasalt. The quartzite is cut by quartz-tourmaline veins. Farther south, east of Mount Annable, the Lena Quartzite Member is represented by brown thin-bedded shaly sandstone interbedded with white quartzite and brown feldspathic micaceous sandstone containing quartzite pebbles. In the far south a ridge of Lena Quartzite consists of white thin-bedded feldspathic quartzite with some interbeds of buff pebbly siltstone and brown friable coarse feldspathic sandstone.

The Pickwick Metabasalt Member, though similar in lithology to the Cromwell Metabasalt Member, comprises basalt that is generally less altered, and sedimentary intercalations that are more abundant and more varied in their lithology. East of Mount Annable, fresh amygdaloidal basalt and epidotised metabasalt are interbedded with coarse-grained friable feldspathic sandstone; shaly siltstone; dark blue calcareous quartzite with pebble beds; limestone; glassy grey, blue and white quartzite; epidotised quartzite; and schistose micaceous quartzite.

West of the Mount Isa Fault, the Eastern Creek Volcanics have been metamorphosed to amphibolite grade. West of the Big River pegmatite and south of Barnhams Dam they consist of hornblende schists, spotted muscovite-biotite schists, and pelitic and quartzite schists, all showing vertical conjugate jointing.

Basalt surrounding the elongate stock of Sybella Granite north of Mount Annable shows a range of high-grade, low-pressure contact effects decreasing gradually eastwards and sharply westwards. The rocks within the aureole all show a strong north-northwest-trending foliation. Apart from the main granite mass, numerous small stocks and dykes of leucogranite and white pegmatite also intrude the volcanics; directly adjacent to these small intrusions, the country rock is massive amphibolite which is commonly thinly veined, migmatitic style, whereas away from the intrusions the rocks are brown or black mica schists, black hornblende schists, or cordierite schists. Gneissic rocks in which granitic bands alternate with micaceous or muscovite pegmatite bands are commonly 'interbedded' with the schists. Crenulation cleavage and kink-bands in the schists are indicative of multistage folding.

Except for minor shears and quartz veins, thermal effects are not evident along any of the other contacts between Eastern Creek Volcanics and Sybella Granite.

Ꝑhe$_s$ consists of white thin-bedded orthoquartzite, and forms an almost continuous ridge from Kahko Creek to the southern margin of the Sheet area.

<u>Petrography</u>: The volume percent compositions of samples of Ꝑhc, Ꝑhl, and Ꝑhe are shown in Table 7. The least altered basalts of Ꝑhc and Ꝑhp are composed of about 60 percent actinolite, clinozoisite and chlorite in varying proportions, and about 40 percent albite. The mafic minerals are usually in subradial to subparallel fibrous aggregates of laths, the interstices between the laths being occupied by subhedral or anhedral untwinned plagioclase. Accessory minerals are sphene, quartz, biotite, relict clinopyroxene, and hematite.

The more metamorphosed basalts are even-grained with an average grainsize of about 0.08 mm.

## TABLE 7. VOLUME PERCENT COMPOSITION OF THE EASTERN CREEK VOLCANICS

| Sample No.<br>Mineral | 1.<br>1004B | 2.<br>1005 | 3.<br>1008 | 4.<br>1054 | 5.<br>1051 | 6.<br>1157 | 7.<br>1041G |
|---|---|---|---|---|---|---|---|
| Quartz | 8.8 | 1.5 | 33.7 | 41.3 | 51.6 | 42.9 | 60.6 |
| K-feldspar | | | | 0.4 | 1.1 | | |
| Plagioclase | | 34.8 | | | | 26.1 | 9.6 |
| Hornblende | 46.0(act$^+$) | 34.8(act) | 50.6 | | | | 14.0 |
| Clinozoisite | 28.9 | 1.5 | | 15.4 | 0.9 | | 12.6 |
| Biotite | | 8.3 | 0.5 | 28.1 | | 6.8 | |
| Muscovite | | | | | 36.0 | 24.2 | 2.1 |
| Opaques | 3.6 | 6.1 | 6.7 | 8.6 | 3.7 | | |
| Sphene | 6.8 | 6.3 | | 5.8 | 2.3 | | 1.0 |
| Zircon | | | | | 0.2 | | |
| Apatite | | | | 0.2 | | | |
| Chlorite | 0.6 | 1.7 | 0.5 | | 3.7 | | |
| Calcite | 4.3 | | | 0.2 | | | 0.1 |
| Tourmaline | | | | tr | 0.5 | | |
| Vesicles | 1.0 | 5.0 | 8.0 | | | | |

+ actinolite

Key:
1. 1004B: Ᵽhc; clinozoisitic metabasalt
2. 1005: Ᵽhc; vesicular metabasalt, vesicles filled with chlorite-sphene-plagioclase±quartz±biotite
3. 1008: Ᵽhc; vesicular metabasalt, spherical vesicles filled with quartz-hornblende-sphene-stilpnomelane-biotite
4. 1054: Ᵽhc$_q$; dark current-bedded, graded-bedded, micaceous clinozoisitic lithic arenite
5. 1051: Ᵽhl; foliated muscovite lithic arenite
6. 1157: Ᵽhe$_q$; coarse mica-feldspar-gneiss; alternate bands are muscovite-biotite schist and quartz-plagioclase-muscovite pegmatite
7. 1041G: Ᵽhe$_q$; foliated basalt/quartzite hornfels

TABLE 8. CHEMICAL ANALYSES OF THE EASTERN CREEK VOLCANICS

| | 1.<br>1002 | 2.<br>1054 | 3.<br>1167 |
|---|---|---|---|
| $SiO_2$ | 50.88 | 60.84 | 69.52 |
| $TiO_2$ | 1.35 | 2.49 | 1.00 |
| $Al_2O_3$ | 14.20 | 12.32 | 19.32 |
| $Fe_2O_3$ | 3.23 | 8.19 | .69 |
| FeO | 8.50 | 1.89 | 2.99 |
| MnO | .19 | .09 | .07 |
| MgO | 5.89 | 2.96 | 6.85 |
| CaO | 8.64 | 5.17 | .28 |
| $Na_2O$ | 3.25 | 2.94 | .46 |
| $K_2O$ | 1.02 | 2.48 | .74 |
| $P_2O_5$ | .16 | .20 | .18 |
| $CO_2$ | .05 | .10 | .05 |
| $H_2O^+$ | 1.97 | 1.15 | 1.78 |
| $H_2O^-$ | .08 | .05 | .08 |
| Total | 99.41 | 100.87 | 100.41 |

1. 1002; Ꝑhc, vesicular metabasalt
2. 1054; $Ꝑhc_q$, micaceous clinozoisitic lithic arenite
3. 1167; Ꝑhe, cordierite schist

The amygdaloidal basalts contain up to 20 percent vesicles. Vesicle size ranges from 1 mm to 1 cm; vesicles are well rounded to amoeboid, symmetrical, and filled with coarse-grained clinozoisite and quartz in varying proportions, and accessory minerals.

The occurrence of apparently primary quartz distinguishes the basalts as tholeiitic.

Chemical analyses of a relatively fresh metabasalt and two sedimentary intercalactions are shown in Table 8.

The association of actinolite, albite, and epidote (clinozoisite) indicates that they have been metamorphosed in the greenschist facies (Miyashiro, 1973). At higher grades actinolite would be replaced by hornblende, and plagioclase becomes more calcic, at the expense of epidote.

The schistose metabasalts are composed of actinolite, chlorite, sericite, and clinozoisite in varying proportions.

Medium-grained well-sorted epidotised sandstones from the west side of the Mount Isa Fault show a foliated or granoblastic polygonal web texture (see Spry, 1969, p. 187) in which a network of equant quartz grains encloses nuggety epidote grains; the reverse relation is also present. Accessory minerals are orthoclase, sphene, garnet, muscovite, zircon, allanite, and opaque oxides. The assemblage indicates that the sandstones have been metamorphosed in the lower (albite-epidote-almandine) amphibolite facies (Miyashiro, 1973).

The amphibolites within the Sybella Granite aureole north of Mount Annable are composed of about 50 percent hornblende, 40 percent plagioclase, and 10 percent quartz in a granoblastic polygonal aggregate. The tendency for hornblende to mantle plagioclase may be relict ophitic texture. Grainsize of both minerals is about 3 mm. Plagioclase is untwinned and carries abundant poikilitic inclusions of quartz and hornblende.

Hornfelsic rocks occur close to the granite contact and appear to have been derived from mixing of basalt, sandstone, and granite. The groundmass is a recrystallised polygonal mosaic of quartz and feldspar. Up to 30 percent red-brown biotite, acicular and euhedral opaques, cordierite, and garnet are included in the groundmass minerals, forming a sieve texture. Retrogressed sillimanite, consisting of masses of fibrous white mica with sillimanite cores, was found in one sample at the contact.

The gneissic rocks within the aureole are most commonly composed of a granitic component and a micaceous schistose component; layers of leucopegmatite are present in places. The granitic component can be identified as the coarse-grained porphyritic phase of the Sybella Granite. The schistose layers consist of quartz, muscovite, and biotite arranged in sinuous foliae winding through a groundmass of equant polygonal quartz, feldspar, and micas. The leucopegmatite veins contain coarse-grained quartz, alkali feldspar, and usually some muscovite and epidote. Less commonly the gneisses contain bands of plagioclase and actinolite or hornblende.

Dicussion: The origin and chemical affinities of the Eastern Creek Volcanics in the Sheet areas to the north and east of Oban have been well documented by Robinson (1968), Derrick & others (1974), Hill & others (1975), Glikson & others (1976), and Wilson & others (1977). These authors concluded that the Eastern Creek Volcanics are the products of a history commencing with frequent outpourings of continental tholeiitic flood basalts onto an initially shallow but deepening epicontinental basin. The eruptions were followed by a lull in volcanic activity and an influx of detritus into the basin. A final but quieter stage of volcanism was accompanied by the accumulation of more abundant and more varied sedimentary interbeds than were deposited during the first stage of volcanic activity.

The nature of the Eastern Creek Volcanics in the Oban Sheet area is consistent with the inferred history outlined above.

In the Mount Isa Sheet area, to the north, the Mount Isa Fault is considered to form the eastern limit of the Sybella Granite intrusion, which may have initiated it (Hill & others, 1975). The trough in which the Mount Isa Group was deposited lies east of the fault. The inferred sequence of events is: granite intrusion, accompanied and followed by deformation and faulting, subsequent deposition of the Mount Isa Group, and a second stage of faulting (including reactivation of the Mount Isa Fault). In the southern part of the Oban Sheet area, there is no evidence of a metamorphic discontinuity between Ꝑhe near the Sybella Granite and Ꝑhe near outcrops of the Mount Isa Group; Ꝑhe, Ꝑhm, and Ꝑiw south of Barnhams Dam have been physically deformed to the same extent. It therefore appears that the main period of deformation postdated deposition of the Mount Isa Group. This deformation may have coincided with the second stage of faulting. Alternatively, parts of the Sybella Granite may be younger than the Mount Isa Group, although this seems unlikely in view of the most recent isotopic age determinations on the Sybella Granite, which may be as old as 1750 m.y. (R.W. Page, BMR, personal communication).

## Myally Subgroup (Ꝑhm)

Most of the Myally Beds as defined by Carter & others (1961) have been redefined as the Myally Subgroup by Derrick & others (1976a). The redefinition and subdivision of the subgroup into four formations - the Alsace Quartzite at the base, and the overlying Bortala Formation, Whitworth Quartzite, and Lochness Formation - is based on exposures where the subgroup is thickest, in the Prospector 1:100 000 Sheet area. A very much condensed section of the subgroup is exposed in the Oban Sheet area, and although its lithology corresponds mostly to that of the Whitworth Quartzite, the thickest and most widespread formation of the subgroup, a direct correlation is not possible. For this reason, the subgroup has not been subdivided in the Oban Sheet area.

Up to 1200 m of interbedded quartzite and siltstone formerly mapped as Mount Guide Quartzite in the southeastern corner of the Sheet area have been remappped as Myally Subgroup. A small outcrop in the south lies within the Mount Isa Group synclinorium. The subgroup forms steep-sided ridges covering about 100 $km^2$.

Stratigraphic relations: The Myally Subgroup forms the upper part of the Haslingden Group. In the Oban Sheet area the subgroup rests disconformably on the Cromwell Metabasalt Member of the Eastern Creek Volcanics, as the two upper members of Ꝑhe are missing from the sections in contact with the Myally Subgroup. The subgroup is overlain unconformably by the basal formation of the Mount Isa Group, the Warrina Park Quartzite. The eastern contact of the main belt of Myally Subgroup is faulted against Malbon Vale Formation. The Judenan Beds exposed west of the Mount Isa Fault in the north are probably equivalents of the Myally Subgroup.

Field occurrence and lithology: The Myally Subgroup dips eastwards at $40^0$ to $90^0$, and is locally overturned to the west. In the main outcrop between 0 370350 and 0 370220 the basal beds of the subgroup are white or greyish brown thin parallel-bedded locally ferruginous glassy quartzite with interbedded cream silty sandstone. Ripple marks are common. The quartzite-sandstone sequence is overlain by a sandstone-siltstone sequence, in which red to brown friable feldspathic ferruginous pebbly sandstone is interbedded with buff pebbly siltstone. The upper part of the subgroup consists of interbedded massive white cross-bedded quartzite and white sandy siltstone. Beds throughout the Myally Subgroup are generally less than 1 m thick.

West of the main outcrop belt the subgroup is exposed along a structural high within the Mount Isa Group synclinorium. This outcrop of Myally Subgroup is more deformed than that to the east, as shown by its well-developed cleavage, vertical conjugate joints, schistosity, and flattening. The basal part of the subgroup here consists of alternating beds of white schistose quartzite and pebbly ferruginous sandstone. This is overlain by white schistose sublabile muscovite sandstone. The top third of the subgroup consists of highly compressed vertically jointed orange schistose quartzite (including sample 1209A - quartzose arenite). The nature and extent of deformation in this block are similar to that in the Big River area.

TABLE 9: VOLUME PERCENT COMPOSITION OF THE JUDENAN BEDS AND MYALLY SUBGROUP, AND CHEMICAL ANALYSIS OF THE JUDENAN BEDS

| Sample No.<br>Mineral | 1.<br>1021C | 2.<br>1033 | 3.<br>1209A |
|---|---|---|---|
| Quartz | 6.6 | 79.6 | 54.8 |
| Feldspar | 38.7(ser$^+$) | 13.4 | |
| Hornblende | 22.6 | 0.4 | |
| Biotite | | 1.6 | |
| Muscovite | | 0.6 | 40.3 |
| Clinozoisite | 5.8 | 2.0 | |
| Clinopyroxene | 13.7 | | |
| Zircon | | tr | |
| Sphene | | 0.8 | |
| Opaques | 5.8 | | |
| Allanite | 6.8 | | |
| Apatite | | 0.2 | |
| Chlorite | | 1.4 | |
| Stilpnomelane | | | 4.7 |

| | 1.<br>1021C |
|---|---|
| $SiO_2$ | 54.12 |
| $Ti_2O_3$ | .92 |
| $Al_2O_3$ | 13.10 |
| $Fe_2O_3$ | 4.42 |
| FeO | 3.95 |
| MnO | .12 |
| MgO | 6.00 |
| CaO | 9.96 |
| $Na_2O$ | 5.35 |
| $K_2O$ | .32 |
| $P_2O_5$ | .12 |
| $CO_2$ | .15 |
| $H_2O^+$ | 1.08 |
| $H_2O^-$ | .05 |
| Total | 99.66 |

+ sericite

Key: 1. 1021C: Ꝑhj; granofels consisting of bands of basalt and epidote quartzite

2. 1033: Ꝑhj; foliated feldspathic arenite; pendant in Ꝑgs

3. 1209A: Ꝑhm; foliated muscovite-rich quartzose arenite

Petrography: The volume percent composition of one sample of Ꝑhm is shown in Table 9. The quartzose arenite of Ꝑhm along the southern boundary of the Sheet area is medium-grained, well-sorted, and highly compressed. It consists of about 50 percent quartz, forming parallel-aligned lensoid grains, separated by a matrix of narrow muscovite trails.

