DEPARTMENT OF
~~NATIONAL RESOURCES~~
NATIONAL DEVELOPMENT

# BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS



Record 1979/24



## GEOLOGY OF THE KENNEDY GAP 1:100 000 SHEET AREA (6757), QUEENSLAND



by

I.H. Wilson, R.M. Hill, T.A. Noon, B.A. Duff, and G.M. Derrick

Record 1979/24

# GEOLOGY OF THE KENNEDY GAP 1:100 000 SHEET AREA (6757), QUEENSLAND

by

I.H. Wilson, R.M. Hill, T.A. Noon, B.A. Duff, and G.M. Derrick

CONTENTS

*Initials indicate chief authors of various sections

FIGURES

TABLES

## ABSTRACT

The Kennedy Gap 1:100 000 Sheet area (6757) lies between 20°00'S and 20°30'S, and 139°00'E and 139°30'E. Mount Isa lies about 25 km south of the southeastern corner of the Sheet area.

The Sheet area contains mainly Precambrian rocks, and some Cambrian and Mesozoic strata. Precambrian rocks are of Carpentarian age and belong to the Haslingden, Mount Isa, and McNamara Groups, and the Sybella Granite.

The Haslingden Group contains the oldest rocks. At the base are feldspathic sandstone, tuff, siltstone and metabasalt of the lower Leander Quartzite, overlain by orthoquartzite of the upper Leander Quartzite. This is overlain conformably by the basaltic Eastern Creek Volcanics, which in the east are overlain by Myally Subgroup sandstone. In the west they are conformably overlain by the Judenan Beds, probable correlatives of the Myally Subgroup.

A major phase of dolerite intrusion preceded the intrusion of the granite; rare dolerite dykes postdate the granite. The Sybella Granite intrudes the Eastern Creek Volcanics and the Judenan Beds; uplift, folding, and erosion of the Judenan Beds occurred before extrusion of rhyolite and minor basalt of the Carters Bore Rhyolite, which was followed by a further period of uplift and erosion.

