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Record 1979/56

GEOLOGY OF THE QUAMBY 1:100 000 SHEET AREA (6957), QUEENSLAND

by

I.H. Wilson , T.A. Noon , R.M. Hill , & B.A. Duff

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ABSTRACT

The Quamby 1:100 000 Sheet area (6957) in northwestern Queensland is bounded by latitudes 20°00'S and 20°30'S and longitudes 140°00'E and 140°30'E.

The oldest rocks in the Sheet area belong to the Lower Proterozoic to Carpentarian Tewinga Group. The Carpentarian rocks are in the Soldiers Cap, Mary Kathleen, and Mount Albert Groups, and the Wonga, Burstall and Naraku Granites. Adelaidean, Cambrian, and Mesozoic sediments, Tertiary and Quaternary deposits, overlie the Carpentarian rocks.

The Tewinga Group (Argylla Formation) comprises pink sheared porphyritic rhyolite and metamorphosed psammitic sediments, and is intruded by the Wonga Granite and dolerite dykes.

The Soldiers Cap Group consists of metamorphosed feldspathic sandstone, quartzite, amphibolite, and ?metabasalt. It is overlain by Mary Kathleen Group (Ballara Quartzite, Corella Formation). The Ballara Quartzite overlies the Argylla Formation disconformably in the west, but relations with the Soldiers Cap Group are not known. The Corella Formation, mainly laminated calc-silicate rocks and calc-silicate breccia, overlies Ballara Quartzite and Soldiers Cap Group, and is intruded by the Wonga, Burstall, and Naraku Granites, and dolerite.

Following slight uplift and deformation of the Mary Kathleen Group, the Mount Albert Group (Knapdale Quartzite and 'Lady Clayre Dolomite') was deposited. The Knapdale Quartzite, mainly feldspathic and calcareous sandstone, is overlain by dolomite and dolomitic pyrrhotitic siltstone of the 'Lady Clayre Dolomite'.

?Adelaidean rocks include the Quamby Conglomerate, a ferruginous conglomeratic sandstone preserved in grabens in the south of the Sheet area. The Cambrian Kajabbi Formation consists of a basal sandstone and an upper unit of silty limestone, calcareous siltstone, and minor chert, and is restricted to the Landsborough Graben in the Quamby Sheet area. Mesozoic rocks include the Toolebuc Limestone (limestone and calcareous shale) and undivided strata of the Gilbert River Formation and Wallumbilla Formation.

Nine Cainozoic units have been recognised but only one, the Wondoola Beds, has a formal name.

Low-pressure high-temperature metamorphism of the Lower Proterozoic and Carpentarian rocks reached amphibolite facies in much of the Sheet area. Minor anatexis indicates that temperatures were as high as about 700^{o}C at pressures of up to 4 kb. The Mount Albert Group was metamorphosed only to upper greenschist facies. Adelaidean and younger rocks are unmetamorphosed.

Deformation accompanying metamorphism resulted in north-trending, locally double-plunging tight to isoclinal folds. Faulting preceded and accompanied the folding. A later period of strike-slip faulting was the last recorded Carpentarian event. Younger normal faulting formed a horst and graben system active from late Triassic to post-Mesozoic time.

Mineral deposits in the Quamby Sheet area include gold, copper, limestone, cobalt, scheelite and ironstone. A major lead-zinc prospect at Dugald River is being evaluated by CRA Exploration Co. The Sheet area is also being investigated for sedimentary uranium. Minor phosphate occurs in the Cambrian sequence.

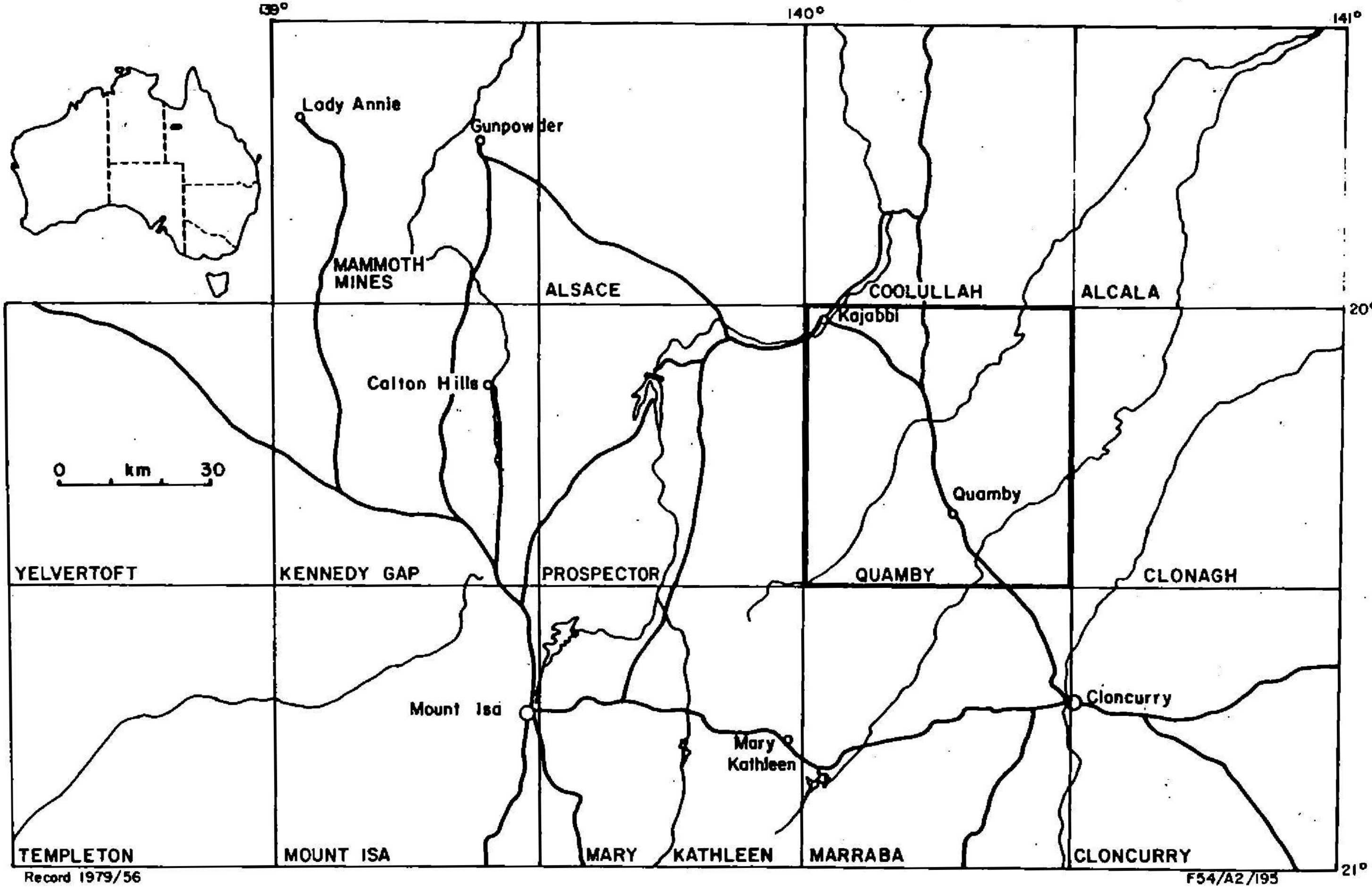


Fig.1 Location map QUAMBY 1:100 000 Sheet area

INTRODUCTION

Location

The Quamby 1:100 000 Sheet area (6957) is bounded by latitudes 20°00'S and 20°30'S, and by longitudes 140°00'E and 140°30'E (Fig. 1), in northwest Queensland. It lies in the northern portion of the Cloncurry 1:250 000 Sheet area, SF/54-2. The township of Quamby, which is 40 km northwest of Cloncurry, is near the middle of the Quamby Sheet area, and Kajabbi is near the northwest corner. Cloncurry is about 1760 km by road from Brisbane and 770 km west of the port of Townsville to which it is linked by rail. Mount Isa, the main population centre in the region is 123 km west of Cloncurry.

Object

This Record presents the results of semi-detailed regional geological mapping of the Precambrian rocks and regional geological mapping of the younger rocks in the Quamby 1:100 000 Sheet area by members of the Bureau of Mineral Resources (BMR) and Geological Survey of Queensland (GSQ).

The aims of the survey were to:

(1) produce a map at 1:100 000 scale of the geology;
(2) reassess the stratigraphy, structure, petrology, economic geology and geological history of the region; and
(3) prepare a detailed report of the geology.

Access

Access to and within the Sheet area is generally good. The sealed Cloncurry-Quamby Road traverses northwesterly across the southern portion of the Quamby Sheet area and then from Quamby northwards through the centre of the Sheet area as the Burke Developmental Road. A formed earth road joins Kajabbi to the Burke Developmental Road and another, the Burketown-Quamby Road traverses from Quamby north-northeasterly across the Sheet area. Formed earth roads and tracks from the major road system to station homesteads, water-bores, and small mines and prospects form a close network throughout the area.

Quamby, and Kajabbi, the rail terminus, are served by a branch railway line from Cloncurry; both Kajabbi and Quamby have landing grounds, and so do some of the larger cattle stations.

Population and industry

Kajabbi and Quamby, the only two towns in the Sheet area, have populations of about 40 and 10 respectively. About 30 other people are involved with cattle-raising and mining.

Climate

The following summary is based on reports by Slatyer (1964) on the Leichhardt-Gilbert area, which includes the Quamby 1:100 000 Sheet area, and by Carter, Brooks & Walker (1961).

The area has a semi-arid monsoonal, tropical climate, with well-defined wet and dry seasons. Nearly all the rain falls between November and April - most of it during January and February. Occasionally, additional light rain falls in the early winter months. The area lies between the 380 and 500 mm isohyets of annual rainfall, which trend easterly; rainfall decreases to the south.

The annual average maximum temperature for the area is about $32^{\circ}C$ and the annual average minimum temperature is about $17^{\circ}C$. The highest monthly average maximum is $38^{\circ}C$, in December, and the lowest monthly average minimum is $8^{\circ}C$, in July. Relative humidity is low, ranging from about 25 percent during winter to a maximum average during the wet season of about 50 percent.

Vegetation, soils, and pasture

The following description is summarised from Perry & Lazarides (1964) and Sleeman (1964). Details of vegetation are also given by Carter & others (1961).

The rocky hills and steeper slopes formed over the Precambrian igneous and metamorphic rocks are covered with a thin veneer of skeletal soil which supports only a sparse low woodland over a spinifex grass layer. The trees are mostly 3 to 6 m high; snappy gum (Eucalyptus brevifolia) is the most common, except on basic rocks, where bloodwood (E. terminalis) and western box (E. argillacea) dominate. Less common are silverleaf box (E. pruinosa), ghost gum (E. papuana), and shrubs including wattle (Acacia spp.) and turkey bushes (Cassia spp.). Soft spinifex (Triodia pungens) occurs on the acid rocks and laterite, and has a low stocking rate. Hard spinifex (T. burkensis, T. molesta, and T. longiceps) forms a mid-height grass layer which is useless for grazing.

Between the steep rocky terrain in the west and the open plains to the northeast are low foothills and undulating plains which formed over Precambrian rocks at the edge of the Cloncurry Complex. They are covered by red and yellow earths, skeletal sands, and clay loams, which support a similar tree layer to the higher-relief areas but with an arid short-grass community rather than spinifex. Typical grasses are kerosene grass (Aristida arenaria) and Enneapogon spp. This grass community provides good-quality forage but yield is low.

Along the narrow alluvial plains adjacent to the larger watercourses in the area a distinctive vegetation has developed on the light-textured red and yellow earths and brown soils. The tree community is open and includes ghost gum, bloodwood, and bean tree (Bauhinia cunninghamii), 6 to 10 m high. A lower tree layer (3 to 5 m), including paperbarks (Melaleuca spp.), is present especially near permanent waterholes. Shrubs, including mimosa (Acacia fornesiana) and konkerberrys (Carissa lanceolata), are commonly present. Chloris divaricata is the most common grass but three-awn (Aristida pruinosa), kerosene grass (A. broroniana), pitted blue grass (Bothriochloa decipiens var. cloncurrensis) blue grass (B. ewathiana), and kangaroo grass (Themeda australia) are also prominent in some stands. Buffel grass (Cenchrus ciliaris) introduced by the Afghanistan camel drivers in the late 1800s has partly replaced the native community in the Cloncurry region. Forage quality is fairly good and the stocking rate is high but in some places pastures have been badly damaged by heavy grazing.

The larger plains are generally treeless except for areas of silverleaf box (E. pruinosa) woodland which generally occur on red and yellow earths and more rarely on deep sandy soils and shallow skeletal soils. The tree layer is open and 5-6 m high. Silverleaf box is by far the most common tree but whitewood (Atalaya hemiglauca), beefwood (Grevillea striata) and bloodwood (E. terminalis) are common. The associated grass community includes Aristida spp., Sehima nervosum and kangaroo grass (Themeda australia). These grasses seem to be of fairly good quality but their stocking rate is only moderate.

The treeless plains are dominated by two grass communities, Mitchell grasses (Astrebla spp.) and blue grass (Dichanthium spp.)/browntop (Eulalia fulva). The Mitchell grasses give a moderate yield of good quality forage during and shortly after the wet season and poor quality during the dry season, but have a fairly high stocking rate. The blue grass/browntop community provides a greater bulk of poorer-quality forage than the Mitchell grass and also has a relatively high carrying capacity.

Water resources

Most of the creeks and rivers in the Sheet area contain surface water during and for only a few weeks after the main wet season. A few large permanent and semi-permanent waterholes are located along or near the Cloncurry, Corella, Dugald and Leichhardt Rivers. In areas of Precambrian outcrop, groundwater is pumped from shallow bores along the main creek systems, but in the plains water is pumped from shallow aquifers in the flat lying Mesozoic sediments. Most pumping is done by windmills supplemented by diesel engines during the less windy months. The water is generally pumped into circular earth storage tanks, known as 'turkey nests' from which it is reticulated to watering troughs.

Previous literature

The first systematic survey of the Precambrian belt of northwest Queensland was carried out by BMR and GSQ between 1950 and 1959 and reported by Carter & others, (1961) who included a comprehensive bibliography of geological work carried out in the region before 1960. Reports dealing specifically with the Quamby 1:100 000 Sheet area are listed in this Record along with more recent literature.

Records on the geology of other 1:100 000 Sheet areas in the region, Cloncurry (7056) (Glikson & Derrick, 1970), Marraba (6956) (Derrick, Wilson, Hill, & Mitchell, 1971), Mary Kathleen (6856) (Derrick, Wilson, Hill, Glikson, & Mitchell, 1977), Mount Isa (6756) (Hill, Wilson & Derrick, 1975), Prospector (6857), (Wilson, Derrick, Hill, Duff, Noon & Ellis, 1977) and Kennedy Gap (6856), (Wilson, Hill, Noon, Duff, & Derrick, 1979) have been completed.

Present investigation

A reconnaissance of the geology of the Quamby Sheet area was made during September 1973 by I.H. Wilson (GSQ), party leader, T.A. Noon (GSQ), B.A. Duff and R.M. Hill. Final check mapping was done by the same team in September 1974, with help from G.M. Derrick. Further detailed mapping around the Dugald River prospect was carried out by Wilson and Derrick during 1975. The mapping was carried out using coloured aerial photographs at 1:25 000 scale. K. Grimes (GSQ) mapped the Cainozoic and Mesozoic units in the region during 1969 and advised and assisted in the photo-interpretation of these units in the Sheet area.

Concurrent investigations and reports

Syntheses of the regional geology based on the recent BMR/GSQ mapping have been published by Plumb & Derrick (1975) and Wilson & Derrick (1976). The major stratigraphic units in the Sheet area have been redefined where necessary; these include the Tewinga Group (Derrick, Wilson, & Hill, 1976a), Soldiers Cap Group (Derrick & others, 1976b), Mary Kathleen Group (Derrick & others, 1977a), Mount Albert Group (Derrick & others, 1977b), and igneous intrusives (Derrick & others, 1978). A regional synthesis of the Mesozoic and Cainozoic geology has been made by Grimes (1972).

Maffi & others (1974) and Maffi (1974) appraised remote sensing methods for geological mapping in the region, including the use of Earth Resources Satellite imagery (LANDSAT) and Side-looking airborne radar (SLAR). An airborne magnetic and radiometric survey was made of the area by BMR in 1973 (Tucker, 1975). A program of geophysical mapping of Precambrian rocks beneath a thin cover of Mesozoic and Cainozoic cover was conducted by BMR in 1975 (Mutton & Almond, in prep.).

A regional synthesis of the mode of copper mineralisation was made by Wilson, Derrick, & Hill (1972) and a summary of company exploration surveys in the area has been compiled by Noon (1974).

Aerial photographs and maps

Aerial photographs:

(a) K17 black and white at 1:50 000 scale taken in 1950 by RAAF; available from the Division of National Mapping, Department of National Development, Canberra.

(b) RC9 black and white at 1:85 000 scale taken in 1966 by Adastra; available from the Division of National Mapping.

(c) Black and white at 1:50 000 scale taken in 1970; available from the Lands Department, Queensland.

(d) Colour at 1:250 000 scale taken in 1972; available from the Division of National Mapping.

(e) Photomosaics of the K17 and RC9 photography (a and b above) at 1:250 000 and 1:100 000 scale respectively; available from the Division of National Mapping.

Side-looking airborne radar:

SLAR Imagery at 1:100 000 scale taken by Goodyear-Aerospace covers the southern half of the Quamby Sheet area; available from the Division of National Mapping.

Satellite imagery:

LANDSAT 1 scenes that cover most of the Cloncurry 1:250 000 Sheet area are listed with percentage cloud cover shown in brackets; available from the Division of National Mapping.

LANDSAT 1

1116-00073	(0)
1152-00073	(0)
1224-00075	(70)
1296-00074	(0)
1386-00064	(0)
1422-00060	(0)

Maps:

(a) Topographic map at 1:250 000 scale - Cloncurry, Sheet SF54-2 - compiled in 1961 from K17 aerial photography of the Royal Australian Survey Corps; available from the Division of National Mapping.

(b) Topographic map at 1:100 000 scale - Quamby, Sheet 6957 - compiled from RC9 aerial photography by the Division of National Mapping.

(c) Current 1:100 000-scale Mining Lease Atlas maps 6957 (Quamby); available from the Mines Department, Queensland.

(d) Current 1:100 000 Block Identification map, Series B (Cloncurry); available from the Mines Department, Queensland.

(e) Current 1:2 500 000 Authority to Prospect (Minerals) map of Queensland; available from the Mines Department, Queensland.

Nomenclature

Streckeisen's (1967) classification has been used in this Record for naming igneous rocks; Crooks's (1960) for arenites; and Joplin's (1968b) for metamorphic rocks. The term 'granofels', defined by Goldsmith (1959), is used instead of 'granulite' or 'hornfels' for a metamorphic rock with a granoblastic texture. All textural terms describing both igneous and metamorphic rocks are used in the sense defined by Joplin (1968a, 1968b).

The grainsizes used to classify sediments are as follows: fine, 0.125 to 0.25 mm; medium 0.25 to 0.5 mm; coarse, 0.5 to 1 mm; and very coarse, 1 to 2 mm. The bedding thickness terms used for sedimentary rocks are: laminated, less than 1 cm; thin-bedded, 1 to 50 cm; medium-bedded, 50 cm to 2 m; and thick-bedded, over 2 m. If the grainsize of the granitic rocks is less than 1 mm, it is described as fine; if 1 to 5 mm, as medium; if 5 mm to 3 cm, as coarse; and if over 3 cm, as pegmatitic.

In describing the amount of a mineral present in a rock, 'accessory' is used to mean less than 10 percent, and 'trace' less than one percent; 'essential' is used to describe any mineral whose presence is essential to the classification of the rock. Estimated modal analyses are visual estimates of the percentage of mineral constituents observed in a thin-section, compared with standard charts for estimating percentage composition of rocks and sediments (Compston, 1962). All specimen numbers prefixed by 'R' are GSQ rock numbers and those prefixed by 'M' are GSQ microslide numbers; all other numbers are BMR registered numbers with the prefix 7520 deleted, except where otherwise stated. 'Agd' is used in tables for average grain diameter, measured in millimeters.

GEOMORPHOLOGY

A summary description of the geomorphology of the Precambrian mineral belt is given by Carter & others (1961). The geomorphology of the Leichhardt-Gilbert region, which includes the Quamby Sheet area, has been described by Twidale (1964, 1966). Grimes (1979), Doutch (1976), and Smart, Grimes, Doutch, & Pinchin (in press) have also discussed the physiography and geomorphology of the Sheet area in regional studies of the Carpentaria and Karumba Basins.

Physiography

The Quamby Sheet area contains examples of two physiographic divisions of Twidale (1964): the Isa Highlands, which occur in the west and south, and the Carpentaria Plain, which occupy the remainder of the Sheet area. The Isa Highlands, renamed the Isa Uplands by Smart & others (in press), consist of complex ridges and maturely dissected plateaux which in the Quamby Sheet area average about 300 m above sea level, and reach a maximum elevation of 448 m in the southwest (Fig. 4); relief ranges from 100 to 200 m. The Carpentaria Plains (Fig. 3) slope gently to the northeast in the Sheet area; elevations range from 200 to 120 m and local relief rarely exceeds 20 m.

The small streams are structurally controlled but the larger streams such as the Leichhardt River, Dugald River, Cabbage Tree Creek, and Cleanskin Creek are superimposed or subsequent. Most of the Sheet area drains into the Cloncurry-Flinders River system, but streams in the northwest drain into the Leichhardt River.

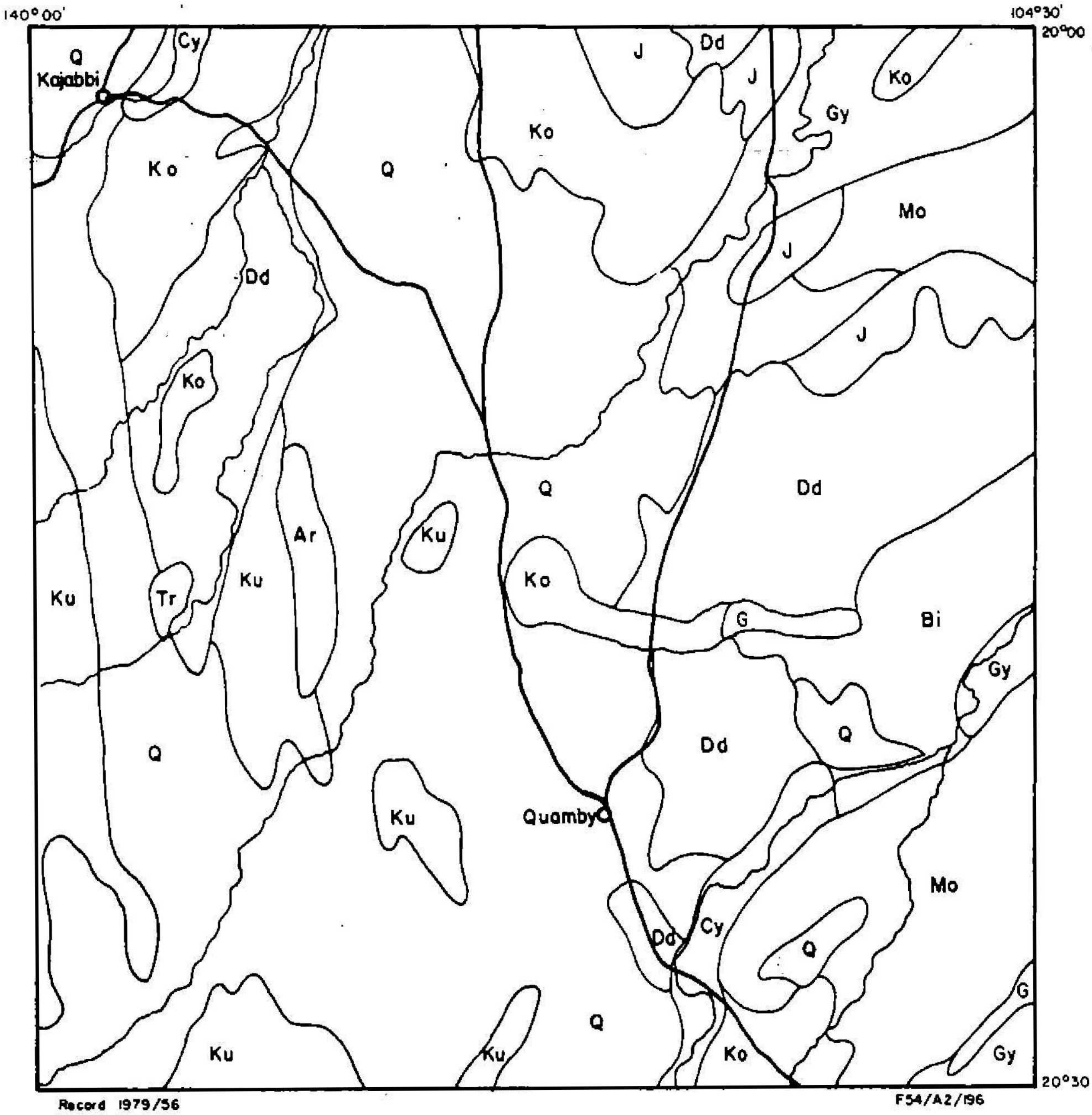
Erosion surfaces

Minor evidence of pre-mid-Mesozoic and Early to mid-Tertiary erosion surfaces are present in the Quamby Sheet area. An Early Cambrian or Late Proterozoic surface (Sub-Georgina Surface of Grimes, 1979) is inferred to be present in the Sheet area. The pre-mid-Mesozoic surface (Sub-Carpentaria Surface of Grimes, 1979) is recognised in the Landsborough Graben and in the planated ridge tops in the southwest and on the Knapdale Quartzite. This surface was warped by earth movements before the widespread deposition of Jurassic continental sediments (Grimes, 1972).

The early to mid-Tertiary surface (Aurukun Surface of Doutch, 1976) is a lateritised or silicified surface. Peneplanation during the Pliocene and Pleistocene (Doutch, 1976) is responsible for much of the erosional plains in the east of the Quamby Sheet area (Twidale, 1964).

Land systems

Land systems are areas of country (landscapes) with similar patterns of topography, rocks, soils, and vegetation. Perry, Sleeman, Twidale, & Pritchard (1964) mapped 12 land systems in the Quamby Sheet area (Fig. 2) in their study of the Leichhardt-Gilbert area. These systems are listed in Table 1 and are related to the physiographic divisions and geomorphic units defined by Twidale (1964) and Smart & others (in press).



Ar Argylla
Bi Balbirini
Cy Cloncurry
Dd Donaldson
G Georgina
J Julia
Ko Korong
Ku Kuridala
Mo Monstraven
Q Quamby
Tr Torwood
Gy Gregory

Fig 2, Land systems in Quamby Sheet area

TABLE 1. LAND SYSTEMS IN THE QUAMBY SHEET AREA

Physiographic division	Geomorphic unit	Land systems	Description	Surfaces
Isa Uplands	Maturely dissected hill country	Argylla	Imaturely dissected plateau	Pre-mid Mz, early to mid-T
		Kuridala	Maturely dissected hill country	Pre-mid Mz, early to mid-T
		Torwood	Immaturely dissected plateaux (mesas)	early to mid-T
Carpentaria Plains	Plains of erosion	Donaldson	Undulating plain, slightly dissected	late T - Q
		Julia	Rolling plains, braided stream channels	late T - Q
		Quamby	Large undulating plains with concave slopes low ridges, some pediments	late T - Q
	Alluvial plains	Korong	Outwash plain and low plateaux	Pliocene
		Monstraven	Riverine paludal plains, slightly dissected	Pleistocene
		Balbirini	Riverine paludal plains, slightly dissected	Pleistocene
		Gregory	Covered plain, many abandoned channels	early Recent
		Cloncurry	Covered plain levees and interlevee areas	
		Georgina	Clay plains, bar plains in braiding streams	late Recent

STRATIGRAPHY

The oldest rocks in the Sheet area belong to the Lower Proterozoic to Carpentarian Tewinga Group; they are overlain by Carpentarian (Middle Proterozoic) rocks of the Soldiers Cap, Mary Kathleen, and Mount Albert Groups, which are intruded by the Wonga, Burstall, and Naraku Granites.

Adelaidean (upper Proterozoic), Cambrian and Mesozoic sediments overlie the Precambrian rocks. Tertiary and Quaternary deposits are widespread across the Sheet area.

LOWER PROTEROZOIC TO CARPENTARIAN

TEWINGA GROUP

The Tewinga Group was defined by Derrick & others (1976a) to include the Leichhardt Metamorphics, Magna Lynn Metabasalt, and Argylla Formation. Only the Argylla Formation is exposed in the Quamby Sheet area where it forms the eastern limb of an isoclinally folded anticline in the west.

Argylla Formation

Introduction

The Argylla Formation consists mainly of porphyritic acid volcanics. It crops out discontinuously near the western edge of the Sheet area, as low rounded rubble-covered hills of moderate to low relief. In some areas the topography reflects a northerly to north-northwesterly structural trend.