Discussion: Wilson & others (1977) presented a detailed model of Myally palaeogeography in four stages. The first stage was the development of an extensive stable shallow shelf which received detritus from quartzitic sedimentary rocks and feldspar-rich plutonic rocks to the west and possibly to the east; the Oban Sheet area represents the southwestern margin of the depositional Shelf. With the onset of a delta-slope environment, a series of silts and clays were deposited (stage 2); this was followed by a period of steady subsidence, during which the thick feldspathic sands of the Whitworth Quartzite accumulated (stage 3). The final stage, at which subsidence ceased and a nearshore environment took over (Wilson & others, 1977), is not represented in the Oban Sheet area. Some evidence for the first three stages is found in the Oban Sheet area, where a quartzite sequence is overlain by a sandstone sequence. The section is very much condensed, however, which is consistent with the location of the Oban Sheet area near the boundary of the depositional shelf. The Myally Subgroup rests disconformably on the Cromwell Metabasalt Member in the south of the Sheet area, which implies non-deposition of the upper Eastern Creek Volcanics, and uplift, before the Myally Subgroup sands were deposited.

## Judenan Beds (Ꝑhj)

The Judenan Beds were defined by Carter & others (1961) and have been informally subdivided by various workers (Hruska, 1970, 1971; Brooks & Shipway, 1960; Wilson, 1972; and Hill & others, 1975).

The subdivision of Hill & others (1975) into three units - a basal quartzite unit, a middle metasiltstone and schist unit, and an upper metabasalt unit - was revised on the basis of mapping in the Kennedy Gap 1:100 000 Sheet area, north of the Mount Isa Sheet area. As a result of this work, Hill & others (1975, in an addendum) noted that the upper basalt unit was a fault slice of Eastern Creek Volcanics, and should be deleted from the Judenan Beds. Correlation of Judenan Beds with exposures to the north is made difficult by their restricted occurrence and their metamorphism.

Outcrops of the Judenan Beds in the Oban Sheet area cover less than 10 km$^2$ and are restricted to two small areas in the northern part of the Sheet area. In one of these, a discontinuous strip of silicified quartz and quartz-sericite schist whose outcrop appears to be mainly fault-controlled forms low rubbly hills flanking the western edge of the main outcrop of the western succession. In the other area, the Big River area, Ꝑhj crops out as low jagged hills of various highly schistose rocks. These outcrops are continuous to the north with the lower unit of the Judenan Beds, Ꝑhj$_1$, mapped in the Mount Isa Sheet area; Ꝑhj has not been subdivided elsewhere in the Oban Sheet area, where less than 1000 m of section is exposed.

<u>Stratigraphic relations</u>: The Judenan Beds are conformably underlain by the Eastern Creek Volcanics and were thought by Carter & others (1961) to be conformably overlain by the Gunpowder Creek Formation or equivalents. Hill & others (1975) have shown, however, that they are unconformably overlain by the newly defined Carters Bore Rhyolite and (in the Mount Isa Sheet area) by the Gunpowder Creek Formation, which in that area is also unconformable on the Carters Bore Rhyolite. The Judenan Beds are restricted by definition to rocks outcropping on the western side of the Mount Isa Fault, but they are probably equivalent to the Myally Subgroup. In the Oban Sheet area, the Judenan Beds are intruded by the main phase of the Sybella Granite.

<u>Field occurrence and lithology</u>: The Big River outcrops of Judenan Beds consist of well-cleaved strongly foliated schists with vertical conjugate joints as a result of multiple folding. A sequence of interbedded blue-grey schistose quartzite, buff schistose sandstone, and spotted grey micaceous schist overlies schistose metabasalt of the Eastern Creek Volcanics. This sequence is overlain by softer grey pelitic schists and schistose sandstone and gneiss in which micaceous bands alternate with quartzose bands. The mica schists are locally retrogressed to chlorite schists. The schists have been metamorphosed at moderate pressure and low temperature as a result of multiple folding on northerly and easterly trending axes, and show minor contact effects as a result of intrusion of the Sybella Granite.

The Judenan Beds in the discontinuous outcrops to the southeast of the Big River area are heavily silicified but appear to be less deformed than those to the northwest. The main lithology is rubbly weathering white or light brown quartzite, commonly ferruginised, with some medium to coarse-grained quartz-sericite rocks.

Petrography: The volume per cent compositions of two samples of Phj and the chemical composition of one of them are shown in Table 9.

Discussion: The stratigraphy of the Judenan Beds is obscured in the Oban and Mount Isa Sheet areas by complex faulting, metamorphism and poor exposure of lower and upper contacts. However, mapping in the Kennedy Gap Sheet area, north of the Mount Isa Sheet area, where the unit is less deformed, has revealed that there is a general stratigraphic succession through the Beds from quartzite to metasiltstone to quartzite. The lithology of the Judenan Beds is thus similar to that of the Myally Subgroup, and the two units are regarded as stratigraphic equivalents. Hill & others (1975) concluded that the Judenan Beds were probably deposited in a shallow low-energy marine environment.

## Carters Bore Rhyolite (Phr)

A thin but distinctive porphyritic rhyolite overlying the Judenan Beds in the Mount Isa and Kennedy Gap Sheet areas (Hill & others, 1975; G.M. Derrick, personal communication) has been defined by Derrick, Wilson, & Hill (1978) as the Carters Bore Rhyolite. It was included by Plumb & Derrick (1975) in the Haslingden Group, but Cavaney (1975) considered it as equivalent to a sequence of acid volcanics that are unconformable on the Haslingden Group. This relation has yet to be resolved. In the Oban Sheet area, the Carters Bore Rhyolite covers less than 0.5 km$^2$, and is less than 300 m thick.

Stratigraphic relations: Deformation has obscured the relation between the Carters Bore Rhyolite and the underlying Judenan Beds, but it is probably disconformable on the Judenan Beds (Hill & others, 1975), and is unconformably overlain by the Gunpowder Creek Formation. Page (1976) determined a zircon U-Pb age of 1678 ± 2 m.y. for the Carters Bore Rhyolite. The rhyolite may therefore be comagmatic with the Sybella Granite.

Field occurrence and lithology: The Carters Bore Rhyolite crops out in a narrow belt on the limb of a syncline in the Big River area, where it forms low jagged hills. The rhyolite is strongly foliated and cleaved, and dips steeply south. It is maroon when fresh, but is most commonly mottled pink to brown, and consists of phenocrysts of clear quartz and white partly kaolinised feldspar 2 to 3 cm across in a very fine-grained quartzofeldspathic groundmass.

Petrography: The volume percent composition of a sample of Carters Bore Rhyolite is shown in Table 10. The rhyolite contains up to 25 percent each of subhedral embayed K-feldspar phenocrysts up to about 0.5 cm across and ovoid quartz phenocrysts which have been recrystallised to aggregates of polygonal quartz grains. The groundmass consists of quartz (20%), K-feldspar (20%), brown Fe-rich muscovite (10%), and kaolinite. The feldspar phenocrysts carry inclusions of quartz, muscovite, and kaolinite. Foliation of the groundmass around phenocrysts is a result of later shearing. Leucoxene and zircon make up about 0.3 to 1.0 percent of the rock, the former occurring in crescent-shaped bands.

TABLE 10. VOLUME PERCENT COMPOSITION OF THE CARTERS BORE RHYOLITE

| Sample No.<br>Mineral | 1.<br>1143C |
|---|---|
| Quartz phenocrysts | 18.0 |
| K-feldspar phenocrysts | 16.8 |
| Groundmass | 43.4 (40% qtz, 40% Kspr, 20% muscovite) |
| Muscovite | 0.4 |
| Opaques | 5.0 |
| Zircon | 0.2 |
| Leucoxene | 0.2 |
| Vein quartz | 16.0 |

Key: 1. 1143C; porphyritic flow-foliated rhyolite

Discussion: The thinness and restricted extent of the Carters Bore Rhyolite may indicate that the rhyolite represents a minor volcanic event; alternatively it may represent the edge of an extensive sequence of acid volcanics to the noorthe. The results of chemical analysis of the rhyolite and the Sybella Granite being undertaken at present may show whether or not the rhyolite is an extrusive equivalent of the granite.

## McNamara Group

### Gunpowder Creek Formation (Ᵽrw)

The Gunpowder Creek Formation and Mingera Beds were defined by Carter & others (1961) as contemporaneous units conformably overlying the Judenan Beds. Cavaney (1975) has redefined the Gunpowder Creek Formation to include both units, which are now known to be unconformable on the Judenan Beds. The redefined Gunpowder Creek Formation is part of the newly erected McNamara Group (Cavaney, 1975). A small syncline of Gunpowder Creek Formation in the Big River area of Oban was mapped as Judenan Beds by Carter & others (1961); however, rocks here extend northwards into the Mount Isa Sheet area, where they have been remapped as Gunpowder Creek Formation by Hill & others (1975). These workers have subdivided the Gunpowder Creek Formation into four main units and several more subunits based on the alternating sandstone-siltstone-shale lithology of the formation. The basal sandstone-conglomerate unit and an upper siltstone-shale unit are exposed in the syncline of Gunpowder Creek Formation in the Oban Sheet area. About 400 m of the formation is represented, covering about 2 km$^2$ of low rises and gentle valleys.

Stratigraphic relations: The Gunpowder Creek Formation is part of the McNamara Group, which is equivalent to the Mount Isa Group. The McNamara Group unconformably overlies the Eastern Creek Volcanics, the Judenan Beds, the Carters Bore Rhyolite, and the Sybella Granite (Hill & others, 1975). The Gunpowder Creek Formation is conformably overlain by the Paradise Creek Formation and unconformably by the Pilpah Sandstone in the Mount Isa Sheet area (Hill & others, 1975). Its top is not exposed in the Oban Sheet area.

Field occurrence and lithology: The Gunpowder Creek Formation occurs in a shallowly northwest-plunging syncline, the limbs of which dip inwards at about 50°. The basal unit of the formation (Ᵽrw$_1$) consists of micaceous quartzite schists and orange feldspathic schistose sandstone, with some pebble beds at the base. These are overlain by well-cleaved black carbonaceous shale (Ᵽrw$_3$), ferruginous siltstone, and thinly-laminated black siltstone (Ᵽrw$_{3f}$).

Petrography: The shale unit $Prw_3$ is a laminated aggregate of quartz, muscovite, kaolinite, and accessory carbonaceous material and microcline.

The Gunpowder Creek Formation is considered by Hill & others (1975) to have been deposited in a subsiding trough on the eastern margin of a transgressive sea that lay to the west of an eroding highland made up of Sybella Granite and Haslingden Group.

## Mount Isa Group (Pi)

As the host to the Cu-Pb-Zn orebodies of Mount Isa, the Mount Isa Group has been studied by a large number of workers. The structural complexity of the Leichhardt River fault trough (Glikson & others, 1976), in which the Mount Isa Group occurs and the similarity between alternating lithologies within the group, however, has obscured the stratigraphic relations in many areas, and several conflicting subdivisions of the group have been proposed. The history of work on the Mount Isa Group and the stratigraphic schemes that have been used are documented by Carter & others (1961), Hill & others (1975), Derrick & others (1976b), and Wilson & others (1977). The nomenclature used in this report is that of Derrick & others (1976b), who redefined the Mount Isa Group of Bennett (1965), by adding a new basal formation, the Warrina Park Quartzite, formerly part of the Myally Subgroup, to Bennett's sevenfold subdivision of the group. The Mount Isa Group thus contains eight formations, of which the lower four crop out in the Oban Sheet area; the Warrina Part Quartzite, the Moondarra Siltstone, the Breakaway Shale, and the Native Bee Siltstone. Carter & others (1961) mapped wedges of undifferentiated Mount Isa Shale north of Widgewarra and south of Mount Annable. Riley & Duris (1967) extended both these belts of Mount Isa Group, and remapped as Mount Isa Group two areas west of Widgewarra (around 0 373700) and south of Bottom Yappo Bore (around 0 355510) mapped by Carter & others (1961) as Judenan Beds; they distinguished the Moondarra Siltstone, Breakaway Shale, and Native Bee Siltstone, and mapped a quartzite underlying the Mount Isa Group as the top of the Myally Subgroup. This quartzite is here identified as Warrina Park Quartzite, and is included in the Mount Isa Group (Derrick & others, 1976b). The extent of outcrop of Mount Isa Group as mapped by Riley & Duris (1967) corresponds closely with that shown on the Oban 1:100 000 Sheet accompanying this report. Mather (1967) identified Myally Beds overlain by Moondarra Siltstone and overlying units as high as the

Urquhart Shale in the Blue Hills area, but Weber (1968) concluded that the highest stratigraphic level represented in the area is Native Bee Siltstone or equivalent. No definite Native Bee Siltstone equivalents were found in the Blue Hills area during the 1:100 000 mapping program; it is considered that the youngest Mount Isa Group sediments in this area are Breakaway Shale or equivalent.

Stratigraphic relations: The Mount Isa Group is the uppermost group of the western succession and overlies the Haslingden Group unconformably (Derrick & others, 1976b). The top of the group is not exposed, so the upper units may have been eroded or not deposited in that part of the depositional trough now exposed in the Oban Sheet area.

Field occurrence and lithology: The Mount Isa Group in the Oban Sheet area is confined to a narrow north-northwest-trending belt extending from near the northeastern corner of the Sheet area to the middle of its southern boundary. The belt is a tight synclinorium, and the Mount Isa Group is tightly compressed. The narrow northerly parts of the belt are overturned to the east. Where the syncline widens in the south, dips are shallow in the middle of the basin, and basin-and-dome folds predominate. Parts of the synclinorium have been faulted out along the Mount Isa-Mount Annable fault zone, so that it is exposed in four fault blocks: the Mount Guide block extends for about 12 km south from the northern boundary of the Sheet area; the Yappo block extends for 9 km south of Yappo Creek; the Mount Annable block extends from 4 km north of Mount Annable south to Waverley Creek; and the Blue Hills block extends from Waverley Creek to the southern boundary of the Sheet area. The Mount Isa Group covers a total of about 100 $km^2$.

In the Mount Guide block the western limb of the synclinorium is overturned to the east; the Mount Isa Group dips westward at 50°. The synclinorium is truncated on the east by a major north-northeast-striking, locally gossan-filled fault, as a result of which the eastern limb of the synclinorium and the upper two formations of the Eastern Creek Volcanics have been lost.

In the Yappo block, folding on east-trending axes superimposed on north-south folds has produced tight basin-and-dome structures. Deformation was not as intense in this block as in the Mount Guide block. Strongly outcropping gossans and quartz veins locally mark the eastern boundary of the block.

Prominent ridges of sheared sandstone and quartzite frame the Mount Annable and Blue Hills blocks, which are locally faulted against the uppermost units of the Eastern Creek Volcanics on both their eastern and western margins. Faults in the eastern part of the Blue Hills block are strongly gossanous. Riley & Duris (1967) correlated the fault along the western boundary of the Mount Annable block with the Mount Isa Fault, on the basis of the difference in metamorphic grade across it. The greater thickness of the Moondarra Siltstone in the Blue Hills block compared with its thickness in the other three blocks may represent local deepening or structural flattening of the basin, as the underlying Warrina Park Quartzite remains at a constant thickness. The faults enclosing the synclinorium in the Mount Annable and Blue Hills blocks are gossanous. The Blue Hills block shows internal highs of Myally Subgroup and Eastern Creek Volcanics which may represent original irregularities in the depositional surface.

The marginal zones of the Mount Annable and Blue Hills blocks, especially in the areas north of Mount Annable and south of Barnhams Dam, are highly compressed and sheared by a low-temperature, moderate-pressure metamorphism, which has altered the rocks to greenschist facies (biotite zone) grade (see Metamorphism). The Eastern Creek Volcanics, Myally Subgroup and Mount Isa Group south of Barnhams Dam are metamorphosed to the same extent as the Eastern Creek Volcanics and Judenan Beds in the Big River area. If the compression and metamorphism were related to granite intrusion, either part of the Sybella Granite is younger than the Mount Isa Group, or the granite is entirely older than Pi, and faults initiated at the time of intrusion were reactivated after deposition of the Mount Isa Group with accompanying metamorphism. Mather (1967) considered that the Blue Hills and Mount Annable blocks represent a complex syncline plunging south at the northern end and north at the southern end - i.e., a structural basin.