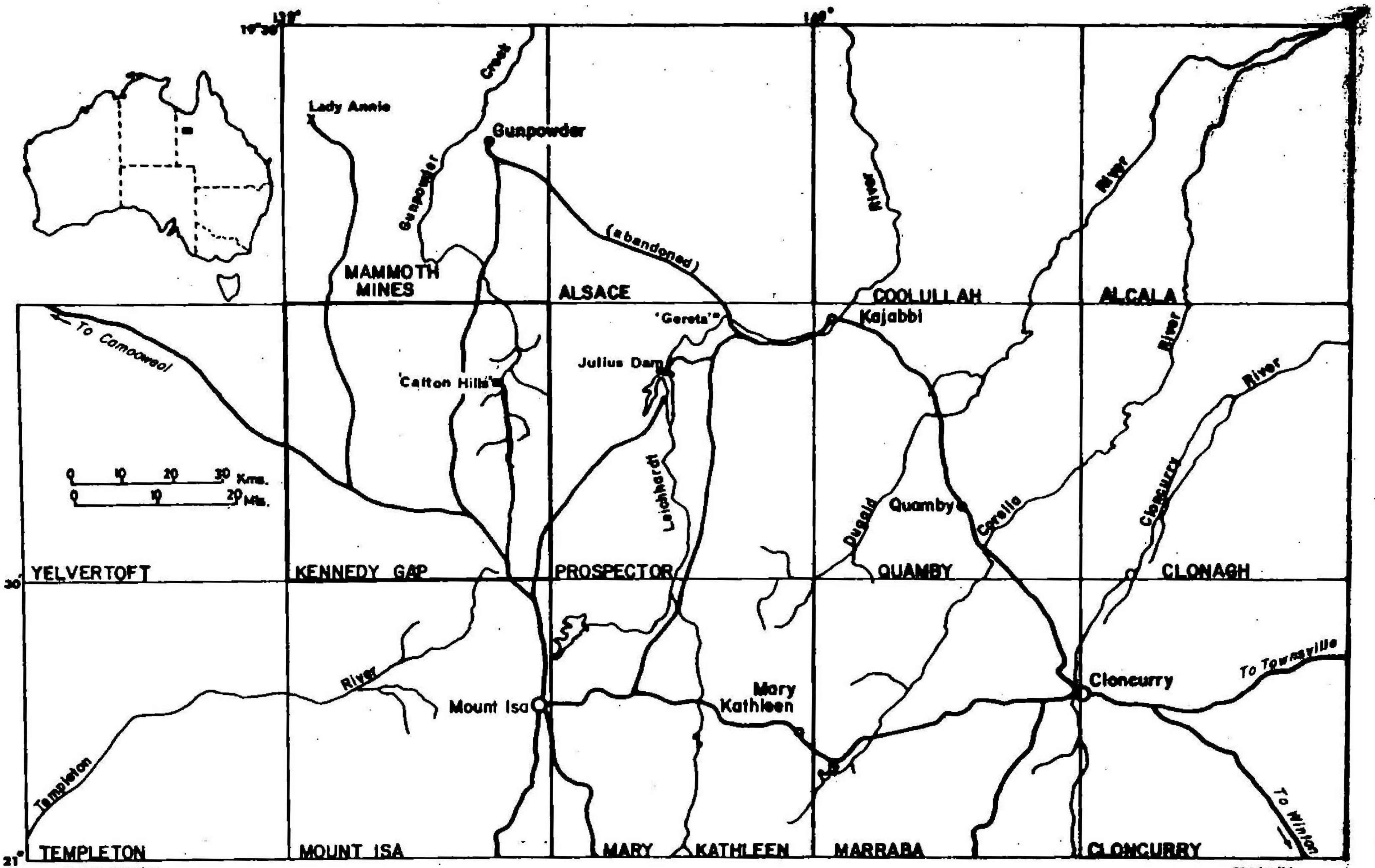
Deposition of conglomerate, sandstone, and siltstone of the Mammoth Formation was followed by the Warrina Park Quartzite - the basal formation of the Mount Isa Group; similar rocks in the west of the Sheet area comprise the Torpedo Creek Quartzite Member of the Gunpowder Creek Formation - the basal, mainly siltstone-rich formation of the McNamara Group. Probable correlatives in the Mount Isa Group are the Moondarra Siltstone and the Breakaway Shale. The Mount Oxide Chert Member of the Paradise Creek Formation separates the Gunpowder Creek Formation from the overlying dolomitic Paradise Creek Formation, equivalents of which to the east are assigned to the Native Bee Siltstone.

The Paradise Creek Formation is overlain conformably by the dolomitic and stromatolitic Esperanza Formation, which is overlain by the Lady Loretta Formation (dolomitic and carbonaceous siltstone and shale) and Shady Bore Quartzite. The Riversleigh Siltstone, the youngest Carpentarian unit, overlies the Shady Bore Quartzite conformably.

A major period of folding produced north-south-trending folds, or basins and domes, associated with a north-trending cleavage and low greenschist facies metamorphism. Contact metamorphism about the Sybella Granite has produced hornblende hornfels facies rocks which are locally retrogressed to greenschist facies.

Some east and northwest-trending faults appear to have been active as early as deposition of the McNamara and Mount Isa Groups. North-trending faults repeat folded sequences of these younger groups. The most recent faults appear to be northeast and northwest-trending strike-slip faults.

Carpentarian rocks in the Sheet area have produced a small amount of copper and gold; uranium and lead-zinc prospects have been extensively investigated.




Record 1979/24

F54/A1/85

Fig.1 Location map KENNEDY GAP 1:100 000 Sheet area

# INTRODUCTION

## Location

The Kennedy Gap 1:100 000 Sheet area (6757) lies in northwest Queensland and is bounded by latitudes 20°00'S and 20°30'S, and longitudes 139°00'E and 139°30'E (Fig. 1). It forms the northeastern portion of the Mount Isa 1:250 000 Sheet area SF/54-1. The city of Mount Isa, which is about 1970 km by road from Brisbane, is situated 25 km south of the southeast corner of the Sheet area.