TABLE 2
SUMMARY DESCRIPTIONS OF STRATIGRAPHIC UNITS, QUAMBY 1:100 000 SHEET AREA

Group	Rock Unit	Symbol	Thickness (m)	Description	Stratigraphic relations	Remarks
CAINOZOIC		Ql		Clay, silt		Lagoonal deposits
		Qha		Sand, silt, gravel		Recent alluvium
		Qa		Silt, sand clay		Alluvium
		Qas		Sand, gravel		Abandoned stream channel
		Qpa		Clay, silt		Old alluvium
		TQb		Black soil		On TQr and Cretaceous mudstone
	Wondoola Beds	TQr		Red and grey clay, silt, sand		
		Czs		Sand, gravel, clay		Colluvium
		Td		Ferricrete, silcrete (billy)		Duricrust
MESOZOIC	Toolebuc Limestone	Klo	7-25	Limestone, calcareous shale	Conformably overlies Wallumbilla Formation conformably overlain by Allaru Mudstone	
		M	5-50	Quartzose and sub-labile sandstone, siltstone, mudstone, minor conglomerate	Unconformably overlies Carpentarian, Adelaidean(?) and Cambrian units	Mostly Gilbert River Formation, some Wallumbilla Formation
CAMBRIAN	Kajabbi Formation	-€	500-600	Flaggy limestone, basal sandstone, grit	Unconformably overlies Carpentarian and ?Adelaidean units. Unconformably overlain by Mesozoic units	

Group	Rock Unit	Symbol	Thickness (m)	Description	Stratigraphic relations	Remarks
?ADELAID-EAN	Quamby Conglomerate	Ᵽuq	About 300	Conglomerate, sandstone, greywacke	Unconformably overlies Corella Formation, unconformably overlain by Mesozoic units	
Mount Albert Group	'Lady Clayre Dolomite'	Ᵽpk_d	About 3000	Black fine dolomite, pyrrhotitic siltstone	Appears to conformably overlie Knapdale Quartzite, may be unconformably overlain by Cambrian units	
	Knapdale Quartzite	Ᵽpk	At least 2000	Pink feldspathic and micaceous fine-grained sandstone, quartzite	?Disconformably overlies Corella Formation. Conformably overlain by 'Lady Clayre Dolomite'	Undivided
	Knapdale Quartzite	Ᵽpk_t	About 100	Pink feldspathic and micaceous siltstone, minor pebble conglomerate	Thin unit near top of Knapdale Quartzite	
		Ᵽpk_s	About 300	Grey siltstone, black shale, scapolitic siltstone	Unit at top of Knapdale Quartzite	
		Ᵽpk_c	About 500	Calcareous feldspathic medium-grained sandstone, pink quartzite, siltstone	Unit at base of Knapdale Quartzite	
CARPENTARIAN Mary Kathleen Group	Corella Formation	Ƀkc	About 2000	Laminated calc-silicate, metasiltstone, para-amphibolite	Conformably overlies Ballara Quartzite, disconformably or unconformably overlies Soldiers Cap Group. Overlain ?disconformably by Knapdale Quartzite	Undivided
		Ƀkc_{3f}	90-260	Argillaceous limestone, black shale	Lens near top of Corella Formation	"Footwall Limestone" of Whitcher (1975)
		Ƀkc_{3s}	About 200	Black laminated shale, siltstone	Isolated outcrop in Quamby Fault zone	
		Ƀkc_{3d}	About 100	Shale, sheared calcareous siltstone, cordierite (?staurolite) and mica schist	Probably overlies Ƀkc_{3f}	
		Ƀkc_{3c}	About 10	Chert, micaceous siltstone, ferruginous siltstone	Possibly underlies Ƀkc_{3d}. Faulted against Knapdale Quartzite	

Group	Rock Unit	Symbol	Thickness (m)	Description	Stratigraphic relations	Remarks
CARPENTARIAN (continued) Mary Kathleen Group (continued)	Corella Formation (cont'd)	Pkc_{3l}	About 100	Metalimestone marble	Lens in Pkc_3	
		Pkc_3	At least 1000	Calcareous scapolitic siltstone, metalimestone, calc-silicate rock, biotite-hornblende schist	Uppermost informal member of Corella Formation	
		Pkc_{2a}	?	Para-amphibolite laminated ferruginous calc-silicate rock	Part of middle unit of Corella Formation	Highly deformed and metamorphosed
		Pkc_{2b}	400-1500	Metabasalt	Most of the middle unit of Corella Formation in northwest	
		Pkc_{2t}	?	Siltstone, micaceous siltstone, schist, minor calc-silicate rocks	Most of the middle unit of Corella Formation in south	Highly deforme
		Pkc_{2q}	100-300	Quartzite, calcareous quartzite, feldspathic quartzite	Commonly occurs at base of middle unit of Corella Formation	
		Pkc_2	Mostly less than 1000	Sandstone, siltstone, para-amphibolite schist, laminated calc-silicate rock	Middle informal member of Corella Formation	
		Pkc_{1r}	-	Calcareous and calc-silicate breccia, ferruginous limestone	Lenses in lowest unit of Corella Formation	In zones of intense deformation
		Pkc_1	Up to 1000	Laminated calc-silicate rock, calcareous siltstone, schist, scapolitic calcareous granofels	Lowest informal member of Corella Formation	
	Ballara Quartzite	Pkb	At least 200	White medium-grained quartzite	Disconformably overlies Argylla Formation, conformably overlain by Corella Formation	
Soldiers Cap Group	-	Po_q	Possibly as much as 10 000	Quartzite, feldspathic quartzite, psammitic schist, amphibolite	Base of unit not exposed, possibly unconformably overlain by Corella Formation	

Group	Rock Unit	Symbol	Thickness (m)	Description	Stratigraphic relations	Remarks
LOWER PROTEROZOIC TO CARPENTARIAN Tewinga Group	Argylla Formation	Pea	About 2000	Sheared porphyritic rhyolite, quartzofeldspathic gneiss, muscovite schist	Base of unit not exposed in Sheet area. Known to conformably overlie Magna Lynn Metabasalt. Disconformably or unconformably overlain by Ballara Quartzite	
		Pea_q	About 50	Quartzite	Lens in Argylla Formation	
		Pea_m	About 1500(?)	Sheared acid and basic volcanics with abundant aplite and pegmatite; metasediments	Upper part of Argylla Formation	

Stratigraphic relations

The base of the Argylla Formation is not exposed in the Sheet area. In Sheet areas to the west and southwest the Argylla Formation is known to overlie the Magna Lynn Metabasalt conformably. A zircon age of 1777 ± 7 m.y. was obtained from specimens of the Argylla Formation in the Prospector Sheet area about 15 km to the west (Page, 1978).

The Argylla Formation is overlain disconformably or unconformably by the Ballara Quartzite, the basal unit of the Mary Kathleen Group. The formation is intruded by dolerite and the Wonga Granite.

Lithology and field occurrence

Three subdivisions of the Argylla Formation are recognised in the Quamby Sheet area. The oldest (shown on the map as Ꝑea) is mainly sheared porphyritic rhyolite. This unit is overlain by a thin quartzite (Ꝑea$_q$), which is in turn overlain by a schistose unit containing some recognisable sheared acid and basic volcanics with abundant aplite and pegmatite veins (Ꝑea$_m$).

Ꝑea is composed mainly of pale grey to pink sheared porphyritic rhyolite and some possible dacite. Some rocks are very pale and altered. A primary flow foliation has not been recognised in the porphyritic volcanics, but a steeply east-dipping metamorphic foliation is widely developed. The most deformed rocks are quartzofeldspathic gneiss and muscovite schist. Some dark laminated medium-grained schistose metasediments are intercalated with the volcanics. This unit covers about 15 km^2 and is intruded by aplite, pegmatite, and metadolerite dykes and masses of Wonga Granite.

Pea$_q$ is a grey to white quartzite which forms a persistent ridge within the Argylla Formation. The quartzite is complexly folded and displaced by faults. Several aplite veins cut the quartzite. Less than 1 km^2 of this unit has been mapped in the Quamby Sheet area.

Pea$_m$ is the most variable unit in the Argylla Formation. It contains pale brown to pink laminated sheared porphyritic acid volcanics, spotted basic rocks which may be metavolcanics, and various schists and quartzite. The most common schist is mid-grey poorly laminated medium-grained biotite-feldspar-quartz schist which probably represents a highly deformed metasediment. Hornblende occurs in some schists, and muscovite is abundant in places. White medium-grained orthoquartzite occurs locally. Most of the quartzite is pale pink, thin to thick-bedded, medium to coarse-grained, and feldspathic. The feldspathic quartzite grades into dark grey glassy quartzite containing hornblende segregations. Minor calc-silicate rocks also occur in this unit. The unit covers about 30 km^2, and is intruded by aplite, pegmatite, metadolerite, quartz, and calcite veins, and by masses of Wonga Granite.

Petrography

Two thin sections of Pea$_m$ were examined, and estimated modal compositions are presented in Table 3. Specimen 4048 is a grey spotted schist which is interbanded with amphibolite and mafic quartzite. In thin section the micas are strongly foliated, and the quartz and microcline have a granoblastic texture. Sphene is the main accessory mineral, although apatite and dark brown euhedral tourmaline grains are widely distributed. Specimen 4066 is a highly metamorphosed sediment which is interbedded with dark grey laminated quartzite and minor calc-silicate rocks. The specimen has a granuloblastic texture except for the scapolite, which occurs partly as radiating sheafs of prismatic crystals.

TABLE 3

ESTIMATED MODAL COMPOSITIONS, ARGYLLA FORMATION (Pea_m)

Specimen	q	k	sc	mu	bi	hb	di	ap	sp	to	agd (mm)	Name
4048	55	10		20	15			tr	tr	tr	0.3	Schist
4066	2	33	10			tr	55	tr			0.2	Granofels

agd - average grain diameter, ap - apatite, bi - biotite, di - diopside, hb - hornblende, k - microcline, mu - muscovite, q - quartz, sc - scapolite, sp - sphene, to - tourmaline, tr - trace

Discussion

The volcanic rocks in this formation have a streaky appearance due to rotation and shearing of phenocrysts during post-depositional deformation. Metamorphism has recrystallised the acid volcanics and produced a granoblastic texture in the metasediments. The presence of diopside and hornblende indicates amphibolite facies metamorphism. Biotite-muscovite schist which may have formed after the peak of the metamorphism occurs in areas of extreme shearing. Pegmatite and aplite veins are commonly deformed, and probably formed during the metamorphism. Some of the apparently undeformed veins may be related to the younger phases of the Wonga Granite.

In the Sheet area the upper part of the Argylla Formation contains a higher proportion of metasediments and basic metavolcanics than the formation typically contains in Sheet areas to the west and southwest. A similar sequence of pelitic, psammitic, and basic schist was recognised to the south in the Marraba Sheet area (Derrick & others, 1971). Some of the psammitic schists may be metamorphosed volcaniclastic sediments.

The Argylla Formation may contain the oldest rocks exposed in the Quamby Sheet area. The uncertainty results from the unknown relation between the Argylla Formation and the Soldiers Cap Group (Eo_q) in the east of the Sheet area. This relation is discussed in the following section on the Soldiers Cap Group.

CARPENTARIAN

SOLDIERS CAP GROUP

Introduction

The Soldiers Cap Group was defined by Derrick & others (1976b), who also defined its three constituent formations with reference to type sections in the Cloncurry 1:100 000 Sheet area. Previously, the group had been named the Soldiers Cap Formation (Carter & others, 1961), and had been mapped in the Cloncurry and Duchess 4-Mile Sheet areas to the south and east of Cloncurry. The first worker to suggest that the Soldiers Cap Group (Formation) extends north into the Quamby Sheet area was Muggeridge (1974), who considered that the schist, amphibolite, and quartzite cropping out from 10 to 20 km northwest of Quamby is overlain unconformably by calc-silicate rocks of the Corella Formation and is thus not part of the Corella Formation as indicated by previous workers. He subdivided these Soldiers Cap Group rocks into a lower schist unit about 2500 m thick and an upper quartzite-amphibolite unit about 7000 m thick. Geophysical studies by BMR in the northwest of the Cloncurry 1:100 000 Sheet area and the southwest of the Clonagh Sheet area suggest that rocks of the Soldiers Cap Group extend into the Quamby Sheet area below a cover of Mesozoic and Cainozoic sediments (Mutton & Almond, in prep.).

The rocks shown as Soldiers Cap Group (Po_q) on the first-edition Quamby 1:100 000 geological map were mapped as Corella Formation (Pkc_{2n}) on the preliminary-edition map. The main outcrop is a folded north-trending belt east of the Mount Rose Bee Fault from near Naraku siding to the northern boundary of the Sheet area. Small areas of poorly exposed rubbly quartzite occur in the southeast of the Sheet area. The total area of outcrop is about 150 km^2.

Stratigraphic relations

The base of the Soldiers Cap Group is not exposed in the Quamby Sheet area: the lowest part of the sequence occurs towards the east, where it is folded, intruded by granite and dolerite, and poorly exposed. The group is overlain, possibly unconformably, by the Corella Formation, although the contact is extensively faulted. The Naraku Granite, aplite, pegmatite, and metamorphosed dolerite dykes intrude the Soldiers Cap Group.

Lithology and field occurrence

The unit is composed mainly of feldspathic quartzite, orthoquartzite, amphibolite, schist, and minor calc-silicate rocks. Outcrop is generally poor, occurring as rubbly low-lying ridges in sandy plains, with some better exposures in deeply eroded creek banks and along rounded quartzite strike-ridges south of the Dugald River. The rocks have a steeply west-dipping to vertical metamorphic foliation which in most areas is roughly parallel to lithological layering.

The main rock type is a white to pink fine to medium-grained feldspathic quartz or meta-arkose which grades locally into a pale greenish brown to fawn glassy mafic quartzite containing lenticles or segregations of hornblende which appear to be partly transposed into metamorphic foliation (S_1). Minor beds of orthoquartzite also occur in this unit. Recrystallisation has resulted in elongate quartz grains which give these rocks a characteristic striated glassy appearance. Bedding is seldom discernible in the

Fig. 3. Carpentaria Plains east of Mount Malakoff

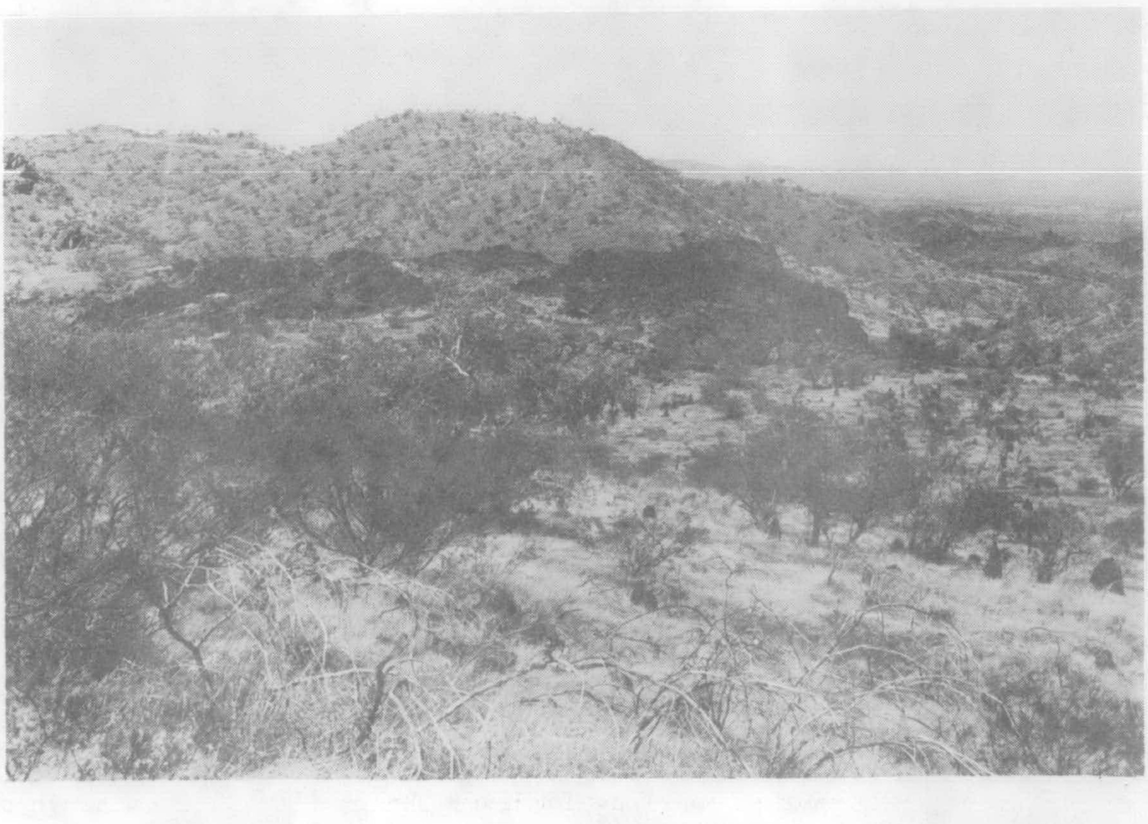


Fig. 4. Maturely dissected hills in the Mount Godkin Range; part of the Isa Uplands

Fig. 5. Folded amphibolite in road-cut about 7 km northwest of Quamby

Fig. 6. Outcrop of the 'Dugald River Shale' (Bkc_{3d}) 2 km south of the lead-zinc prospect

feldspathic quartzite, and outcrops are generally extensively fractured. Tourmaline-orthoclase-quartz pegmatite, aplite, and small masses of Naraku Granite intrude the unit, which also contains concordant bands of layered amphibolite that may be metadolerite sills or metabasalt.

A sequence of white to pale grey medium to coarse-grained thin parallel to cross-bedded orthoquartzite and fine to medium-grained quartzite occurs at the top of the Soldiers Cap Group to the west and northwest of Naraku siding. Conformable amphibolite layers are abundant in this sequence, but aplite and pegmatite veins are rare.

The amphibolite generally is dark bluish grey and strongly foliated and occurs in concordant bands 20 to 30 m wide (Fig. 5). The contacts with the feldspathic quartzite are locally irregular and may represent a stoped contact that has subsequently been transposed into S_1. In many areas the amphibolite is partially segregated into felsic and mafic bands. The felsic bands are typically rich in scapolite; the mafic layers are rich in strongly lineated hornblende. Diopside occurs in some of the amphibolite. Quartz, pegmatite, and aplite appear to have intruded the amphibolite before deformation as the veins are strongly transposed into the metamorphic foliation. Some psammitic and calc-silicate xenoliths have been recognised in the amphibolite bands.

Most of the schist occurs in the feldspathic quartzite as thin interbeds of muscovite-feldspar-quartz schist. Minor biotite schist and scapolite-quartz-feldspar-hornblende-biotite schist occur in the amphibolite.

Minor lenses of calc-silicate rock are spatially associated with the amphibolite. Most are finely laminated and brecciated and consist essentially of calcite, feldspar, and diopside. Calcite and quartz veins intrude the calc-silicate rock.

Some basic igneous rocks are only slightly altered and retain relict ophitic textures. These rocks are believed to be metadolerite intruded after the major deformation and metamorphism. Epidote is commonly developed. These metadolerites have not been mapped separately from the more abundant amphibolite within the Soldiers Cap Group.

Petrography

Eight estimated modal compositions are presented in Table 4.

In thin section the feldspathic quartzite shows evidence of tectonism and metamorphism in the undulose extinction of the quartz grains, the local development of ribbon quartz, and the sutured or polygonal boundaries of the quartz and feldspar grains. No original detrital textures are recognisable. The typical mineral assemblage is quartz-microcline-sphene-opaques although sericitised plagioclase is more abundant than microcline in some specimens. In other specimens small anhedral grains of ferrohastingsite, large scapolite porphyroblasts, garnet, and diopside are present. Small relict clasts or segregations up to 3 cm thick consisting of calcite-quartz-chalcopyrite (actinolite) are aligned parallel to the regional metamorphic foliation at one locality about 8 km north-northeast of Koolamarra siding.

The orthoquartzite specimens in thin-section contain a few percent of microcline. Specimen 0067 is very fine-grained and shows little evidence of deformation. The grains appear to have retained their subangular detrital habit and are well sorted.

The dark bands in the foliated amphibolite consist essentially of hornblende, scapolite, and poikiloblastic diopside. The grains are xenomorphic and the texture is granoblastic to granuloblastic. Relict plagioclase laths occur in one specimen (0227). Sphene, epidote, opaques, and quartz are minor constituents. The diopside porphyroblasts in specimen 0224 appear to be partly replaced by hornblende or actinolite. A pale band from a segregated amphibolite consists of a granoblastic mosaic of scapolite, sericitised plagioclase, and sphene; the sphene occurs as elongate granular aggregates in patches of pink alteration, possibly due to finely disseminated hematite.

No specimens of schist or calc-silicate rock were examined in thin section.

TABLE 4. ESTIMATED MODAL COMPOSITIONS, SOLDIERS CAP GROUP

Specimen	q	p	m	sc	mu	bi	hb	di	ep	op	sp	zr	agd (mm)	Name
4005	33	60			2	tr			1	1	3		2	?Aplite
0223	85	10			3					2	tr	tr	2	Pink feldspathic quartzite
0224				45			41	10		1	3		0.15	Ortho-amphibolite
0225		30		60							10		0.4	Pale band from amphibolite
0227	15	15		20	5		25	15	2		3	tr	0.4	Ortho-amphibolite
0067*	65	20	15		tr								0.15	Feldspathic quartzite
0082*	50	1	42	1			4	1	tr		1			Feldspathic quartzite or aplite
M8064	20	30	13				35				1	1		Quartz-hornblende-plagioclase granofels

* 1974 collection (Register Nos. 7420.....)

agd - average grain diameter, bi - biotite, di - diopside, ep -epidote, hb - hornblende, m- microcline, mu - muscovite, op - opaques, p - plagioclase, q - quartz, sc - scapolite, sp- sphene, tr - trace, zr - zircon.

Discussion

The presence of ferrohastingsite and diopside indicates that the Soldiers Cap Group in the Sheet area has been metamorphosed to at least lower amphibolite facies. The ribbon texture and recrystallisation of quartz grains and the presence of garnet also indicate a relatively high metamorphic grade. Scapolite is widely distributed. Epidote, actinolite, muscovite (sericite), and biotite may have been formed during retrograde metamorphism.

The feldspathic quartzite was probably originally a labile or arkosic medium-grained sandstone with a ferruginous, calcareous, and clayey matrix. During metamorphism ferromagnesian minerals developed in the matrix. The orthoquartzite probably represents a more mature sediment which was better sorted and contained much less matrix than the rocks which formed the feldspathic quartzite.

The origin of the conformable foliated amphibolite layers is unresolved, though most were probably derived frm basic igneous rocks. As the metamorphism has obliterated the primary textures, it is not possible to distinguish lavas from sills, though both - together with a later phase of intrusive dolerite (in which relict ophitic textures are visible) - are probably represented in the sequence. The banding in the amphibolite appears to result from metamorphic segregation, and a saline metamorphic fluid is thought to have converted plagioclase to scapolite.

The schists probably represent more-pelitic rocks; some of them occupy shear zones which postdate the regional metamorphism. Calc-silicate rocks have probably formed from local areas of laminated calcareous siltstone or shale.

The correlation of this schist-amphibolite-quartzite sequence in the Quamby Sheet area with the Soldiers Cap Group as defined in the Cloncurry Sheet area to the southeast is doubted by some workers. The main differences between the two sequences are the coarser grainsize and higher feldspar content of the quartzose units and the significant presence of calc-silicate rocks in the Quamby Sheet area.

Other rock units with which the schist-amphibolite-quartzite sequence in the Quamby Sheet area may correlate include the middle unit of the Corella Formation (as shown on the preliminary map), the Ballara Quartzite, the Mitakoodi Quartzite and Marraba Volcanics of the Malbon Group, and the Argylla Formation. Correlation with the middle unit of the Corella Formation is unlikely because a structural discordance between the Corella Formation and the schist-amphibolite-quartzite sequence near the Magnet copper mine implies a stratigraphic break at the top of the middle member of the Corella Formation (Derrick & others, 1977a) - this has not been recorded elsewhere. A similar problem precludes the correlation of the schist-amphibolite-quartzite sequence with the Ballara Quartzite, as the Corella Formation generally appears to be conformable on the Ballara Quartzite.

Correlation of the schist-amphibolite-quartzite sequence with the Malbon Group (Mitakoodi Quartzite and Marraba Volcanics) is possible as both sequences contain similar rock types (but at a higher metamorphic grade in the Quamby Sheet area) and both sequences are overlain by the Mary Kathleen Group. The Malbon Group is correlated with the Soldiers Cap Group in the Cloncurry 1:100 000 Sheet area by some workers (Carter & others, 1961; Derrick & others, 1976b). We prefer to correlate the Quamby sequence with the Soldiers Cap Group rather than the Malbon Group because of the similar metamorphic grade and because geophysical evidence suggests that the two areas may be continuous beneath a thin cover of Mesozoic strata (Mutton & Almond, in prep.).

The relation between the Argylla Formation and the schist-amphibolite-quartz sequence has not been established. The Argylla Formation is the oldest formation in the west of the Sheet area, and the schist-amphibolite-quartzite sequence contains the oldest rocks in the east. The two units do not come in contact in outcrop; the minimum separation of exposures of the two units is 16 km. The intervening area is folded and displaced by several major faults so that the relative positions of the two units at the time of deposition cannot be established.

Younger rocks offer little control on the relation between the two units. The Argylla Formation is overlain disconformably by the Ballara Quartzite and the Corella Formation; the schist-amphibolite-quartzite sequence is overlain, possibly unconformably, by rocks which have been mapped as Corella Formation but cannot be correlated confidently with the Corella Formation rocks in the west of the Sheet area. No characteristic rock type or marker horizon has been recognised in both sequences.

The lithologies of the two units are quite different. The Argylla Formation is composed of acid volcanic rocks, schist (derived from acid volcanic or volcaniclastic rocks and minor possible basic volcanic rocks) and quartzite. The rocks mapped as Soldiers Cap Group (Po_q) include quartzite, schist (derived from fine-grained feldspathic sediments), and amphibolite (some of which may be derived from basic volcanic rocks). If these two units are correlatives they represent considerable facies variation with acid volcanics decreasing, and basic volcanics and quartzite increasing, to the east.

A similar correlation problem occurs to the south where the Argylla Formation is exposed in the Marraba Sheet area and Soldiers Cap Group rocks (and its type section) occur in the Cloncurry Sheet area. The basal part of the Soldiers Cap Group south of Cloncurry may be a correlative of the upper part of the Argylla Formation (Derrick & others, 1976b); if so, then the schist-amphibolite-quartzite sequence in the Quamby Sheet area probably represents the upper part of the Soldiers Cap Group and are broadly correlative of the Malbon Group, which overlies the Argylla Formation in the Marraba Sheet area.

The geophysical evidence, broad lithological and metamorphic similarities, and relations with the Corella Formation support the correlation of the schist-amphibolite-quartzite sequence in the Quamby Sheet area with the Soldiers Cap Group to the south.

MARY KATHLEEN GROUP

The Mary Kathleen Group was defined by Derrick and others (1977a) to include the Ballara Quartzite, Overhang Jaspilite, Chumvale Breccia, Corella Formation, Mount Philp Agglomerate, Marimo Slate, Answer Slate, Staveley Formation, and Kuridala Formation. Only the Ballara Quartzite and the Corella Formation have been recognised in the Quamby Sheet area, where the Corella Formation is the most widespread stratigraphic unit. The Mary Kathleen Group overlies the Tewinga Group and the Soldiers Cap Group with possible unconformities. It is overlain by the Mount Albert Group, the Quamby Conglomerate, and Mesozoic and Cainozoic sediments, and is intruded by the younger phases of the Wonga Granite, the Burstall Granite, the Naraku Granite, aplite, pegmatite, and dolerite.

Ballara Quartzite

Introduction

The Ballara Quartzite crops out as a thin upstanding ridge of quartzite which separates the schist and sheared acid volcanic rocks of the Argylla Formation from the laminated calc-silicate rocks of the Corella Formation in the southwest of the Sheet area. In some areas north and south of Cleanskin Creek the quartzite is too thin to be mapped at 1:100 000 scale and locally the unit cannot be recognised on the ground. The total area of outcrop of the Ballara Quartzite in the Sheet area is about 2 km^2.

Stratigraphic relations

The stratigraphic relations of the Ballara Quartzite are poorly demonstrated in the Sheet area because of intense deformation and a strongly developed metamorphic foliation. From areas to the south and west of the

Sheet area the Ballara Quartzite is known to overlie the Argylla Formation disconformably or locally unconformably and to be overlain conformably by the Corella Formation. In the Quamby Sheet area the boundaries with these units are concordant: no facing structures have been recorded from the Ballara Quartzite or adjacent outcrops.

Lithology and field occurrence

The Ballara Quartzite consists of white orthoquartzite, pale grey mafic quartzite, and pink feldspathic quartzite. The sequence is generally finer-grained towards the top and grades into schist and calc-silicate rocks of the Corella Formation. The quartzite is strongly sheared and in places extensively silicified. A steeply north-plunging lineation in some of the mafic quartzite is defined by hornblende prisms. The unit is thickest in the midwest of the Sheet area, where it appears to be at least 200 m thick.

Petrography

One specimen of Ballara Quartzite was examined in thin-section. The quartz occurs as coarse grains, very strained, with sutured boundaries. Small well oriented euhedral hornblende prisms are concentrated in bands. Other bands are rich in epidote, and calcite occupies some intergranular areas. An estimated modal composition is presented in Table 5.

TABLE 5. ESTIMATED MODAL COMPOSITIONS, BALLARA QUARTZITE

Specimen No.	q	ca	ep	hb	op	ap	sp	zr	agd (mm)	Name
4037	92	1	2	4	1	tr	tr	tr	2	Hornblende-bearing orthoquqrtzite

Abbreviations: agd-average grain diameter, ap-apatite, ca-calcite, ep-epidote, hb-hornblende, op-opaques, q-quartz, sp-sphene, tr-trace, zr-zircon

Discussion

Before 1970 the Ballara Quartzite had not been mapped north of Mary Kathleen mine. Subsequent 1:100 000 mapping has shown that this unit extends at least 100 km farther north to Dobbyn and the Crusader mine. The unit is thickest in the southwest and northeast of the known area of outcrop. It probably formed on a linear clastic shoreline as defined by Selley (1970).

Corella Formation

Introduction

The Corella Formation is the most extensive formation in the Mount Isa Inlier. It contains a wide range of rock types but is characterised by laminated calcareous sediments. In the Quamby Sheet area, these sediments are metamorphosed to calc-silicate rocks of the amphibolite facies. Breccia is commonly developed in the calc-silicate rocks. Some other rock types within the formation are quartzite, metasiltstone, schists, metabasalt and chert. The formation covers about 500 km^2 in the southwestern half of the Quamby Sheet area. Though most of the formation is low-lying, the calc-silicate breccia occurs as rugged hills and ridges, the quartzite forms prominent ridges, and the amphibolite in the Mount Godkin Range and some of the calc-silicate units in the west of the Sheet area and northwest of Quamby form rugged ridges. Tight to isoclinal folding is evident in some areas.

Stratigraphic relations

The Corella Formation appears to have a gradational conformable contact with the underlying Ballara Quartzite. The Knapdale Quartzite overlies the Corella Formation but the nature of this contact is equivocal and is discussed in the section on the Knapdale Quartzite. The Corella Formation is overlain unconformably by the Quamby Conglomerate, Mesozoic rocks, and Cainozoic sediments. The younger phases of the Wonga Granite, the Burstall Granite, the Naraku Granite, aplite, pegmatite, and dolerite intrude this formation.