The extent of deformation of the <u>Warrina Park Quartzite</u> (Ꝑiw) varies from one part of the trough to another. Exposures on the western limb of the synclinorium are generally strongly sheared, possibly because of their proximity to the Mount Annable Fault zone, whereas those on the eastern limb are relatively undeformed.

The lithological composition of Ꝑiw varies from north to south. The total thickness of Ꝑiw, the proportion of conglomerate in the formation, and the average size of the pebbles, all increase southwards.

In the Mount Guide block, Piw is uniform sheared feldspathic quartzite.

In the Yappo and Mount Annable blocks, a persistent, metre-thick bed of glassy blue quartzite is overlain by 10 to 15 m of sheared and cleaved pebble conglomerate which grades upwards into sheared, sparsely pebbly, brown pyrite-pitted, ferruginous, micaceous quartzite locally showing crenulation cleavage. The quartzite is overlain by coarse brown sandy shale and friable micaceous sandstone.

In the eastern part of the Blue Hills block, a thin basal bed of glassy blue quartzite is overlain by a distinctive pebble/boulder conglomerate. The conglomerate is overlain by light brown medium to thick-bedded, current-bedded friable micaceous quartzite which grades upwards into olive ferruginous, micaceous, shaly, quartzose sandstone. Pebbles are common throughout the sandstone, decreasing gradually in abundance up-sequence.

Piw in the southern part of the Blue Hills block is a dark well-bedded, graded epidote-rich, micaceous quartzite, with interbeds of sharply defined graded pebble beds. The dark quartzite is overlain by interbedded brown and red ferruginous, micaceous, heavy-mineral-banded current-bedded quartzite, white quartzite, friable buff muscovite quartzite, and grey siltstone.

The sequence of Piw on the western side of the Blue Hills block is more deformed than that on the eastern side of the block. Sheared, schistose conglomeratic sandstone at the base is overlain by sheared, vertically jointed orange feldspathic, ferruginous schistose quartzite overlain by interbedded olive-brown sandy siltstone, schistose quartzite, and mica schist.

The conglomerate of the Warrina Park Quartzite typically forms jagged subvertical rock-faces, resulting from parting along bedding planes, along ridge shoulders. The best and least deformed exposures of the conglomerate are in the eastern side of the Blue Hills block, where the pebbles have not been flattened. The conglomerate is about 20 m thick and consists of up to 30% pebbles and boulders. The matrix is brown feldspathic sandstone and the pebbles are generally very poorly cemented in the matrix. The pebbles are randomly distributed and poorly sorted, so that in a single bed the lengths of the longest diameter of most of the pebbles range from 2 to 20 cm with rare boulders about 1.5 m across. The pebbles are mostly of four different types of quartzite: blue, white, heavy mineral-banded, and black-and-white banded. Commonly pebbles are included within other pebbles. A small proportion of the pebbles are siltstone, and at one locality in the western side of the block basalt pebbles were found. The pebbles are smooth and well rounded; many are spherical or ellipsoidal, but some irregularly shaped pebbles were found alongside perfectly spherical ones.

In the Yappo block and the northern part of the Mount Annable block, the conglomerate beds have been strongly deformed so that pebbles are flattened elongate ellipsoids, with their long axes in the bedding plane parallel to the north-northeasterly strike of the beds, and their short axes normal to the bedding plane. The ratio of long axis to intermediate axis is as high as 20:1 and of intermediate axis to short axis as high as 6:1. Few pebbles in these blocks are longer than about 20 cm. As in the Blue Hills block, the pebbles are mostly of quartzite; some are siltstone. Bedding in the matrix can be seen to warp around the flattened pebbles; there is no evidence of fracture of either the matrix or the pebbles. Pebbles in the Yappo and Mount Annable blocks constitute about half of the total rock.

The conglomerate in all blocks grades upwards into gritty, shaly sandstone as the amount and size of the pebbles gradually decreases.

In the southern part of the Blue Hills block, the conglomerate is of quite a different character from the beds just described. Even-grained well-bedded, well-sorted, graded-bedded quartzite contains pebble beds 10 cm thick alternating with even-grained beds. The pebbles are generally less than 5 cm across. The well-sorted nature of the conglomerate in this part of the synclinorium indicates a lower-energy environment with lower depositional rates and more persistent sedimentation than in the narrower parts of the synclinorium to the north.

The Moondarra Siltstone (Pim), which conformably overlies the Warrina Park Quartzite, ranges from massive black quartzitic siltstone with a flinty fracture to soft grey thinly parallel-laminated well-cleaved carbonaceous siltstone that weathers bluish white. Chalcopyrite films and gossans are associated with the latter. Ferruginous siltstone is also common near the base of the formation, and grey banded dolomitic siltstone and black calcareous shale are common near the top and predominate in the southern part of the Mount Annable block and in the Blue Hills block, where the formation is thickest. The dolomitic siltstone and calcareous shale show intricate polyclinal and cylindrical folding (Mather, 1967) indicative of basin-and-dome multiple folding, although their average dip is less than 30°.

The overlying Breakway Shale (Pib) forms distinctive low rubbly, shaly strike ridges devoid of vegetation and soil cover. The formation is less extensive than the Warrina Park Quartzite or the Moondarra Siltstone. Pib is present overlying Pim in the Mount Guide block, where it is faulted against Eastern Creek Volcanics on its eastern boundary; similar ridges are present in the Blue Hills block. The Breakaway Shale is variegated red, brown, purple, and grey fissile, ripple-bedded sericitic, and siliceous. Dips are generally shallow.

The Native Bee Siltstone (Pin) is similar to the Moondarra Siltstone.

TABLE 11. VOLUME PERCENT COMPOSITION OF THE WARRINA PARK QUARTZITE

| Mineral Grouping | | Sample No<br>Mineral | 1.<br>1201D | 2.<br>1210 | 3.<br>1215 | 4.<br>1216 |
|---|---|---|---|---|---|---|
| Q | Q | Quartz | 41.3 | 62.7 | 64.9 | 77.9 |
| L | F | K-feldspar | | 0.2 | 11.9 | |
| | R | Biotite | | 6.0 | 7.5 | |
| | | Muscovite | | 11.0 | 1.4 | |
| | | Opaques | | | 2.0 | |
| | | Zircon | | | 0.7 | |
| | | Stilpnomelane | | 0.4 | 2.3 | |
| | | Tourmaline | | | | 0.5 |
| M | | K-feldspar | 7.5 | | | 0.5 |
| | | Biotite | 0.8 | 6.4 | 7.5 | 3.6 |
| | | Muscovite | 9.5 | 11.0 | 1.4 | 16.0 |
| | | Opaques | 2.6 | | | 0.5 |
| | | Epidote | 20.6 | | | |
| | | Sphene | 1.4 | | 0.4 | 0.5 |
| | | Calcite | 11.4 | | | |
| | | Chlorite | 4.9 | 2.3 | | 0.5 |

Key: 1. 1201D: epidote quartzose arenite

2. 1210: micaceous arenite

3. 1215: micaceous feldspatholithic arenite

4. 1216: muscovite quartzose arenite

For explanation of mineral grouping and sample numbers, see Table 4 and Figure 3.

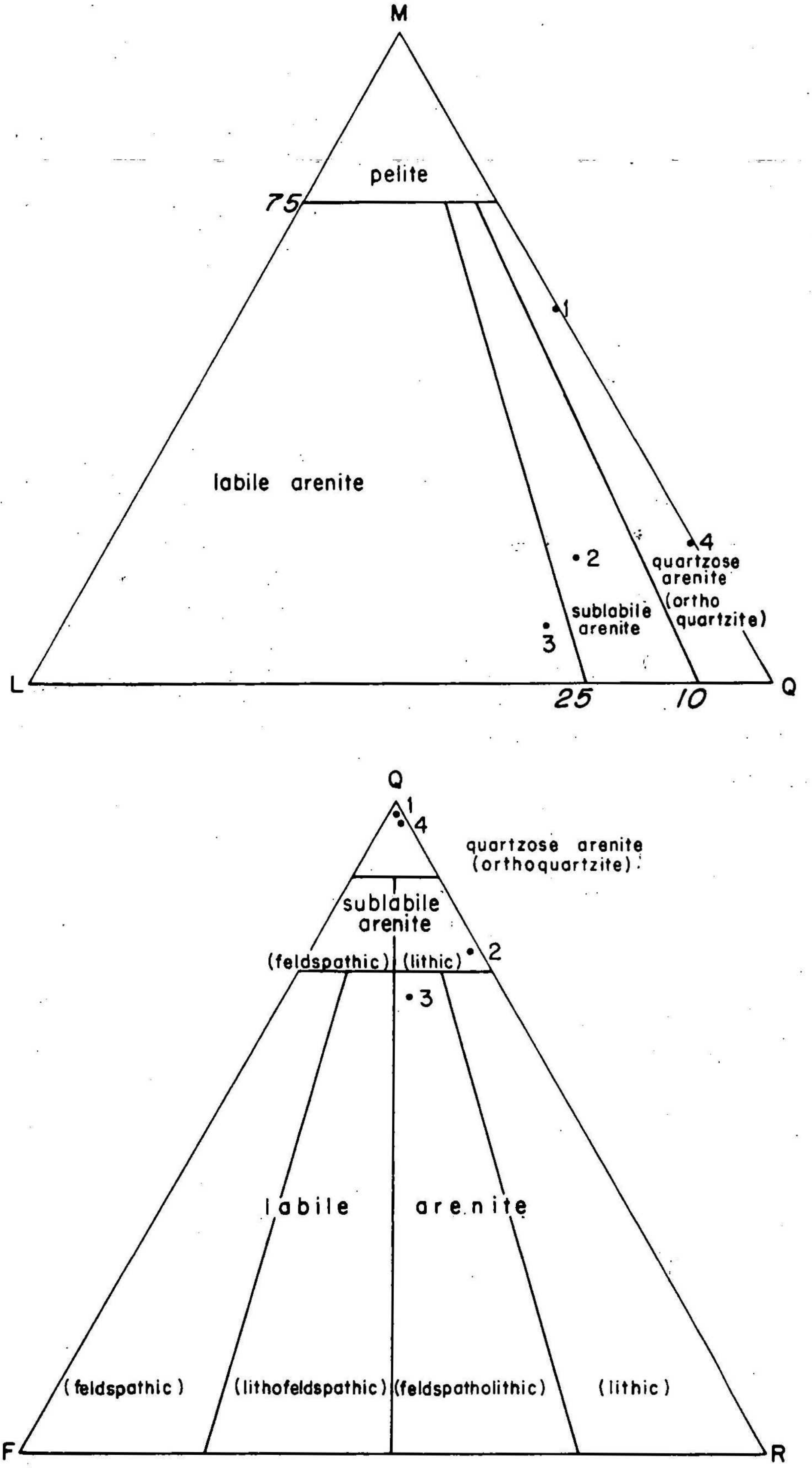

Fig. 4 Classification of the Warrina Park Quartzite in MLQ and QFR diagrams (Folk, 1968). Diagram apices as in figure 3; sample Nos refer to Table II

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Petrography (Table 11, Figure 4): The ferruginous micaceous quartzite (quartzose arenite) of Ꝑiw consists of a medium to fine aggregate of poorly rounded, subspherical to polygonal quartz grains (60 to 70%), interstitial fox-red biotite, muscovite, and minor opaque oxides, feldspar, and stilpnomelane. Dark bands contain concentrations of biotite and opaque oxides.

The blue quartzite of Ꝑiw in the southern part of the Blue Hills block consists of about 60 percent moderately well-rounded subspherical quartz grains in a matrix of epidote (15%), muscovite (10%), calcite (10%), and minor sphene and opaque oxides.

The banded dolomitic siltstone of Ꝑim consists of an irregular to polygonal aggregate of quartz, calcite, dolomite, and minor K-feldspar, plagioclase, and chlorite.

The carbonaceous siltstone of Ꝑim consists of a dense aggregate of quartz, muscovite, calcite, opaque oxides, and carbonaceous material.

In the Ꝑib shales, parallel-aligned quartz grains are separated by trails of muscovite, carbonaceous material, hematite, and minor kaolinite. The variegated colours of the shale at any single locality are produced by variation in the amounts of carbonaceous material and hematite present. Quartz is generally about 30 percent, but muscovite ranges from 30 to 50 percent and carbonaceous matter and hematite correspondingly range from 40 to 20 percent.

Discussion: Derrick & others (1976b), Wilson & others (1977), and Hill & others (1975) interpret the sedimentary features of the Mount Isa Group as indicative of deposition in a broad, shallow sea. The basal conglomerate was deposited on a shallow shelf, and the overlying sand, silt, and shale were deposited during a subsequent, possibly tectonically controlled, transgression. In the Oban Sheet area, the relatively high ratio of conglomerate to quartzite within the Warrina Park Quartzite, the discontinuities and thickness changes of Ꝑiw within the synclinorium, and the apparent non-deposition of the upper units of the group, suggest that the depositional sea shallowed to the south.

## CAMBRIAN

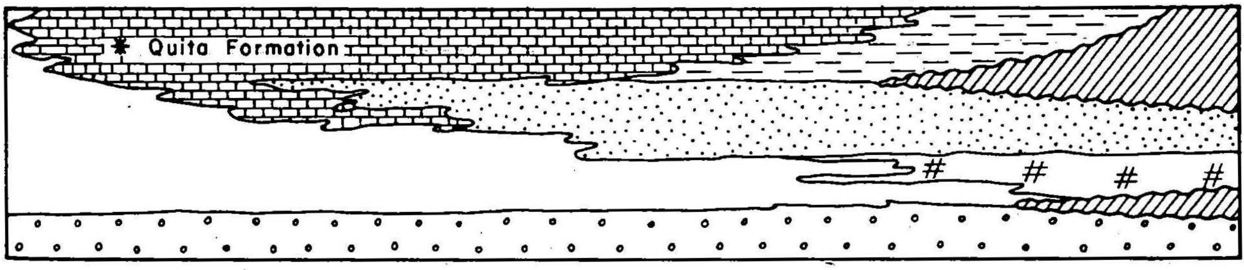
Palaeozoic sediments of the Georgina Basin crop out in central and western parts of the Oban Sheet area, and onlap eastwards onto the Precambrian belt. Most of the Palaeozoic area is covered by Cainozoic alluvium, but isolated remnants of Cambrian rocks are exposed along the western edge of the

Sybella Granite outcrop area. The Cambrian of the Georgina Basin has been extensively studied and a comprehensive bibliography presented by Smith (1972). De Keyser (1972) and de Keyser & Cook (1972) revised the stratigraphic nomenclature of the Cambrian, and have simplified the problem of mixed biostratigraphic, lithostratigraphic, and chronostratigraphic nomenclature by referring the rocks of the system to six distinctive mappable lithosomes. Each lithosome is represented by different formations in different areas, and may straddle several time zones. The lowermost four lithosomes are represented in the Oban Sheet area, including the Beetle Creek Formation of the third lithosome, which has been successfully prospected for phosphate deposits elsewhere; however, the concentration of phosphate in the Cambrian of the Oban Sheet area has been found to be uneconomic (Offenberg, 1976; Rogers, 1976).

Stratigraphic relations (Figure 5): The Cambrian is unconformable on the Sybella Granite, and the youngest exposed Cambrian formation is unconformably overlain by unnamed Mesozoic sediments. The basal Cambrian formation, the Riversdale Formation, is unconformably overlain by the Thorntonia Limestone; these two formations are overlain conformably or disconformably by the Beetle Creek Formation and the Inca Formation.

Field occurrence and lithology (Fig. 5): The Cambrian rocks form distinctive low, flat-topped hills of gently folded rocks, the more extensive areas of outcrop being capped with a veneer of Mesozoic sandstone and conglomerate. Contacts between formations are gradational. Some slump and convolution structures occur. Lateral facies changes are common and rapid. Although unmetamorphosed, the Cambrian sediments have been locally faulted.