## Object

This Record presents the results of detailed reconnaissance geological mapping of the Kennedy Gap 1:100 000 Sheet area by members of the Bureau of Mineral Resources (BMR) and Geological Survey of Queensland (GSQ). Records on the geology of five 1:100 000 Sheet areas to the south and east, Cloncurry (7056) (Glikson & Derrick, 1970), Marraba (6956) (Derrick & others, 1971), Mary Kathleen (6856) (Derrick & others, 1974), Mount Isa (6756) (Hill & others, 1975) and Prospector (6857) (Wilson & others, 1977) have already been completed. The Mary Kathleen study has recently been published (Derrick & others, 1977).

The aims of the survey were to:

1. present a map at 1:100 000 scale of the Precambrian geology;

2. reassess the stratigraphy, structure, petrology, economic geology, and geological history of the region;

3. prepare a detailed report of the geology.

## Access

Access to and within the Sheet area is generally good. The sealed Barkly Highway traverses the southern part of the Sheet area. Two well-formed earth-roads traverse northwards from the Barkly Highway: the more westerly one, known locally as 'McNamara's highway' leads to the Lady Annie copper mine and

Lady Loretta lead-zinc deposit in the Mammoth Mines 1:100 000 Sheet area, to the north; the more easterly road leads to the township of Gunpowder and the Mammoth and Mount Oxide copper mines. A third parallel minor road gives access to Calton Hills station and continues northwards along the Gunpowder Creek valley.

A network of pastoral and mining tracks gives good access to the rest of the area. A landing ground has been constructed at Calton Hills.

## Population and industry

There are no townships in the Sheet area and Calton Hills is the only occupied dwelling. The old May Downs homestead has been replaced by a new homestead farther south in the Mount Isa 1:100 000 Sheet area.

Cattle-raising is the only significant industry in the area. Calton Hills, May Downs, and Yelvertoft lease most of the Sheet area for grazing. Despite intensive prospecting, little mining has taken place within the Sheet area.

## Climate

The area has a semi-arid tropical climate with well-defined wet and dry seasons. Nearly all the rain falls between November and April; the peak months are January and February. The area lies between the 400 mm and 500 mm isohyets of annual rainfall, which trend northwest; rainfall increases to the northeast. Most rainfall results from isolated storms yielding 20 to 50 mm; however, some general rain accompanies the weak monsoonal activity during the summer. Minor falls up to 5 mm occur in the winter months.

The annual average maximum temperature for the area is about 32 $^{o}$C and the annual average minimum temperature is about 17 $^{o}$C. The highest monthly average maximum is 38 $^{o}$C, in December, and the lowest monthly average minimum is 8 $^{o}$C, in July. Relative humidity is low, ranging from about 25 percent during winter to a maximum monthly average during the wet season of about 50 percent. Detailed accounts of the climate of the area are given by Slatyer & Christian (1954) and Slatyer (1964).

## Vegetation

Detailed accounts of the vegetation and pasture in the Sheet area are given by Perry & Christian (1954) and Perry & Lazarides (1964); a summary is given by Carter & others (1961) and an illustrated popular account of both the flora and fauna is given by Horton (1976).

The vegetation is well stratified into a tree layer and a grass layer, each of which is classified into communities on the basis of its prominent species. The eastern part of the Sheet area carries the same communities as the Prospector Sheet area, to the east: mainly the Isa Highland Sparse Low Woodland and the Western Spinifex Communities, which are generally found together. The species of the Isa Highland Sparse Low Woodland Community are Eucalyptus brevifolia (snappy gum), E. terminalis (bloodwood), E. argillacea (western box), E. pruinosa (silverleaf box), E. papuana (ghost gum), Acacia spp., and Cassia spp. The species of the Western Spinifex Community are Triodia pungens (soft spinifex), T. burkensis, T. molesta (hard spinifex), and T. longiceps.

Species of trees that grow in communities mainly restricted to watercourses include Eucalyptus camaldulensis (river red gum) and Melaleuca leucadendron (paper bark), and to a lesser extent Hakea lorea (corkwood) and Acacia cambagei (gidyea), and in limey soils Bauhinia cunninghamii (bean tree). Grevillea stricta (beef wood), G. wickhamii, and G. dryandiiare common on the tops of most planated ridges. The Arid Short Grass Community - Aristida arenaria (kerosene grass) and Euneapogon spp.- grows in small patches in valleys throughout the Sheet area.