Lithology and field occurrence

In the Quamby Sheet area the Corella Formation has been divided, where possible, into three stratigraphic units which have the status of informal members. These units are referred to as the basal, middle, and uppermost units and are shown on the maps as Ꝑkc$_1$, Ꝑkc$_2$, and Ꝑkc$_3$ respectively. These informal members have been subdivided into 14 mappable units on the Quamby first-edition geological map. The relations between these units and the 17 shown on the preliminary geological map are presented in Table 6.

TABLE 6. CORELLA FORMATION MAPPING UNITS USED ON THE PRELIMINARY AND FIRST EDITIONS OF THE QUAMBY GEOLOGICAL MAP

Map symbol: Prelim.	Map symbol: 1st Editn		Description
Ꝑkc$_{3q}$	Ꞓ	*	Quartzite
Ꝑkc$_{3s}$	Ꝑpk$_d$	*	Black fine-grained dolomite, dolomitic pyrrhotitic siltstone
"	Ꝑkc$_{3s}$		Black laminated shale, siltstone
"	Ꝑkc$_{3f}$		Argillaceous limestone, black shale
Ꝑkc$_{3t}$	Ꝑkc$_{3d}$		Shale, sheared calcareous siltstone, cordierite (staurolite) and mica schist
Ꝑkc$_{3c}$	Ꝑkc$_{3c}$		Chert, micaceous siltstone, ferruginous siltstone
Ꝑkc$_{3l}$	Ꝑkc$_{3l}$		Metalimestone, marble
Ꝑkc$_3$	Ꝑkc$_3$		Calcareous scapolitic siltstone, metalimestone, calc-silicate rock, biotite-hornblende schist
Ꝑkc$_{2a}$	Ꝑkc$_{2a}$		Para-amphibolite, laminated ferruginous calc-silicate rock
Ꝑkc$_{2b}$	Ꝑkc$_{2b}$		Metabasalt
Ꝑkc$_{2t}$	Ꝑkc$_{2t}$		Siltstone, micaceous siltstone, schist, minor calc-silicate rock

Map symbol			
Prelim.	1st Editn		Description
Ꝑkc$_{2n}$	Ꝑo$_{q}$	*	Quartzite, feldspathic quartzite, psammitic schist, amphibolite
Ꝑkc$_{2q}$	Ꝑkc$_{2q}$		Quartzite, calcareous quartzite, feldspathic quartzite
Ꝑkc$_{2}$	Ꝑkc$_{2}$		Sandstone, siltstone, para-amphibolite, schist, laminated calc-silicate rock
Ꝑkc$_{1r}$	Ꝑkc$_{1r}$		Calcareous and calc-silicate breccia, ferruginous limestone
Ꝑkc$_{1}$	Ꝑkc$_{1}$		Laminated calc-silicate rocks, calcareous siltstone, schist, scapolitic calcareous granofels
Ꝑkc$_{3p}$	"		Scapolitic calc-silicate, biotite-hornblende schist, marble, abundant aplite and pegmatite veins
Ꝑkc	Ꝑkc		Laminated calc-silicate, metasiltstone, para-amphibolite

Note: * indicates units now excluded from the Corella Formation

Ꝑkc$_{1}$ consists mainly of laminated slightly calcareous calc-silicate rocks. These rocks typically have a brown to black furrowed or pitted weathered surface and appear as alternating green and pink or red bands when freshly broken. The main minerals are calcite, quartz, feldspar, scapolite, hornblende, and diopside. Garnet, sphene, and epidote (including the manganiferous epidote piedmontite) are less common. Some more-siliceous metasediments are grey to brown in colour, generally finer grained, and commonly phyllitic. Locally these phyllitic siltstones grade into pelitic schists containing biotite, hornblende, and muscovite, and porphyroblasts of sillimanite, scapolite, garnet or ?cordierite. Other minor rock types are coarse-grained marble, impure limestone containing porphyroblasts of actinolite or scapolite, laminated para-amphibolite, and garnet-magnetite-amphibole rocks. The unit covers about 160 km^2 in the Sheet area.

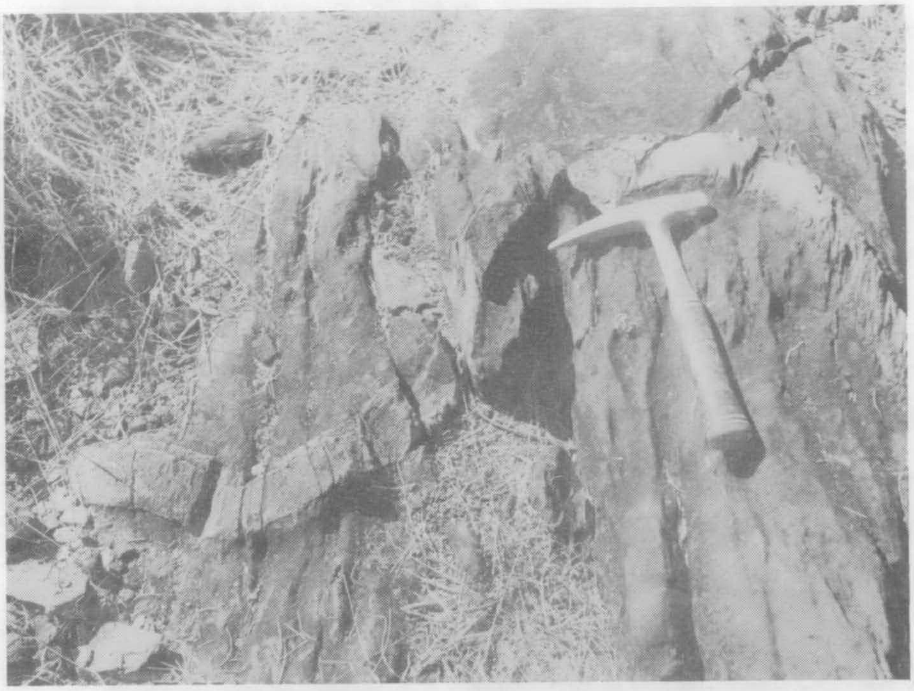


Fig. 7. Folded siltstone band in cleaved 'Dugald River Shale' about 2.5 km south of the lead-zinc prospect

Fig. 8. Very tight fold in basal member of Corella Formation (Bkc_1) 2 km northwest of Volga copper mine

Fig. 9. Isoclinal folds in basal member of Corella Formation (Bkc_1) 2 km northwest of Volga copper mine

Fig. 10. Intricate folding in laminated Corella Formation (Bkc_1) 2.5 km northwest of Volga copper mine

A typical sequence of Pkc_1 in the northwest of the Sheet area contains banded amphibolite in which hornblende-diopside (-biotite)-rich layers alternate with paler quartzofeldspathic layers, overlain by scapolitic calc-silicate rock with interbeds of pure limestone up to 6 m thick. A sequence from east of the Mount Rose Bee fault near the Bedford mine has, at its base, brecciated black-weathering calc-silicate rock and scapolitic limestone; this is overlain by a foliated amphibolite (metadolerite?), then medium to coarse grained calc-silicate rock in which diopside-calcite-scapolite layers about 8 cm thick alternate with thinner fine-grained quartzofeldspathic layers; a weak transposition layering is developed locally. Farther north, the unit forms isolated bouldery outcrops of strongly deformed calc-silicate rock in which transposition and breccia are common. These rocks are highly calcareous and are invaded by pink calcite veins and lenses.

A piedmontite-bearing layer about 30 m thick was mapped by Muggeridge (1974) in two outcrops about 1 km northeast and woutheast of the Quamby Queen mine. The rocks in this layer are described as well-bedded diopside-hornblende-hematite-piedmontite marble with interbeds of laminated piedmontite-potash feldspar-quartz-garnet gneiss. Muggeridge placed this layer at the top of what we have mapped as the lower member of the Corella Formation and reports that it is a well-exposed marker bed in areas to the south near Evandean homestead.

The thickness of Pkc_1 appears to be between 300 and 1 000 m, although intense deformation and folding limit the accuracy of these estimates, especially in the south of the Sheet area. The broad area of Pkc_1 southwest of Quamby consists of tightly folded, brecciated, and calcite-veined black-weathering laminated fine-grained calc-silicate rocks. Even more intense deformation was observed along Cleanskin Creek near the southwestern corner of the Sheet area, where grey laminated slightly calcareous metasediments, porphyroblastic scapolite-biotite schist, and amphibolite are isoclinally folded (Figs. 8-10, 12, 15).

Granite intrudes Ꝑkc$_{1}$ in most areas. Dolerite, aplite, and pegmatite are abundant in the east. The calc-silicate rocks are altered to 'red rock; near some dolerite dykes. The 'red rock' consists of hematite-stained felsic minerals, hornblende, and sphene.

Ꝑkc$_{1r}$ is mapped where brecciation of Ꝑkc$_{1}$ has completely disrupted the bedding. During deformation the calcite-rich bands appear to have migrated to areas of low stress and the more competent bands of calc-silicate minerals, quartzofeldspathic rock, or amphibolite have fractured and become disoriented. In some areas, blocks of alternating pink and green banded calc-silicate rock in excess of 10 m across have been randomly rotated. The breccia generally has a ragged knobbly outcrop and covers about 35 km^2 in the Sheet area.

The brecciation appears to be developed only in the more calcareous rocks and the surrounding Ꝑkc$_{1}$ unit is invariably folded. The largest area of breccia occurs along the faults which bound the Quamby Conglomerate. Dolerite is commonly spatially associated with the breccia, but whether it cause the brecciation or was intruded into the breccia is not known. The breccia adjacent to the dolerite is commonly altered to 'red rock' and some of the dolerite shows similar alteration.

Ꝑkc$_{2}$, the undivided middle member of the Corella Formation is less calcareous than the basal and uppermost members. The unit consists of intermixed metamorphosed sandstone, siltstone, para-amphibolite, schist and minor laminated calc-silicate rock. The unit is generally poorly exposed and covers 20 km^2 in the south of the Quamby Sheet area.

The rocks are grey to fawn, finely laminated, slightly calcareous, locally porphyroblastic siltstone nd schist with interbeds of calcite-actinolite granofels. Pink to grey laminated silty calc-silicate rocks, calc-silicate breccia, and pink foliated feldspathic quartzite are minor consittuents. Near the Burstall Granite the unit consists of brown laminated cherty calc-silicate hornfels. Granite, dolerite, aplite, pegmatite, quartz, and quartz-ilmenite veins intrude this unit. Thickness is mostly less than 1000 m.

Pkc_{2q} consists mainly of buff to white thin-bedded fine-grained slightly feldspathic quartzite. Cross-bedding is widely developed despite recrystallisation, silicification, and structural deformation. The quartzite is interbedded locally with biotite-quartz-muscovite schist and generally becomes finer-grained towards its top, which is mostly composed of brown laminated micaceous siltstone. Adjacent to faults the quartzite is silicified or ferruginised and quartz veins are common.

It occurs as a persistent thin sequence below the metabasalt unit in the west of the Sheet area, in nine discrete areas of outcrop between the Dugald River and Camel Creek, and in one small outcrop east of the Quamby Fault in the south of the Sheet area. The total area of outcrop is about 15 km^2, and the unit forms steep-sided ridges and hills. The maximum thickness is about 300 m, northwest and north of the Native Companion mine, although most sequences are about 100 m thick. The unit appears to be highly lenticular.

The quartzite north of the Mount Quamby gold mine is more ferruginous than the remainder of the unit. Generally the unit is more feldspathic towards the east. The unit appears to represent deposition in a strandline environment.

Pkc_{2t} is characterised by schistose siltstone and pelitic schist. It also comprises minor calcareous siltstone, fine-grained sandstone, and brown laminated fine-grained calc-silicate rocks. Scapolite porphyroblasts occur in some of the siltstone. The main outcrops of this unit lie to the south and west of the Native Companion mine, and smaller outcrops are north and south of the Copper Blocnde mine and south of Quamby. The total area of outcrop is about 60 km^2, but much of this area is poorly exposed in low-lying sandy plains. The poor outcrop and the strongly developed schistosity in some of the outcrops inhibit the recognition of structures. The thickness is not known.

Quartz, quartz-tourmaline, and calcite veins cut this unit, and some intrusive masses of granite and dolerite have been recorded.

Pkc_{2b} is a metabasalt unit which is only recorded in the west of the Sheet area, where it covers about 36 km^2. The unit is low-lying, poorly exposed, and outcrops are partly obscured by caliche and a pale grey soil. The unit has a soft grey tone on colour aerial photographs. The most abundant rock type is a dark blue-grey fine-grained amphibolite containing quartz of quartz-calcite amygdales. This rock is almost certainly derived from amygdaloidal basalt. Concordant belts of medium-grained amphibolite 20 to 40 m thick probably represent dolerite sills. Minor tuff, laminated calcareous siltstone, calc-arenite, calc-silicate rock, and grey impure limestone occur as lenses and thin interbeds in the metabasalt sequence. One specimen of acid volcanic rock was recorded from north of Kajabbi.

In the amphibolite, layering is common and appears to be due to metamorphic segregation. The dark layers are mostly composed of hornblende or biotite and the pale layers are feldspathic. The calc-silicate rock commonly displays pull-apart structures, brecciation, or transposed bedding. Some of the limestone lenses may be intrusive masses of calcite. The metadolerite has retained some ophitic texture and in places chilled margins can be recognised.

Copper mineralisation occurs in some of the quartz veins which intrude the amphibolite. At the surface the mineralised veins are ironstained and gossanous, and contain malachite and chalcocite.

Pkc_{2a} consists of amphibolite and laminated ferruginous calc-silicate rock. The amphibolite is mostly medium-grained and foliated. Because of its foliation, its close association with laminated calc-silicate rock, and the absence of igneous textures, the amphibolite is thought to have been derived from sedimentary rocks such as ferruginous marl or dolomitic shale. Scapolite porphyroblasts are present in some of the amphibolite. Veins of calcite, aplite, pegmatite, and granite cut this unit, and some of the massive amphibolitte is probably metadolerite. This unit covers about 14 km^2 in the Sheet area, and forms rugged ranges east of the Copper Blonde mine and low, poorly exposed ridges south of Quamby. Most areas of outcrop are highly deformed, and no estimate of thickness is possible. Carter & others (1961) mapped the large mass of amphibolite in the Mount Godkin Range as dolerite.

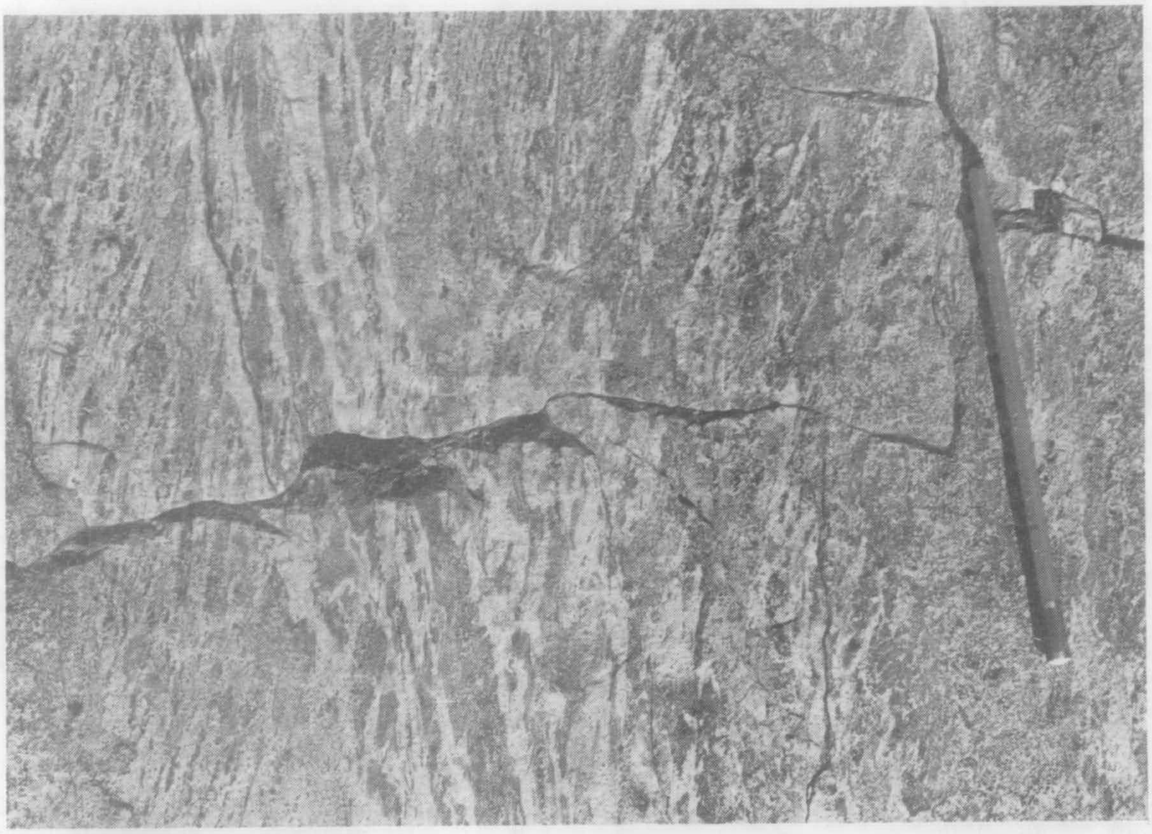


Fig. 11. Transposition in laminated Corella Formation (Bkc) at Mount Malakoff

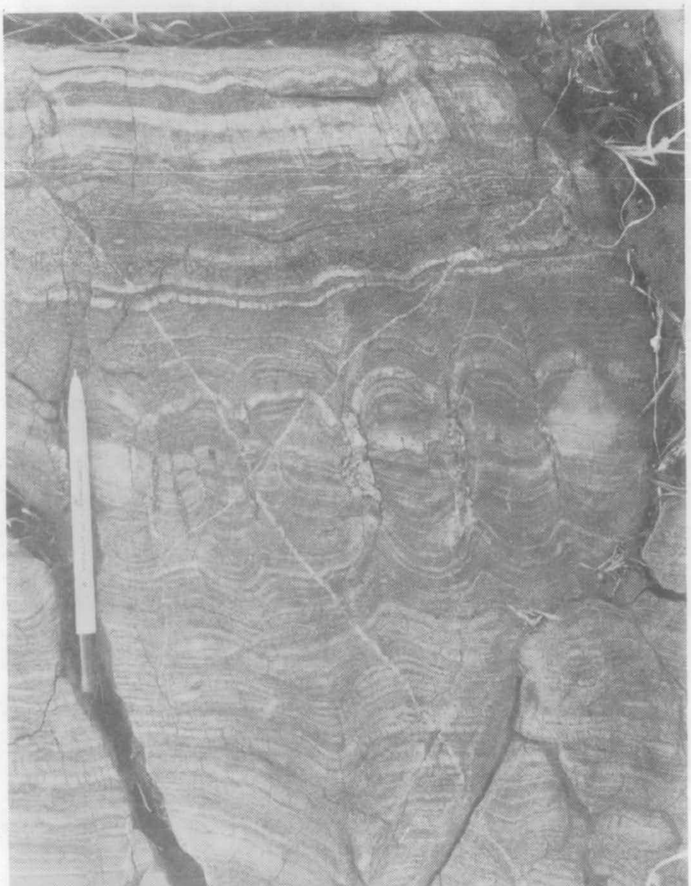


Fig. 12. Boudinaged laminated calc-silicate rocks in Corella Formation (Bkc_1) 2.5 km northwest of Volga copper mine

Fig. 13. Columnar and domal siliceous stromatolites in Corella Formation (Bkc_{3c}) near Lady Clayre mine

Fig. 14. Detail of columnar stromatolite, showing digitate, rarely branched columns with gently convex laminae (Bkc_{3c}), near Lady Clayre mine

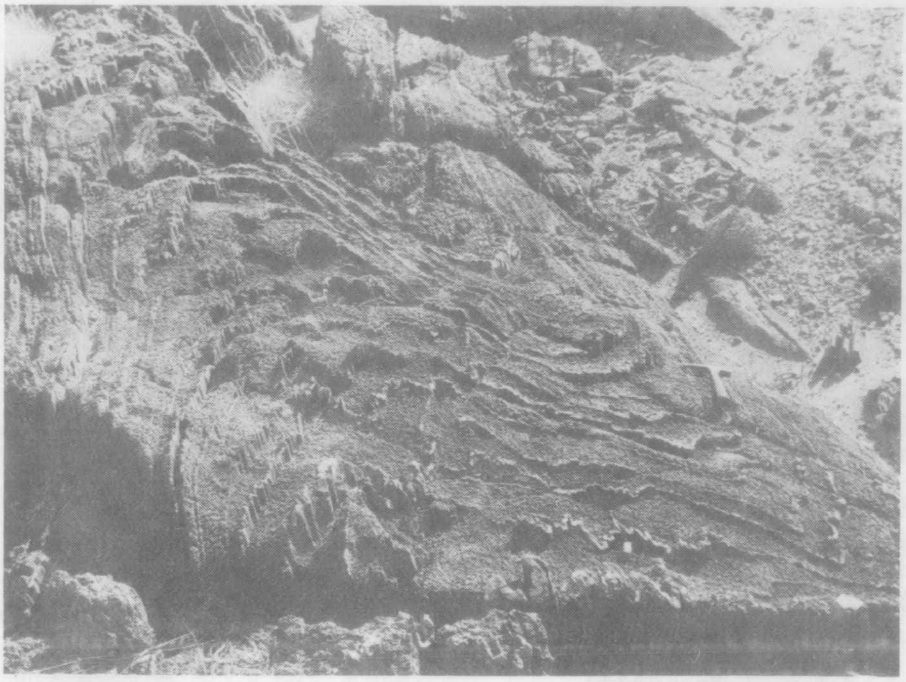


Fig. 15. Tight drag folds in Corella Formation 2 km northeast of Copper Blonde mine

Ekc_3, the undivided uppermost member of the Corella Formation, consists mainly of calcareous scapolitic siltstone, metalimestone, calc-silicate rock, and biotite-hornblende schist. This unit is recognised in the west and central parts of the Sheet area, where it is generally exposed as low rubble-covered hills and ridges and over a total outcrop area of almost 90 km^2. It is probably at least 1 000 m thick, but estimates of thickness are not reliable owing to complex folding and faulting.

In the west of the Sheet area this unit is composed of medium to fine-grained calc-silicate granofels with greenish scapolite porphyroblasts (to 4 mm long), grey to brown coarse to medium-grained metalimestone with rare scapolite porphyroblasts, and thin calcareous siltstone interbeds. The unit overlies metabasalt of unit Ekc_{2b}, and dolerite which appears to have intruded as a sill along this contact.

To the east of the Knapdale Quartzite, scapolitic calc-silicate rock, pyritic calcareous shale, minor metalimestone, quartzite, metasiltstone, and scapolitic schist occur in this unit. Calcite veins have developed by mobilisation of carbonate from scapolitic limestone beds. Quartz veins are also abundant.

In the southwest near the Copper Blonde mine, laminated, highly calcareous calc-silicate rocks of this unit are intruded by dolerite and Burstall Granite.

Ekc_{31} is only mapped in one area of about 0.3 km^2 east of the Copper Blonde mine. Here, grey medium-grained marble, grey laminated mobilised limestone, and minor slightly scapolitic limestone occur near a large mass of dolerite.

Ekc_{3c} is characterised by beds of grey laminated chert about 1 m thick, which are interbedded with grey shale, pyritic siliceous siltstone, purple brown sandstone, and a chloritic schist. The sequence is isoclinally folded and much of it is extremely brecciated. Columnar stromatolites were first recognised in this sequence by geologists of Anaconda Australia Inc. (G. Dimo, personal communication 1974); large domal structures have been recognised more recently (Figs. 13, 14).

The total area occupied by this unit is only a few hundred square metres: the outcrop shown on the geological maps has been exaggerated. The chert sequence is about 10 m thick and generally dips south to southeast at 60^{o} to 80^{o}. Locally the sequence is overturned.

The relation between this chert unit and the Knapdale Quartzite is confused by faulting. The chert unit appears to be folded, and faulted against extremely fractured quartzite to the north. Minor folds in the chert imply dextral movement along this fault, and possibly vertical movement with downthrow to the south.

$\underline{Pkc}_{3d}$ is a generalised representation of the 'Dugald River Shale' of Whitcher (1975). The unit consists of black shale, slate, spotted schist, and minor sheared calcareous siltstone (Figs. 6,7). Whitcher reported that the dark grey to black pyritic or pyrrhotitic cordierite-spotted shales in the north contain the Dugald River lead-zinc lode. Fissile slate and schist are more common in the south, where pink to brown cordierite, andalusite, and possibly staurolite spotted schists are widespread but relatively poorly exposed. Complex folding and the poor exposure prevent accurate thickness measurements.

A small area of grey spotted schist, pyritic shale and andalusite slate in the Lady Clayre mine area has been mapped as Pkc_{3d} because its rock types and stratigraphic position are similar to the 'Dugald River Shale'.

The total area mapped as this unit is about 2 km^2. It is proposed to formally name this unit the Dugald River Shale Member of the Corella Formation in a future publication.

$\underline{Pkc}_{3f}$ corresponds to the footwall limestone at the Dugald River prospect, which Whitcher (1975) described as a 'prominently outcropping bed of black, well-bedded, argillaceous limey sediments' from 90 to 260 m thick. It locally grades into calcareous black shale and black slate. This unit covers almost 2 km^2.

$\underline{Pkc}_{3s}$ contains black laminated shale and siltstone which cover 1 km^2 in an area to the east of the Quamby Conglomerate along the southern boundary of the Sheet area, and in a small area north of the Native Companion mine. This unit is generally poorly exposed and low-lying.

Pkc is undivided Corella Formation and is mapped in the small inliers of Proterozoic rocks which occur in the east of the Sheet area. The main rock types are brown to grey or black laminated calc-silicate rocks which typically contain hornblnde, diopside, and scapolite. Biotite schist is locally abundant. These metasediments are extensively veined by granite, pegmatite, and aplite related to the Naraku Granite, and locally show transposition of bedding - e.g., at Mount Malakoff (Fig. 11).

Petrography

Specimens of laminated calc-silicate rock, marble, metasiltstone, quartzite, ironstone, hornfels, schist, para-amphibolite, metabasalt, and acid volcanics have been examined in thin-section. Estimated modal compositions of 43 specimens are presented in Table 2.

Calc-silicate rock is the main rock type in the basal and the uppermost members of the Corella Formation. It is mostly fine-grained and typically granoblastic to granuloblastic. Grainsize is mostly irregular, but a regular alternation of fine and medium-grained bands is recognised in some specimens. Porphyroblastic or poikiloblastic textures are quite common. The mineral assemblages vary widely and some are listed below. (The minerals are listed in order of decreasing abundance.).

Calcite-plagioclase-hornblende ±quartz ± epidote ± scapolite ± diopside
Calcite-quartz-scapolite-biotite
Microcline-scapolite-hornblende ± quartz ± plagioclase ± calcite ± diopside.
Plagioclase-hornblende-diopside ± quartz ± biotite ± opaques
Plagioclase-biotite-scapolite-microcline-quartz
Scapolite-diopside
Scapolite-cordierite-diopside-plagioclase.

The accessory minerals are sphene, tourmaline, apatite, zircon and allanite.

The presence of diopside, hornblende, cordierite, and calcic plagioclase in the rocks indicates generally low-pressure amphibolite facies metamorphism.

The marble or metalimestone are most abundant in the uppermost member. They are fine-grained, granoblastic, and have mineral assemblages dominated by calcite. Biotite, plagioclase, quartz, scapolite, epidote, and actinolite/hornblende occur in minor amounts; tourmaline, sphene, and zircon are common accessory minerals. Banding is defined by grainsize variation and increased amount of mafic minerals.

Metasiltstone is most abundant in the middle member but it also occurs in the basal member. The rocks are mostly very fine-grained and foliated. The typical mineral assemblage is microcline-quartz-biotite. Scapolite, calcite, hornblende, opaques, epidote, sillimanite, and garnet occur in minor amounts. The main accessory minerals are zircon and sphene.

Only one specimen of schist was examined. It is a fine-grained strongly foliated rock consisting of garnet, biotite, quartz, and muscovite. Garnet porphyroblasts up to 1 mm diameter are fractured, and appear to have developed before the schistosity which bends around them.

Para-amphibolite is a major component of the middle member. It is mostly fine to medium-grained and has a granoblastic texture. Compositional and grainsize variations produce a strong banding in most specimens. The typical mineral assemblage is plagioclase-hornblende-epidote-opaques although microcline or scapolite may be dominant in some specimens. One specimen consists almost entirely of subhedral hornblende prisms. Traces of calcite and biotite occur in some specimens, and sphene and zircon are the main accessory minerals.

Two metabasalts from the middle member (in Ᵽkc$_{2b}$) were examined. They are fine to medium-grained and have a granoblastic to granuloblastic texture displaying some relict plagioclase laths. The mineral assemblage is plagioclase or scapolite, hornblende, and diopside, and minor to accessory amounts of epidote, calcite, opaques, and sphene. The plagioclase is strongly sericitised.

A specimen of acid volcanics from the mainly metabasalt unit (Ᵽkc$_{2b}$) was examined. This fine-grained granoblastic rock consists essentially of plagioclase and quartz with minor to trace amounts of microcline, muscovite, chlorite, opaques, epidote, leucoxene, and calcite. Recrystallisation has almost completely obliterated the primary texture, but relict plagioclase phenocrysts are recognisable.

Some highly altered xenoliths in granite or specimens adjacent to granite outcrops were examined. These rocks range from very fine to medium-grained, and have granoblastic to granuloblastic texture. The mineral assemblages quartz-plagioclase-hornblende-diopside, quartz-plagioclase-biotite, and quartz-microcline-hornblende-diopside were recorded. Calcite, epidote, and opaques occur in minor amounts.

Discussion

Correlation within the Corella Formation is a major stratigraphic problem in the Quamby Sheet area because major north to northeast-trending faults have broken the outcrop into several unconnected areas. The least disrupted area of outcrop is to the west of the Landsborough Graben, where a sequence of laminated calcareous and calc-silicate rock, quartzite, and metabasalt consistently overlies the Ballara Quartzite or the Argylla Formation.