Discussion: The lithosomes were deposited under various shallow marine or supratidal conditions (de Keyser & Cook, 1972). Shoreline sandstone-mudstone-chert-phosphorite deposits give way westwards to limestone in the deeper parts of the basin, while dolomites are thickest in the deepest, central, part of the basin. The Cambrian deposits in the Oban Sheet area represent shoreline or very shallow-marine sediments.



| | | |
|---|---|---|
| INCA FORMATION | ☰ | *Well-bedded, thinly laminated siltstone, grey silt-shale, siliceous shale, fine-grained sandstone, thin-bedded chert, bituminous limestone* |
| BEETLE CREEK FORMATION | ▒ | *Quartzose, grey, brownish-pink or white phosphatic siltstone, nodular chert and chert breccia, shale, phosphatic limestone* |
| ARDMORE CHERT MEMBER | # # | *Black and white banded convoluted chert, algal chert, vuggy grey quartzitic chert, yellow nodular chert* |
| THORNTONIA LIMESTONE | ☐ | *Sandy basal section, cream to brown to grey, platy dolomite, dolomitic limestone, chert nodules and layers increasing upwards* |
| RIVERSDALE FORMATION | ∘ ∘ ∘ ∘ | *Red micaceous siltstone and sandstone, polimictic quartz pebble conglomerate, sedimentary breccia, silicified feldspathic sandstone, massive porcellanitic siltstone and mudstone* |

✱ Quita Formation is not exposed in the Oban Sheet area

Fig. 5 Stratigraphic relations of the Cambrian in the Oban Sheet area (after de Keyser, 1972)

## MESOZOIC

Thin cappings of poorly consolidated sediments on Cambrian rocks in the central part of the Sheet area have been mapped as Mesozoic. The base of the capping is marked by a white quartz and black pebble conglomerate (Offenberg, 1976). The conglomerate is overlain by a mixture of varicoloured siltstone, silty claystone, ferruginous quartzose sandstone, and chert.

## CAINOZOIC

According to Noakes & Traves (1954), the Cainozoic was a time of erosion and terrestrial deposition. Deposition of the unconsolidated alluvia now covering extensive tracts of the Oban Sheet area followed land movements at the end of the Tertiary. The following four Cainozoic units have been mapped in the Oban Sheet area.

Czr consists of medium-grained alluvial quartz sands and silts deposited in former stream channels and on flood plains.
Czs consists of residual medium to coarse-grained sand and silt, and is best developed over granitic terrains, where transport of the quartz and feldspar-rich detritus has been minimal; it is generally coarser-grained than Czr.
Qf consists of fine-grained alluvia forming well-developed black-soil profiles. Deposition of this unit occurs in the low-lying, poorly-drained plains surrounding the larger rivers.
Qra has been distinguished where a significant amount of coarse river bed sand and gravel has accumulated in the wider stream channels. The pebbles are mostly of quartzite, sandstone, and granite.

## PROTEROZOIC INTRUSIVE ROCKS

### Sybella Granite

The Sybella Granite and some porphyry dykes associated with the granite (see following section, 'Porphyry dykes') are the only acid intrusive bodies in the Oban Sheet area. The Sybella Granite was formally defined by Carter & others (1961), who recognised several types of granite, only one of which crops out in the Sheet area. The Sybella Granite has been described by Joplin (1955), Joplin & Walker (1961), Wilson (1972), and Hill & others (1975); the last-named authors subdivided the granite into three main and three minor phases in the Mount Isa Sheet area. This subdivision is followed in the Oban Sheet area, where one main and two minor phases can be distinguished.

The main phase, $Pgs_1$, is coarse-grained, generally porphyritic foliated biotite granite; the two minor phases are microgranite, $Pgs_3$, and pegmatite, $Pgs_4$. $Pgs_1$ crops out discontinuously in a southward widening belt, from 4 km to 10 km wide, along the western edge of the Precambrian area, and disappears under Phanerozoic sediments to the west. Exposures consist of jointed tors and pavements that form low hills and inselbergs. $Pgs_3$ forms two small bodies at O 269365 and O 298595, and $Pgs_4$ crops out in an elongate mass at O 325735.

<u>Field relations</u>: $Pgs_1$ probably intrudes the Malbon Vale Formation, as it intrudes the Mount Guide Quartzite in the Mount Isa Sheet area; $Pgs_1$ intrudes the Eastern Creek Volcanics in the Oban Sheet area and probably also the Judenan Beds. There is no direct evidence that the Sybella Granite is older than the Mount Isa Group; however, quartz-tourmaline pebbles present in the equivalent Gunpowder Creek Formation (Hill & others, 1975) are thought to be derived from the pegmatites of the granite, indicating that the granite is probably older than the Gunpowder Creek Formation and hence also older than the Mount Isa Group. In the Oban Sheet area, both the pegmatite and microgranite phases intrude $Pgs_1$. Hill & others (1975) have summarised the results of geochronological work on the Sybella Granite. The currently accepted ages of $Pgs_1$ and $Pgs_3$ are 1646 ± 15 m.y. and 1557 ± 40 m.y. respectively, based on total-rock Rb-Sr isochrons, but a zircon U-Pb age of 1678 ± 2 m.y. on the Carters Bore Rhyolite (Page, 1976), may be a minimum age for the Sybella Granite. Recent zircon dating of $Pgs_1$ indicates that it may be as old as 1750 m.y. (R.W. Page, BMR, personal communication).

<u>Field occurrence and lithology</u>: The Sybella Granite is exposed as remnants of an elongate north-trending complex. The contact of the granite with the surrounding rocks, and the foliation in the granite, are parallel to the north to north-northeast regional structural trend. This trend is also followed by numerous quartz dykes and shear zones that cut the granite east of Newmans Dam and south of Waverley Creek; between Waverley and Kahko Creeks, the quartz dykes define a second, east-northeasterly trend. The rocks in the shear zones

are quartz-muscovite augen schists containing porphyryblasts (or xenoblasts?) of quartz in a dense muscovite matrix. Some of the schists are feldspathic and may be sheared granite, but others may be pendants of sheared metasedimentary rocks, as some of the quartz augen are probably former pebbles.

Six large basic pendants have been mapped in the granite, mainly in the areas north and west of Mount Annable. They consist of massive hornblende-plagioclase hornfels.

$Pgs_1$, the predominant phase, varies from coarse-grained to medium-grained, from porphyritic to even-grained, and from massive to foliated or gneissic. Mafic mineral content (mainly biotite) ranges from about 5 percent to about 20 percent, and feldspars may be red or white. In the poorly foliated or massive types, phenocrysts are single subhedral or euhedral crystals, but in the foliated types, the phenocrysts are ovoid-shaped aggregates of anhedral grains whose boundaries radiate from the centre of the aggregate.

In the Big River area, the granite is coarse-grained, strongly foliated, and rich in mafics, carrying about 10 percent each of biotite and hornblende. The foliation is defined by the alignment of red feldspar augen separated by sinuous bands of groundmass minerals, and is considered to be deformational (see Discussion). Some quartz-feldspar-muscovite-beryl pegmatites ($Pgs_4$) occur here and have been consteaned at Big River.

The degree of foliation decreases southwards; east of Newmans Dam and between Nine Mile and Kahko Creeks poorly-foliated medium to coarse-grained white-feldspar-biotite granite containing plagioclase and K-feldspar phenocrysts, predominates.

The elongate stock of Sybella Granite intruding Eastern Creek Volcanics north of Mount Annable consists of a core of foliated medium-grained red-feldspar-biotite granite with K-feldspar augen, surrounded by a zone of recrystallised crenulated microgranite. The microgranite is pink to dark bluish-black, being darkest where fully recrystallised. Very rarely is the granite parallel-foliated, but the microgranite is commonly parallel-foliated and compositionally banded. Aplite dykes, quartz-alkali feldspar ± muscovite pegmatites, and small foliated banded quartz-plagioclase-epidote-leucogranite stocks also intrude the granite and metabasalt. Various hybrid rocks are present along the contact between the granite and the country rocks - quartz-rich granitoids represent mixed granite and quartzite, and granodiorites consisting of alternating narrow hornblende-rich bands and feldspathic bands appear to have formed from granite contaminated by basalt xenoliths.

Sybella Granite exposed between Kahko and Waverley Creeks is lithologically similar to granite in the Big River area, but shows evidence of greater deformation in its gneissic texture: feldspar augen are elongate and connected by narrow feldspar 'necks' to give the appearance of boundinage structure. The feldspar boudin layers are separated by bands of recrystallised aligned groundmass minerals. Granite in the southern part of this area e.g. around 0 245335, is massive coarse, even-grained, red-feldspar-biotite granite.

South of Waverley Creek, the granite is much less foliated than to the north. Here it is massive coarse to medium even-grained to porphyritic red or white feldspar granite, with mafic content ranging between 10 and 20 percent.

Petrography: The modal volume percentage compositions of selected samples of the Sybella Granite and related dyke rocks are given in Table 12. The relative proportions of quartz, microcline, and plagioclase are plotted in Figure 6. Both Table 12 and Figure 6 illustrate the wide range of compositions spanned by the granite and the dykes. All the samples examined fall in the field of alkali feldspar granites (Streckeisen, 1973), except for the white medium to fine mafic-rich granites (nos. 4, 5, 6, and 22 of Table 12), which fall in the field of normal granites (see Fig. 6).

The petrographic characteristics of four types of $Pgs_1$ are described below. Coarse-grained foliated porphyritic red-feldspar mafic-rich granite - e.g. nos. 1, 2, 9, 21 of Table 12 - is allotrimorphic granular (foliation plane sections show minerals aligned in narrow bands separated by sigmoid boundaries). Winding irregular boundaries separate mafic-rich bands from feldspathic bands. Within bands, monomineralic sub-bands are locally developed. Quartz forms aggregates of elongate, interlocking grains with sutured boundaries and undulose extinction.

TABLE 12. VOLUME PERCENT COMPOSITION OF THE SYBELLA GRANITE

| | 1. 1144C | 2. 1099 | 3. 1088 | 4. 1103B | 5. 1073B | 6. 1080A | 7. 1093E | 8. 1070A | 9. 1151A | 10. 1077B | 11. 1080B | 12. 1146 | 13. 1147 | 14. 1062 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quartz | 21 | 32 | 35 | 30 | 23 | 29 | 30 | 27 | 35 | 26 | 23 | 39 | 26 | 28 |
| Microcline | 34 | 34 | 32 | 18 | 15 | 20 | 32 | 40 | 25 | 26 | 41 | 38 | 29 | 52 |
| Plagioclase | 22 | 21 | 24 | 35 | 36 | 37 | 28 | 26 | 25 | 23 | 29 | 17 | 27 | 15 |
| Composition* | | | $An_{3}$ | $An_{65}$ | $An_{65}$ | $An_{27}$ | $An_{10}$ | $An_{0}$ | $An_{10}$ | $An_{0}$ | $An_{3}$ | | $An_{10}$ | $An_{3}$ |
| Biotite | 9 | 9 | 5 | 12 | 22 | 11 | 5 | 5 | 10 | 10 | 4 | 5 | 10 | 4 |
| Muscovite | 0.1 | 0.3 | 0.4 | 0.5 | 0.3 | - | 1.9 | 1 | 0.1 | 0.2 | 0.5 | - | - | 0.6 |
| Hornblende | 11 | 0.1 | 2 | 0.2 | 0.1 | 1.2 | 1.0 | 0.3 | 3.8 | 8.5 | 0.7 | 0.5 | 7 | - |
| Epidote (incl. clinozoisite) | - | 1.3 | - | 0.7 | 0.4 | 0.4 | 0.3 | 0.3 | 1 | 1.7 | 0.5 | - | - | - |
| Opaque oxides | 0.5 | 1.0 | 0.1 | 1.2 | 0.6 | 0.2 | 0.1 | - | 0.1 | 0.8 | 0.4 | - | - | - |
| Sphene | 1 | 0.6 | 0.6 | 1 | 0.6 | 0.3 | - | - | 0.3 | 1.4 | - | 0.2 | 1 | - |
| Zircon | 0.4 | 0.2 | 0.1 | 0.6 | 0.9 | 0.5 | 0.5 | 0.4 | 0.1 | 1 | 0.2 | 0.3 | 0.2 | - |
| Allanite | - | 0.2 | 0.7 | 0.5 | 0.3 | - | 0.1 | - | 0.1 | 0.5 | - | 0.1 | - | 0.2 |
| Apatite | 0.2 | 0.1 | 0.1 | 0.3 | 0.6 | 0.3 | 0.2 | - | - | 0.6 | 0.1 | - | - | 0.1 |
| Fluorite | tr | 0.2 | - | tr | - | tr | 0.3 | tr | .1 | tr | tr | tr | tr | - |
| Chlorite | 0.2 | - | - | - | 0.2 | - | 0.6 | - | - | - | 0.3 | - | - | - |
| Calcite | - | - | - | - | - | 0.1 | - | - | - | 0.3 | 0.3 | - | - | - |

*approximate compositions (± 10%) estimated from XRD data.

TABLE 12 (cont'd)

| | 15.<br>1045 | 16.<br>1046 | 17.<br>1160C | 18.<br>1144E | 19.<br>1160E | 20.<br>1154B | 21.<br>1150A | 22.<br>1082 | 23.<br>1086 | 24.<br>1041H | 25.<br>1077C | 26.<br>1093C | 27.<br>1023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quartz | 33 | 26 | 31 | 31 | 44 | 24 | 30 | 19 | 46 | 27 | 25 | 31 | 32 |
| Microcline | 35 | 31 | 40 | 37 | 17 | 34 | 22 | 21 | 21 | 33 | 37 | 33 | 35 |
| Plagioclase | 25 | 25 | 17 | 32 | 23 | 33 | 26 | 40 | 23 | 24 | 21 | 23 | 9 |
| Composition | | | $An_{15}$ | | | | | $An_{22}$ | $An_{3}$ | | $An_{23}$ | $An_{5}$ | |
| Biotite | 2 | 10 | 2.8 | 0.1 | - | - | 13 | 13 | 7.2 | 11 | 11 | 5 | 10 |
| Muscovite | 3.5 | 1 | 6 | - | 0.5 | 9 | 0.1 | 1.5 | 2.6 | 2.2 | 0.3 | 7 | 2 |
| Hornblende | - | 0.4 | - | - | - | - | 6 | 1.4 | - | - | 1.4 | - | - |
| Epidote (incl. clinozoisite) | 0.5 | 3 | 0.4 | - | 14 | - | 0.6 | 0.9 | 0.1 | 0.7 | 1.9 | 0.3 | 0.7 |
| Opaque oxides | 0.5 | 1.8 | 0.6 | - | - | - | 0.3 | 0.4 | - | 0.3 | 0.6 | - | 1.3 |
| Sphene | 0.5 | - | 1 | - | 0.5 | - | 1.5 | 1.1 | - | 0.3 | 0.1 | - | 6 |
| Zircon | - | 0.5 | 0.3 | - | 0.2 | - | 0.7 | 0.6 | - | 0.5 | 0.5 | - | 3 |
| Allanite | - | 0.6 | 0.7 | - | 0.5 | - | - | 0.5 | - | 0.6 | 0.1 | 0.5 | 0.5 |
| Apatite | 0.1 | 0.3 | 0.4 | - | - | - | - | 0.4 | - | 0.3 | 0.5 | - | tr |
| Fluorite | 0.1 | tr | - | - | - | - | .2 | 0.2 | tr | - | tr | 0.2 | - |
| Chlorite | 0.1 | - | - | - | 0.4 | - | - | - | - | - | - | - | tr |
| Calcite | - | - | - | - | - | - | - | - | - | - | - | - | 0.2 |

Explanation of rock types: Table 12, Figure 6.