The gently undulating plains with low rubbly rises in the western part of the Sheet area are also characterised by Eucalyptus brevifolia and Triodia spp. Low stunted Eucalyptus spp. (mallee), Acacia spp. (wattle), and Cassia spp. form areas of scrubland on the plains also; isolated clumps of gidyea (Acacia cambagei and A. georginae) are also common. Both Astrebla spp. (Mitchell grass) and Iseilema spp. (Flinders grass), associated with green herbaceous plants, grow on the restricted black-soil plains which have formed in areas of poor drainage.

## Water resources

Most of the creeks and rivers in the Sheet area contain surface water only during and for a few weeks after the main wet season. Large permanent waterholes are restricted to Mingera Creek, Wilfred Creek, Gunpowder Creek, Gidya Creek, and the Buckley River. Minor rockholes in rugged quartzite and slate terrains are generally inaccessible to cattle. Bores located on the alluvial flats along major watercourses, and earth dams supplement the natural surface waters for the pastoral industry.

## Previous literature

Carter & others (1961) have listed a comprehensive bibliography of geological work carried out in the Precambrian belt of northwest Queensland before 1960. Reports dealing with the Kennedy Gap Sheet area are also listed in the bibliography of this Record along with more recent relevant works up to 1977.

De Keyser (1958), Carter & others (1961), Cavaney (1975), and Holyland (1975) have described the most important regional geological mapping in the Kennedy Gap Sheet area.

The available aerial photographs, photomosaics, and maps for the Sheet area are listed in Table 1.

## Present investigation

This Record presents the results of mapping by a team of five geologists, two from GSQ (IHW,TAN) and three from BMR (RMH, BAD, GMD) during 1974. Vehicle traverses were made where possible, and extensive foot traverses covered the area in an irregular grid with spacings generally less than 2 km.

1:25 000 colour aerial photographs were used in the detailed reconnaissance mapping but 1:85 000 black and white photographs were used for the detection of large-scale structures. The geological overlays were compiled by M.R. Little using Division of National Mapping 1:100 000 topographic bases enlarged to photoscale.

The following rock classifications have been used in this Record: Streckeisen's (1967) for igneous rocks; Crook's (1960) and Folk's (1968) for sedimentary rocks; and Winkler's (1974) and Joplin's (1968) for metamorphic rocks.

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 (Compton, 1962). All specimen numbers prefixed by M are GSQ microslide numbers; all other numbers are BMR-registered numbers with the prefix 7420 deleted. 'Agd' is used in tables for average grain diameter, measured in millimetres.

Table 1. Photographic and Cartographic Coverage, Kennedy Gap Sheet Area

(a) Photographic coverage of whole Sheet area.

(1) 1950 1:50 000 K17 flown by RAAF for Division of National Mapping

(2) 1966 1:85 000 RC9 flown by Adastra for Division of National Mapping

(3) 1970 1:50 000 flown by Adastra for Lands Department, Queensland

(4) 1972 1:25 000 (colour) flown for Division of National Mapping.

(5) Mosaics of (1) and (2) available from Division of National Mapping

(b) SLAR Imagery at 1:100 000 flown in 1972 by Goodyear-Aerospace for the Department of National Development covers the southern part of the Sheet area. Available from Division of National Mapping.

(c) LANDSAT images showing percentage cloud cover (available from Division of National Mapping)

| | |
|---|---|
| 1027 - 00123 | 0 |
| 1117 - 00132 | 20 |
| 1189 - 00131 | 50 |
| 1207 - 00133 | 10 |
| 1315 - 00131 | 10 |
| 1402 - 00120 | 70 |
| 2059 - 00012 | 0 |
| 2239 - 00001 | 0 |
| 2292 - 23594 | 0 |

These scenes have a Nominal Scene Centre 106-074. A brochure - 'Air Photographs and Related Products', available from the Department of National Resources, Division of National Mapping - shows the location of Nominal Scene Centres. A microfiche catalogue listing all scenes is also available from the Division of National Mapping.