TABLE 7. ESTIMATED MODAL COMPOSITIONS, CORELLA FORMATION

Specimen No.	Minerals q	k	p	sc	si	sd	mu	bi	gt	ch	hb	di	ep	ca	op	al	ap	f	sp	to	zr	agd (m)	Unit	Name
0222	25		10				2				tr		5	55					3	tr		0.5	1	Brecciated calc-silicate
0228			23					1			15			50					3	2		0.5	1	Transposed calc-silicate
4007	8		65				tr				2	20	5						tr		tr	0.2	1	Calc-silicate hornfels
4009	23		70				tr	4						1	2				tr		tr	0.8	1	Granite or altered sediment
4050	tr	55	7	25							10				3	tr						0.2	1	Scapolite-microcline granofels
4075	5	50		20				1			15	8		tr		tr			1			0.2	1	Calc-silicate granofels
4090	25	49			15			10	3												tr	0.3	1	Garnet-sillimanite granofels
4091	7		55					2			20	15			1		tr		tr			0.2	1	Diopside-hornblende granofels
MB060	20		12								8				60							0.2	1	Ironstone
MB063			65							tr	2			29					4			0.5	1	Red rock
MB065	20		27								45				4				4			0.12	1	Para-amphibole
4040			60								20		10	10					tr			0.2	2	Granofelsic amphibolite
4041	tr	48	5	20							25				2		tr					0.1	2	Granofelsic amphibolite
4042			70							1	8		10	4	7				tr		tr	0.2	2	Granofelsic amphibolite
4043			73								20		5		tr				2		tr	0.02	2	Banded granofels

Specimen No.	Minerals																				agd (m)	Unit	Name
	q	k	p	sc	si	sd	mu	bi	gt	ch	hb	di	ep	ca	op	al	ap	f	sp	to	zr			
4044			53								35		10		2							0.02	2	Granofelsic amphibolite
4047	60	10	5	10				15									tr		tr		tr	0.1	2	Scapolitic siltstone
4055	25	45		5				10					12	tr	3						tr	0.05	2	Metasiltstone
4060	40	40	9								4	4			1		tr		2			0.05	2?	Metasediment
4017			1								98				1							0.03	2a	Amphibolite
4034				58				10			25			2	5				tr		tr	0.5	2a	Scapolitic amphibolite
4035	5	50									22		15	3	5				tr			0.03	2a	Metasiltstone
4036	5	10	75					3						2	3		2	tr	tr			0.6	2a	?Altered dolerite
0218	35	2	58				1			1			tr	tr	3							0.15	2b	?Acid volcanic
0220			40								18	40		tr					2			0.5	2b	Metabasalt
4076				50							46		1		1		tr		2			0.1	2b	?Metabasalt
4020	20						60	15	3						2				tr		tr	0.3	2q	Garnetiferous schist
MB065	97						1			tr				1	tr					2		1.5	2q	Quartzite
4031	25			25				15						32	2					1		0.2	2t	Scapolite granofels
4033	9	10	40	10				25					3		3		tr			tr	tr	0.2	2t	Scapolite-biotite granofels
0221	10		20								30	20	3	20	1				3	3	tr	0.3	3	Calc-silicate granofels
4029	8			3			2	22						63	1					1	tr	0.2	3	Calc-silicate granofels
4030	20			10				10						58	1					1		0.2	3	Banded calc-silicate granofels

Specimen No.	Minerals																					agd (m)	Unit	Name
	q	k	p	sc	si	cd	mu	bi	gt	ch	hb	di	ep	ca	op	al	ap	f	sp	to	zr			
4032	5	38	tr	25				30					7		3		tr			tr		0.2	3	Scapolite-biotite granofels
M8062	8		4				3							85								0.5	3	Calcareous granofels
4039			25								5		10	60					tr			0.3	3	Impure marble
M8052	32						1	5						60	2							0.1	3f	Calcareous metasiltstone
M8059	15						34	10						40	1							0.03	3f	Calcareous metasiltstone
4012	tr			69								40							1			0.2	-	Scapolite granofels
4013		1	10	50		20						18							1			0.3	-	Cordierite-diopside-scapolite granofels
4024	15	tr	65					20									tr					0.2	-	Quartzofelspathic xenolith
M8057	10		30								55				2				3			0.6	-	Hornblende hornfels
M8061	20		58								20								2	tr		0.5	-	Hornblende hornfels

Abbreviations: agd-average grain diameter, al-allanite, ap-apatite, bi-biotite, ca-calcite, cd-cordierite, ch-chlorite, di-diopside, ep-epidote, f-fluorite, gt-garnet, hb-hornblende, k-potash feldspar, mu-muscovite, op-opaques, p-plagioclase, q-quartz, sc-scapolite, si-sillimanite, sp-sphene, to-tourmaline, tr-trace, zr-zircon

The Argylla Formation and Ballara Quartzite are not recognised in sequences to the east, where they are either concealed by younger rocks, or are facies equivalents of Soldiers Cap Group rocks in the Boomarra Horst. The calc-silicate sequence which overlies the Soldiers Cap Group in the Boomarra Horst may correlate with the basal member of the Corella Formation in the western sequence, but, as these sequences are separated by faults and younger sediments, this correlation cannot be proved.

If this correlation is accepted, some facies variations within the Corella Formation become apparent. The basal member becomes more calcareous and more brecciated to the east. The middle member contains metabasalt in the western sequence only. Farther east the middle member is represented by more abundant quartzite and, in some areas, pelitic schist, metasiltstone, or para-amphibolite. A similar facies variation was noted in the Marraba Sheet area (Derrick & others, 1971). The uppermost member contains black, mineralised carbonaceous shale in the Dugald River and Lady Clayre area, but in other areas this member is highly calcareous. Algal cherts similar to those to the north of the Lady Clayre mine may also occur to the east of the mine and to the east of the 'Dugald River Shale' sequence.

The piedmontite bed noted near Quamby by Muggeridge (1974) at the top of the lower member could be a useful marker. The similarity between this bed and the manganiferous upper part of the Overhang Jaspilite, especially near the Overhang mine indicates similar environments for the basal member of the Corella Formation in the Quamby Sheet area and the Overhang Jaspilite, which underlies the Corella Formation in the Marraba Sheet area and farther south. An alternative interpretation is that the two sequences are correlatives. This implies that the basal member of the Corella Formation in the Quamby Sheet area is older than the Corella Formation as it was redefined by Derrick & others (1977a). The abundance of iron-rich rocks in the basal member of the Corella Formation in the Quamby Sheet area, especially southeast of the Mount Roseby homestead, is another similarity with the Overhang Jaspilite although no jasper has been recorded in the Quamby Sheet area.

The Corella Formation is metamorphosed to the amphibolite facies in almost all the Quamby Sheet area. The widespread granite intrusions rarely display obvious contact-metamorphic effects although one specimen from the western edge of the Sheet area is regarded as a hornfels. Diopside is most abundant near the large granite bodies. Scapolite development is widespread and bears no obvious relation to metamorphic grade. Retrogression of some samples near granites indicate that some granites may postdate the main regional metamorphism.

The original sediments represented by the Corella Formation were probably carbonates, pelites, and minor psammites, deposited on a shallow marine shelf during a transgression, interrupted by a minor regression when the psammitic middle member and basic volcanics were deposited. The volcanics are interbedded with laminated limestone which may indicate that the volcanism was marine. Pillow basalts were recognised in a similar sequence to the south in the Marraba Sheet area (Derrick & others, 1971). The abundance of scapolite is thought to indicate evaporitic sequences (Ramsay & Davidson, 1970), which may have formed in a lagoonal environment.

MOUNT ALBERT GROUP

Knapdale Quartzite

Introduction

The Knapdale Quartzite was formally defined by Carter & others (1961). A discussion of the Knapdale Quartzite based on mapping in 1973 and 1974 was presented by Derrick & others (1977b) in their definition of the Mount Albert Group.

The area of outcrop of the Knapdale Quartzite is about 35 km^2; it is roughly 15 km long and up to 3 km wide. It forms a prominent long low range (Fig. 16) surrounded entirely by recessive calcareous or dolomitic rocks: the Corella Formation to the east and an unnamed younger unit to the west, for which the name 'Lady Clayre Dolomite' is proposed. Estimates of thickness indicate that the Knapdale Quartzite is not less than 2000 m thick.

Fig. 16. Immaturely dissected pre-mid-Mesozoic plateau surface at southern end of Knapdale Quartzite

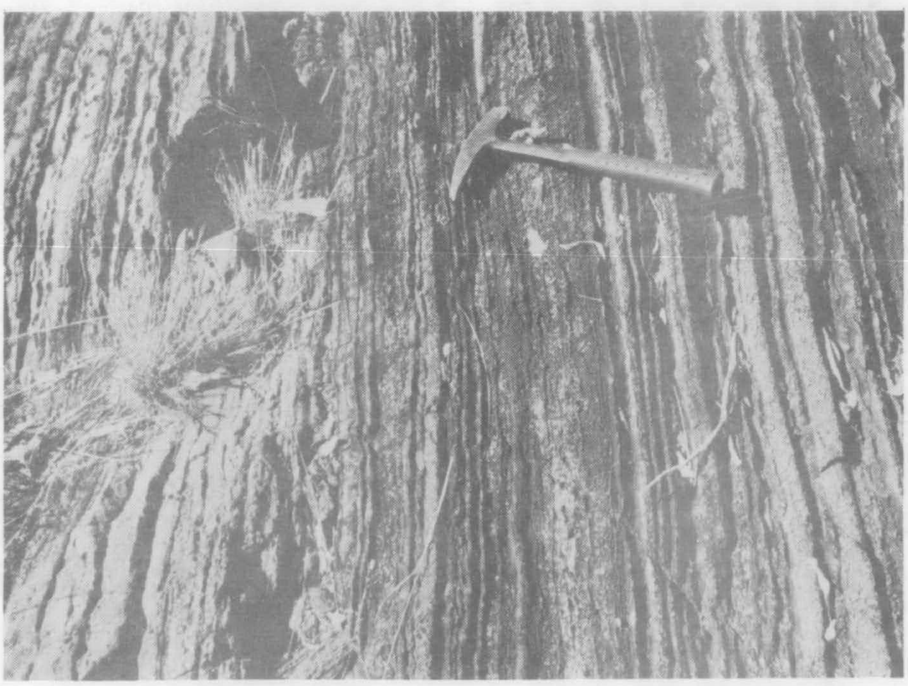


Fig. 17. Typical exposure of layered granofels in Knapdale Quartzite (Bpk_5) to west of Knapdale Range

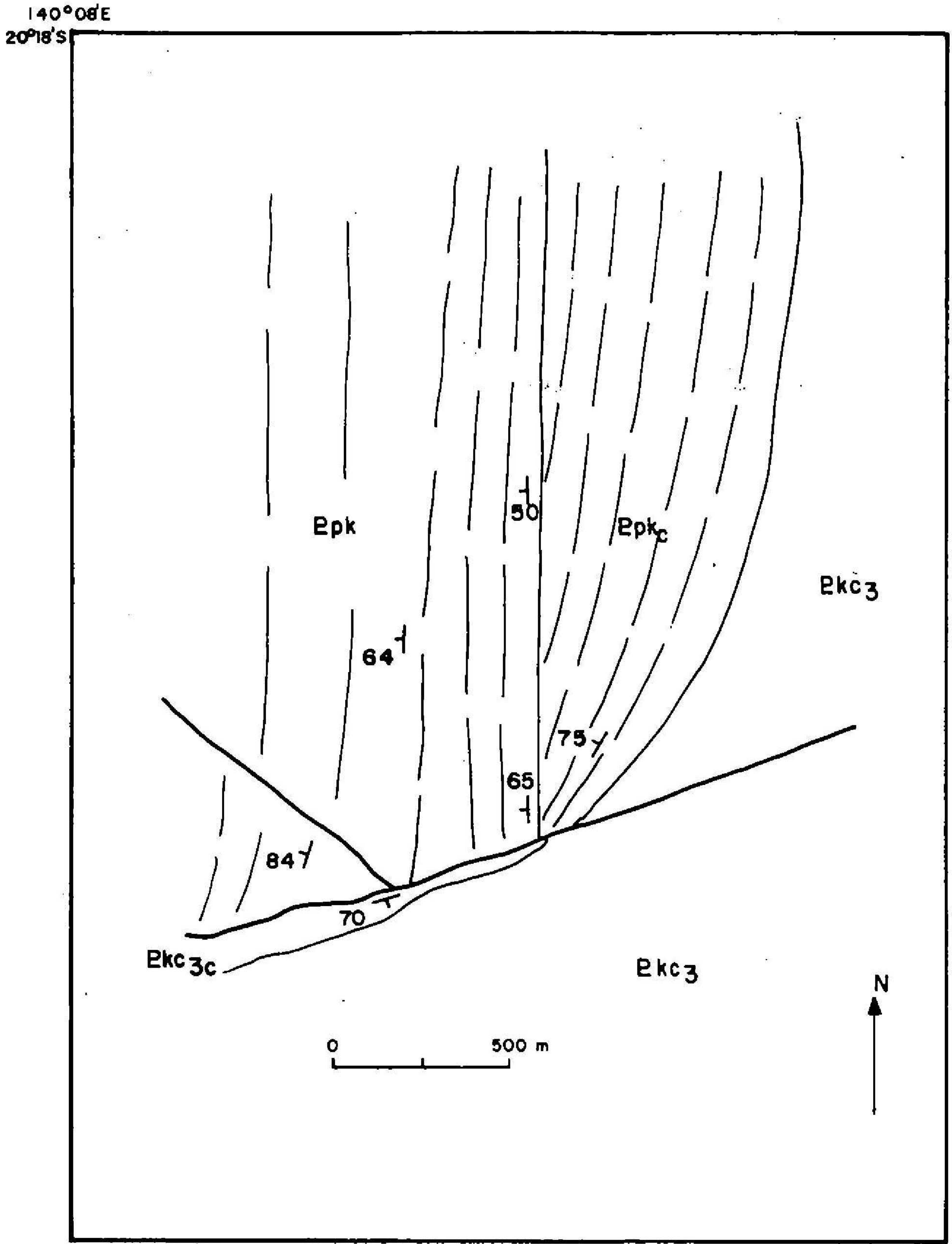


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Fig 18 Minor angular stratigraphic break between Ꞓpkc and Ꞓpk at the southern end of the Knapdale Quartzite.

Stratigraphic relations

The lower part of the Knapdale Quartzite appears to be conformable on the siltstone, shale, and calc-silicate rocks that contain the Dugald River lode in the upper part of the Corella Formation. The upper contact of the quartzite is faulted, but appears to be overlain by the 'Lady Clayre Dolomite'. The quartzite is not intruded by granitic or basic rocks.

Lithology and field occurrence

The Knapdale Quartzite is composed mainly of quartzite and sandstone, with minor siltstone and calc-silicate granofels. After the field mapping, a fourfold subdivision of the formation was established. It is, from the top to the base:

- Ᵽpk$_s$ - grey siltstone, black shale, scapolitic siltstone
- Ᵽpk$_t$ - pink feldspathic and micaceous siltstone, minor pebble conglomerate
- Ᵽpk - pink feldspathic and micaceous fine-grained sandstone, medium-grained quartzite
- Ᵽpk$_c$ - calcareous feldspathic medium-grained sandstone, pink quartzite, siltstone.

Ᵽpk$_c$. The eastern third of the area of outcrop of the Knapdale Quartzite has a substantial carbonate component. It comprises pink to purple fine-grained feldspathic sandstone, grey to brown thin cross-bedded fine-grained slightly ferruginous sandstone, pink to purple medium-grained sandstone with minor pyrite, pink fine-grained quartzite, brown siltstone, and medium-grained friable micaceous arenite. Siltstone laminae and mud flakes commonly occur in the calcareous arenites. Adjacent to faults the quartzite is brecciated. At the southern end of the mass there is a minor angular stratigraphic break with overlying quartzite (Fig. 18). This may have been produced by faulting, or it may represent a slight time break in deposition in this part of the basin. In thin-section (M8075, Table 8) the rock is well-sorted and is composed of subrounded quartz, tourmaline, plagioclase feldspar, and fine granular opaques.

Ppk. The greater part of the Knapdale Quartzite is pink fine-grained feldspathic quartzite interbedded with pink to brown micaceous sandstone. It is consistently west-dipping and youngs to the west. Sedimentary structures include ripple-marks, cross-stratification, and synaeresis or mud-cracks. Cross-stratification is medium-scale with sets about 12 cm thick. Ripples are of the symmetrical oscillation type. Flame structures at sandstone-siltstone interfaces attest to some soft sediment disturbance. Current-flow determinations indicate flow from the north. Adjacent to faults the quartzite is intensely brecciated. In thin-section (M 8074, Table 8) the rock is a massive fine-grained, well-sorted feldspathic quartzite composed of quartz, muscovite, chlorite, calcite, plagioclase and potash feldspar, and tourmaline.

Ppk_t. Towards the top of Ppk, a thin lens of recessive siltstone is poorly exposed: it consists of mainly pink feldspathic and micaceous siltstone, greyish purple finely laminated siltstone, greenish phyllitic siltstone, and porphyroblastic pelitic schist. Occasional blocks of pebble conglomerate appear to be derived from within the siltstone. The pebbles are pink to brown fine-grained quartzite.

Ppk_s. This unit crops out to the west of the main range of Knapdale Quartzite. It comprises recessive calcareous siltstone; calcareous, scapolitic, and pyritic shales; black to bluish-grey micaceous metasiltstone; fine-grained sandstone; black shale; and layered granofels is shown in Figure 17. Several small mines are located in sheared and fractured grey scapolite-bearing metasiltstones near the contact with the underlying quartzite of Ppk. The sediments of the unit are identical with Corella Formation sediments to the west, south, and east.

Discussion

The rocks of the Knapdale Quartzite are among the youngest Carpentarian or Middle Proterozoic rocks exposed in the Sheet area. They appear to have been metamorphosed to the chlorite grade of the greenschist facies.

Carter & others (1961) consider that the Knapdale Quartzite may be a correlative of the Roxmere Quartzite, which crops out in the Cloncurry, Mount Angelay, Marraba, and Malbon 1:100 000 Sheet areas to the south.

Considerable controversy centres around the relations between the Knapdale Quartzite and surrounding rocks. G. Dimo (Anaconda Australia, personal communication August, 1974) suggested that thin algal beds near the southeast margin of the quartzite (Figs. 13, 14) are unconformable on the Knapdale Quartzite. These algal beds are strongly folded and deformed and appear to have been tectonically emplaced against the quartzite. Much of the problem relating to contact relations is due to the fact that surrounding rocks are easily weathered and are covered by a thick quartzite scree. We suggest here that these algal cherts near Lady Clayre are related to siliceous, possibly algal beds just east of the Dugald River lode - i.e., they are a part of the Corella Formation and therefore older than the Knapdale Quartzite.

The similar rock types, stratigraphic sequences, and base-metal anomalies to the east, west, and south of the Knapdale Quartzite have led many company geologists to correlate sequences in these three areas. This correlation is not supported by our structural or stratigraphic studies and we have concluded that the sequences to the east and south are older than the Knapdale Quartzite, and are mapped as Corella Formation, but the sequence to the west is younger than the quartzite and is mapped as the 'Lady Clayre Dolomite' in the Mount Albert Group.

The evidence suggests that the Knapdale Quartzite was deposited in a small shallow restricted basin which developed on the uneven surface of the upraised Corella Formation shelf. It is a near-shore shallow-water deposit; the stratigraphic break above Ꝑpk$_c$, and pebble bands in Ꝑpk$_t$, may indicate several minor regressions and areas of local uplift.

The quartzite near the western margin of the Knapdale Quartzite is sheared and strongly fractured. We consider that the black shale and grey metasiltstone west of the quartzite represent a return to shallow-water euxinic conditions after the deposition of the quartzite. It is thus similar to the shale and siltstone of the White Blow Formation, which crops out 55 km to the southwest in the Mary Kathleen Sheet area (Derrick & others, 1977). Therefore, the Knapdale Quartzite is possibly a correlative of the Deighton Quartzite which underlies the White Blow Formation.

TABLE 8. ESTIMATED MODAL COMPOSITIONS, KNAPDALE QUARTZITE

	q	f	mu	bi	ch	gt	ca	op	to	agd (mm)	
M 8053	28		1	8		2	60	1	tr	0.1	Calc-silicate granofels (Ᵽpk$_s$)
M 8047	61	25	5		5		4		tr	0.2	Feldspathic quartzite (Ᵽpk)
M 8075	79	10						1	10		Tourmaline quartzite (Ᵽpk$_c$)

age - average grain diameter, bi - biotite, ca - calcite, ch - chlorite, f - feldspar, gt - garnet, mu - muscovite, op - opaques, q - quartz, to - tourmaline, tr - trace.

'Lady Clayre Dolomite'

Introduction

A thick sequence of brown to black laminated pyritic fine-grained dolomite and dolomitic siltstone occurs to the west and southwest of the Knapdale Quartzite. This sequence was mapped as Corella Formation by Carter & others (1961), and was correlated with the Dugald River lode sequence by Sturmfels (1952, cited in Knight, 1965). More recent work by Thomas (1961, cited in Whitcher, 1975) indicates that this sequence is younger than the 'Dugald River Shale'. Geologists from Carpentaria Exploration Co. Pty Ltd and Anaconda Australia Inc. have held contrary views.

This unit is well exposed as flat to gently undulating country with low strike ridges. It covers about 60 km^2, and is about 3 000 m thick. It was labelled Ᵽkc$_{3s}$ on the preliminary edition map, but is labelled Ᵽpk$_d$ on the first-edition map.

Stratigraphic relations

The 'Lady Clayre Dolomite' appears to overlie the Knapdale Quartzite conformably although the contact is sheared and mostly covered with quartzite scree. The dolomitic sequence may be overlain by a quartzite which has been assigned a Cambrian age, but the contacts between these units are also extensively faulted.

Lithology and field occurrence

The main rock type is brown to black, thin, well-bedded to laminated dolomite and pyrrhotitic dolomitic siltstone which typically contains ovoid porphyroblasts of chiastolite, scapolite, or actinolite. Patches and spots of pyrite are also common. Some 10 to 20 cm thick interbeds of grey laminated fine-grained siliceous siltstone also occur in this unit. Some folding has been recognised in this unit but most strata dip 60 to 80 to the west.

Petrography

Estimated modal compositions of 8 specimens from this unit are presented in Table 9. The rocks are very fine-grained but 4019 has small porphyroblasts that are possibly of scapolite. The main mineral component in 4 specimens is dolomite, which occurs as a mosaic of small interlocked grains. Small anhedral quartz and euhedral muscovite flakes are also present. The opaque minerals occur as fine dust and elongate flakes of pyrrhotite.

TABLE 9. ESTIMATED MODAL COMPOSITIONS, 'LADY CLAYRE DOLOMITE'

Rock No.	q	ac	sc	ch	mu	bi	dl	gt	op	to	agd (mm)	Name
4018	20				25		53		2		0.06	Pyrrhotitic silty dolomite
4019	10		3		3		82		2		0.03	Pyrrhotitic silty dolomite
M8048	35				20		5		40		0.05	Metasiltstone
M8049	15				9	30			45	1	0.12	Ferruginous metasiltstone
M8050	15			2	2		80		1		0.1	Dolomitic metasiltstone
M8051	10				7	20	50	10	3		0.15	Dolomitic metasiltstone
M8054	30	5			55	5			5		0.03	Metasiltstone
M8055	40				18	20			22		0.02	Limonitic siltstone

Abbreviations:- ac - actinolite, agd - average grain diameter, bi- biotite, ch - chlorite, dl - dolomite, gt - garnet, mu - muscovite, op - opaques, q - quartz, sc - scapolite, to - tourmaline

Discussion

The persistent lamination and fine grainsize of this unit indicates deposition in a low-energy environment. Few ripple marks or micro-cross-laminations are present, indicating that current action was minimal. The abundance of pyrite and pyrrhotite also supports a quiet depositional environment in which euxinic conditions prevailed.

The similarity of rock types in this area and those near the Dugald River lead-zinc prospect may be interpreted as either a structural repetition of the same stratigraphic sequence or cyclic sedimentation which deposited similar sedimentary sequences before and after the regression represented by the Knapdale Quartzite. The latter alternative is supported by the structural evidence seen by the authors.

If the Knapdale Quartzite is a correlative of the Deighton Quartzite (Derrick & others, 1977b), and if the 'Lady Clayre Dolomite' overlies the Knapdale Quartzite, then the 'Lady Clayre Dolomite' may correlate with the White Blow Formation in the Mary Kathleen Sheet area (Derrick & others, 1977b). Also accepting the correlations G.M. Derrick in Wilson & others (1977) suggested that the Deighton Quartzite is a correlative of unit A of the Surprise Creek Beds, which in turn are correlated with the Mammoth Formation (Wilson & others, 1979). The 'Lady Clayre Dolomite' may correlate with the upper part of the Mammoth Formation or the lower part of the McNamara Group (Wilson & others, 1977). The Paradise Creek Formation in the lower part of the McNamara Group is a dolomitic unit not unlike the 'Lady Clayre Dolomite'.

CARPENTARIAN INTRUSIVE ROCKS

Wonga Granite

Introduction

The rocks Shepherd (1946b) called the 'Wonga Series' were subsequently formally defined as the Wonga Granite by Carter & others (1961). Joplin (1955) described the large mass of porphyritic granite which intrudes calc-silicate rocks 26 km west of Quamby as synchronous (syntectonic) and probably of deep-seated origin.

The Wonga Granite is composed mostly of fine to medium-grained strongly foliated porphyritic biotite granite and gneissic granite. It occurs in several elongate masses in the west of the Sheet area and covers about 60 km^2. The granite is typically exposed as low bouldery ridges and tors in sandy flats. Aplite and pegmatite veins are common.

Stratigraphic relations

Three phases of the Wonga Granite are recognised in the Quamby Sheet area. All the phases intrude the Argylla Formation, and at least the two younger phases intrude the Corella Formation. The oldest phase of the granite appears to have a concordant contact with the Corella Formation; no xenoliths of the Corella Formation have been recognised in this phase. Dolerite dykes intrude all phases.

Lithology and field occurrence

The three phases of the Wonga Granite contain distinct rock types; from youngest to oldest these are:

Egw_3 - leucogranite, aplite, and pegmatite

Egw_2 - pink to grey fine-grained moderately porphyritic foliated granite or melanogranite; aplite and minor pegmatite

Egw_1 - pale pinkish grey to dark grey medium-grained, coarsely porphyritic (or porphyroblastic), strongly foliated to gneissic granite or melanogranite; minor pegmatite.

The oldest phase, $\underline{Pgw}_1$, is characterised by large (30-50 mm) rounded microcline crystals which are strongly aligned parallel to the foliation in the groundmass of quartz, microcline, and biotite (Fig. 19). In the darker rocks biotite is the main mineral. The foliation is folded in some shear zones (Fig. 20), and locally a crenulation cleavage is developed. Few xenoliths occur in this phase: basic rocks and fine-grained ?granodiorite are most common, but recrystallised acid volcanic rocks have also been recorded. The xenoliths are typically streaky and elongated parallel to the foliation. In the more gneissic granites the xenoliths tend to lose their identity and are presented by poorly defined patches rich in biotite or microcline.

Contacts of Pgw_1 with older rocks are rarely exposed but they are broadly concordant with the north to north-northwest-trending regional foliation. The granite is fine-grained and less porphyritic near the contacts.

This phase of the Wonga Granite is poorly exposed and typically forms broad valleys covered with weathered bouldery rubble. Some better exposures occur in the larger stream channels. This phase covers about 26 km^2 in the Quamby Sheet area. In the Marraba and Mary Kathleen Sheet areas, to the south, the Wonga Granite was not subdivided, but a two phase subdivision was used in the Prospector Sheet area, to the west.

$\underline{Pgw}_2$ is the most extensive phase of the Wonga Granite in the Quamby Sheet area, where it covers 35 km^2. The strong foliation and the generally euhedral 10-20 mm phenocrysts characerise this phase (Fig. 21). Finer-grained and darker varieties occur near the margins of some of the intrusions of this phase and these darker rocks are typically intruded by paler, more typical granite. Pgw_2 intrudes Pgw_1 (Fig. 23), the Argylla Formation, the Ballara Quartzite, and the Corella Formation, and is intruded by aplite, pegmatite, leucogranite, and basic dykes (Fig. 22).

Xenoliths are abundant and range from blocks of acid volcanics and granite to schlieren of basic and calc-silicate rock. Xenoliths are mostly 10-20 mm long.