| | | |
|---|---|---|
| 1. | 1144C* | Coarse porphyritic red-feldspar foliated biotite-hornblende granite; Ꝑgs$_1$ |
| 2. | 1099 | Coarse porphyritic red-feldspar foliated granite; Ꝑgs$_1$ |
| 3. | 1088 | Coarse porphyritic white-feldspar foliated granite; Ꝑgs$_1$ |
| 4. | 1103B | Fine white-feldspar mafic-rich foliated granite; Ꝑgs$_1$ |
| 5. | 1073B | Medium white-feldspar mafic-rich granite; Ꝑgs$_1$ |
| 6. | 1080A | Medium white-feldspar mafic-rich granite; Ꝑgs$_1$ |
| 7. | 1093E | Medium white-feldspar granite; Ꝑgs$_1$ |
| 8. | 1070A | Coarse red-feldspar granite; Ꝑgs$_1$ |
| 9. | 1151A | Coarse porphyritic red-feldspar granite; Ꝑgs$_1$ |
| 10. | 1077B | Medium white-feldspar granite; Ꝑgs$_1$ |
| 11. | 1080D | Coarse red-feldspar granite; Ꝑgs$_1$ |
| 12. | 1146 | Coarse porphyritic white-feldspar granite; Ꝑgs$_1$ |
| 13. | 1147 | Coarse porphyritic white-feldspar granite ; Ꝑgs$_1$ |
| 14. | 1062 | White-feldspar microgranite; Ꝑgs$_3$ |
| 15. | 1045 | Pink recrystallised microgranite; contact of Ꝑgs$_1$ with Ꝑhe |
| 16. | 1046 | Black recrystallised foliated microgranite; contact of Ꝑgs$_1$ with Ꝑhe |
| 17. | 1160C | Pink crenulated microgranite; chilled contact of Ꝑgs$_1$ with Ꝑhe |
| 18. | 1144E | Aplite; intrudes Ꝑgs$_1$ |
| 19. | 1160E | Epidote pegmatite; intrudes Ꝑhe |
| 20. | 1154B | Muscovite pegmatite; intrudes Ꝑhe |
| 21. | 1150A | Coarse porphyritic red-feldspar granite; Ꝑgs$_1$ |
| 22. | 1082 | Medium white-feldspar mafic-rich granite; Ꝑgs$_1$ |

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* sample numbers are second half of BMR registered rock numbers; the first half of all except nos. 15, 16, and 27 is 7653. For example, no. 1 is 76531144C. The first half of nos. 15, 16, and 27 is 7553. For example, No. 15 is 75531045.

| | | |
|---|---|---|
| 23. | 1086 | Medium white-feldspar granite with quartz phenocrysts; Pgs$_1$ |
| 24. | 1041H | Porphyritic red-feldspar microgranite; chilled contact of Pgs$_1$ with Phe |
| 25. | 1077C | Black microgranite; intrudes Pgs$_1$ |
| 26. | 1093 | Black microgranite; intrudes Pgs$_1$ |
| 27. | 1023 | Grey quartz-feldspar porphyry dyke |

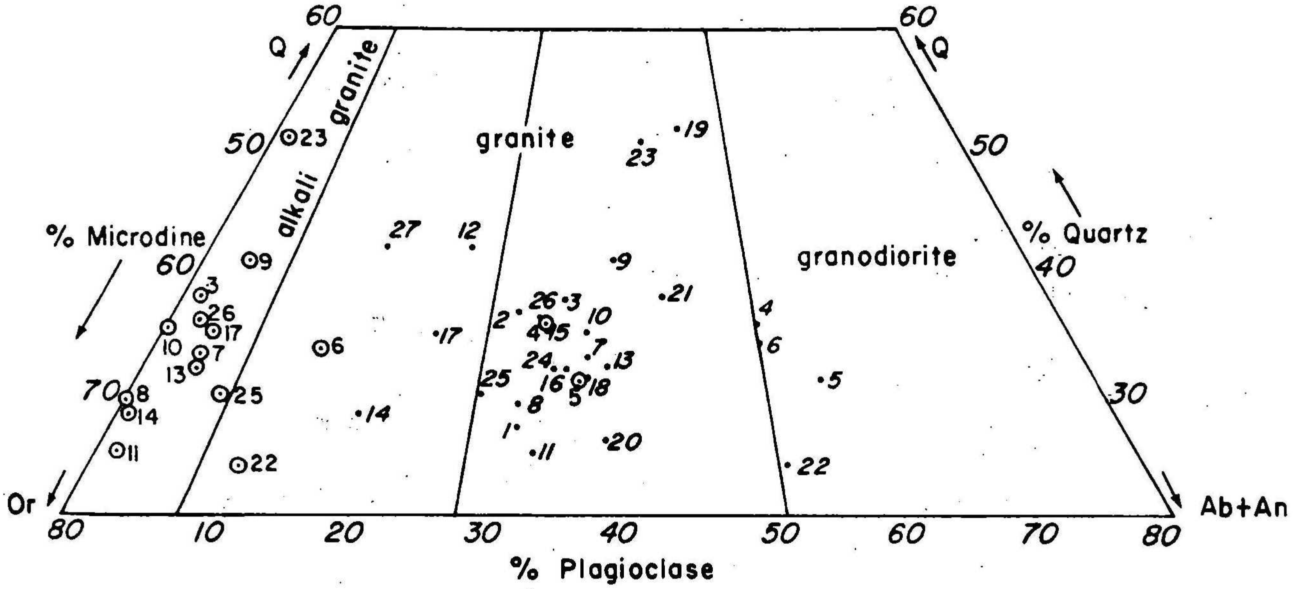

Fig. 6 Part of Q-Or-(Ab+An) diagram showing volume percent composition of quartzofeldspathic minerals of the Sybella Granite. Sample Nos. refer to Table 12. Some samples are also plotted with respect to superimposed Q-Or+Ab-An plot, showing their classification according to Streckeisen (1973)

17• sample position with respect to Q-Or - Ab+An apices

17⊙ sample position with respect to Q-Or+Ab - An apices

Massive medium to coarse-grained porphyritic white feldspar granite - e.g. nos. 3, 7, 10, 12, 13 of Table 12 - carries phenocrysts of microcline and/or plagioclase in an allotriomorphic granular to interlocking, locally recrystallised groundmass. Most of the quartz is recrystallised to a polygonal mosaic. Biotite and minor hornblende form up to about 17 percent of the rock. Plagioclase is commonly rimmed by microcline, and the reverse (rapakivi) relation is evident in several samples in the centre of the poorly foliated plutons east of Newmans Dam and between Nine Mile and Kahko Creeks.

Medium to fine-grained white-feldspar mafic-rich granite - e.g. nos. 4, 5, 6, and 22 of Table 12 - does not appear foliated in hand specimen, but in thin section shows evidence of extreme deformation. The rocks is made up of intersecting bands of elongate recrystallised minerals, the band boundaries following irregular winding paths through the rock and enveloping lensoid feldspar aggregates (Fig. 7a). These rocks are characterised by a higher plagioclase/microcline ratio than in other types. Accessory minerals are hornblende, sphene, muscovite, apatite, epidote, allanite (Fig. 8a,b), fluorite, and opaque oxides.

In the massive coarse-grained, porphyritic red-feldspar granite - e.g. nos. 8 and 11 of Table 12 - intertwined bands of recrystallised minerals wrap around anhedral feldspar phenocrysts. Quartz has an annealed ribbon texture and occurs in monomineralic aggregates (Fig. 7b). Biotite is less abundant than in the other granite types.

The microgranite - e.g., nos. 15, 16, 17, 25, 26 of Table 12 - consists of equal amounts of allotriomorphic granular to polygonal quartz, microcline, plagioclase, and biotite in an interlocking mosaic. The parallel-foliated microgranites are compositionally banded, bands consisting of the following combinations: quartz-microcline, plagioclase, plagioclase-epidote, hornblende-epidote, sphene-hornblende.

Discussion: Characteristics of all of $Pgs_1$ except the elongate stock north of Mount Annable indicate that it was emplaced at an intermediate crustal level, i.e., between the deepest zone where granites are gneissic and surrounded by country rocks regionally metamorphosed to amphibolite grade, and the shallow zone of circular subvolcanic granites with associated volcanic rocks (Buddington, 1959). These characteristics include the elongate, generally concordant form of the batholith, the paucity or absence or recognised associated volcanic activity, the scarcity of aplite dykes, the absence of contact aureoles, the variation in mineralogical composition reflecting incomplete homogenisation of the Ꝑgs$_1$ melt before solidification, and the low (greenschist) grade of metamorphism of the surrounding rocks.

In the area north of Mount Annable, however, characteristics of the granite stock and dyke rocks suggest that a deeper, possibly root, zone of emplacement is exposed. The granitoid rocks are here quite inhomogeneous, pegmatites and migmatites are common, and intrusions are concordant with the country rocks, which are metamorphosed to amphibolite grade.

The foliation of the Sybella Granite is considered to be a tectonic rather than an igneous feature. The degree of foliation is variable and bears no systematic relation to pluton boundaries, which would be expected if the foliation were an igneous flow structure. The extensive recrystallisation and deformation that have been described have metamorphosed the granite to roughly upper amphibolite grade; the development of foliation would have accompanied the early stages of metamorphism.

## Porphyry dykes

Three intrusions of feldspar porphyry are shown on the accompanying map. A narrow dyke cuts a dolerite sill that intrudes Mount Guide Quartzite north of Kahko Creek. Two wider bodies intrude Mount Guide Quartzite near its basal contact, respectively 7 and 10 km east-southeast of Mount Annable.

The structural control on the emplacement of the porphyry dykes is evident from their form and orientation along fold axes or faults and from the localisation of the larger bodies at contacts between Ꝑhv and Ꝑhg.

The smallest dyke consists of subhedral microcline phenocrysts and smaller quartz phenocrysts in a metamorphosed groundmass of quartz, microcline, plagioclase, biotite, chlorite, and accessory muscovite, opaque oxides, sphene, clinozoisite, zircon, and apatite. The microcline phenocrysts are up to 2 cm across, and are rimmed by plagioclase. Both feldspars, especially plagioclase, are heavily clouded with red iron oxides. The clinozoisite is zoned from a metamict core to a clear rim.

The larger porphyry dykes have similar mineralogy, but are less extensively replaced by iron oxides. Myrmekite rimming microcline phenocrysts is abundant.

The stratigraphic level reached by the feldspar porphyry intrusions and the occurrence of the distinctive zoned clinozoisites which also bound in the Sybella Granite provide circumstantial evidence that the feldspar porphyries are associated with the granite.

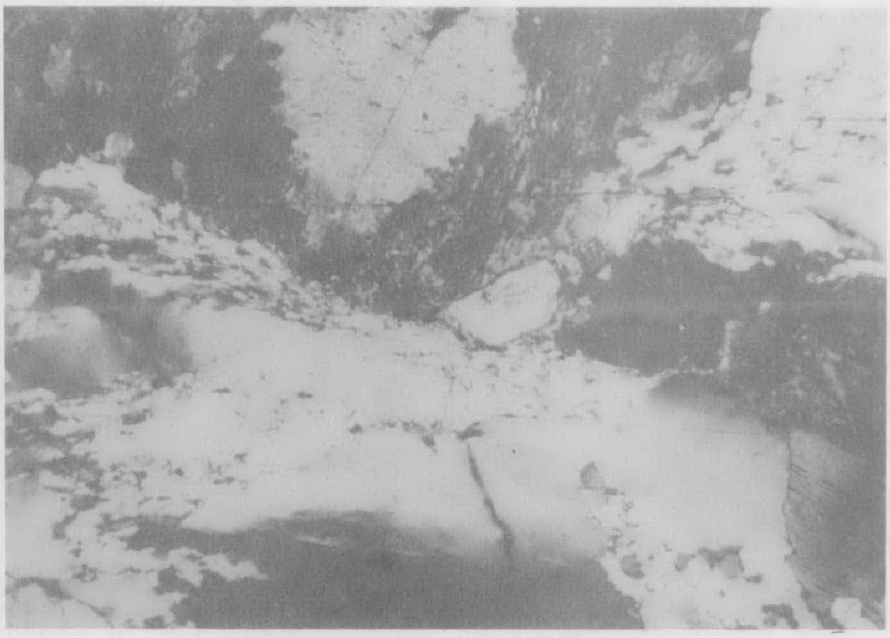

Figure 7a. Mineral bands in deformed $Bgs_1$, Waverley Creek area. Sharp band boundary separates recrystallised quartz (lower half of field) from partly altered feldspar (clear twinned grain and surrounding dark mottled area, upper centre of field). Crossed nicols, x 25.

Figure 7b. Foliated augen granite, $Bgs_1$, Waverley Creek area. Ovoid feldspar aggregates (clouded grains, centre of field and lower left of centre) are surrounded by ribbon-textured quartz. Crossed nicols, x 25.

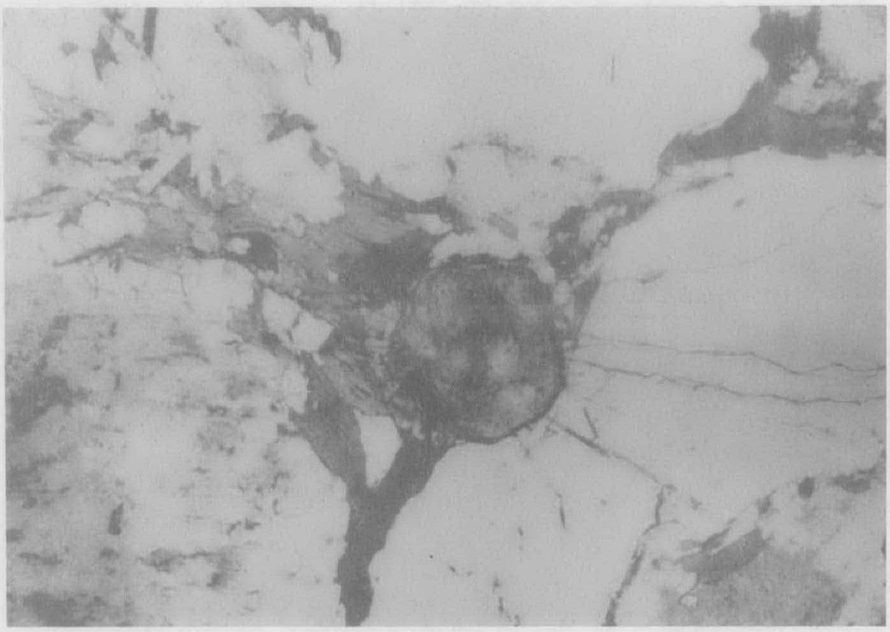

Figure 8a.

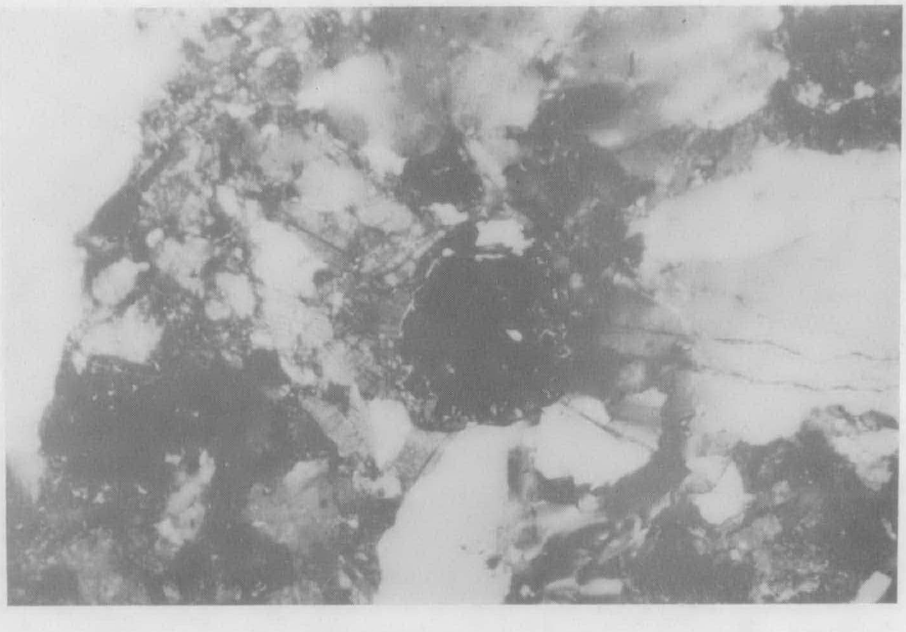

Figure 8b. Metamict allanite in $Bgs_1$, north of Waverley Creek. Central euhedral allanite grain is source of radiating and concentric tension cracks. a. Plane polarised light. b. Crossed nicols. x 25.