(d) Maps of Sheet area

(1) 1960 1:250 000 topographic map SF 54-1 (Mount Isa) Division of of National Mapping
(2) 1972 1:100 000 topographic map 6757 (Kennedy Gap) Division of of National Mapping
(3) current 1:100 000 Mining Lease Atlas Map 6757 (Kennedy Gap), Mines Department, Queensland
(4) current 1:250 000 Mining Lease Atlas Map SF 54-1 (Mount Isa), Mines Department, Queensland
(5) current 1:1 000 000 Block Identification Map, Series B, (Cloncurry), Mines Department, Queensland
(6) current 1:2 534 400 Authority to Prospect (Minerals) Map of Queensland, Mines Department, Queensland

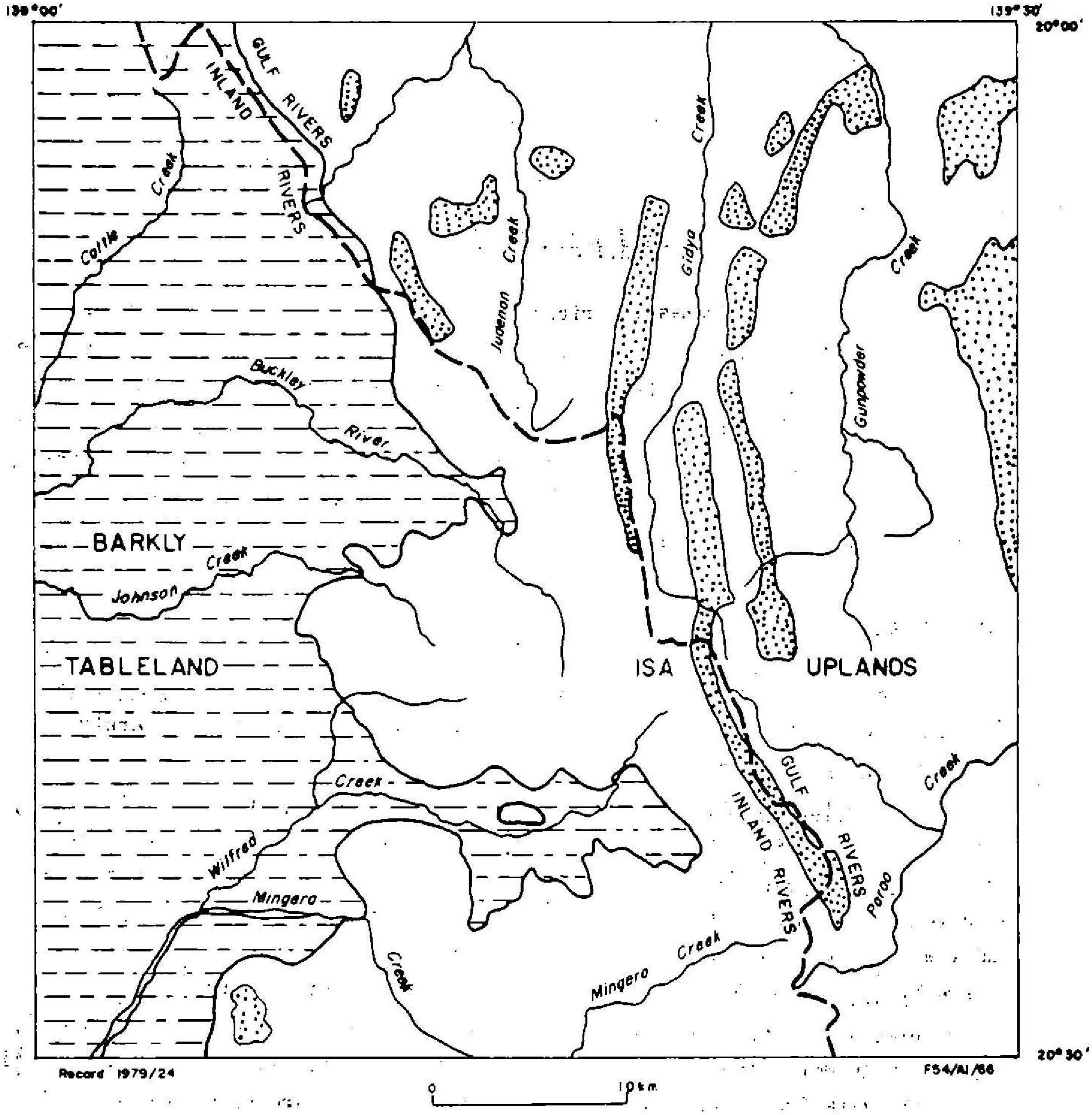
## GEOMORPHOLOGY, PHYSIOGRAPHY

Stewart (1954) has described the geomorphology of the Barkly region, which includes the Kennedy Gap Sheet area and Twidale (1964, 1966) has described the geomorphology of the Leichhardt-Gilbert area, which adjoins the Sheet area. Carter & others (1961) have described the geomorphology in summary form. Grimes (1974, 1979), Doutch (1976), and Smart & others (in prep) have also considered the physiography and geomorphology of the area in regional studies of the Carpentaria and Karumba Basins.

### Physiography

Two physiographic divisions are represented in the Sheet area (Fig. 2): the Isa Uplands in the eastern part of the Sheet area, and the Barkly Tableland in the western part.