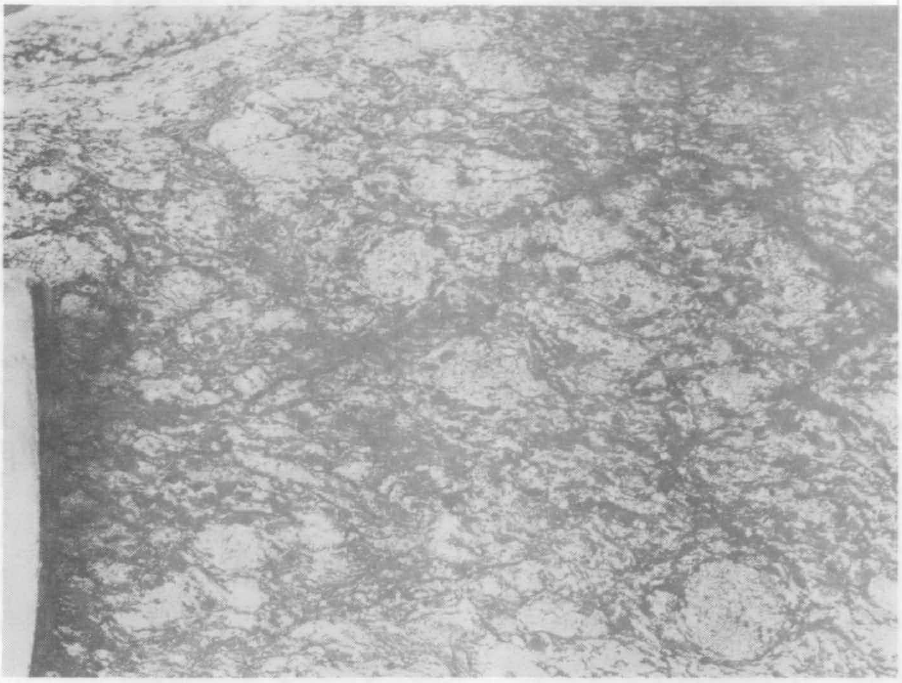

Fig. 19. Foliated augen granite (Bgw_1) 6.5 km northwest of Volga copper mine

Fig. 20. Folded foliation in augen granite (Bgw_1) 6.5 km northwest of Volga copper mine

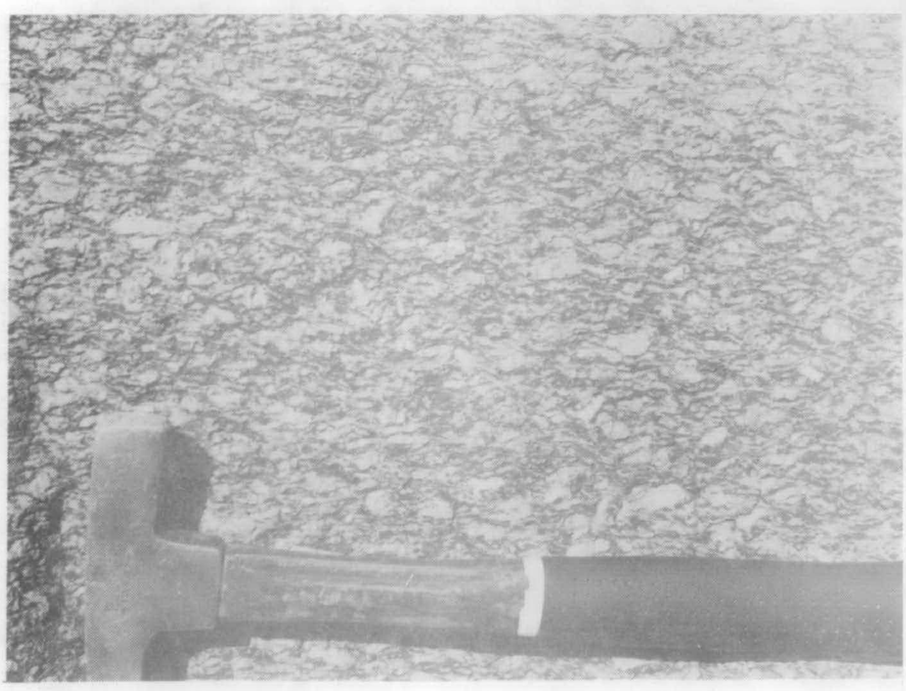

Fig. 21. Foliated porphyritic granite (Bgw_2) 6.5 km west-northwest of Volga copper mine

ig. 22. Augen granite (Wonga Granite) and amphibolite cut by boudinaged aplite vein 0.5 km south of Bohemian Girl mine

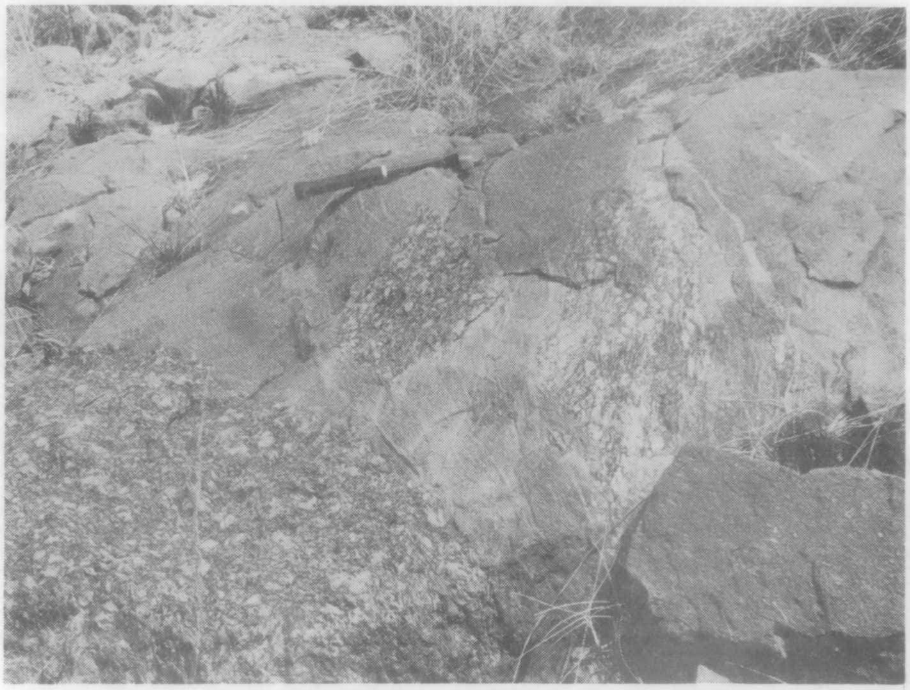

Fig. 23. Foliated porphyritic granite (Bgw_2) intruding foliated augen granite (Bgw_1) 7.5 km northwest of Volga copper

TABLE 10. ESTIMATED MODAL COMPOSITIONS, WONGA GRANITE

No.	q	k	p	mu	bi	ch	ep	hb	di	op	ap	al	f	sp	to	zr	agd (mm)	Phase	Name
4022	30	40	20		7	1	2			tr			tr			tr	0.3	1	Biotite granite
4084	30	50	15	1	4						tr					tr	0.3	1	Porphyritic biotite granite
4085	25	46	25	1	2						tr	tr		1		tr	1.0	1	Biotite granite
4006	34	55	8	tr	3											tr	1.5	2	Foliated porphyritic granite
4007	25	30	10	2				25	8								3.0	2	Contaminated granitic vein
4008	25	65	4		5		tr				tr		tr	1		tr	0.6	2	Biotite granite
4053	30	60	5		5		tr			tr	tr	tr	tr			tr	0.6	2	Porphyritic biotite granite
4065	25	65	5		5						tr		tr	tr		tr	0.6	2	Foliated biotite granite
4086	25	50	20	1	3		1			tr	tr					tr	0.3	2	Foliated biotite granite
4088	35	8	55		1					1						tr	1.0	2	Sodic granite
4089	30	50	17	1	2		tr					tr					0.3	2	Foliated porphyritic granite
MB071	35	35	18		4	2		5		1				tr			0.5	2	Porphyritic hornblende granite
MB027	30	38	30		1	1									tr	tr	0.3	2	Aplite
MB073	45	7	35					5	5	1				2			0.3	2	Contaminated aplite
4049	20	20	55			3				1	tr			tr		tr	0.3	3	Altered sodic granite
4087	35	40	10		7			6			tr			2	tr	tr	1.0	3	Porphyritic hornblende granite

This phase of the Wonga Granite typically occurs as elongate plutons parallel to the regional foliation. Dykes of the granite typically radiate out into the country rock and form vein networks. The outcrop is bouldery, and rugged tors and ridges are common.

The youngest phase, Pgw_3, occurs as small bosses or veins of leucogranite which intrude the two older phases of the Wonga Granite, the Argylla Formation and the Corella Formation. Most of the masses are too small to map at 1:100 000 scale, but two areas covering about 1 km^2 have been mapped near Delta Creek in the southwest of the Sheet area.

The leucogranite is typically streaky and variagated in appearance and occurs with aplite and pegmatite. Xenoliths of Pgw_1 and Pgw_2 are abundant and xenoliths of basic rock, ?acid volcanics, and grey fine-grained ?metasediment occur in some areas. This phase is moderately well exposed as bouldery outcrops.

Petrography (Table 10)

The main components of Pgw_1 are microcline, quartz, and plagioclase which typically occur as a granular mosaic of anhedral grains. The plagioclase tends to be subhedral and is heavily sericitised although clear patches of albite or oligoclase are present. Phenocrysts of microcline exceeding 2 mm in length are subhedral. Biotite is a characteristic minor component of this phase of the Wonga granite and occurs as subhedral to euhedral flakes which are concentrated in thin wispy layers. Some biotite is ragged and heavily chloritised. Euhedral zircon is the most common accessory mineral; allanite and aplite are less common.

Pgw_2 is generally slightly porphyritic, subidiomorphic granular, and distinctly foliated. Microcline and quartz, the main components, are generally anhedral, although the larger microcline grains (4-10 mm) tend to be subhedral. In some specimens the quartz is strained or sheared out into the foliation and recrystallised. Grain boundaries are mostly irregular although some are smooth and curved. The plagioclase is albite or sericitised oligoclase and typically is subhedral. Minor amounts of myrmekite occur along the boundaries of some of the oligoclase. Biotite is subhedral to euhedral, strongly aligned, and partly chloritised. Muscovite occurs as anhedral ragged flakes. The most common accessory mineral is zircon. Apatite occurs as euhedral prisms and needles. Fluorite is a characteristic accessory mineral in this phase of the Wonga Granite, and occurs as intergranular patches associated with microcline.

Two distinct varieties of Pgw_3 were examined. The sodic granite consists of an allotriomorphic granular assemblage of albite, quartz and minor microcline, chlorite, epidote, and opaques. The hornblende-biotite granite consists of an allotriomorphic granular mosaic of microcline and quartz with some subhedral microcline phenocrysts and subhedral albite laths with altered cores. Hornblende and biotite are subhedral and aligned in bands which also contain sphene and tourmaline.

Discussion

An intrusive origin of Pgw_1 has not been established and this gneissic granite may have formed (in part) by metamorphism of coarsely porphyritic acid volcanic rocks in the Argylla Foamation or older units, or by metamorphism of an older granite. The younger phases, Pgw_2 and Pgw_3, have clearly intrusive contacts, but on a regional scale the contacts are concordant. No recognisable contact aureole surrounds the granite bodies, but contact effects would be hard to recognise because of the amphibolite facies low-pressure regional metamorphism in the enclosing rocks, which typically contain diopside, sillimanite, andalusite, garnet, and cordierite.

A strong regional foliation occurs in Pgw_1 and Pgw_2 but is not evident in Pgw_3. This foliation is axial planar to the isoclinal north-trending fold axes, and its presence in Pgw_1 and Pgw_2 indicates that these phases were emplaced before or during the folding. Joplin (1955) regarded the granite as synchronous. The foliation in Pgw_3 is parallel to the contacts and appears to be a flow foliation. In the Prospector Sheet area, to the west, late-stage aplopegmatite dykes are also distinctly post-tectonic.

The Wonga Granite intrudes an anticlinal structure which exposes Argylla Formation adjacent to the granite. If the granite was emplaced by upward migration of a magma, the magma must have been generated by the melting of lower parts of the Argylla Formation or older rocks. It is unlikely that the magma was generated by partial melting of the Corella Formation, which overlies the Argylla Formation, but some local contact migmatisation in the Corella Formation may have formed some of the pegmatite and aplite veins.

The concordance of the contacts, the strong foliation, the lack of a contact aureole, and the absence of true migmatite indicate a relatively deep-seated origin for the Wonga Granite, possibly from the mesozone (Buddington, 1959).

Burstall Granite

Introduction

The Burstall Granite was originally mapped as part of the Wonga Granite (Carter & others, 1961), but was mapped as a distinct granite in the Marraba 1:100 000 Sheet area (Derrick & others, 1971). The granite was formally defined by Derrick & others (1978).

The Burstall Granite is distinguished from the Wonga Granite because:

(a) it is generally less foliated,
(b) it forms rounded intrusions which are expressed by elevated topography, and
(c) it occurs in a belt to the east of the Wonga Granite.

One mass of Burstall Granite occurs near the southwestern corner of the Quamby Sheet area, and several small granitic pods up to 10 km north of this mass have also been mapped as Burstall Granite. The total area of outcrop is about 10 km^2

Stratigraphic relations

The Burstall Granite intrudes the Corella Formation and may intrude dolerite dykes which occur at its margins. Some dolerite dykes appear to intrude the Burstall Granite.

Lithology and field occurrences

The main rock type is a pink to pinkish brown slightly porphyritic fine-grained granite. Locally the granite is darker and contains streaks rich in mafic minerals and elongate granodioritic xenoliths. Minor areas of quartz diorite are present locally. The eastern margin of the granite is very fine-grained porphyry. Some patches of pale slightly sheared granite occur with quartz and quartz-hematite veins.

The main granite mass is well exposed as an incised plateau in the Mount Godkin Range (Fig. 24). The small pods to the north are also upstanding and occur as rounded bouldery hills in areas of poorly exposed Corella Formation.

Petrography (Table 11)

The granite is generally fine-grained, allotriomorphic granular, and slightly porphyritic. Quartz and microcline occur as anhedral grains with irregular to interlocking boundaries. The quartz is typically strained, and the microcline is perthitic in some specimens and slightly altered in places. Albite occurs as anhedral to subhedral sericitised grains and as subhedral phenocrysts up to 5 mm long. The muscovite and biotite are mostly ragged, and the biotite is partly altered to chlorite. Hornblende is present in most specimens and occurs as subhedral to euhedral prisms. The opaques are granular; zircon and apatite occur as euhedral crystals, and sphene occurs as rims on the opaques, as granular aggregates, or as small euhedral grains.

TABLE 11. ESTIMATED MODAL COMPOSITIONS, BURSTALL GRANITE

No.				Minerals												agd	
	q	k	p	mu	bi	ep	ch	hb	ca	di	op	ap	f	sp	zr	(mm)	Name
4021	20	64	10	tr	tr			3			2	tr		1		0.6	Xenolithic hornblende granite
4046	15	5	55			2	tr	15	5		1	tr		2		1.0	Altered quartz diorite
4049	20	20	55			1	3				1	tr		tr	tr	0.3	Sodic granite
4059	30	60	5					4			1	tr	tr	tr	tr	0.1	Sheared microgranite
4061	20	8	55					10		5	1	tr		1		0.1	Sodic microgranite
4063	25	68	4				1				2	tr		tr	tr	0.1	Porphyritic granite
4064	25	5	63			1		3			1	tr		2	tr	0.2	Hornblende-bearing sodic granite

Abbreviations: agd-average grain diameter, ap-apatite, bi-biotite, ca-calcite, ch-chlorite, di-diopside, ep-epidote, f-fluorite, hb-hornblende, k-microcline, mu-muscovite, op-opaques, p-plagioclase, q-quartz, sp-sphene, tr-trace, zr-zircon

The altered quartz diorite consists mainly of slightly porphyritic subhedral oligoclase and hornblende grains in an allotriomorphic granular matrix of quartz, microcline, and hematite-stained altered ?plagioclase, with accessory granular opaques and subhedral sphene and epidote. Calcite occurs as intergranular patches.

The microgranite consists mainly of an allotriomorphic granular matrix of quartz and microcline containing subhedral rounded phenocrysts of albite and microcline up to 5 mm long and flattened recrystallised phenocrysts of quartz 2-3 mm long. Subhedral prisms of hornblende and subhedral to euhedral grains of hornblende, apatite, sphene, and zircon are also present. Fluorite occurs as small intergranular patches.

Discussion

The Burstall Granite is finer-grained and less foliated than the Wonga Granite, and appears to have been intruded at a shallower depth. The microgranite along the eastern margin of the main granite mass appears to be an hypabyssal intrusive but some of it could be a porphyritic volcanic. The small granite pods to the north of the main mass are probably high-level intrusives.

Preliminary data from zircon U-Pb age determination studies (R.W. Page, BMR, personnal communication) indicate that the Burstall Granite is at least as old as or older than the Wonga Granite.

Naraku Granite

Introduction

Cameron (1900) mapped granite in the area occupied by the Naraku Granite. Subsequently Joplin (1955) described the granite, which was formally defined by Carter & others (1961).

The Naraku Granite in the Quamby Sheet area occurs to the east of the Mount Rose Bee Fault. The main exposure is in an elongate pluton to the northwest of Quamby, and numerous isolated outcrops of granite occur to the north, east, and south of Quamby. The total area of outcrop is about 120 km^2. Many small aplitic veins which intrude the Soldiers Cap Group and the Corella Formation are assigned to the Naraku Granite.

Stratigraphic relations

The Naraku Granite intrudes the Soldiers Cap Group, the Corella Formation, and some dolerite bodies. Some coarse-grained, pyroxene-bearing dolerite bodies may intrude the granite, which is overlain unconformably by Mesozoic strata (Fig. 33) and is partly concealed by Tertiary and Quaternary sediments.

Samples of the Naraku Granite from the Marraba Sheet area have yielded Rb-Sr isochron ages of about 1400 m.y. (Plumb & Derrick, 1975). An older phase has been recognised near Cloncurry (R.W. Page, BMR, personal communication). Further samples have been collected from the Marraba Sheet area for U-Pb zircon age determinations.

Lithology and field occurrence

Two intrusive phases of the Naraku Granite are recognised in the Quamby Sheet area. The oldest phase, Pgu_1, is a pale pinkish grey foliated fine to medium-grained, subeven-grained hornblende granite. Locally the granite contains large (60 mm) phenocrysts which are concentrated in discrete layers. Some spindle-shaped pods or lenticles of hornblende-rich material are aligned parallel to a mineral lineation in the granite. Xenoliths of laminated meta-sediments and basic schist are rare. Some areas are extremely sheared (Figs. 25, 27).

Fig. 24. Maturely dissected hills and incised plateau of Burstall Granite in Mount Godkin Range

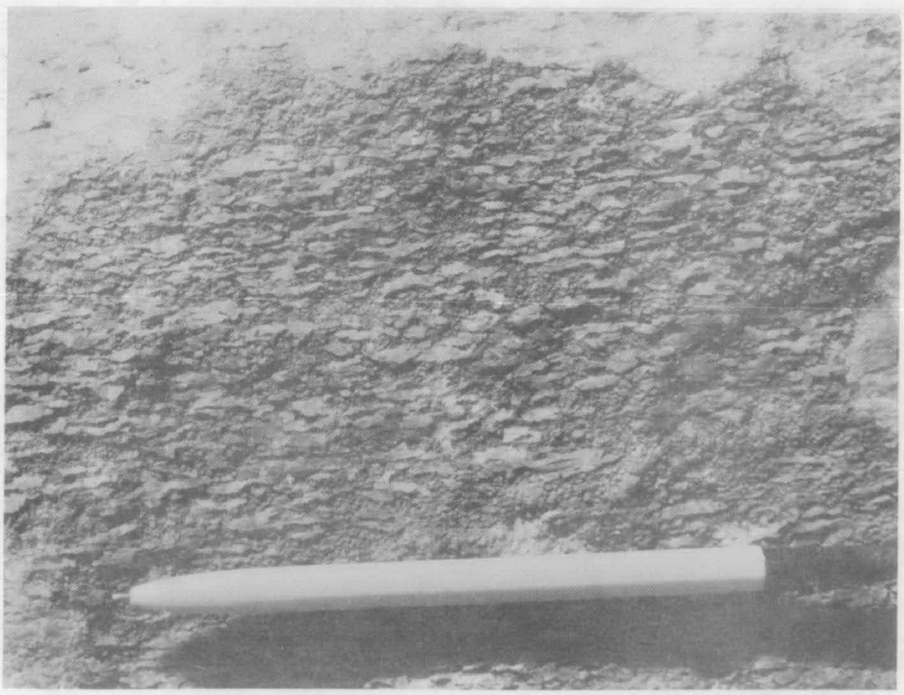

Fig. 25. Ribbon quartz in sheared Naraku Granite 5 km north-northwest of Quamby

Fig. 26. Pegmatite dykes cutting Naraku Granite 5 km north-northwest of Quamby

Fig. 27. Naraku Granite occurring as subcordant veins in highly metamorphosed Corella Formation (or sheared earlier phase of granite) 8 km north-northwest of Quamby

Fig. 28. Dolerite intruding block of grey psammitic schist (?Bea_m) enclosed in Wonga Granite 5.5 km northwest of Volga copper mine

TABLE 12. ESTIMATED MODAL COMPOSITIONS, NARAKU GRANITE

No.	Minerals														agd (mm)	Phase	Name
	q	k	p	mu	bi	ch	hb	ep	ca	op	al	ap	sp	zr			
4001	20		69			tr	10					tr	1		1.5	1	Hornblende granodiorite
4002	30	3	60	1	1			1		4		tr			1.0	1	Granodiorite
4003	40	45	7	1	4			1		2					1.0	1	Foliated biotite granite
4004	30	2	62		5	tr				1		tr		tr	1.5	1	Foliated biotite granodiorite
4009	23		70	tr	4				1	2			tr	tr	1.0	1?	Foliated grano-diorite
4010	25	5	60			tr	5	2	1	1		tr	1		1.5	1?	Foliated horn-blende grano-diorite
4011	30	2	63		4					1	tr		tr		1.5	1	Foliated biotite granodiorite
4016	20	55	20	1	3	tr				1		tr			1.0	1	Granite
4023	26	30	40	tr	4					tr					1.5	1	Granite (monzo-granite)
M8078	35	18	36			tr	8			tr			1		1.0	1	Hornblende granite
M8079	35	18	45			tr	2						tr		0.4	1	Fine-grained granodiorite
M8080	45	5	45				5	tr		tr			tr		1.5	1	Hornblende granodiorite
M8081	45	30	20				3			1			1		1.5	1	Hornblende granite
M8082	55	10	35			tr									0.5	1	Sheared grano-diorite
M8083	35	26	33				4			tr			2		1.5	1	Hornblende granite
M8084	35	20	45					tr	tr	tr			1		1.5	1	Granodiorite
M8085	30	46	20		1	1	2	tr		1			1		1.0	1	Granite
M8076	45	33	10		1	tr	10			tr			1		1.0	2	Hornblende granite
M8077	40	24	35			tr							1		1.5	2	Granite (monzogranite)
4041	30	50	14	1	5					tr		tr		tr	1.0	-	Biotite granite
4015	25	42	30		1	1			tr	1		tr	tr	tr	2.0	-	Granite (monzogranite)

Abbreviations: agd - average grain diameter; al - allanite; ap - apatite; bi- biotite; ca - calcite, ch - chlorite; ep - epidote; hb - hornblende; k - microcline, mu - muscovite; op - opaques; p - plagioclase; q - quartz; sp - sphene; tr - trace; zr - zircon

The younger phase, Pgu$_2$, is typically a pink strongly foliated fine-grained granite (aplogranite) or aplite which occurs as thin veins. The granite is mostly contaminated with calc-silicate minerals such as diopside, ?garnet, and sphene, and occurs with sheared pegmatite. Several isolated outcrops towards the eastern boundary of the Sheet area have been mapped as undivided Naraku Granite (Pgu).

Exposure of the Naraku Granite is usually poor but the younger phase tends to be better exposed than the older phase. The large pluton to the northeast of Quamby is typically expressed as a low sandy flat with weathered granite outcrops in stream channels, and some rows of granite boulders marking veins of the younger phase. Some excellent pavements (Fig. 26) occur in the Corella River 9 km south of Quamby. In the east of the Sheet area, granite outcrops typically occur as widely separated low boundery hills in the flat sandy plains. Much of the granite occurs as shallow-dipping sheets 1 to 2 m thick which intrude the Corella Formation. Veins and small plugs of granite also occur in the Soldiers Cap Group.

Tourmaline pegmatite and minor aplite veins intrude the granite. These veins are pretectonic as they exhibit microstructural deformation textures; they have a strongly impressed regional foliation, and their contacts with the granite are partly transposed. The coarse grainsize in the pegmatite hinders the development of a penetrative foliation, but a pretectonic age for the pegmatite is affirmed by boudinaged tourmaline crystals and kinking of muscovite.

Petrography (Table 12)

The texture of Pgu$_1$ is typically holocrystalline, medium-grained, slightly inequigranular, subidiomorphic granular. The grains mostly have interlocking sutured boundaries although some are smoothly curved. Some fine-grained varieties occur. A foliation is evident in most specimens, especially in the more strongly sheared rocks, which contain an almost cataclastic texture with highly strained polygonal quartz lenticles or ribbons, bent or fractured plagioclase feldspar grains, and bent micas.

The typical mineral assemblage in Egu$_1$ is quartz-oligoclase$\pm$microcline-biotite and/or hornblende-opaques. The quartz is anhedral granular or intergranular and mostly strained. The oligoclase is anhedral to subhedral and sericitised, although twinning and relict zoning are evident. In some specimens the oligoclase is partly replaced by microcline. Most of the microcline is fresh and tartan-twinned but in some specimens the grains are clouded by alteration. Some untwinned feldspar has also been noted. The micas are mostly ragged subhedral flakes and partly aligned. Biotite commonly is partly altered to chlorite. Hornblende (possibly ferrohastingsite) occurs as subhedral to euhedral prisms which are locally embayed. The opaques are typically granular, and the accessory minerals (sphene, apatite, zircon) are mostly euhedral.

The texture of Egu$_2$ is dominated by a strong foliation defined by shearing or flattening of the grains. The rocks are holocrystalline allotriomorphic medium to coarse-grained and equigranular. The main minerals are quartz, microcline, plagioclase, hornblende, and sphene. The quartz is strongly strained and polygonal, and plagioclase is partly altered and clouded. Microcline shows some alteration and biotite is partly altered to chlorite. Sphene and hornblende are subhedral.

Strongly deformed gneiss zones consist of granoblastic layers of quartz plagioclase, and microcline, with some biotite and hornblende. Many layers, and associated cross-cutting veins, are highly albitic. Granite veins in calc-silicate rocks contain both albite and microcline-rich zones, and grains of pyroxene and hornblende similar to those in the associated metasediments.

<u>Discussion</u>

The contacts of the larger masses of Naraku Granite are not well exposed, but the abundant cross-cutting features displayed by the smaller granite bodies provide good evidence of an intrusive origin for the granite. Near some of the contacts of the granite and the Corella Formation, the granite is heavily contaminated with calc-silicate minerals and is strongly foliated, and may have formed by 'granitisation' of the Corella Formation. The presence of calc-silicate minerals in strongly foliated aplite veins which clearly cross-cut the main granite mass and the country rocks is evidence against this hypothesis and favours an intrusive origin. Pyroxene and hornblende in the granite veins may have formed, during regional metamorphism, from primary biotite and hornblende, and minerals in the veins equilibrated with similar assemblages in the Corella Formation.

A large proportion of the Naraku Granite is exposed as veins or sheets intruding the Soldiers Cap Group, amphibolitic dolerite, and the Corella Formation. This stockwork of veins extends for several kilometres from exposure of massive granite in some areas. As the veins tend to be more resistant to weathering than the host rock their abundance is easily overestimated. This must be considered when mapping Pgu_1, Pgu_2, or Pgu.

The extreme deformation is restricted to the granite pluton to the northwest of Quamby fault zone and perhaps is a consequence of movement on the Mount Rose Bee Fault, and/or folding. The central part of the granite is mylonitic and the aplite and pegmatite veins in this area are also extremely sheared. Gross folding within the granite is outlined by folded amphibolite layers.

Dolerite

Introduction

Fine to medium-grained metabasic rocks are abundant in the Quamby Sheet area, where they cover at least 80 km^2. Despite wide variation in appearance and composition these rocks are all mapped as dolerite. Most of the metabasic rocks are amphibolite. The remainder are biotite schist and amphibole-bearing plagioclase-scapolite granofels. Metabasalt and para-amphibolite, where they are recognised, are not mapped as dolerite, but the generally high metamorphic grade may have led to some of these rock types being incorrectly identified as dolerite. This is especially true in the large 'dolerite' masses within the Soldiers Cap Group.

Carter & others (1961) defined 7 groups of dolerite in northwestern Queensland on the basis of form, degree of metamorphism, and stratigraphic host rock. Four of these groups may be present in the Quamby Sheet area. They are: Group II, which occurs as dykes in the Argylla Formation; Group III, premetamorphic dykes and sills in the Corella Formation and older units; Group IV, dykes and stocks - younger than the first orogeny - in the Soldiers Cap Group; they are intruded by granites, and are slightly altered; and Group VI, postmetamorphic linear dykes in the Corella Formation and Wonga Granite.

It has not been possible to distinguish between Group II and Group III dolerites in the Quamby Sheet area as the metamorphism has been very intense. No Group VI dykes have been recognised in the Sheet area. The dolerites can be divided into premetamorphic and late to postmetamorphic. The older (pre-metamorphic) dolerite is now represented by amphibolite or biotite schist. The younger dolerite commonly retains some primary textures and apparently primary mineralogy.

Stratigraphic relations

Apparently intrusive dolerite occurs within the Corella Formation and older stratigraphic units, and in some phases of each of the three granites in the Sheet area, but the younger phases of the Wonga Granite (Egw_2 and Egw_3) and the Burstall and Naraku Granites appear to intrude dolerite. No dolerite has been recorded in the Knapdale Quartzite or younger units.

Lithology and field occurrence

The dolerite in the Soldiers Cap Group is mostly strongly foliated and consists of alternating bands of dark grey amphibolite and white felsic segregations. This banded amphibolite forms large conformable masses in the meta-arenite and quartzite. Where the contacts are locally discordant they are transposed into the tectonic layering. Some elongate bodies of quartzite occur within the dolerite and appear to be xenoliths. Quartz and aplite veins cut the dolerite and are strongly transposed.

TABLE 13. ESTIMATED MODAL COMPOSITIONS, DOLERITE AND METADOLERITE

No.	Minerals																		agd mm	Name
	q	k	p	ca	sc	mu	bi	hb	px	ch	ep	sp	op	al	ap	ru	to	zr		
0224					45			41	10			3	1						0.15	Banded scapolite - hornblende granofels in Po$_q$
0225			30		60							10							0.4	Pale band in amphibolite in Po$_q$
0227	15		15		20	5		25	15		2	3						tr	0.4	Banded amphibolite in Po$_q$
4058	5		30	2				55		3	5	tr	tr						0.25	Amphibolite in Pea$_m$
R5631	1						90			9		tr				tr		tr	3.0	Biotite schist in Pea
4025			62					20			15	1	1		1			tr	0.2	Metabasic in Pkc$_1$
4026	tr		29					70					1						1.5	Metadolerite in Pkc$_1$
4028	tr		34					60				1	5						1.0	Slightly altered dolerite in Pkc$_1$
4032	5	38	tr		17		30				7		3		tr		tr		0.2	?Metasomatised basic in Pkc$_3$
4038	2	30	45				22						tr	1	tr			tr	0.2	Altered dolerite(?) in Pkc$_1$
4045	1		64		1		3	30					1						1.0	Leucocratic altered dolerite in Pkc$_{2a}$
4052	3		60					25	10			1	5		tr				0.3	Metadolerite in Pgw$_2$
MB067			40					60					tr						0.5	Altered dolerite in Pkc$_3$
MB068			50					58			2		tr						0.4	Dolerite in Pgu$_1$
4076					50			46			1	2	1		tr				0.1	Altered basic in Pkc$_1$

Abbreviations: agd - average grain diameter; al - allanite; ap - apatite; bi - biotite; ca - calcite; ch - chlorite; ep - epidote hb - hornblende; k - microcline; mu - muscovite; op - opaques; - plagioclase; px - pyroxene; q - quartz; ru - rutile; sc - scapolite; sp - sphene; to - tourmaline; tr - trace; zr - zircon

Most of the dolerite in the Argylla Formation (Fig. 28) is also a segregated amphibolite which occurs in conformable masses. Some of these rocks have a spotted appearance due to large feldspar phenocrysts, porphyroblasts, or altered amygdales. Veins of granite and aplite cut the dolerites in the Argylla Formation. Adjacent to the larger granite masses, biotite schist is commonly developed.