## Dolerite dykes

Dolerite dykes and sills intrude all units of the Haslingden Group, but are most abundant in the Malbon Vale Formation and Mount Guide Quartzite. Far fewer dykes cut the Myally Subgroup than the underlying formations. Only two dolerite dykes were found cutting units younger than P̲im - they intrude the Sybella Granite 7 km west of Mount Annable.

In P̲hv and P̲hg the dolerite bodies were emplaced parallel to north-northeast-trending fold axes. They are concentrated in areas adjacent to fault and shear zones, but are not associated with the major northwest faults, which they antedate; these faults have affected the Mount Isa Group, which is known to be younger than the dolerites. The intrusions in P̲hv include wide irregularly-shaped sills and narrow linear bodies, in contrast to those in P̲hg, in which all the intrusions are narrow dykes with the exception of one large zoned dolerite sill north of Kahko Creek.

The dolerites emplaced in Phg are usually rimmed by a metre-wide contact aureole of glassy blue recrystallised quartzite.

Alteration and metamorphism of the dolerites are variable and in P̲hg and P̲hv younger dykes have not been distinguished from older ones. Compositions of several unaltered dolerites are shown in Table 13. Most of the dykes in the Sheet area, however, are now composed of variably sericitised plagioclase (55%), actinolite (35%), opaque oxides, quartz, and epidote. Texture varies from sub-spherulitic in which ragged subradial fibrous aggregates of actinolite are separated by allotriomorphic plagioclase, to hornfelsic or schistose. In the actinolitic metadolerites, no original crystal form or igneous texture is discernible.

More rarely, the main mafic mineral is hornblende rather than actinolite. Hornblende metadolerites are composed of plagioclase (55%), poikilitic hornblende (35%), biotite, chlorite, and quartz ± clinopyroxene. The hornblende grains are subhedral and subophitically moulded around plagioclase grains.

TABLE 13. VOLUME PERCENT COMPOSITION OF DOLERITES

| Sample No.<br>Mineral | 1.<br>1007 | 2.<br>1011C | 3.<br>1012A | 4.<br>1019 | 5.<br>1218 | 6.<br>1044 |
|---|---|---|---|---|---|---|
| Plagioclase | 43.1 | 25.5 | 5.4 | 24.0 | 36.8 | 18.5 |
| Hornblende | 3.2 | 48.5 | 55.3 | 58.6 | 25.5 | 64.8 |
| Clinopyroxene | 36.3 | - | - | - | 10.6 | - |
| Opaques | 10.9 | 3.8 | 4.8 | 8.1 | 2.4 | 3.8 |
| Quartz | 1.6 | 19.4 | 29.9 | 7.7 | 16.5 | 12.9 |
| Chlorite | 4.9 | - | 4.6 | 1.6 | 1.8 | - |
| Epidote | - | 2.8 | - | - | 0.4 | - |
| Biotite | tr | - | - | - | 6.0 | - |
| Comments | quartz in myrmekite only; CPX shows fine OPX exsolution lamellae; hornblende is CPX alteration | samples from large sill intruding Ᵽhg; plagioclase largely sericitised and epidotised; hornblende, opaques concentrated in irregular bands | | | banded rock; bands are: quartz/CPX-hornblende/biotite-plagioclase; due to inclusion of quartzite and granite xenoliths | coarse-grained amphibolite; intrudes Ᵽgs |

TABLE 14. CHEMICAL ANALYSES OF DOLERITES

| | 1.<br>1007 | 2.<br>1010A | 3.<br>1010B | 4.<br>1031 | 5.<br>1044 |
|---|---|---|---|---|---|
| $SiO_2$ | 48.65 | 48.42 | 50.74 | 50.76 | 49.50 |
| $TiO_2$ | 2.52 | 1.31 | 1.40 | 1.74 | 2.82 |
| $Al_2O_3$ | 12.91 | 15.75 | 16.33 | 14.79 | 12.65 |
| $Fe_2O_3$ | 4.63 | 5.92 | 5.19 | 3.78 | 5.35 |
| FeO | 11.07 | 6.58 | 4.66 | 9.00 | 11.00 |
| MnO | .23 | .18 | .20 | .19 | .27 |
| MgO | 5.09 | 8.02 | 6.34 | 5.64 | 5.50 |
| CaO | 9.07 | 9.44 | 10.76 | 9.61 | 8.46 |
| $Na_2O$ | 2.12 | 1.43 | 2.51 | 2.28 | 1.67 |
| $K_2O$ | .96 | .36 | .21 | .51 | .45 |
| $P_2O_5$ | .24 | .28 | .29 | .25 | .30 |
| $CO_2$ | .05 | .05 | .05 | .05 | .05 |
| $H_2O^+$ | 1.94 | 2.35 | 1.37 | 1.67 | 1.55 |
| $H_2O^-$ | .04 | .04 | .02 | .04 | .03 |
| Total | 99.52 | 100.13 | 100.02 | 100.26 | 99.60 |

1. 1007; dolerite
2. 1010A; dolerite
3. 1010B; dolerite
4. 1013; banded dolerite
5. 1044; amphibolite

Relatively unaltered dolerite intrudes Lena Quartzite at 0 415647, (sample 1. No. 1007 of Table 13). Subhedral clinopyroxene (36%), plagioclase (43%), opaque oxides (11%), and interstitial myrmekite make up the rock. Clinopyroxene carries exsolution lamellae of orthopyroxene and is locally chloritised.

Chemical analyses of this and several other dolerites are shown in Table 14.

## METAMORPHISM

Criteria used for delineating metamorphic zones: The distribution of metamorphic zones in the Oban Sheet area is shown in Figure 9. The delineation of the zones is based on the observed metamorphic mineral assemblages which are summarised in Table 15, using the zone definitions of Winkler (1976). Winkler defines four broad zones of metamorphism, from the very low grade through to the low grade, medium grade, and finally high grade. The zones correspond roughly to the lower (chlorite) and upper (biotite) greenschist facies and the lower (cordierite) and upper (sillimanite) amphibolite facies of Eskola (1939) respectively.

Minerals that define the zone boundaries are: clinozoisite appearing at the boundary between the very low and low-grade zones; cordierite appearing at the boundary between the low and medium-grade zones; and muscovite breaking down and sillimanite appearing at the boundary of the medium and high-grade zones. Melting curves mark the upper limit of the high-grade zone.

The transition from low to medium grade is recognised in metabasalts by the replacement of the typical low-grade assemblage actinolite-(albite-) clinozoisite by the medium-grade association hornblende-oligoclase or andesine (Turner & Verhoogen, 1960. This criterion was found to be a more useful indicator of the onset of medium-grade metamorphism than the incoming of cordierite in the metapelites, because of cordierite's strong susceptibility to retrograde alteration.

TABLE 15. METAMORPHIC MINERAL ASSEMBLAGES IN THE OBAN SHEET AREA

| | GREENSCHIST | | AMPHIBOLITE | |
|---|---|---|---|---|
| Zone | Chlorite (very low grade) | Biotite (low grade) | Cordierite (medium grade) | Sillimanite (high grade) |
| Formation | | | | |
| Ᵽhv | | quartz-albite-biotite-epidote<br>quartz-muscovite-biotite-epidote-chlorite | | |
| Ᵽhc | | actinolite-albite-quartz<br>epidote-actinolite | hornblende-quartz | |
| Ᵽhc$_q$ | | quartz-biotite(-epidote)<br>quartz-muscovite-biotite | | |
| Ᵽhl | | quartz-muscovite | | |
| Ᵽhp | | actinolite-epidote-albite<br>epidote-chlorite-actinolite | | |
| Ᵽhe$_q$ | | | quartz(-hornblende)-epidote-oligoclase<br>quartz-muscovite (-andesine)-biotite<br>quartz-actinolite-cordierite<br>quartz-biotite-muscovite-andalusite | quartz-cordierite (-muscovite)-biotite (-sillimanite) (-chlorite) |
| Ᵽhj/Ᵽhm | | quartz (-epidote)(biotite)-muscovite | oligoclase-hornblende-clinopyroxene-epidote-quartz | quartz-epidote-muscovite-garnet |
| Ᵽi | quartz-epidote-muscovite-chlorite | quartz-muscovite-biotite | | |

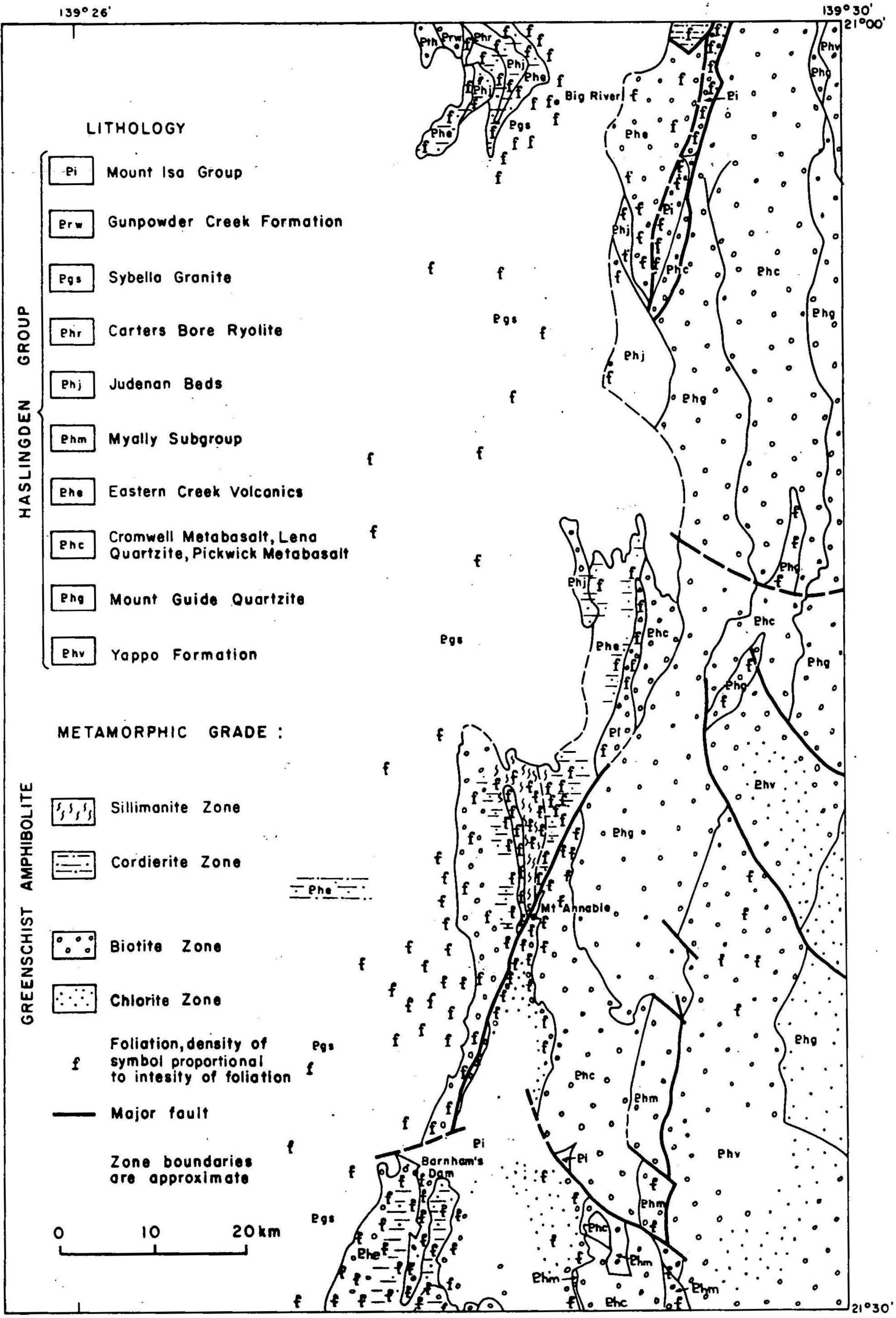

Fig. 9 Metamorphic zone map, Oban 1: 100 000 Sheet area

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Similarly, the incoming of sillimanite, although diagnostic of the transition from medium to high-grade metamorphism, could not be applied in the Oban Sheet area, because of the aluminosilicate's very strong susceptibility to retrogression. Instead, the crystalline form and abundance of muscovite were used in the Oban Sheet area to distinguish local high-grade belts of rock from adjacent medium-grade rocks; for example, in the Mount Annable area, a boundary representing the start of muscovite breakdown was drawn between metapelites containing 35-50 percent of coarse well-crystallised muscovite flakes (medium grade, to the east), and metapelites containing up to 20 percent of fine-grained poorly crystalline muscovite showing evidence of being replaced or of replacing high-grade minerals (high grade, to the west).

Distribution of zones: Low-grade metamorphism is the most wide-spread zone in the Sheet area (Fig. 9). All of the exposures of the Haslingden and Mount Isa Groups east of the Mount Isa/Mount Annable Fault Zone show typical low-grade metamorphic assemblages (Table 15), except for some small areas of very low-grade metamorphosed Malbon Vale Formation and Mount Isa Group. Medium and high-grade rocks are confined to areas west of the Mount Isa/Mount Annable Fault Zone - the Big River, Mount Annable, and Barnhams Dam areas.

The overall metamorphic picture shows a narrow westerly belt of medium to high-grade contact-metamorphosed multiply folded foliated rocks thrust up along a north-northeast-trending fault zone, against a wider easterly belt of low-grade regionally metamorphosed sediments and volcanics. The rocks on both sides of the central fault zone are strongly foliated.

Metamorphic history: An inferred metamorphic history of rocks in the Oban Sheet area is as follows. Three major events produced the metamorphic effects now seen. The earliest event was a regional metamorphism which culminated in intrusion of the Sybella Granite at about 1750 m.y. (R.W. Page, BMR, personal communication). The only structural effect identifiable with this event is the first phase of folding of the multiply folded outcrops of Phe and Phj in the Big River, Mount Annable, and Barnhams Dam areas.

The second event was a medium to high-grade contact metamorphism produced in rocks intruded by the Sybella Granite at intermediate to deep crustal levels (see Sybella Granite section: Discussion). Contact metamorphosed rocks crop out east of the Mount Isa/Mount Annable Fault Zone only, but they do not occur adjacent to all granite contacts. In the Big River and Mount Annable areas only, Ꝑhe and Ꝑhj have been metamorphosed to medium grade within about 2 km of intrusive contacts, and to high grade within about 0.5 km of intrusive contacts. It has been shown (Sybella Granite section: Discussion) that these areas represent deeper cross-sections through the granite and its country rocks than elsewhere in the Sheet area where contact effects are absent.

Major faulting along the north-northeast trending Mount Isa/Mount Annable Fault Zone preluded the final metamorphic event, a low-grade moderate-pressure regional metamorphism. During that time, the Haslingden Group east of the Mount Isa/Mount Annable Fault Zone was folded, the Sybella Granite was deformed and foliated, and the whole area was imprinted with low-grade metamorphic effects. A second stage of major faulting, along north-northwest trending faults, followed the metamorphism.

<u>Contact metamorphic effects in the area north of Mount Annable</u>: The best-developed contact aureole of the Sybella Granite is east of a north-trending elongate pluton intruding Ꝑhe north of Mount Annable. Numerous small pegmatite and leucogranite bodies also intrude Phe within the aureole. The mineralogy of the intrusive and country rocks is tabulated in Table 16, in which the arrangement of the sample columns corresponds to a progression from the centre of the pluton eastwards through the high-grade zone of migmatites into the medium-grade zone of schists and gneisses. Chemical analyses of some of the intrusive rocks are shown in Table 17.

The pluton (1160D, 1041C of Table 16) is somewhat heterogeneous, ranging from medium even-grained to coarse porphyritic; phenocrysts are augen-shaped red K-feldspar or white oligoclase or andesine; biotite content ranges from less than 5 percent to about 25 percent; more muscovite is present than in other outcrops of the Sybella Granite. The pluton shows local zoning in the development of an incomplete more mafic outer rim (1042, 1160B, 1169 of Table 16), which consists of dark fine-grained biotite-rich tonalite containing white circular plagioclase phenocrysts with compositions varying among samples between oligoclase and labradorite. Both the main pluton and the mafic rim are recrystallised to microgranite along contacts. The recrystallised granite (1043C, 1045, 1160C of Table 16) is bluish-grey or pink, foliated, and finely parallel-banded or crenulated; the recrystallised mafic rim (1046, 1048A, B, C, 1160A, 1163 of Table 16) is a black foliated locally schistose rock.