The Isa Uplands (Smart & others, in prep), named the Isa Highlands by Twidale (1964, 1966), occupy most of the Sheet area. The terrain varies from immaturely dissected plateaux and ranges of resistant rocks, mostly quartzites, with residual planated surfaces at elevations of 420 to 520 m, to steep ridges and low hills with narrow V-shaped valleys (Fig. 3) where altitudes are generally less than 400 m. Planated surfaces are generally ferruginised or lateriterised and represent remnants of a Tertiary land surface. The drainage pattern is dense; minor streams are structurally controlled, but larger streams such as Mingera Creek, Paroo Creek, and Gunpowder Creek are superimposed or subsequent.




PHYSIOGRAPHIC DIVISIONS

GEOMORPHOLOGICAL UNITS

ISA UPLANDS

*Immaturely dissected plateau*

*Maturely dissected hill country*

BARKLY TABLELAND

*Plains of deposition*

Drainage divide

Fig 2 Physiographic and geomorphological sketch map, Kennedy Gap 1:100 000 Sheet area, 6757

Fig. 3 Isa Uplands, represented by rugged ridges of Judenan Beds separated by V-shaped valleys, in the southeastern corner of the Kennedy Gap Sheet areas. M1722/12 IHW.

Fig. 4 Flat expanse of Barkly Tableland extending west of the undulating ridges of the Isa Uplands in the southwestern corner of the Kennedy Gap Sheet area. M1670/19 IHW.

The Isa Uplands forms a major drainage divide separating northward-flowing streams draining into the Gulf of Carpentaria from streams flowing south towards Lake Eyre. The land surfaces of the Isa Uplands are being eroded; this fact forms the basis of Stewart's (1954) and Twidale's (1964, 1966) classification of the Barkly region into geomorphological units.