Few of the dolerite dykes in the Corella Formation (Fig. 29) are as deformed as those described above. In several areas, severe alteration has occurred, producing 'red rocks' (Edwards & Baker, 1954). In these rocks the ferromagnesian minerals have broken down, leaving hematite and sphene, and the felsic minerals have developed a red colour from the finely dispersed hematite. These 'red rock' dolerites typically occur in areas of calc-silicate breccia.

Xenoliths of amphibolite and biotite schist occur in some of the granites and may represent fragments of metadolerite.

The younger dolerite bodies occur as irregular masses, discordant dykes 20 to 50 m thick, or, more rarely, sills. Most of these rocks are massive medium to coarse-grained metadolerite in which relict ophitic texture is commonly observed. Chilled margins have been noted in some sills in the northwest of the Sheet area. Feldspar phenocrysts occur in some bodies, and quartz-pyrite blebs occur in a few bodies. Chlorite and epidote are common alteration products in these younger dolerites, and scapolite is abundant in some. In general the dolerite bodies are poorly exposed. They form recessive areas and develop red clayey soil. Some of the larger fresh dolerite masses are well exposed on smooth rounded low ridges covered with cobble to boulder scree.

Petrography (Table 13)

The amphibolites typically consist of granuloblastic assemblages of hornblende and plagioclase, and minor diopside, sphene scapolite, quartz, and opaque minerals. A strong foliation is developed and the segregation into dark and pale layers is evident in some thin sections: the dark layers are composed of hornblende, plagioclase, diopside, sphene, and opaques; the pale layers are composed of plagioclase, scapolite, and some sphene, and have a medium-grained granuloblastic texture.

One specimen of crenulated biotite schist was sectioned. The crenulation cleavage was nearly perpendicular to the foliation defined by the large lepidoblastic plates of biotite and chlorite.

The metadolerite and the slightly altered dolerite have relict ophitic texture with subhedral to euhedral plates, and prisms of hornblende enclosing subhedral plagioclase laths. Some plagioclase is labradorite, but in most specimens the plagioclase has altered to albite. The hornblende is commonly zoned, having a darker outer rim. Partly altered clinopyroxene is present in some specimens. Chlorite and epidote commonly occur as alteration products. A foliation is rarely developed in these metadolerites, although a weak foliation has been observed in some specimens.

Metabasalt in the west of the Sheet area is granoblastic and extensively scapolitised, and, unlike adjacent dolerite, contains abundant sphene. Texturally it approaches amphibolite from areas near Naraku Granite. The metadolerite adjacent to the metabasalt displays a relict ophitic texture and is sphene-poor.

Discussion

Some of the dolerite older than the Corella Formation has been thoroughly reconstituted by metamorphism. Other dolerites in the Sheet area show less complete metamorphism, and in a few dolerite dykes metamorphism is not evident. This range in metamorphic effects is probably due mainly to the relation between the time of intrusion and the peak of the regional metamorphism. Intrusions of granite have metamorphosed nearby dolerite, and alteration of dolerite to biotite schist also suggests extensive potash metasomatism by the granite. The cores of some of the larger dolerite sills have been protected from metamorphism and appear to be less metamorphosed than the margins of these bodies.

The abundance of scapolite as a replacement of plagioclase may be attributed to deuteric fluids of the dolerite by (Edwards & Baker, 1954). Ramsay and Davidson (1970) considered that scapolitisation was due to saline metamorphic fluids. These fluids may have been derived from evaporites in the Corella Formation.

Amphibolite facies metamorphism is indicated by the development of hornblende, diopside, and calcic plagioclase in some of the metadolerite. Retrogression to greenschist facies is indicated by chloritisation and epidotisation.

?ADELAIDEAN

Quamby Conglomerate

Introduction

The 'Quamby Conglomerate' was the name proposed by Ball (1921) for the auriferous conglomeratic succession at and near Mount Quamby. Carter & others (1961) formally defined the Quamby Conglomerate.

In the Quamby Sheet area, the formation crops out in elongate downfaulted blocks 10 km west of, 27 km northwest of and 10 km southwest of, Quamby. It forms steep hills rising in places to 200 m above the surrounding Middle Proterozoic rocks. The total area of outcrop is approximately 17 km^2.

Stratigraphic relations

The Quamby Conglomerate overlies the Corella Formation unconformably. All other contacts are faulted. The unit is about 300 m thick.

Lithology and field occurrence

The Quamby Conglomerate is composed mainly of conglomerate and pebbly feldspathic sandstone. Near the base, the beds are composed of polymict conglomerate with pebbles, cobbles, and boulders of grey metasiltstone, blocky slate, and fine-grained schist. The clasts range in size from 15 mm to 150 mm and are subrounded to well rounded (Fig. 30). The matrix is fine to medium-grained silty sandstone or ferruginous micaceous poorly sorted grit.

Upwards in the sequence the proportion of clasts decreases, but the unit is pebbly throughout. The major lithologies are fine-grained gritty sandstone, laminated ferruginous fine to medium-grained sandstone, black laminated sandstone, ferruginous sandstone with conglomerate, and possibly greywacke. The conglomerate higher in the sequence contains clasts of quartz, quartzite and feldspathic sandstone set in feldspathic sandstone and cross-bedded medium to coarse-grained sandstone. Most of the iron in the ferruginous sandstone appears to be post-depositional.

Discussion

The Quamby Conglomerate represents an accumulation of sediments derived from Middle Proterozoic rocks. It does not appear to have been metamorphosed, so there must have been a substantial period of uplift and metamorphism before it was deposited. Folding in the unit appears to be related to the faulting that formed the graben structure in which the formation is exposed. The ferruginous sandstone may have formed through hydrothermal alteration or lateritisation; a hydrothermal origin is unlikely as no intrusive rocks younger than the conglomerate are known in the area.

Palaeocurrent directions determined from cross-bedding indicate derivation of sediment from the southwest to northwest.

Fig. 29. Contact of metadolerite and laminated calc-silicate rocks of Corella Formation (Bkc_1) 2 km northwest of Volga copper mine

Fig. 30. Exposure of conglomerate band in the Quamby Conglomerate 10 km west of Quamby

Fig. 31. Typical blocky habit of Cambrian calcareous siltstone near Cabbage Tree Creek 8.5 km west of Godkin copper mine

Fig. 32. Outcrop of gently dipping silty limestone 2.5 km south-south-west of Kajabbi

Fig. 33. Mesozoic labile ferruginous sandstone (Gilbert River Formation?) overlying Naraku Granite with pegmatite vein, in Corella River, 8 km southeast of Quamby

TABLE 14. ESTIMATED MODAL COMPOSITION, QUAMBY CONGLOMERATE

No.	Micaceous siltstone clasts	q	mu	op	to	matrix	agd (mm)	Name
4056	15	70	3	2	tr	10	0.8	Sublabile sandstone

Abbreviations: agd - average grain diameter, mu - muscovite, op - opaques, q - quartz, to - tourmaline, tr - trace

CAMBRIAN

Kajabbi Formation

Introduction

Before 1977, Cambrian strata were not recognised in the Quamby Sheet area. The initial discovery was made by geologists of Dampier Mining Pty Ltd, a subsidiary of the Broken Hill Proprietary Co. Ltd, when they mapped Authority to Prospect 1727M in the Landsborough (Kajabbi) Graben - southeast of Kajabbi. The Cambrian age was established by Dr E. Druce (formerly BMR) on the basis of some brachiopod and trilobite fragments (cited in Broken Hill Proprietary Co., 1177). A collection of trilobite fossils from a new locality 2.5 km nearer to Kajabbi was later described at GSQ (Fleming, 1978).

The BMR-GSQ mapping of the Quamby 1:100 000 Sheet area in 1973-74 regarded the limestone, grit and sandstone in the Landsborough Graben as units near the top of the Proterozoic Corella Formation. On the basis of the new fossil discoveries a reinterpretation of the geology in the Landsborough Graben for the Quamby first edition 1:100 000 geological map was made by I.H. Wilson and T.A. Noon of the GSQ early in 1978. Several limestone outcrops in the southwest of the graben were correlated with the fossiliferous Cambrian rocks near Kajabbi, and some quartzite units in the south of the graben were also interpreted to be of probable Cambrian age.

Sturmfels (1952) considered that the quartzite along the east bank of Cabbage Tree Creek is younger than the Corella Formation, and that it may correlate with the Upper Proterozoic Quamby Conglomerate. De Keyser (1965) also considered this quartzite to be younger than the Corella Formation; he also mapped shallow-dipping limestone strata in Cabbage Tree Creek to the west, but he correlated these with the Corella Formation.

The Cambrian strata crop out near the faults which bound the Landsborough Graben, and form eight separate outcrop areas which cover a total of 8 km^2. The quartzite in the south occurs as low rounded ridges. The limestone tends to be recessive and is exposed in stream channels and breakaways that cut through the Mesozoic cover rocks. Some well exposed pavements and blocky slightly disturbed flat-lying sheets of limestone occur.

The Kajabbi Formation has been formally named by Wilson, Gunn and Smit (1979).

Stratigraphic relations

Most of the contacts with older rocks are faulted, but some of the contacts of the quartzite near Cabbage Tree Creek and the 'Lady Clayre Dolomite' in the Mount Albert Group may be unconformable. In the diamond drillhole BHP 4, the Cambrian strata appear to overlie the Corella Formation with an angular unconformity.

The Cambrian strata are overlain unconformably by Mesozoic sandstone and Cainozoic sediments.

Age

A middle Cambrian age was determined from brachiopod and trilobite fossils. E. Druce (cited in Broken Hill Proprietary Co., 1977) correlated specimens from 5 km south of Kajabbi (GR 983797) with the transition between the Inca Formation and the Pomegranate Limestone of the Georgina Basin. Fleming (1978) described a collection of Cambrian agnostid trilobites from 2.5 km south-southwest of Kajabbi (GR 988820). The species recognised were Ptychagnostus cassis, P. nathorsti?, Diplagnostus c.f. humilis, and Pseudophalacroma dubium. This fauna indicates a correlation with the laevigata I Zone (cassis Zone) of Opik (1961), corresponding to the Roaring Siltstone in the northern part of the Burke River Outlier and part of the Devoncourt Limestone in the southern part of the outlier.

Lithology and field occurrence

The 'Kajabbi Formation' consists of two distinct lithologic units: a lower sandy unit, which is exposed in the south; and an upper silty limestone unit, which is exposed in the north. The rocks in the upper unit are mainly pinkish brown to grey massive to laminated calcareous siltstone, grey silty limestone, laminated and brecciated chert, and whitish grey finely laminated siltstone. The limestones are locally pyritic and the siltstone contains rare fossils. In the south, buff fine to medium-grained poorly sorted quartzite, feldspathic calcareous sandstone, and grit of the lower unit predominate.

The Cambrian sediments generally dip less than 30^{o}, but near the Pinnacle Faults dips of 75^{o} to vertical are more typical. The typical blocky outcrop of flat-lying to gently dipping calcareous siltstone and limestone is shown in Figures 31 and 32.

From BHP drill logs (Broken Hill Proprietary Co. Ltd, 1977, 1978a,b) the base of the Cambrian sequence in the west consists of about 5 m of poorly sorted calcareous sandstone grading upward into sandy limestone and pure massive limestone about 20 m thick. This is overlain by deep red to pale grey coarse-grained porous, slightly pyritic sandstone about 80 m thick, and then fractured massive dolomite or limestone with numerous chert bands and pyritic bands. The remainder of the Cambrian sequence is a uniform laminated to thin-bedded calcareous siltstone and silty limestone about 400 m thick. This sequence contains minor carbonaceous layers and zones of disseminated pyrite, and generally becomes more calcareous towards the top. It also contains some breccia zones from 1 to 3 m thick and a 'cyclic' unit about 14 m thick. The cycles are 1 to 2 m thick and grade from a basal laminated calcareous siltstone upward into a limestone which becomes carbonaceous towards the top of the cycle. The top of each cycle is marked by a layer of carbonaceous shale generally less than 1 cm thick.

The breccia zones and the 'cyclic' unit have been used as stratigraphic markers in the four diamond drill holes.

The thickness of the composite section is at least 500 m and may exceed 600 m.

Petrography

Two surface specimens and four drillcore specimens were examined in thin-section. Estimated modal compositions are presented in Table 15.

The sandstone specimens are poorly sorted fine to medium-grained and contain generally well-rounded grains of quartz and minor feldspar grains, muscovite flakes, and rock fragments in a sericitic matrix. The drillcore specimen of sandstone contains a calcareous cement.

Silty limestone is the main rock type in the surface exposures and drillcore. These rocks consist of granular calcite with interspersed angular quartz grains and euhedral muscovite flakes. Opaque minerals occur as very fine-grained specks or granular aggregates. Some cubic forms in the specimen from 134 m in BHP 3 may have been pyrite. Limonite staining is common in the silty limestone.

Pure very fine-grained limestone with very few fragments of quartz and muscovite occurs as bands in some silty dolomite. Stylolites in the limestone contain concentrations of quartz and microcline grains and muscovite flakes set in a calcite cement.

TABLE 15. ESTIMATED MODAL COMPOSITIONS, 'KAJABBI FORMATION'

No.	Clasts					Minerals										agd (mm)	Name
	qt	me	ct	sh	st	q	k	p	mn	ca	ce	lm	op	to	zr		
M8056			2			85		5	8							2.0	Sericitic sandstone
BHP 4/255.50	5	4		3	3	64	3	5	3		10			tr	tr	1.0	Calcareous labile sandstone
M8070						10				85		5				0.05	Silty limestone
BHP 3/134						9			4	85			2			0.02	Silty limestone
BHP2/75						10	tr		2	65	20	2	1	tr	tr	0.04	Silty limestone
BKP2/75						1			1	98						0.01	Limestone band

Abbreviations: agd - average grain diameter, ca - calcite, ce - calcite cement, ct - chert, k - microcline, lm - limonite, me - metamorphic rocks, mu - muscovite/sericite, op - opaques, p - plagioclase, q - quartz, qt - quartzite, sh - shale, st - siltstone, to - tourmaline, tr - trace, zr - zircon.

Discussion

It has not been feasible to divide the Kajabbi Formation into formal upper and lower units because of the discontinuous outcrop and uncertainty of correlations throughout the southern part of the Landsborough Graben.

Most of the Kajabbi Formation was previously mapped as Proterozoic Corella Formation. It is now evident that the rocks are less deformed and less metamorphosed than the rocks of the Corella Formation. The Kajabbi Formation has similar lithology and airphoto pattern to Middle Cambrian sediments of the Burke River Outlier exposed in the Malbon 1:100 000 Sheet area 110 km to the south (Opik, 1961; Noon, 1978). The presence of Middle Cambrian trilobite and brachiopod fossils support this correlation. The whole of the Cambrian sequence drilled by the Broken Hill Proprietary Co. Ltd is weakly phosphatic, but the highest assay was only 1.40 percent phosphorus.

Two speculative correlations may follow from the recognition of this Cambrian sequence in the southern end of the Landsborough Graben. The first is the possibility that the Quamby Conglomerate is a correlative of the lower sandy unit of the Kajabbi Formation. Both of these arenaceous/rudaceous units are younger than the Carpentarian metamorphism, and both lie unconformably on the Corella Formation. The Kajabbi Formation is recognised only in the Landsborough Graben; the Quamby Conglomerate is mapped in two smaller grabens to the southeast. The coarser grainsize and more abundant conglomerate in the Quamby Conglomerate may have resulted from deposition in a more mountainous or more tectonically active area. If the two units are correlatives they may be either Cambrian or Adelaidean in age, as the Cambrian fossils have been found only in the upper unit of the Kajabbi Formation. A Cambrian age is favoured because no obvious stratigraphic break has been recognised within the Kajabbi Formation. The other speculative correlation is that the upper and lower units of the 'Kajabbi Formation' may correlate respectively with dolomite and quartzite intersected in the Mid-Wood Burketown No. 1 exploratory well, about 230 km north-northwest of Kajabbi. This well is located in the Burketown Graben

(Meyers, 1969), the northern extension of the Landsborough Graben. The crypto-crystalline, partly arenaceous 'dolomite' was assigned to the Proterozoic, and the underlying quartzite to the Archaean by Meyers (1969), but Ingram (1973) suggested that the 'dolomite' may correlate with lower Palaeozoic dolomite of the Georgina Basin, 130 km to the west. The occurrence of Cambrian 'Kajabbi Formation' northeast of the Mount Isa Inlier supports this correlation.

MESOZOIC

Toolebuc Limestone

Introduction

The Toolebuc Limestone was first described by Casey (1959) in the Boulia 1:250 000 Sheet area. Mapping by Doutch, Ingram, Smart, & Grimes (1970) and Smart (1972) has shown that this unit extends into the Quamby Sheet area, and that is is synonymous with the Kamileroi Limestone of Laing & Power (1959).

The Toolebuc Limestone consists mainly of pink and grey bedded limestone and yellowish grey shale. It crops out as low rounded rises and small mesas in the northeast of the Quamby Sheet area, where it covers about 8 km^2. The unit is generally flat-lying.

Stratigraphic relations

The Wallumbilla Formation underlies the Toolebuc Limestone conformably and the Allaru Mudstone overlies the limestone conformably, but neither of these relations is clearly exposed in the Quamby Sheet area.

The age of the Toolebuc Limestone is basal late Albian (latest stage in the Early Cretaceous) on the basis of macrofossils and microfossils (Vine & Day, 1965; Smart & others, in press).

Lithology and field occurrence

Grimes (1972) described the Toolebuc Limestone as 'flaggy pink and grey limestone beds overlying a hard grey and yellow calcareous shale containing concretions of limestone'. The upper part of the limestone is vuggy and the lower part is commonly a coquinite. However, drilling has shown that the dominant lithology is a calcareous bituminous shale (Smart, 1972; Smart & others in prep.). Fossils have been reported from several localities but only one locality is recorded on the Quamby first-edition geological map. The thickness of the unit is 7 to 25 m (Grimes, 1972).

Discussion

Because the Toolebuc Limestone is a black calcareous shale similar to other Mesozoic shales in bore it is rarely identified in drillers' logs, but it is radioactive, and thus easily identified in gamma-ray logs. The lower calcareous shale beds contain oil shale (Smart, 1972) which has economic potential in the Julia Creek area about 140 km east of the Quamby Sheet area. The fossils indicate a marine origin for this unit, which appears to have formed as biostromal and biohermal banks and mounds (Williamson, 1967).

Unnamed Mesozoic units

Introduction

Most of the Mesozoic units in the Quamby Sheet area are undivided (shown as M on the 1:100 000 geological map). Outcrops occur as mesas and rolling downs in the Landsborough Graben and along the banks of the Corella River to the southeast of Quamby. The total area of outcrop is about 16 km^2.

Stratigraphic relations

The Mesozoic sequence overlies the Proterozoic Corella Formation, the ?Adelaidean Quamby Conglomerate, and the Middle Cambrian Kajabbi Formation unconformably, and the Naraku Granite non-conformably (Fig. 33). The Mesozoic sequence is overlain by a presumably Tertiary ferruginous silcrete.

The age of these sequences is unknown but may be Late Jurassic or Early Cretaceous (Grimes, 1972). They are probably older than the Toolebuc Limestone, which is Albian.

Lithology and field occurrence

A measured section of a mesa in the Cabbage Tree Creek area at lat. 20°11'S, long. 140°06'E, (Grimes, 1972, fig. 6) is about 37 m thick, and comprises mainly brown fine to medium-grained clayey quartz sandstone with interbeds of white to brown micaceous mudstone containing some concretions. Some of the sandstone is friable and feldspathic, and has large cross-beds. A shaft sunk for water in this area intersected a seam of fair quality non-coking coal about 10 cm thick (Dunstan, 1920).

The Mesozoic strata overlying the Quamby Conglomerate are highly ferruginous conglomerate consisting of well-rounded quartzite clasts in a silicified clayey matrix; they form a few isolated blocks tens of metres across.

In the Corella River the exposed base of the Mesozoic sequence rests on granite and pegmatite of the Naraku Granite (Fig. 33). The sequence consists of about 5 m of buff to brown poorly sorted feldspathic grit with pebble beds, and buff, locally cross-bedded fine to medium-grained, slightly ferruginous feldspathic clayey sandstone, overlain by several metres of pale grey laminated siltstone or blue grey mudstone (Wallumbilla Formation; Grimes, 1972).

Petrography

One specimen of buff feldspathic clayey sandstone from the Corella River sequence was examined petrographically. The rock contains moderately sorted angular subspherical grains of quartz (40 percent), microcline (24 percent), and plagioclase (10 percent) with an average grain diameter of about 0.2 mm. Minor amounts of angular fragments of subhedral tourmaline grains, books of chlorite, and granular opaque minerals also occur in a matrix (12 percent) consisting of limonite-stained clay.

Discussion

The unnamed Mesozoic units which are exposed in the Quamby Sheet area probably correlate with the Gilbert River Formation (Grimes, 1972), but the lack of fossils in this Sheet area and the discontinuous nature of the outcrops prevent precise correlation.

The sandstone units in the Quamby Sheet area appear to be fluvial. Palaeocurrents from the south-southwest are indicated in the Corella River sequence. Grimes (1972) considered the fluvial sediments in the Cabbage Tree Creek area to have formed in a north-draining valley.

Some marine mudstone, equivalent to the Wallumbilla Formation, may be included near the top of the unnamed Mesozoic units in some areas. The Wallumbilla Formation has been recognised in some drillholes. In the northeast of the Sheet area the Allaru Mudstone overlies the Toolebuc Limestone in the subsurface.

CAINOZOIC

Introduction

Nine Cainozoic units have been recognised in the Quamby Sheet area by K.G. Grimes (GSQ). Only one of these units, the Wondoola Beds, has been named. The other units are referred to by their map symbol. The map symbols, area of outcrop, and brief descriptions are presented in Table 16.

TABLE 16. DESCRIPTIONS OF CAINOZOIC UNITS

Symbol	Area (km^2)	Description
Ql	2	Lagoonal deposits : clay, silt
Qha	60	Recent alluvium : sand, silt, gravel
Qa	100	Alluvium : silt, sand, clay
Qas	45	Abandoned stream channel: sand, gravel
Qpa	500+	Old alluvium : clay, silt
TQb	300	Black soil developed on TQr and Cretaceous mudstone
TQr	240	Wondoola Beds : red and grey clay, silt, sand
Czs	420	Colluvium : sand, gravel, clay
Td	25	Duricrust : ferricrete, silcrete (billy)

Stratigraphic relations

The Cainozoic units are listed in Table 16 in approximate stratigraphic sequence - the youngest units at the top. The units tend to overlap in time. With the probable exceptions of Td, TQr, Qpa, and Qas the units are currently accumulating.

Grimes (1972) considered the duricrust, Td (the deep-weathering profile, Czd on the Cloncurry 1:250 000 preliminary to second-edition geological map), to be early to middle Tertiary. Unit Czs postdates erosion of the duricrust, and probably ranges in age from late Tertiary to the present (Grimes, 1972). The Wondoola Beds, TQr, are considered to be Pleistocene to ?Holocene in age (Doutch & others, 1970; Grimes & Doutch, 1978). Most TQb is a soil developed on TQr during the Holocene. The unit is probably still forming. Unit Qp2 is probably of Pleistocene age, but may in part, be contemporaneous with TQr. Unit Qas probably ranges in age from Pleistocene to Holocene. Unit Qa is younger than Pleistocene. Units Qha and Ql are Recent deposits.

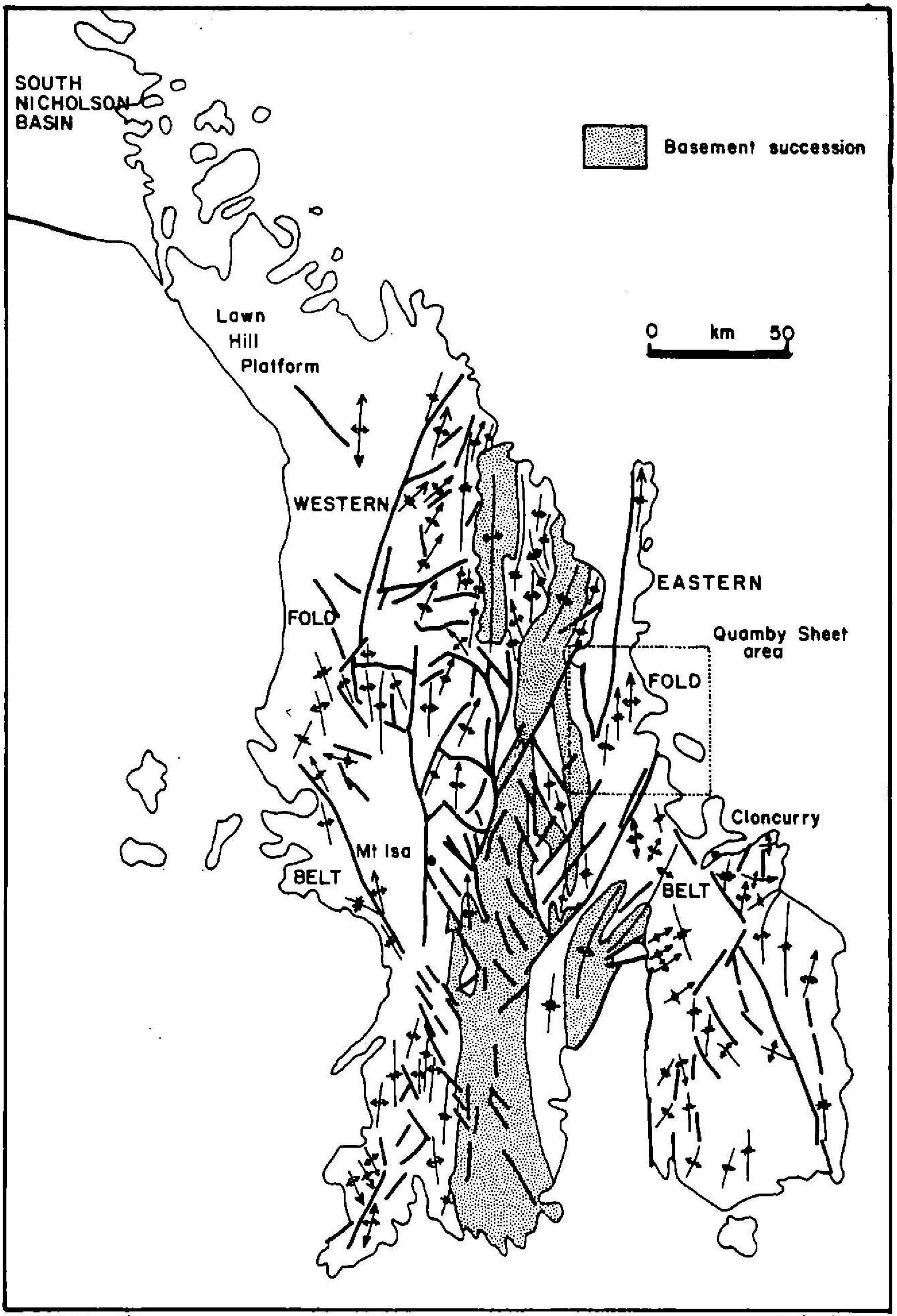

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Fig 34 Structural setting of the Quamby Sheet area

Petrography

One specimen of duricrust was examined in thin section. It consists of angular to subrounded grains of quartz set in a fine-grained siliceous clayey cement.

STRUCTURE

The Quamby Sheet area is situated in the Eastern Fold Belt of the Proterozoic Mount Isa Inlier (Fig. 34). It lies entirely within the Mount Isa Orogenic Domain (Plumb & Derrick, 1975) and contains some of the most highly deformed and metamorphosed rocks in the inlier. Less deformed ?Adelaidean, Cambrian, and Mesozoic sequences also occur in the Sheet area.

Folding is evident in all rocks other than Mesozoic strata. In the Cambrian and ?Adelaidean rocks, the folds are open. The Proterozoic rocks are tightly to isoclinally folded, and axial-planar foliations are widely developed. In some areas, transposition layering or metamorphic segregations have developed.

Faults with vertical displacements affect all strata of Mesozoic age or older. Faults with horizontal displacements are restricted to Proterozoic rocks. Large granite plutons and abundant dolerite dykes and plugs further complicate the structure of the Proterozoic sequence. Intense deformation within the Corella Formation is marked by a characteristic calc-silicate breccia.

Previous work

The major structural elements in the Quamby Sheet area were recognised by Carter & others (1961) who included the area in the Lower Proterozoic eastern geosynclinal belt. They noted the general meridional trend, evidence of two orogenic deformations caused by east-west compression, folds of various scales, several types of faults, and various minor structures.

De Keyser (1965) made some detailed observations in the central part of the Sheet area, noting the steep westerly dips in the Dugald River area and Knapdale Quartzite, and the more open folding to the west and south. He also recognised large-scale steeply plunging folds to the east of the Mount Rose Bee Fault. The less intense folding in the Quamby Conglomerate was attributed to the drag effects of faults.