TABLE 16. MINERALOGY OF THE MOUNT ANNABLE CONTACT AUREOLE: a) INTRUSIVE ROCKS

| Zone | Main pluton | | Macif rim | | | Recrystallised margin, main pluton | | | | Recrystallised margin, mafic rim | | | | Leucogranites, pegmatites | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample No. (BMR reg'd No.) | 1160D | 1041C | 1042 | 1160B | 1169 | 1045 | 1160C | 1041A,H | 1043A,B,C | 1046 | 1048A,B,C | 1160A, | 1163 | 1047 | 1154B | 1160E |
| Rock type | granite | | tonalite | | | microgranite | | | | microgranite | | | | peg-matite | leuco granite | epidote pegmatite |
| Lithology & texture | coarse, augen of K-spar or plag; groundmass recryst, foliated | | dark, fine-grained foliated groundmass; white poikilitic plag phenos | | | fine, pink to blue, recryst, foliated parallel-banded | | relic K-spar phenos | | fine-grained, black hornfelsic to schistose | | | | coarse<br>massive, white to pink or green | medium | coarse |
| Mineral assemblage (in order of abundance) | quartz<br>K-spar<br>plag<br>biotite<br>muscvte | quartz<br>plag<br>muscvte<br>chlorite<br>K-spar | quartz<br>plag<br>biotite<br>chlorite | | | | K-spar<br>quartz<br>plag<br>muscvte<br>chlorite | | | K-spar<br>plag<br>quartz<br>muscvte<br>biotite | | | quartz<br>plag<br>biotite | quartz<br>plag<br>K-spar | quartz<br>K-spar<br>plag<br>muscvte | plag<br>quartz<br>epidote |
| K-feldspar (triclinicity, wt% KAlSi$_3$O$_8$ | max microcline<br>95% Or | | | | | max microcline<br>95% Or | | 91% Or | | max microcline | 88% Or (A) | 90% Or | | max microcline | | |
| Plagioclase composition | oligo-calse | andesine | oligo-clase | ande-sine | labrad-orite | albite | oligo-clase | | albite+olig(A)<br>olig-andes (B)<br>oligoclase (C) | oligoclase | | | byt-own-ite | albite | | oligo-clast |

Comments

1. Accessory minerals are abundant in all intrusive rocks except for the leucogranite and pegmatite dykes. The accessory minerals are:- zircon, clinozoisite, allanite, apatite, opaques, fluorite, sphene, chlorite.

2. Muscovite is appreciably more abundant in intrusive rocks in the Mount Annable area than in outcrops of Sybella Granite elsewhere in the Sheet area: its abundance decreases sharply in the high grade zone of the aureole and increases in the medium grade zone.

3. Feldspar compositions and triclinicity determined using standard XRD methods.

TABLE 16. MINERALOGY OF THE MOUNT ANNABLE CONTACT AUREOLE: b) COUNTRY ROCKS

| Zone | Migmatites | | | | Schists & gneisses | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sample No. (BME reg'd) | 1041B,F,G | 1158 | 1166B | 1167 | 1155C | 1157 | 1156 | 1159 | 1154A | 1168 |
| Rock type | granite veined metabasalt | meta-basalt | metapelite | | granite-veined metapelite | | | metapelite | | |
| Lithology & texture | fine-grained foliated banded hornsfelsic amphibolite | foliated amphibolite | medium-grained massive, dark blue to brown, etched surface | | mica gneiss | | | mica schist | | |
| Mineral assemblage (in order of abundance) | quartz<br>plag<br>hornblende<br>clinozoisite | hornblende<br>quartz<br>actinolite<br>plag<br>muscvte<br>epidote | quartz<br>cordierite<br>muscvte<br>biotite<br>sillimanite<br>chlorite<br>tourmaline | | quartz<br>muscvte<br>plag<br>K-spar | | | quartz<br>muscvte<br>biotite<br>andalusite | muscvte<br>quartz<br>biotite<br>hematite | muscvte<br>quartz<br>cordierite |
| Plagioclase composition | oligoclase | andesine | | | oligoclase - andesine | | | | | |
| Metamorphic grade | high grade (upper amphibolite) | | | | medium grade (lower amphibolite) | | | | | |

## TABLE 17. CHEMICAL ANALYSES OF INTRUSIVE ROCKS IN THE MOUNT ANNABLE AREA.

| Sample No.[1] | 1042 | 1160B | 1160C | 1043A | 1043B | 1160A | 1160E |
|---|---|---|---|---|---|---|---|
| $SiO_2$ | 69.12 | 62.70 | 72.16 | 70.13 | 71.76 | 71.23 | 71.25 |
| $TiO_2$ | 0.79 | 1.26 | 0.48 | 0.56 | 0.55 | 0.62 | 0.27 |
| $Al_2O_3$ | 13.43 | 14.53 | 12.81 | 13.40 | 13.93 | 13.04 | 13.53 |
| $Fe_2O_3$ | 3.66 | 3.60 | 1.63 | 1.91 | 2.00 | 2.47 | 2.60 |
| FeO | 1.93 | 4.49 | 0.75 | 1.96 | 2.05 | 1.56 | 0.28 |
| MnO | 0.05 | 0.09 | 0.03 | 0.05 | 0.05 | 0.02 | 0.03 |
| MgO | 1.24 | 2.11 | 0.53 | 0.73 | 0.31 | 0.98 | 0.29 |
| CaO | 3.07 | 3.98 | 1.07 | 1.45 | 2.71 | 1.11 | 6.21 |
| $Na_2O$ | 4.61 | 3.94 | 2.13 | 2.51 | 3.59 | 2.79 | 4.33 |
| $K_2O$ | 0.95 | 1.81 | 7.14 | 5.75 | 1.78 | 5.44 | 0.24 |
| $P_2O_5$ | 0.21 | 0.31 | .07 | 0.12 | 0.12 | 0.16 | 0.06 |
| $CO_2$ | 0.05 | 0.05 | .05 | 0.05 | 0.05 | 0.05 | 0.05 |
| $H_2O^+$ | 0.67 | 0.86 | .51 | 0.84 | 1.73 | 0.64 | 0.68 |
| $H_2O^-$ | 0.03 | 0.07 | .07 | 0.07 | 0.03 | 0.04 | 0.08 |
| Total | 99.76 | 99.80 | 99.38 | 99.48 | 100.66 | 100.15 | 99.90 |

[1] For sample descriptions, see Table 16a.

Intermediate stages in the recrystallisation can be seen in 1041A, H, (Table 16) which carry relic phenocrysts, and in 1043A, B, C, in which the wavy augen foliation of the original granite is successively more compressed to narrowly spaced parallel-foliated bands. A slight tendency for plagioclase to be less calcic in the microgranites than in the original granite reflects exsolution of calcium during recrystallisation and its crystallisation in clinozoisiste; clinozoisite replaces plagioclase in several of the microgranite samples.

Small bodies of leucogranite and pegmatite intrude the main pluton and the country rocks, indicating that they were products of the last phase of intrusive activity. The bodies (e.g., 1047, 1154B, 1160E of Table 16) are massive coarse-grained white or pink dykes or stocks with different mineral components. Many are characterised by the presence of albite or calcic plagioclase rather than K-feldspar, and carry up to 20 percent muscovite, epidote, or hornblende.

The country rocks are metabasalts and metapelites of Phe. They have been metamorphosed to high-grade rocks within the zone of migmatites, which extends for about 0.5 km along the eastern margin of the main pluton, and to medium-grade rocks within the zone of schists and gneisses, which extends a further 1.5 km away from the pluton (see Fig. 9). The mineralogy of the country rocks is summarised in Table 16. The metabasalts in the zone of migmatites (1041B, F, G, 1158 of Table 16) are massive hornfelsic acid-veined amphibolites; the metabasalts in the zone of schists and gneisses are schistose actinolitic or muscovite-biotite rocks, gneissic where they are acid-veined. The metapelites in the zone of migmatites (1166B, 1167 of Table 16) are massive, cordierite-quartz-bearing rocks; the metapelites in the zone of schists and gneisses (1155C, 1157, 1156, 1159, 1154A, 1168 of Table 16) are cleaved, foliated quartz-mica schists and quartz-feldspar-mica gneisses.

## ECONOMIC GEOLOGY

Mineralisation and mining: The calcareous sediments of the Moondarra Siltstone of the Mount Isa Group are host to sporadic low-grade copper mineralisation. The mineralisation is not of the same type as that of the ore mined at Mount Isa; its occurrence coincides with gossanous silicified fault zones along or near the eastern boundaries of the outcrop blocks of Mount Isa Group. Copper has been mined at Mount Guide (Leiver's Lease), Mount Annable, and Blue Hills (the Webber Mine), where malachite, chrysocolla, cuprite, chalcocite, and native copper - together with hyaline opal - line cavities and joints in gossanous quartz veins. The country rocks are steeply dipping laminated blue-grey calcareous shale and siltstone, and sandstone, and show no surface mineralisation, but chalcopyrite has been recorded from drill core of the Moondarra Siltstone in the Mount Annable block.

Although prospecting of the Mount Isa Group in the Oban Sheet area has been largely motivated by the possibility that mineralised Urquhart Shale equivalents are present, it is now generally believed that, except for a small wedge of Native Bee Siltstone at 0 390769, the youngest stratigraphic level represented in the Sheet area is that of the Breakaway Shale, and that mineralisation in the Mount Isa Group is restricted to small uneconomic deposits located along fault zones and/or contacts.

Copper mineralisation has been found in the Eastern Creek Volcanics in a mode of occurrence similar to that in the Mount Isa Group deposits. Strongly sheared actinolite, chlorite, and pelitic schists host disseminated malachite and azurite at Bald Hill, and in the Big River area.

None of the above-described deposits is currently being worked, operations at the Webber mine having been the most recent to discontinue.

Beryl occurs in pegmatites of the Sybella Granite at Big River, and the nearby Bong Bong and Welcome Strike prospects. The beryl occurs in sections of two roughly parallel north to northwest-trending pegmatites 7 and 10 km long. The pegmatites intrude foliated granite, and muscovite schists, and actinolite schist, biotite schist, and epidote quartzite of the Eastern Creek Volcanics. The pegmatites consist of different proportions of K-feldspar, albite, quartz, muscovite, beryl, tourmaline, apatite, garnet, graftonite $(Fe, Mn, Ca)_3 P_2O_8$) and bertrandite, a hydrated pseudomorph of beryl. The beryl is generally clouded, green to yellow, and massive, but individual crystals up to 1 m long are not uncommon.

Exploration: Exploration in the Oban Sheet area has been focussed on the search for base metals in the Mount Isa Group southwards along strike from the Mount Isa ore deposits, and, more recently, prospecting for phosphate in the Cambrian strata, principally in the Beetle Creek Formation. Details of the areas surveyed and the results obtained have been documented by Noon (1977).

In the Mount Guide block near the Mount Guide mine, Carpentaria Exploration Company and Ausminda found Cu, Pb, and Zn anomalies related to mineralisation at depth along the Moondarra Siltstone/Eastern Creek Volcanics contact. As grades of channel and drill samples were generally less than 0.2% Cu, it was concluded that no economic deposits were present.

Diamond drilling by Broken Hill South through Moondarra Siltstone in the Yappo and Mount Annable blocks gave similar results - sporadic low-grade mineralisation but no economic deposits.

The area with the most potential appeared to be the Blue Hills block, where Longreach Group Management-Pechiney carried out detailed geological mapping and geochemical and geophysical surveys. The results defined four areas of carbonate-rich pelites, black shale, and marble anomalously high in Cu, Pb, and Zn, the main anomaly being centred on a gossanous, jasperoid dyke north of the Webber mine. Mining here stopped in 1973, and the anomalies have not been followed up.

Three exploration projects by Australian Fertilizers Limited, ICI Australia Limited Phosphate Joint Venture, and Queensland Phosphate Limited found that the main phosphatic unit of the Cambrian, the Beetle Creek Formation, had a very restricted outcrop and subsurface distribution in the Oban Sheet area, and contained no economic phosphate deposits.

Mount Isa Mines Limited have costeaned and sampled the three beryl prospects Big River, Bong Bong, and Welcome Strike, and concluded that although Big River has fairly extensive reserves they are not quite of high enough grade for bulk mining.

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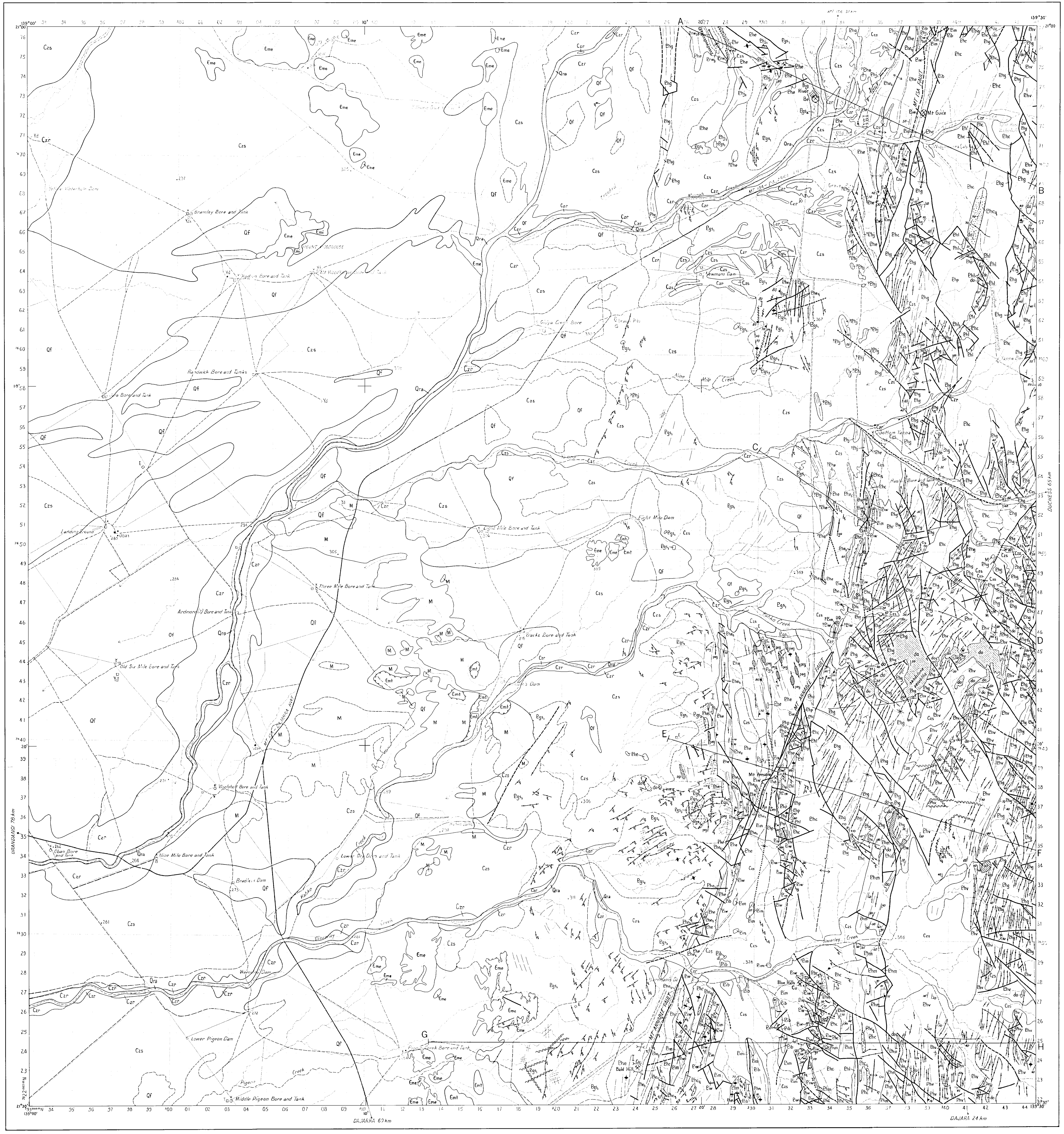
AUSTRALIA 1:100000 GEOLOGICAL SERIES