Structural domains in the Quamby Sheet area

Some of the major faults in the Sheet area separate subareas with contrasting structural style. Six of these subareas or domains (listed A to F) have been recognised; they are shown in Figure 35 and are listed below:

A. the Mount Godkin-Kajabbi block in the west of the Sheet area, to the west of the Pinnacle Fault

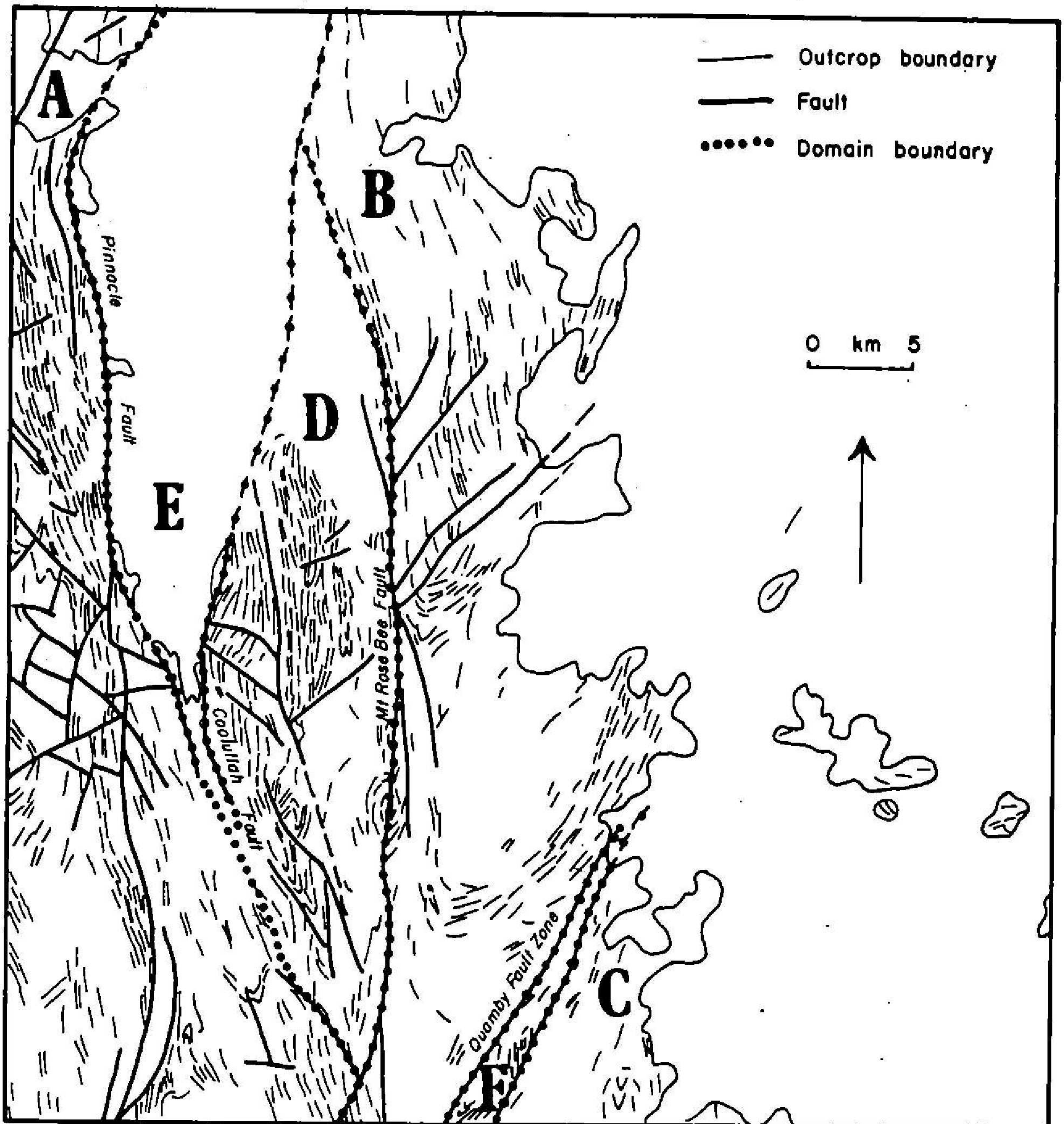
B. the Boomarra Horst, exposed east of the Mount Rose Bee Fault, but covered by Mesozoic strata and Cainozoic deposits to the east

C. the Evandean block, southeast of the Quamby Fault Zone

D. the Dugald River block, between the Coolullah and Mount Rose Bee Faults

E. the Landsborough Graben, bounded by the Pinnacle and Coolullah Faults, and

F. the Federal Graben, which lies in the Quamby Fault Zone.



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A. Mt Godkin – Kajabbi block
B. Boomarra Horst
C. Evandean block
D. Dugald River block
E. Landsborough Graben
F. Federal Graben

Fig 35 Structural domains in the Quamby Sheet area

Domain A: the Mount Godkin-Kajabbi block

Stratigraphy. This structural domain contains Argylla Formation, Ballara Quartzite, and Corella Formation rocks intruded by Wonga Granite, Burstall Granite, and dolerite. In the north many sections are apparently continuous, but in the south the sequence is disturbed by faults and intrusions.

Faulting. The oldest faults in this domain trend east-southeast and east-northeast in the area from Tea Tree Creek in the south to the northern limit of the Sheet area. Changes in stratigraphic sequences across some of these faults may indicate penecontemporaneous deformation. These early faults appear to have vertical (?normal) displacements, and are displaced by northeast to northwest-trending faults, some of which may be younger than the folding of the sequence. Many of these faults are parallel to contiguous bedding. The youngest faults recognised in this domain are northeast-trending dextral strike-slip faults. The two main examples are: in the northwest corner of the domain, the Mount Remarkable Fault, which has a calculated strike-slip displacement of 25 km (Wilson & others, 1977); and in the southwest of the domain, the Wonga Fault, which has several kilometres strike-slip displacement. The Pinnacle Fault which bounds the domain to the east is a north-trending normal fault which probably antedates the strike-slip movement.

Folding. The major fold in this domain is the eastern limb of a complex isoclinal north-trending anteform which extends along the entire western margin of the Quamby Sheet area; the fold closes in the Prospector Sheet area to the west. A small tightly folded synform occurs around 960500. The structure in the Mount Godkin Range is probably a complex north-plunging anticline with an intrusion of Burstall Granite in its core. The western limb of this fold is complicated adjacent to splays of the Wonga Fault.

Minor structures. Microfolds within this domain generally dip about 70^{o} to the north although doubly-plunging folds have been recognised in the north of the domain. Lineations dip to the north and northeast. Cleavage in the western part of the domain is vertical and strikes north to northeasterly. In the southeast of the domain the cleavage trends northwest. A metamorphic foliation in the southwest of the domain has a north to northwest trend. This foliation is also developed in the Wonga Granite. Transposition is well advanced (Fig. 9) and in the calc-silicates in the northeast double boudinage has occurred only in the isoclinally deformed areas.

Domain B: the Boomarra Horst

Stratigraphy. This structural domain contains highly deformed quartzite and amphibolite which probably correlate with the Soldiers Cap Group, calc-silicate rocks of the Corella Formation, a large highly deformed pluton of Naraku Granite, and dykes of dolerite, aplite, and pegmatite.

Faulting. The most conspicuous faults trend northeast, but they are of only minor structural significance. Some of these faults may have horizontal displacements, and appear to be younger than a poorly represented set of northwest-trending faults. The youngest faults are splays of the Mount Rose Bee Fault and possibly sympathetic faults related to the Quamby Fault Zone. These faults appear to be normal with downthrows to the east.

Folding. The dominant fold style in this domain has an open north-trending concentric pattern. It is best developed in the Corella Formation and locally merges into isoclinal folds. In the isoclinally folded regions, intrafolial folds have developed through transposition, and minor folds are doubly-plunging.

The Naraku Granite in this domain is strongly sheared and in thin section it records deformation as flattened grains, sutured grain boundaries, 'ribbon' quartz, and deformation lamellae. This evidence indicates that the folding postdates the intrusion of this pluton of Naraku Granite. Metadolerite bands (?dykes) within the granite also appear to be folded.

Minor structures. The open folds are accompanied by a weak axial-plane fracture foliation which is mapped as a north to northeast-trending cleavage. This cleavage is recognised in the more competent layers by a rodding parallel to the b-fold axis.

In the isoclinally folded parts of the Corella Formation and metadolerite an axial-plane transposition foliation is developed. In the metadolerite this transposition is represented by a metamorphic segregation foliation. Leucosome veins in the metadolerite, and granite and dolerite contacts in the Corella Formation, are transposed into the regional north-trending foliation that is axial planar to the north-trending folds. Double boudinage of the Corella Formation in areas of isoclinal folding have produced much of the calc-silicate breccia in the south of this domain.

Domain C: the Evandean Block

Stratigraphy. The Corella Formation, Soldiers Cap Group, Naraku Granite, and minor Mesozoic sedimentary rocks are exposed in this domain. Poor outcrop allows little stratigraphic control.

Faulting. No faults have been recognised in this domain, but some northwest and northeast-trending quartz veins southeast of Quamby may represent faults. A strong north-northeast-trending lineament also occurs in this area. Another lineament marked by quartz outcrops occurs near No. 9 bore, near 380348.

Folding. Open south-plunging folds are recognised in the southwest of this domain.

Minor structures. A north to north-northeast-trending axial-planar structure is poorly developed. Schistosity is developed near the Quamby Fault Zone. Minor folds generally plunge to the south. Much of the outcrop is of calc-silicate breccia in areas of the Corella Formation that are mostly tightly folded. Shear zones cut the Naraku Granite, but most of the granite is far less deformed than the pluton in the Boomarra Horst to the northwest.

Domain D: the Dugald River Block

Stratigraphy. This domain exposes a sequence of upper Corella Formation rocks, the Knapdale Quartzite, and the 'Lady Clayre Dolomite' which lies to the west and southwest of the Knapdale Quartzite. Facing evidence from each of these units indicates that the sequence is mainly younging to the west. Minor unmetamorphosed dolerite intrudes the Corella Formation.

Faulting. Some of the northeast and northwest-trending faults may have been contemporaneous with deposition of the Knapdale Quartzite. A younger set of similarly oriented faults is younger than the Knapdale Quartzite and 'Lady Clayre Dolomite' to the west. The fault which truncates the southern end of the Knapdale Quartzite is a major example of the younger set of faults, and as it also truncates a fresh dolerite this set is probably younger than the folding. The youngest faults appear to be the the strike faults, such as those in the Coocerina Shear Zone at the western margin of the Knapdale Quartzite. Some workers consider that the Coocerina Shear Zone is a major fault with downthrow to east that repeats the stratigraphic sequence below the Knapdale Quartzite (that is the sequence to the east) in the area to the west of the Knapdale Quartzite. Our work suggests that the 'Lady Clayre Dolomite' is probably younger than the Knapdale Quartzite (and the Corella Formation) and that displacement in the Coocerina Shear Zone was small.

Folding. Tight to isoclinal folds occur in the Corella Formation, especially near the Dugald River lead-zinc prospect and the Lady Clayre copper mine. In the northwest, the Knapdale Quartzite is overturned in one small fault block; the remainder of this formation dips and faces consistently to the west. Broad open folds occur in the dolomite sequence, especially to the southwest of the Knapdale Quartzite.

Minor structures. Minor folds in the domain generally plunge to the north but the deeply plunging major folds are reflected by some south-plunging minor folds. Axial-planar structures are poorly developed: a weak metamorphic foliation is developed in the east of the domain and a cleavage which trends north to northwest is developed in the west. A strong northwest-trending joint system is developed in the Knapdale Quartzite.

Domain E : the Landsborough Graben

Stratigraphy: Mesozoic, Cambrian, and ?Adelaidean rocks are exposed in this domain. Proterozoic rocks have been intersected in one drillhole.

Faulting. The only fault recognised in this domain is a splay off the Pinnacle Fault in the southwest. The domain is bounded by normal faults which are younger than the Cambrian strata and have been reactivated since deposition of the Mesozoic roks.

Folding. Dips between 10^{o} and 30^{o} are common in the Cambrian strata. The dips are mostly directed away from the bounding faults and indicate that folding is probably due to drag near these faults as the graben subsided. The Mesozoic strata dip gently to the east. The dips are 5^{o} or less and the strata may have been slightly deformed during the faulting.

Domain F : the Federal Graben

Stratigraphy. This domain exposes the Corella Formation and the ?Adelaidean Quamby Conglomerate.

Faulting. Several minor, probably normal, faults are related to the bounding faults of the graben within this domain.

Folding. The Quamby Conglomerate occurs as a tightly folded syncline which probably was formed during the subsidence of the graben. The Corella Formation is highly brecciated in this domain.

Minor structures. A cleavage is poorly developed near some of the faults.

Structural synthesis

The sequence of structural events in the Quamby Sheet area is not fully known. The earliest structures are most difficult to resolve because of subsequent deformation. Some deformation may have accompanied intrusion of the earliest phase of the Wonga Granite into the Argylla Formation in the west of the Sheet area. This intrusion and deformation may have occurred before the deposition of the Ballara Quartzite and Corella Formation.

During the deposition of the sediments and basic volcanic rocks in the Corella Formation, minor penecontemporaneous ?normal faulting appears to have occurred. These faults trend east-southeast to east-northeast.

Subsequent minor faulting with northeast to northwest trends appears to be temporally related to intrusion of the later phases of the Wonga Granite, and the Burstall and Naraku Granites. As the Wonga Granite is extensively faulted, it may be older than the other granites. The main folding episode affected the Wonga Granite and Naraku Granite to the northwest of Quamby, indicating that these two granites were intruded before the main folding episode.

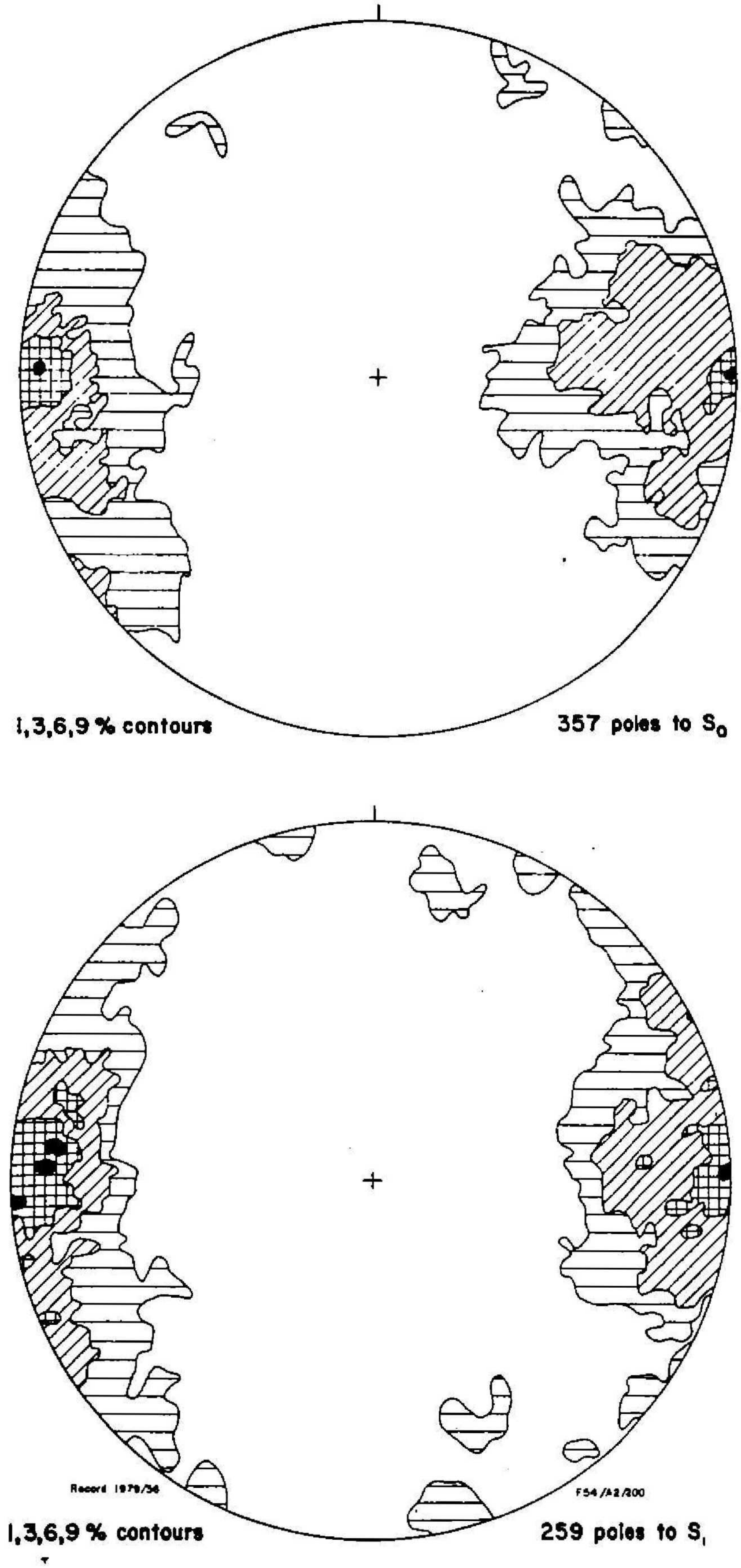

Fig 36 Stereographic projections of poles to S_0 and S_1 surfaces in the Carpentarian rocks of the Quamby Sheet area

The deposition of the Knapdale Quartzite may have occurred before or after the intrusion of the granites but as the unit is extensively faulted, deposition before the intrusion of the Naraku Granite is favoured.

The main folding episode then affected the Carpentarian rocks in the whole of the Sheet area, producing open basins-and-domes to elongate isoclinal folds owing to inhomogeneous strain during deformation. The calc-silicate breccia in the Corella Formation is believed to have formed mostly during this deformation in the most highly deformed areas. Some of the northeast to northwest faults may have remained active during this folding episode. The double plunge of many of the folds formed at this time may be due to a second folding episode, but little evidence supports this theory. Stereographic projections of poles S_o and S_1 surfaces in the Carpentarian rocks are presented in Figure 36.

Major dextral northeast-trending strike-slip faults represent the next structural event. These faults are poorly expressed in the Quamby Sheet area in comparison with areas to the south and west where this fault system is the dominant structure.

The youngest faults are the nearby north-trending normal faults which form boundaries to the structural domains in the Sheet area - i.e., from west to east, the Pinnacle Fault (east block down, 100 m displacement), Coolullah Fault, (west, ?500 m), Mount Rose Bee Fault (west, ?500 m) Quamby Fault Zone western boundary (east, ?200 m), and Quamby Fault Zone eastern boundary (west, ?200 m). These faults are commonly filled by large quartz veins. The Mount Rose Bee Fault appears to displace areas of Quamby Conglomerate; retrogression from amphibolite to greenschist-grade metamorphic rocks may have taken place along the eastern side of the fault during fault movement.

This youngest period of faulting has affected ?Adelaidean and Cambrian strata. Doutch & others (1970) considered that the Coolullah Fault became active near the beginning of the Jurassic when the Landsborough Graben (Burketown Depression) began to subside. They recognised a fault of a similar age, the Boomarra Fault, marking the eastern limit of the Boomarra Horst; this fault is interpreted to trend northwards from near Granada homestead (GR 339781) but it is concealed beneath Mesozoic and Cainozoic sediments. Minor reactivation of these faults may have occurred since the Mesozoic.

METAMORPHISM

Metamorphism has affected the Carpentarian sedimentary and volcanic rocks in the Quamby Sheet area, but the ?Adelaidean and Phanerozoic rocks are unmetamorphosed. The dominant metamorphism is a low-pressure regional metamorphism from greenschist to mainly amphibolite facies grade (Fig. 37). Some greenschist facies metamorphism is due to retrogression in shear zones. Contact metamorphism is not well developed, despite the abundant granite and dolerite intrusions.

Mineral assemblages

The acid volcanic rocks of the Argylla Formation contain quartz-microcline-albite-muscovite(-biotite) assemblages; the sediments in this formation contain quartz-microcline-scapolite-diopside(-hornblende) assemblages, with accessory sphene. Dolerite dykes intruding the Argylla Formation are typically plagioclase-diopside-hornblende-sphene assemblages. Some sheared metadolerite consists of biotite and chlorite.

The quartzite in the Soldiers Cap Group typically contains quartz-microcline(-plagioclase)-sphene-opaques. Hornblende (?ferrohastingsite), scapolite, diopside and garnet occur in some specimens. The texture of the quartzite and these index minerals indicate a high metamorphic grade. The amphibolite bands in this group consist of hornblende-scapolite-diopside (-plagioclase) assemblages with sphene, epidote, opaques, and quartz in minor amounts. Muscovite-feldspar-hornblende-biotite schist, and scapolite-quartz-feldspar-hornblende-biotite schist occur locally.

The Corella Formation contains a wide range of rock types. Calc-silicate assemblages are characteristic, but schist, quartzite, metabasalt, and para-amphibolite are also present. Typical calc-silicate assemblages are:

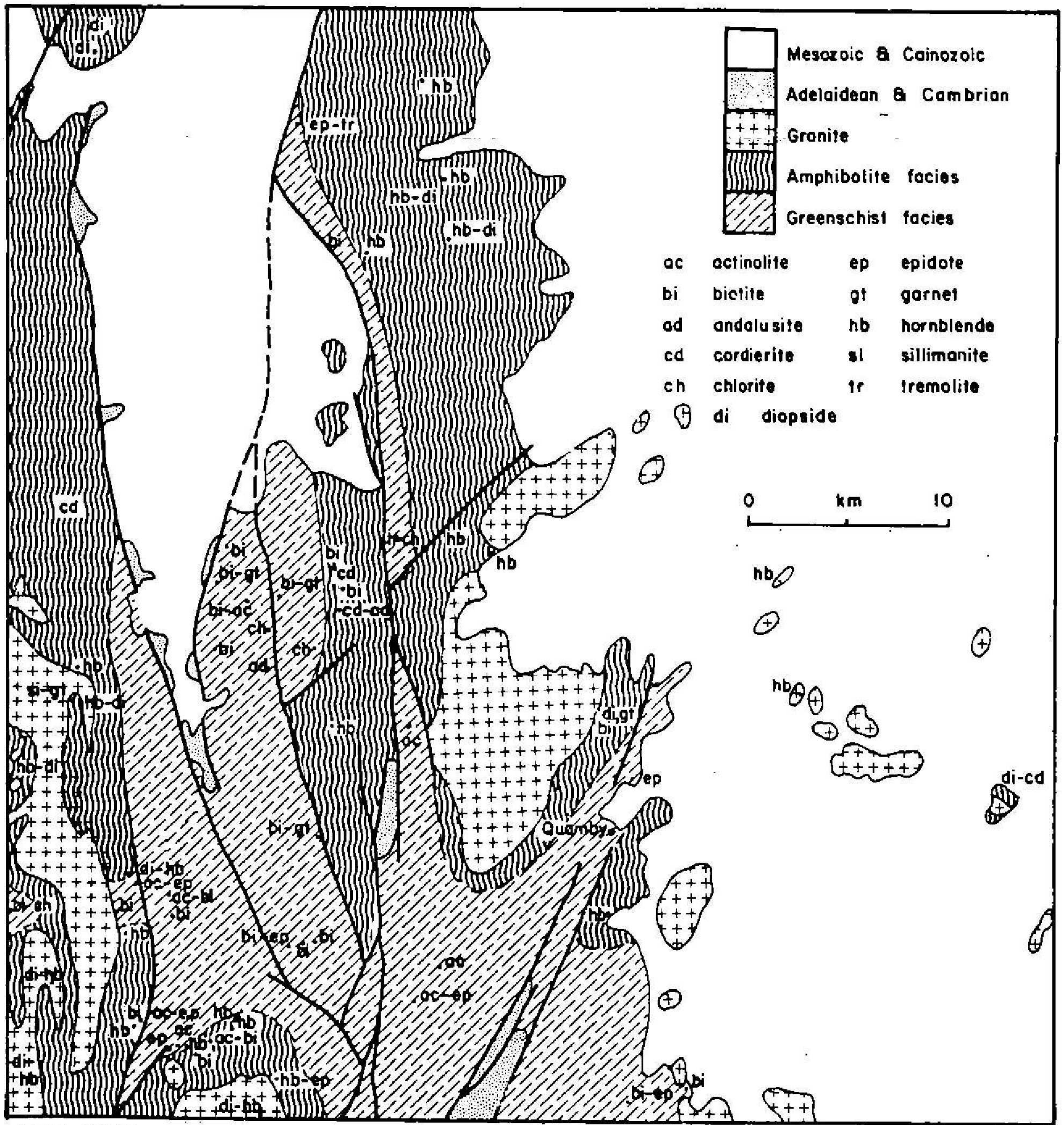

Fig 37 Distribution of metamorphic facies and index minerals in the Quamby Sheet area

Calcite-plagioclase-hornblende±quartz±scapolite±diopside
Calcite-quartz-scapolite-biotite
Microcline-scapolite-hornblende±quartz±plagioclase±calcite+diopside
Plagioclase-hornblende-diopside±quartz±biotite±opaques
Plagioclase-biotite-scapolite-microcline-quartz
Scapolite-diopside-garnet-quartz-plagioclase
Scapolite-diopside
Scapolite-cordierite-diopside-plagioclase

Sphene is a common accessory and makes up to 20 percent of some specimens. Apatite is also abundant.

The schist in the Corella Formation typically contains quartz, muscovite, biotite, and garnet. Some metasiltstone is schistose and contains microcline, biotite, quartz, scapolite, calcite, hornblende, opaques, epidote, sillimanite, cordierite, andalusite, and garnet. The typical assemblage in the para-amphibolite is plagioclase-hornblende-epidote-opaques±microcline±scapolite. Whitcher (1975) recorded altered cordierite and andalusite from graphitic shales at Dugald River; staurolite is also present in schist in the area (I.G. Whitcher, CRA Exploration, personal communication, 1977).

The predominance of quartzose rocks in the Knapdale Quartzite prevent accurate determination of metamorphic grade. The texture in the Knapdale Quartzite indicate that the metamorphism was less intense than in the quartzites of the Corella Formation and the Ballara Quartzite in the Sheet area. The presence of minerals such as chlorite confirm a lower grade. Porphyroblasts in unit Ppk_t near the top of the formation have not been identified. Biotite and garnet occur in a calc-silicate granofels at the top of the formation.

The 'Lady Clayre dolomite' which overlies the Knapdale Quartzite, is only slightly metamorphosed. The sequence is dominated by very fine-grained dolomite which shows no evidence of recrystallisation. Quartz and muscovite are the other common minerals in this unit. Scapolite, chlorite, biotite, garnet, and actinolite are typical metamorphic minerals of the greenschist facies. Scapolite commonly occurs as small porphyroblasts.

Index minerals and metamorphic facies

Diopside and hornblende are widely distributed in the Argylla Formation, the Soldiers Cap Group, and the Corella Formation. These four minerals are characteristic of the amphibolite facies. The presence of cordierite and sillimanite (rather than kyanite) is typical of low-pressure facies series (Winkler, 1974). Garnet and andalusite are present in parts of the Soldiers Cap Group and the Corella Formation; garnet has also been recorded from the Knapdale Quartzite. These minerals are typical of upper greenschist facies. The knotted texture of the porphyroblastic rocks in Ppk_t are also consistent with greenschist facies metamorphism.

Scapolite, apatite, and sphene are widely distributed and appear to be unrelated to metamorphic grade. Plagioclase is commonly oligoclase, An_{12-18}, even in rocks of amphibolite grade; this is probably due to an abundance of sodium and preferential distribution of calcium to scapolite, diopside, and amphibole during metamorphism.

Biotite and chlorite are widely distributed by probably occur mostly in areas of retrogression associated with later shearing. In Pkc_{2b} in the northwest of the Sheet area diopside is altering to tremolite in a retrogressive reaction. Epidote and garnet may also be products of retrogression in some areas.

Contact metamorphism is difficult to distinguish from low-pressure regional metamorphism. Diopside is developed consistently in rocks adjacent to granite plutons (but it is also evident in more distant localities, especially in the Soldiers Cap Group). Near the eastern contact of the Burstall Granite, chlorite appears to be altering to hornblende. Many samples adjacent to granites show hydrothernal alteration, epidote and tremolite commonly forming from plagioclase, diopside, and ferrohastingsite.

The distribution of the various index minerals is shown in Figure 37.

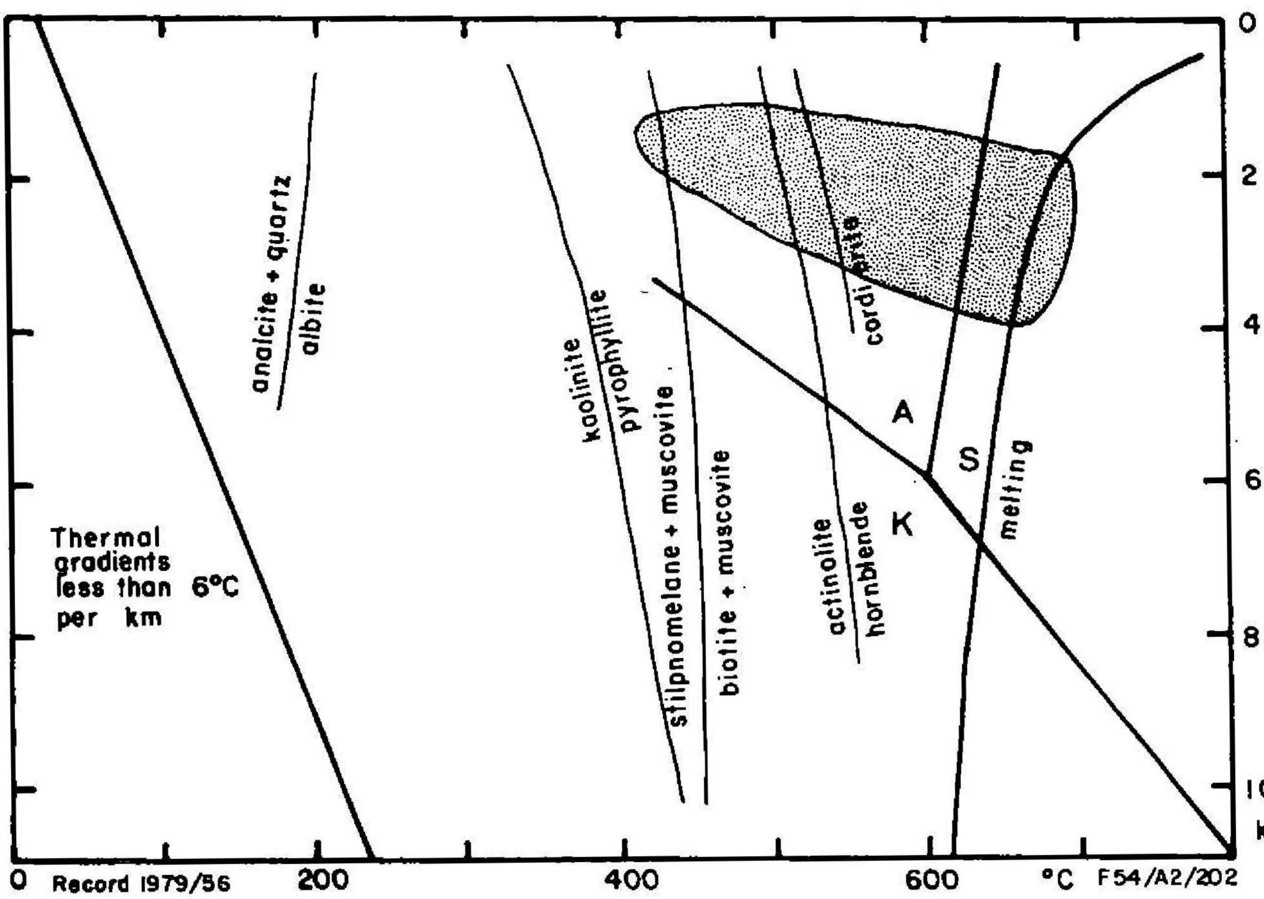

Fig 38 Possible pressure and temperature conditions during metamorphism in the Quamby Sheet area

Conditions and timing of metamorphism

Figure 38 indicates the possible range of pressure and temperature during the metamorphism: a temperature range from 400°C to 700°C and pressures ranging from about 1 kb to 4 kb are suggested.