# OBAN

QUEENSLAND

SHEET 6755



## WESTERN SEDIMENTARY SUCCESSION

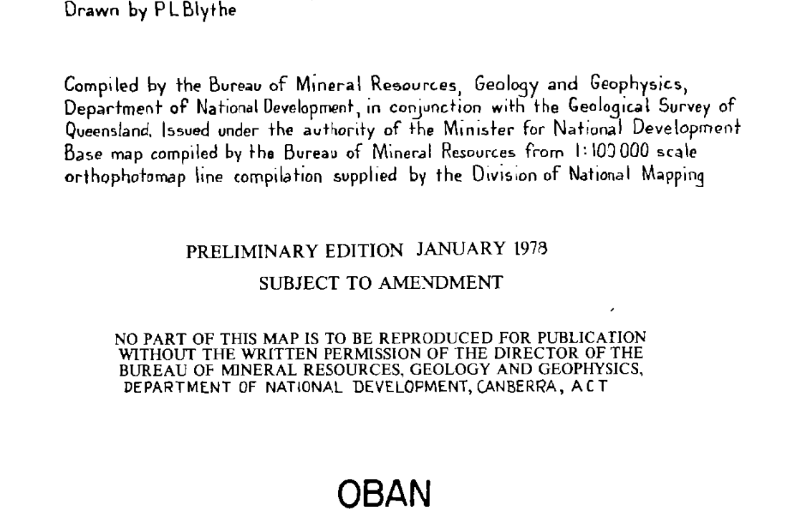
West of Mt Isa or Mt Annable Fault | East of Mt Isa or Mt Annable Fault

| | | |
|---|---|---|
| QUATERNARY / CAINOZOIC | Qra | River bed gravel and sand |
| | Qf | Black soil plains: fine alluvium in shallow depressions |
| | Czs | Residual sand and silt |
| | Czr | River bed and floodplain deposits, alluvium |
| MESOZOIC | M | Ferruginous grits and conglomerate, sandstone, siltstone, silcrete, ferricrete |
| CAMBRIAN / PALAEOZOIC | Emi | INCA FORMATION: Shale, siltstone, chert |
| | Eme | BEETLE CREEK FORMATION: Banded, convoluted or quartzitic chert, chert breccia, coquinite, siltstone |
| | Emt | THORNTONIA LIMESTONE: Grey platy dolomite, dolomitic limestone, chert |
| | Emh | RIVERSDALE FORMATION: Conglomerate, red conglomeratic sandstone |
| | do | Dolerite of various ages, undivided; metadolerite, amphibolite |
| CARPENTARIAN / PROTEROZOIC | Ein | MT ISA GROUP, NATIVE BEE SILTSTONE: Bedded dolomitic siltstone, minor chert |
| | Erw₃f | McNAMARA GROUP, GUNPOWDER CREEK FORMATION: Ferruginous siltstone, sandstone, minor conglomerate |
| | Eib | MT ISA GROUP, BREAKAWAY SHALE: Blue laminated shale |
| | Erw₃ | McNAMARA GROUP, GUNPOWDER CREEK FORMATION: Black shale, laminated silty and micaceous shale |
| | Eim | MT ISA GROUP, MOONDARRA SILTSTONE: Dolomitic siltstone, shale |
| | Eiw | MT ISA GROUP, WARRINA PARK QUARTZITE: Brown feldspathic sandstone, conglomerate, ferruginous siltstone, quartzite |
| | Erw₁ | McNAMARA GROUP, GUNPOWDER CREEK FORMATION: Fine to medium feldspathic sandstone, minor conglomerate |
| | Egs₄ | SYBELLA GRANITE: Feldspar-muscovite-beryl-quartz pegmatite |
| | Egs₃ | SYBELLA GRANITE: Massive fine to medium even grained granite |
| | Egs₁ | SYBELLA GRANITE: Foliated coarse porphyritic biotite granite |
| | do | Dolerite, metadolerite, amphibolite |
| | Ehr | CARTERS BORE RHYOLITE: Porphyritic rhyolite |
| | Ehj | HASLINGDEN GROUP, JUDENAN BEDS: Undivided quartzite, feldspathic quartzite, pelitic schist |
| | Ehj₁ | HASLINGDEN GROUP, JUDENAN BEDS: Quartzite, feldspathic quartzite, pelitic schist, foliated quartzite, sericitic schist |
| | Ehm | HASLINGDEN GROUP, MYALLY SUBGROUP: Quartzite, interbedded white quartzite and buff siltstone, brown feldspathic arenite, conglomerate |
| | Eheq | HASLINGDEN GROUP, EASTERN CREEK VOLCANICS: Quartzite, epidote quartzite, pelitic schist, foliated micaceous quartzite, cordierite schist, pelitic schist |
| | Ehp | Pickwick Metabasalt Member, EASTERN CREEK VOLCANICS: Metabasalt, amygdaloidal metabasalt |
| | Ehpq | Quartzite, epidote quartzite, siltstone, limestone, micaceous quartzite |
| | Ehe | EASTERN CREEK VOLCANICS: Metabasalt, amphibolite, metabasalt schist, mica schist |
| | Ehl | Lena Quartzite Member: Brown and maroon feldspathic sandstone, quartzite, feldspathic quartzite |
| | Ehes | Quartzite, feldspathic quartzite |
| | Ehc | Cromwell Metabasalt Member: Metabasalt, amygdaloidal metabasalt, flow top breccia |
| | Ehcq | Quartzite, epidote quartzite, micaceous quartzite |
| | Ehg | MOUNT GUIDE QUARTZITE: White quartzite, cream feldspathic quartzite |
| | Ehg | MOUNT GUIDE QUARTZITE: Buff feldspathic quartzite, white orthoquartzite, minor sandstone, siltstone |
| | Ehv | MALBON VALE FORMATION *: Friable feldspathic and micaceous sandstone, greywacke, conglomerate, micaceous siltstone; minor basalt |

* Name not yet approved

| | |
|---|---|
| Geological boundary | |
| Unconformity (U opens towards younger formation) | |
| Anticline showing plunge | |
| Syncline showing plunge | |
| Fault showing relative horizontal movement (q indicates quartz filled) | |
| Where location of boundaries, folds and faults is approximate, line is broken; where inferred, queried; where concealed, boundaries and folds are dotted, faults are shown by short dashes | |
| Shear zone | |
| 30 | Strike and dip of strata |
| | Prevailing strike and dip of strata |
| 10 | Strike and dip of strata – facing not known |
| | Prevailing strike and dip of strata – facing not known |
| | Vertical strata |
| | Vertical strata – facing not known |
| | Horizontal strata |
| 70 | Strike and dip of overturned strata |
| | Unmeasured strike and dip of overturned strata |
| | Dip < 15° (airphoto interpretation) |
| | Dip 15°-45° (airphoto interpretation) |
| | Dip > 45° (airphoto interpretation) |
| | Trend line (airphoto interpretation) |
| | Lineament (airphoto interpretation) |
| | Joint pattern (airphoto interpretation) |
| | Top of bed indicated by cross-bedding |
| 50 | Strike and dip of joint |
| | Vertical joint |
| | Horizontal joint |
| 75 | Strike and dip of foliation |
| | Prevailing strike and dip of foliation |
| | Vertical foliation |
| 70 | Strike and dip of cleavage |
| | Prevailing strike and dip of cleavage |
| | Vertical cleavage |
| | Dyke or vein (Unless indicated otherwise all dykes are dolerite) ap – Aplite, go – Gossan, peg – Pegmatite, po – Porphyry, q – Quartz |
| DD | Diamond drill hole |
| | Unworked deposit |
| | Mine – minor; not worked |
| | Costean |
| Cu | Copper |
| Be | Beryl |
| | Bore with windpump |
| | Abandoned Bore |
| T | Water tank |
| E | Earth tank or dam |
| | Dam on stream |
| WH | Waterhole |
| | Road |
| | Vehicular track |
| "Oban" | Homestead |
| ■ | Building |
| Yd | Yard |
| | Fence |
| ·314 | Elevation in metres, height approximate |
| abd | Abandoned |

## DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS

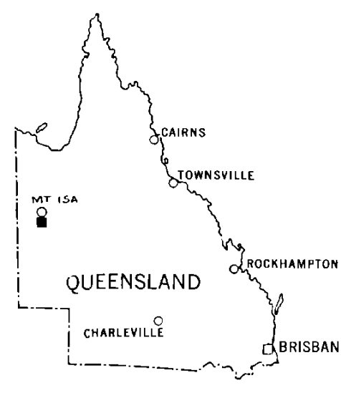


## INDEX TO 1:100 000 MAPS

1:250 000 maps shown in brown

| | | | | | |
|---|---|---|---|---|---|
| WOOROONA<br>6557 | YELVERTOFT<br>6657 | KENNEDY GAP<br>6757 | PROSPECTOR<br>6857 | QUAMBY<br>6957 | CLONAGH<br>7057 |
| BULLECOURT<br>6556 | MOUNT ISA<br>SF 54-1<br>TEMPLETON<br>6656 | MOUNT ISA<br>6756 | MARY KATHLEEN<br>6856 | CLONCURRY<br>SF 54-2<br>MARRABA<br>6956 | CLONCURRY<br>7056 |
| HEADINGLY<br>6555 | GOA CREEK<br>6655 | OBAN<br>6755 | DUCHESS<br>6855 | MALBON<br>6955 | MOUNT ANGELAY<br>7055 |
| URANDANGI<br>6554 | URANDANGI<br>SF 54-5<br>CARANDOTTA<br>6654 | ARDMORE<br>6754 | DAJARRA<br>6854 | DUCHESS<br>SF 54-6<br>MOUNT MERLIN<br>6954 | SELWYN<br>7054 |

141°00' 20°00' 22°00' 141°00'



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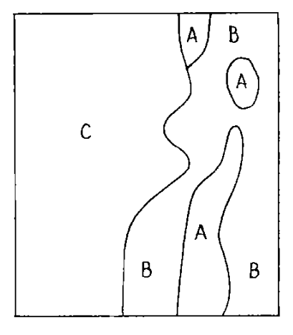
## RELIABILITY DIAGRAM



A Detailed mapping.

B Detailed reconnaissance: numerous traverses and airphoto interpretation

C Reconnaissance: traverses and airphoto interpretation

## GRID REFERENCE

TO GIVE A UNIQUE REFERENCE ON THIS SHEET TO NEAREST 100 METRES

IGNORE the SMALLER figures of any grid number; these are for finding the full co-ordinates. Use ONLY the LARGER figures of the grid number, e.g. 293000

SAMPLE POINT: MOUNT WOODHOUSE

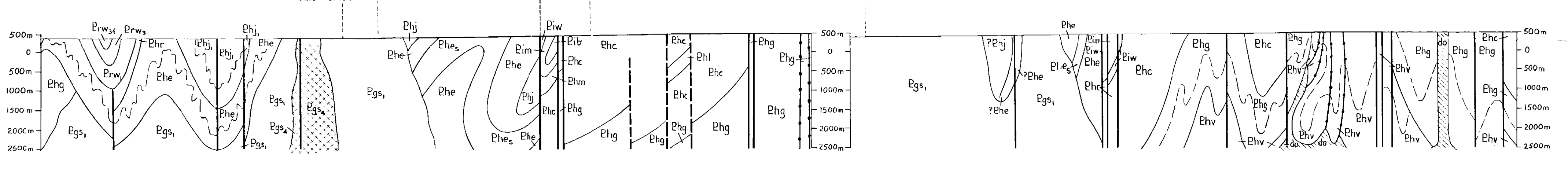
| | | |
|---|---|---|
| 1. Quote this 1:100 000 map sheet: | 6755 | |
| 2. Locate first VERTICAL grid line to LEFT of point and read LARGE figures labelling the line either in the top or bottom margin, or on the line itself: | 06 | |
| 3. Estimate tenths from grid line to point: | 3 | |
| 4. Locate first HORIZONTAL grid line BELOW point and read LARGE figures labelling the line in either the left or right margin, or on the line itself: | | 65 |
| 5. Estimate tenths from grid line to point: | | 3 |
| SAMPLE REFERENCE: | 6755-063653 | |

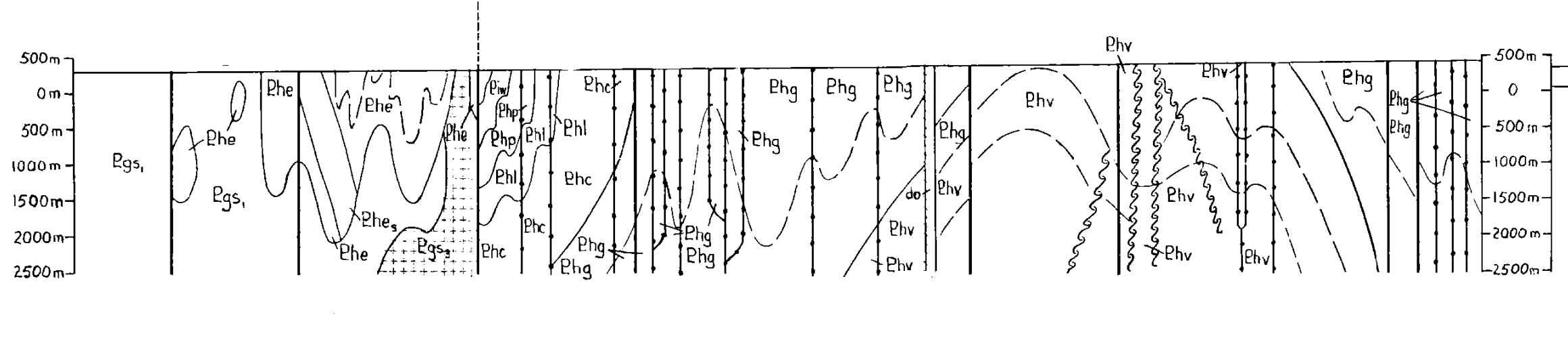
Brown numbered grid lines are 1000 metre intervals of the Australian Map Grid, Zone 54
Grid values are shown in full only at the south west corner of the map
Transverse Mercator Projection

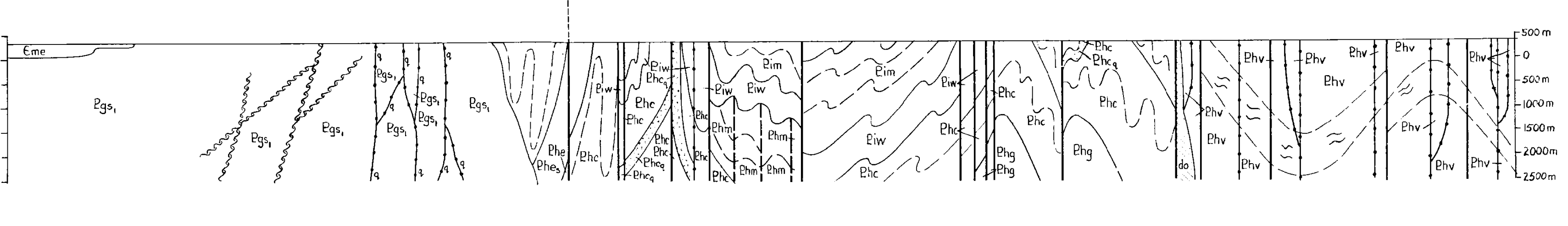
## Sections

Cainozoic sediments omitted from section

Scale: $\frac{V}{H} = 1$







Geology 1952-1957 by E K Carter, A A Öpik, D M Traves, L C Noakes, K A Townley,
J F Ivanac, W M Roberts BMR; B W Hawkins GSQ
1957-1962 by K G Smith BMR
1967-1972 by F de Keyser, P J Cook BMR
To 1976 by the geological staff of Mines Exploration Pty Ltd
Detailed mapping and geological revision
1975 by C M Gardner BMR
1976 by C M Gardner, R M Hill, R J Bultitude BMR, T A Noon GSQ
Compiled 1976 by P L Blythe
Design and drafting by Cartography Section, BMR
Drawn by P L Blythe

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