The regional metamorphism is probably younger than deposition of the Knapdale Quartzite and the Lady Clayre Dolomite. The metamorphism is broadly related to intrusion of some of the granites, but retrogression near some granite contacts suggests that the granites were intruded after the main peak of metamorphism. Some metamorphism probably accompanied folding.

Isotopic dating by incremental-heating Ar^{39}-Ar^{40} techniques indicates that metamorphism of the Corella Formation began about 1570 m.y. ago in the Marraba Sheet area to the south (Green, 1975). K-Ar dating indicates that metamorphism had ceased by 1400 m.y. ago when Ar ceased to leak from the rocks and minerals. Page (1978) considered that the metamorphism was synchronous with the intrusion of the Wonga Granite, which has yielded a U-Pb zircon age of 1670 to 1625 m.y. As the Wonga Granite is deformed and metamorphosed, its age provides a maximum age of the metamorphism.

GEOLOGICAL HISTORY

Rocks in the Quamby Sheet area record a period of Proterozoic deposition from late in the formation of the basement succession (Tewinga Group), until late in the deposition of the eastern succession of the Cloncurry Complex. (Soldiers Cap, Mary Kathleen, and Mount Albert Groups). They are intruded by the Wonga, Burstall, and Naraku Granites, and by dolerite dykes, sills, and plugs, and are overlain by ?Adelaidean, Cambrian, Mesozoic, and Cainozoic strata.

Tewinga Group time

The Tewinga Group (Derrick & others, 1976a) extends from 1865 ± 3 m.y. to 1777 ± 7 m.y. according to U-Pb zircon dates determined for the Leichhardt Metamorphics and Argylla Formation by Page (1978). Only the upper part of this sequence (part of the Argylla Formation) is exposed in the Quamby Sheet area, but the similarity of the acid volcanics in this Sheet area to those in areas to the west suggest a similar environment. These acid volcanics are thought to have formed mostly as ignimbrite sheets from a chain of fissure volcanoes located near the western boundary of the Quamby Sheet area.

The prevalence of psammitic and calcareous sediments intercalated with the volcanics is evidence of possibly marine deposition and may indicate the location of the palaeoshoreline. Wilson (1978) established a continental margin model for the volcanic rocks of the Tewinga Group; this is consistent with the observations in the Quamby Sheet area.

The earliest phase of the Wonga Granite, a strongly sheared augen granite, may have been comagmatic with the Argylla Formation.

Soldiers Cap Group time

Some sediment was probably deposited in the east of the Quamby Sheet area during Tewinga Group time but the change of facies and lack of isotopic dates for the eastern area has prevented any correlations. The oldest rocks in the east of the Sheet area occur in the Boomarra Horst, and they have been assigned to the Soldiers Cap Group, which may be as old as the top of the Argylla Formation (Derrick & others, 1976b).

Deposition of mainly arenaceous sediments proably was accompanied by basic volcanism. Some of the dolerite dykes and sills in the Argylla Formation and the Soldiers Cap Group may have been intuded at this time.

A period of deformation may have occurred at the close of Soldiers Cap Group deposition, but it is not well documented in the Quamby Sheet area.

Mary Kathleen Group time

The beginning of Mary Kathleen Group sedimentation in the west of the Sheet area is marked by the relatively mature clean sand of the Ballara Quartzite. This is possibly a shoreline deposit that formed during a marine transgression. In the east no similar quartzite has been recognised, but quartzite near the top of the Soldiers Cap Group may be broadly equivalent.

Sand deposition was followed by deposition of calcareous siltstone of the Corella Formation. The uniform layering in this formation may indicate seasonal fluctuations in a shallow shelf or lagoonal environment. Sedimentation appears to have been slow as evidence of currents is scarce. Evaporites are thought to have formed at intervals in the deposition. The salts were probably remobilised during the later metamorphism to produce the scapolite which is abundant in this formation.

Towards the middle of Corella Formation time the shallow sea may have temporarily regressed, forming arenaceous sediments. Basic volcanics overlie these arenites in the west, where there was slight tectonism, but evidence of volcanism is absent in the east: a manganese and iron rich horizon at a similar stratigraphic level to the volcanics may represent a weathering profile formed during a break in deposition in the east.

The upper part of the Corella Formation contains relatively pure limestone and black shale. These rook types may have formed in deeper water on a marine shelf. The sulphide-bearing shales in the Dugald River lode probably formed in a deep depression in which euxinic conditions prevailed. Stromatolitic chert and anyhydrite pseudomorphs in the Lady Clayre copper mine/Dugald River area indicate a shallow, probably intertidal, environment.

Minor tectonism may have occurred at the close of Mary Kathleen Group deposition. The second phase of the Wonga Granite may have intruded in the west of the Sheet area at about this time. This Wonga Granite phase has yielded a U-Pb zircon age of 1671 ± 8 from an area near Mary Kathleen (Page, 1978).

Mount Albert Group time

In the Quamby Sheet area the Mount Albert Group is preserved only in the Dugald River block, immediately east of the Landsborough Graben. Deposition appears to have been most significant in the depression which contains the Dugald River lode. The scapolitic calc-silicate rocks at the top of the Corella Formation are overlain, apparently conformably, by calcareous sandstone at the base of the Knapdale Quartzite.

A break in sedimentation within this unit is marked by onlap of the feldspathic quartzite which overlies the calcareous sandstone. Later tectonism is recorded as the minor pebble conglomerate and micaceous siltstone in unit Ppk_t near the top of the Knapdale Quartzite.

A gradual return to quiescence, and the deposition of calcareous sediments at the top of this unit, indicate a marine shelf environment similar to the environment that existed for most of the Corella Formation deposition. The overlying 'Lady Clayre Dolomite' is locally pyritic or pyrrhotitic and possibly represents deposition in a basin with restricted circulation.

This is the youngest Proterozoic deposition recorded in the Quamby Sheet area, but sedimentation continued much later in areas to the west.

Granite intrusion, metamorphism, and crustal uplift in the Quamby Sheet area finally terminated deposition.

The major tectonic event

During the intrusion of the Naraku Granite and other granites and dolerite, the thermal gradient was probably steepened, leading to regional metamorphism. An intense folding event also occurred at about this time and strong axial-planar structures were formed. The folding was inhomogeneous, forming doubly-plunging folds. In the older rocks, folding intensity ranges from isoclinal to tight. In the younger rocks the folding is more open and basins-and-domes are typical of the 'Lady Clayre Dolomite'. Calc-silicate breccia formed in the intensely deformed areas of the Corella Formation. Some faulting was probably associated with the folding. The metamorphism was probably active at least 1570 m.y. ago, but had ceased by 1400 m.y., when the region had cooled sufficiently for the rocks to retain Ar (Green, 1975).

The strike-slip faults

After the folding major northeast-trending strike-slip faults developed, with dextral displacements in the range of 3 to 25 km.

Adelaidean events

Towards the end of the Adelaidean (or possibly early in the Cambrian) deposition of the Quamby Conglomerate began. As this unit is now preserved in grabens, sedimentation may have been restricted to these downfaulted blocks. On the other hand, sedimentation may have been more widespread, possibly occurring throughout the Landsborough Graben and areas to the southeast. The abundance of conglomerate in the southeast possibly indicates nearby source areas with appreciable relief.

Cambrian events

The lower unit of the Kajabbi Formation has yielded no fossils to confirm its Cambrian age but it appears to be conformably overlain by the Middle Cambrian fossiliferous unit. The Kajabbi Formation extends throughout the Landsborough Graben and almost certainly was much more extensive. The upper unit shows no evidence of a basin margin faceis adjacent to the Pinnacle Fault which is the western boundary of the graben. The Cambrian deposition may have been continuous with deposition in the Georgina Basin, 100 km to the west. Subsequent uplift of the Mount Isa Inlier may have completely removed the Cambrian strata by erosion, except for sequences of greater thickness preserved in deeper basinal area.

Mesozoic events

Activation of north-trending normal faults possibly began late in the Triassic, and the Landsborough Graben may have begun to form as part of the Burketown Depression (Doutch & others, 1970).

Deposition of a fluvial sandstone was followed by mudstone and fossiliferous limestone of marine origin until Cretaceous time. Minor reactivation of the north-trending normal faults continued into the Cainozoic.

Cainozoic events

The early Cainozoic was probably marked by extensive erosion leading to peneplanation of the region. Deep weathering and development of a duricrust occurred in the mid-Tertiary until the final movement on the north-trending faults occurred.

Deposition of colluvium and the Wondoola Beds probably began late in the Tertiary and extended into the Quaternary. Alluvium and soil development is mostly due to Quaternary deposition.

ECONOMIC GEOLOGY

History

The discovery of gold in the Bower Bird area (in the adjoining Prospector Sheet) in 1867 led to an influx of prospectors to the Cloncurry region. Later in the same year gold was also discovered at Top Camp, south of Cloncurry, and subsequently in the Pumpkin Gully, Gilded Rose, and Soldiers Cap areas near Cloncurry. The life of the goldfields was shortlived, and by 1872 most of the miners had left for the Palmer Gold Field in northeastern Queensland.

Lees (1907) reported that Ernest Henry, in association with Roger Sheaffe, had discovered 'extensive copper deposits' in the Cloncurry district as early as 1865. Henry had taken out a mineral selection over the Great Australian copper deposit, near Cloncurry, in 1867. The search for copper became increasingly important from that time, especially after the decline in production from the goldfields.

The route chosen for the track to the Bower Bird Gold Field undoubtedly influenced the discovery and development of copper prospects in the Quamby Sheet area. It went from Cloncurry northwest to Quamby, then to the Longamundi Waterhole on the Dugald River, round the northern end of what is now the Knapdale Quartzite, and then due west to the Leichhardt River and the Gold Field. Prospecting activity was greatest near this access road. The first official Cloncurry report in 1880 referred to the securing of lodes at the Dugald River. Ball (1908) described three groups of mines and prospects adjacent to the Dugald River - the Una, Lady Clayre, and Longamundi groups.

Lack of communications retarded the growth of mining activity, but the completion of the rail link to Cloncurry from Townsville in 1908 provided a cheap means of transport to the port of Townsville and the smelters at Chillagoe and in the south. The erection of smelters on the field also provided incentive for mining, and the region recorded its highest production in the years 1911-1920.

The release of government control on the price of copper in 1918, and the closure of the last smelter in 1920 contributed to a decline in the search for, and exploitation of, copper prospects. At this time the emphasis on prospecting had turned to cobalt. Cobalt mineralisation was discovered at the Queen Sally mine in 1924, and later at the Centipede lode. Both these mines were of limited extent and neither had significant production. The discovery of gold at Mount Quamby in 1908 was of minor interest because the deposit was not extensive.

Mining activity increased in the region during the Second World War when the lead smelter at Mount Isa Mines was converted to treat copper ores. The smelter reverted to lead production in 1946, resulting in a slump in production from small mines such as those in the Quamby Sheet area. The completion of the copper smelter at Mount Isa in 1953 resulted in renewed production from the smaller mines. The need for high-grade carbonate for flux for use in the smelters led to the discovery and development of mines such as the Quamby Queen, 2 km northwest of Quamby.

Since then, mining in the Quamby Sheet area has been sporadic, reaching a peak during the 'mineral boom' of the late 1960s when it became possible to work small mines economically. The first Authority to Prospect was granted in 1932; up to December 1978, 59 of them had been granted in the Sheet area (Table 17). Figure 39 shows areas covered by stream-sediment geochemical surveys in the Quamby Sheet area.

The extent of mining activity in the Sheet area has been less than in Sheet areas to the west and south, and only 23 mines have recorded production of 1 tonne or more of copper metal. Two limestone mines, one gold mine, and one cobalt mine have recorded production (Table 18). The major mineral resource in the Sheet area has been copper followed by gold, limestone, and cobalt. Lead zinc at Dugald River constitutes a major, but as yet subeconomic, resource in the Sheet area. The following sections present brief descriptions of the occurrences of the major metals and their ores as well as the non-metallic minerals.

Metalliferous minerals

Cobalt

Cobalt occurrences are common in the western half of the Sheet area, at the northern extent of a belt of cobalt mineralisation which extends from Kajabbi in the north to Mount Cobalt in the south. They have been described by Rayner (1938) and Brooks (1979).

TABLE 17.

COMPANY REPORTS FOR AUTHORITIES TO PROSPECT, QUAMBY SHEET AREA

A to P No.	Company	Date Granted	Date Revoked	Qd Mines Dept, Company Report (CR) No.
-	Mount Isa Mines	2/32	5/32	NR
-	Mount Isa Mines	11/33	7/34	NR
-	Mount Isa Mines	3/35	12/36	NR
-	Broken Hill South	2/49	12/52	NR
-	Consolidated Zinc	11/51	4/53	NR
5	Uranium Search	5/54	4/55	3006
29	Enterprise Exploration	6/56	6/58	123, 124, 147, 148, 149
41	Mount Isa Mines	8/56	3/57	81
84	Rio Tinto	1/57	10/58	151, 243
97	Rio Tinto	4/57	10/58	243
128	Rio Tinto	10/58	11/60	357, 358, 391, OR
170	Consolidated Zine & CRA	11/60	1/64	690, NA
204	Mount Isa Mines	10/60	10/66	OR
222	Noranda & Placer/Ausminda	8/63	8/66	1509, 2025
232	CRA Exploration	10/63	10/64	OR
242	Ausminda	4/64	9/66	1509, 1907, 2409
284	Australian Selection	8/65	10/66	2022
308	Australian Selection	1/66	11/67	2161, 2362
309	Ausminda	1/66	5/68	2122, 2393
359	Mount Isa Mines	8/66	10/69	2449, OR, NA
362	Kennecott Explorations	7/66	2/68	2107, 2497
367	Carpentaria Exploration Co.	12/66	2/68	2496, 2550, NA
380	CRA Exploration	8/66	12/68	2110, 2261, 2451, 2789, OR
391	Kennecott Explorations	4/67	6/67	2216
504	Australian Aquitaine Petroleum	4/68		2755, 4718
622	CRA Exploration	6/69	4/70	3256, 3313
623	CRA Exploration	6/69	5/70	3256, 3313

A to P No.	Company	Date Granted	Date Revoked	Qd Mines Dept, Company Report (CR) No.
546	Nickel Mines	8/69	8/71	3973
655	Placer & Newmetal	7/69	7/71	3654
723	Placer Prospecting	1/70	3/71	3497
794	VAM	5/70	6/72	NR
1069	Austral Pacific	9/70	9/72	4240
1133	Oilmin	11/72		4883
1296	Carpentaria Exploration Co.	8/73		5240, 5572
1270	Carpentaria Exploration Co.	8/73		5241, 5645
1304	CRA Exploration	10/73		5221, 5321
305	CRA Exploration	10/73		5196, 5613, 5770, 5771
312	Australian Aquitaine Petroleum	11/73		5137, 5711
330	CRA Exploration	12/73	12/74	5281, 5439
370	Union Miniere	6/74		5300, 5412, 5647, 5732
390	Chevron Exploration	7/74		5267, 5392
404	Otter Exploration	8/74		5124
422	Chevron Exploration	9/74		5254, 5388
423	Otter Exploration	9/74		5105
425	CRA Exploration	9/74		5316, 5770
435	Otter Exploration	10/74		5121, 6000
441	Chevron Exploration	1/75		5294, 5523
560	Carpentaria Exploration Co.	9/75		5645, 5966, 6043, 6448
727	Dampier Mining	12/76		6229
762	CRA Exploration	5/77		NA
766	Dampier Mining	5/77	4/78	6293, 6490
781	Mines Administration & Teton	5/77		NA
832	Mines Administration & Teton	9/77		NA
865	Mines Administration & Teton	11/77		NA
866	Mines Administration & Teton	11/77		NA
920	Aust. & NZ Exploration	2/78		NA

A to P No.	Company	Date Granted	Date Revoked	Qd Mines Dept, Company Report (CR) No.
1977	Marathon Petroleum	5/78		NR
1983	CRA Exploration	5/78		NR
2044	CRA Exploration	9/78		NR

NA - Reports not available

NR - No reports

OR - Other reports, not relevant to Quamby Sheet area

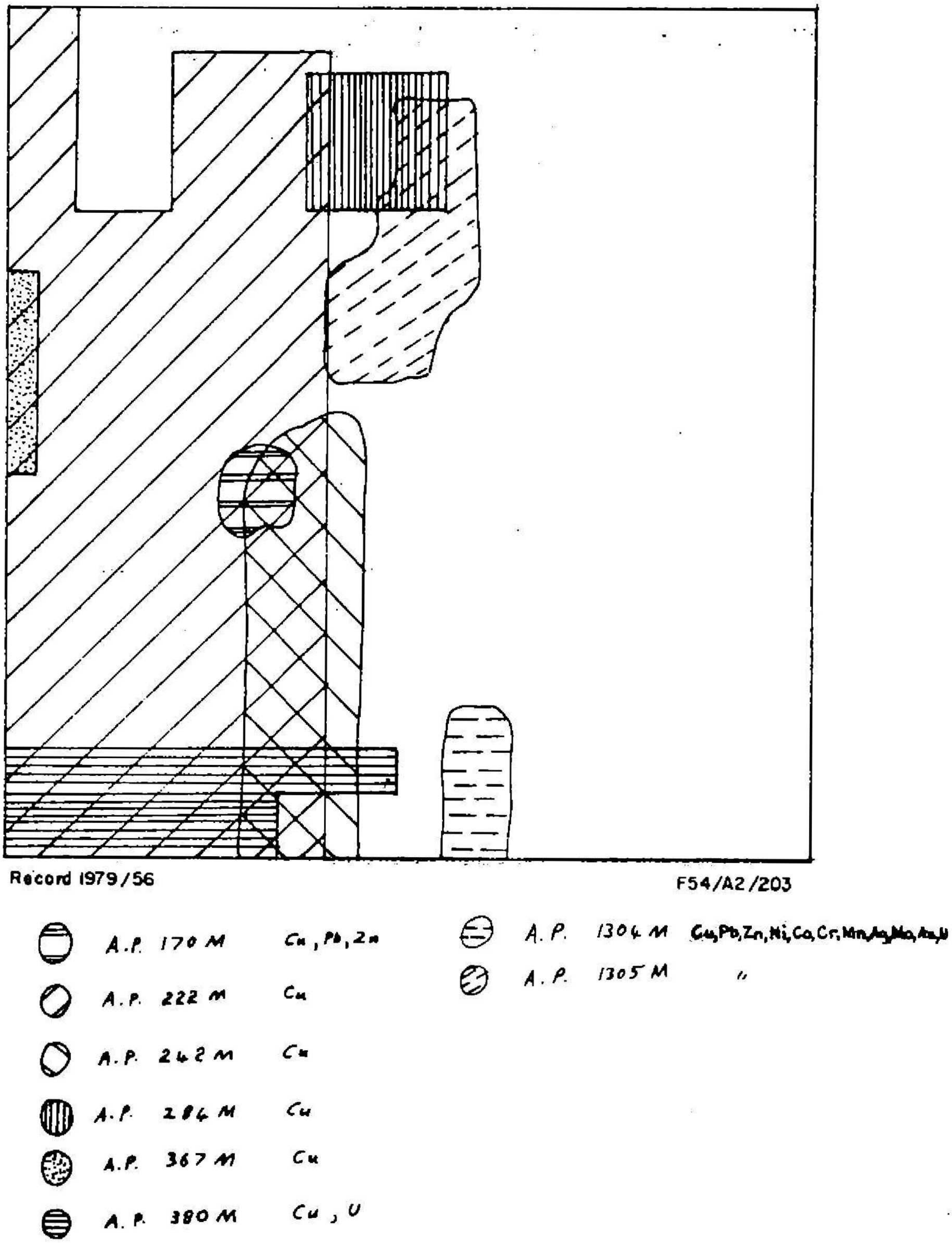

Fig. 39 Areas covered by stream-sediment geochemical surveys, Quamby 1:100 000 Sheet area

TABLE 18. PRODUCTION FROM MINES IN THE QUAMBY SHEET AREA TO DECEMBER 1978

Mine	M.L. No.	Years of production	Ore (tonnes)	Cu (tonnes)	Au(g)	Ag(g)	Co(tonnes)	Ls(tonnes)	W(tonnes)
Bedford	6310	1938,42-45,56,71-74	368.2	20.67					
Bohemian Girl	5877	1943,44,57	522.9	47.3	167.2				
Borehead	6016	1968	64.6	2.4					
Companion		1942,43	82.2	7.1	206.8				
Copper Blonde		1957,58, 76-77		37.6				10926	
Dugald area		1905,06	43.6	13.2					
Gem	1747	pre 1936	5.0	1.0	19.8				
General, The									6
Jenny Lea	6785	1970, 71	15.8	1.8					
Koolamarra area		1953	103.6	14.6					
Lady Clayre	5700	1920	524.6	25.7		1379.9			
Late Volga	6336		316.2	22.8					
Magnet	450	1906,14,15,17,19, 23,28 1938-40	5945.4	735.9	6552.2				
Mount Godkin	1486	1908,09,22,23	26.4						
Mount Quamby		1921,31-35	54.5		5505.8				
Naraku area			779.2	95.3	773.7				
Naraku squibs		1939,41,43,44	26.4	1.0	130.3				
Native Companion	6284	1905,07,09,11,12,17, 23,27, 1941,42,69,70	577.9	97.9	325.9				
North Bedford		1943,45	15.2	1.8					
North Volga		1941, 42	60.9	6.6		113.3			
Quamby Queen		1948-53						2094.7	
Queen Sally	6813	1925	26.2				2.6		
Roseby	6260	1969	22.7	1.0					
Tin Lizzie		1942,43,45	41.6	5.8	28.3				
Una	280	1905-08,27	174.7	32.7	946.5				
Volga	3832	1913,14 1940-43	200.9	27.8	476.1				
Wallaby Hill	6786	1971	26.1	1.1					
Wallaroo Flat	MF2873	1926	61.6	7.5	127.5				

Two lodes have been mined: the Queen Sally (Saint Smith, 1925) and the Centipede. The Queen Sally, which is 16 km southeast of Kajabbi, was the major cobalt mine in the district. The cobalt is present as black oxide (asbolite) in association with limonite and quartz; erythrite and cobaltite occur in patches. Malachite and azurite are also present in the lode.

At the Centipede lode, 11.2 km south-southwest of Kajabbi, asbolite (hydrated manganese oxide and cobalt oxide) is associated with malachite, chrysocolla, calcite, and silica in vein deposits in amphibolite. The ore grade is 0.3 percent to 0.6 percent cobalt (Rayner, 1938).

The Dugald River region has scattered cobalt mineralisation. At the Godkin mine, 1 km west of the Dugald River, malachite and azurite with veins and crusts of erythrite occur in slate at the contact with impure and siliceous limestone. At the Coocerina lode, 24 km west of the Godkin mine, black oxide (asbolite) is associated with copper mineralisation. Cobalt mineralisation is also present at the Lady Belle lode, in the Native Companion area.

Copper

The controls on copper mineralisation in the Cloncurry region were discussed in detail by Carter & others (1961), Derrick & others (1971), and Wilson & others (1972). The history and production of copper mining in northwest Queensland to 1959 was summarised by Carter & others (1961). Recorded production from mines in the Sheet area to 1973 is presented in Table 18.

Although copper deposits were discovered in the Sheet area in the 1880s, large-scale mining did not commence until the late 1930s. The largest producing mine in the Sheet area was the Magnet (735.9 tonnes Cu); most other mines produced less than 50 tonnes of copper metal.

Copper mineralisation is concentrated in the western half of the Sheet area. Nearly all known copper deposits are tectonically controlled, occurring in shear zones and fault zones. The copper deposits associated with the gold prospect at Mount Quamby (GR 139462) are unique, being stratigraphically rather than structurally controlled (Carr, 1971a, b). The mineralisation is malachite, chrysocolla, pyrolusite, and lepidocrocite, restricted to bands averaging 15 m in width and nowhere wider than 100 m.

The majority of deposits occur within the siltstone, slate, limestone, and calc-silicate rock of the Corella Formation. The Volga group of mines, 8 km northwest of Mount Maggie, occur within the coarse porphyritic phase of the Wonga Granite. The Naraku and the Gem both occur within the Naraku Granite. Chalcopyrite has been recorded locally in the Naraku Granite.

Secondary mineralisation is the major source of ore. Malachite and azurite occur in most mines in association with ferruginous and gossanous siliceous material. Chrysocolla, cuprite, chalcocite, and minor covellite also occur.

Primary mineralisation has been intersected only at the larger mines. Chalcopyrite is the major ore mineral. At the Bedford and the Magnet it occurs in sheared and altered basic rocks. At the Volga Group and the Bohemian Girl, chalcopyrite with minor bornite and covellite has been intersected at depth. Chalcopyrite also occurs in association with the Copper Blonde limestone deposit (Brooks, 1957).

At the time of inspection (1973-75) the Bedford was the only mine operating on a regular basis. The decline in mining activity can be attributed to falling copper prices in the period 1973-77, but rising prices in 1978-79 should result in a resurgence of gouger activity in the area.

Gold

Gold was discovered in the Mount Quamby area in 1908. Alluvial deposits were worked intermittently, but the major source of gold was the Quamby Conglomerate. The gold occurs in the matrix of the conglomerate and is considered to be of alluvial origin, derived from copper-gold deposits in the older Corella Formation (Ball, 1921). The gold is erratically distributed throughout the conglomerate and this fact, combined with the lack of water for treatment, caused the Mount Quamby Gold Mining Company to close its stamp battery after only a brief period of operation in 1921. No mining for gold has been carried out since that time.

Iron

In Sheet areas to the south, iron deposits have been worked on a small scale for ironstone flux for copper smelting (Brooks, 1956). Most of the deposits are of hydrothermal replacement type and consist largely of hematite. In the Sheet area several lensoidal ironstone bodies occur in the Corella Formation 3 km southeast of Mount Roseby homestead. The mineralisation is mainly hematite with minor magnetite adjacent to the contact with the Naraku Granite.

Lead-zinc

The Dugald River prospect is a low-grade deposit of apparently stratiform lead-zinc mineralisation (Knight 1953, 1965; Whitcher, 1975). A great deal of interest has been shown in this prospect owing to its similarity to the Mount Isa deposit, although it is thought to be slightly older (Plumb & Derrick, 1975). The deposit occurs in graphitic and calcareous shales of the Corella Formation. Abundant scapolite and some pseudomorphs after anhydrite indicate that evaporative conditions may have existed near the metal-bearing shale basin.

Ferruginous gossans and iron oxides are developed on the Dugald River deposit in places, and there are scattered occurrences of lead oxides and copper carbonates. The lode crops out in the form of a ridge over 1.5 km in length.

Zinc has been completely leached from the upper levels of the Dugald River lode, but is five to ten times more abundant than lead in the primary zone. Lead and zinc occur at the surface and in the primary zone, but the grade decreases with depth. The ratio of silver to lead is about 1 g silver per 1 percent lead. Minor amounts of gold also occur. The primary sulphides in the Dugald River lode are pyrrhotite, sphalerite (marmatite), galena, pyrite, arsenopyrite, tetrahedrite, and pyrargyrite. Cerussite and both yellow and red lead oxides occur in the oxidised zone, which is about 40 m deep (Knight, 1953).

The lode occurs in a shear zone between two strike faults, dips steeply west, and pitches shallowly to the north. The main ore shoot has been intersected at a depth of 260 m (Knight, 1953). Reserves of 1 280 000 tonnes grading 11.6% Zn, 1.6% Pb, and 37 g/t Ag (Whitcher, 1975) have been recently upgraded to 40 million tonnes at a grade of 10-12% Zn equivalent (CRA, 1977).

Manganese

The only reported occurrences of manganese are in association with cobalt deposits. Asbolite occurs at the Centipede lode, the Queen Sally, and at the Coocerina lode and the Godkin lode in the Dugald River area. Asbolite is essentially hydrated oxide of manganese, containing a variable percentage of cobalt oxide (up to 40 percent) mechanically mixed with it. None of the occurrences is of economic interest.

Molybdenum

Molybdenite occurs at two localities. It is found in association with copper ores at the Magnet, 16 km northwest of Quamby, and in siliceous veins in aplitic granite near the Native Companion, 14 km southwest of Quamby.

Nickel

Nickel occurs in association with cobalt at the Queen Sally cobalt mine. Carter & others (1961) reported that one sample of ore assayed 0.8 percent nickel.

Tungsten

Scheelite has been mined at The General, which is 27 km south of Kajabbi by road. It occurs as pockets and fine disseminations in quartz veins, associated with a large lens of calcite in hornblende schist (Shepherd, 1946a). The recorded production is 6 tonnes of tungsten.

Non-Metallic minerals

Amethyst

An outcrop of poor quality amethyst is located to the west of the Burke Developmental road 8 km north-northwest of Quamby. It occurs in medium-grained Naraku Granite, and is of mineralogical interest only.

Diopside

Large crystals of diopside occur in the coarse crystalline calcite at the Quamby Queen limestone deposit. Some crystals are up to 30 cm across. The occurrence is of mineralogical interest only.

Limestone

Two deposits of limestone in the Sheet area, the Quamby Queen and Copper Blonde, have been mined for use as flux in the smelting of base metals.

The Quamby Queen deposit is about 3 km north of Quamby. It is composed of coarse crystalline calcite with numerous pods of diopside crystals. The last recorded production from the deposit was in 1953. The cost of selective mining necessary to remove the diopside now makes the deposit uneconomic.

The Copper Blonde deposit is 25 km southwest of Quamby, to the west of Mount Godkin Range. It is composed of coarsely crystalline calcite which has been formed by the deposition of limestone in favourable structural features, or the recrystallisation of lenticular beds of limestone in situ. The value of the deposit is enhanced by the presence of small pockets and veins of copper ores - malachite and chalcocite at the surface, and primary chalcopyrite only a few feet below the surface. Over 10 926 tonnes of limestone were extracted from this deposit in the two years of its operation, 1957 and 1958.

Large deposits of secondary limestone have been developed recently in the Pooncarie mine area, 8 km south-southwest of Kajabbi.

Sphene

An outcrop of coarse crystalline sphene occurs at the northern end of Longamundi Waterhole, on the Dugald River. The sphene occurs in association with red feldspar (coloured by fine hematite) and diopside in grey schists. Veins of aplite and pegmatite intrude the schist adjacent to the 'red rock'. The occurrence is of mineralogical interest only.

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