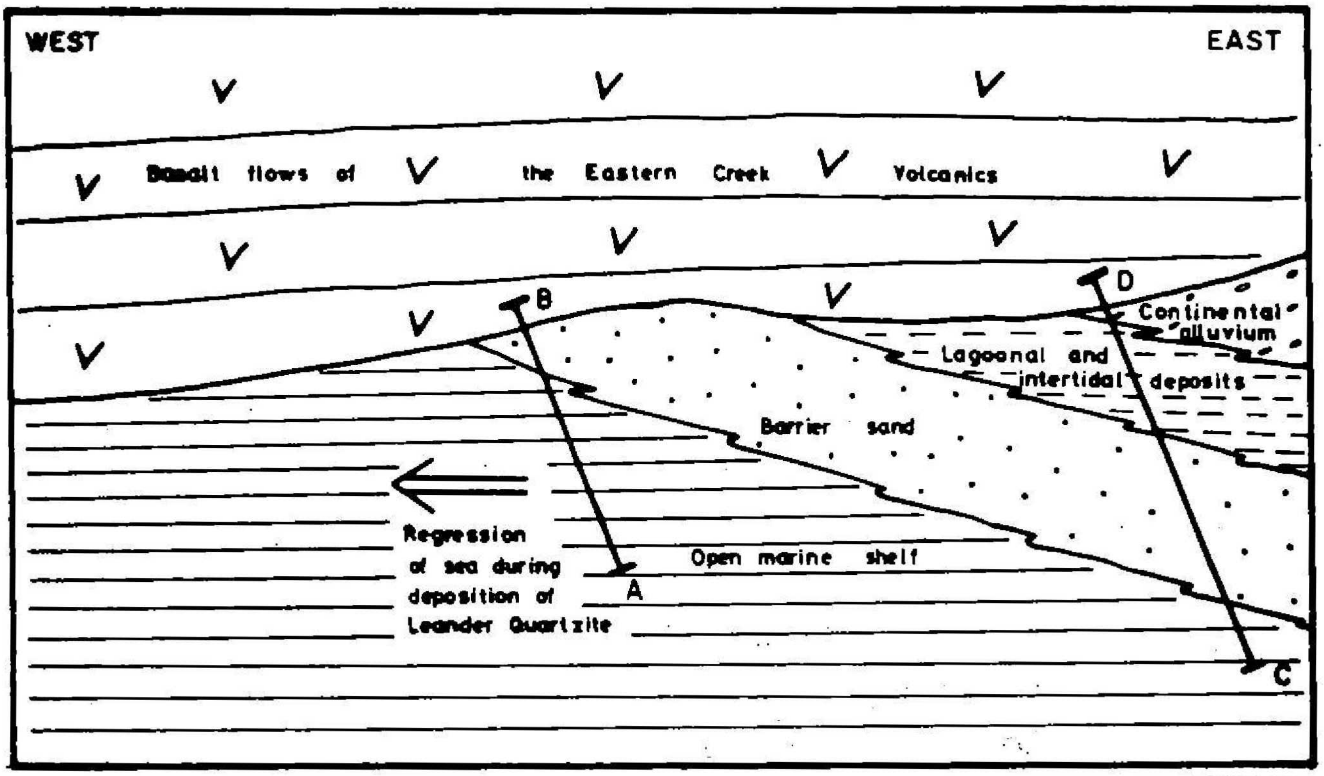
The Barkly Tableland (Smart & others, in prep) is characterised by flat to undulating country with an open drainage network. In the Sheet area, elevation ranges from 320 to 360 m. The drainage system shows a gradual change from the narrow channels in V-chaped valleys in the immaturely dissected country of the Isa Uplands to wide braided channels in the open plains (Fig. 4).

In the Sheet area this division includes black-soil plains (shown as Qf), sandy open plains (shown as Czs) lateritic plains (shown as Czd) and the flood plains of the drainage-system (corresponds to Czr). Stewart (1954) considered the lateritic plain in the southwest of the Sheet area to be a stable land surface; the other units are sites of deposition.

## Erosion surfaces

Two erosion surfaces are evident in the Sheet area; they were developed in the early Mesozoic and mid-Tertiary. Grimes (1979) has identified an older surface- an Early Cambrian unconformity at the base of the Georgina Basin sequence - north and south of the Sheet area; he has suggested that it be called the 'Sub-Georgina Surface'.

Twidale (1966) considered that by the early Mesozoic the whole Mount Isa region had been peneplained. Grimes (1979) has called this surface the 'Sub-Carpentaria Surface', which he considers to be a Jurassic to Early Cretaceous unconformity surface at the base of the Carpentaria Basin sequence. It is evident in mesas and planated ridges where Mesozoic sediments are preserved (Grimes, 1974). Earth movements warped it and allowed the incursion of an epeiric Mesozoic sea in which was deposited a widespread cover of sediments. Grimes (1972) has shown that farther east these sediments consist of a Jurassic to Lower Cretaceous continental sequence and a Cretaceous marine sequence.




Record 1979/24

F54/A1/71

Fig. 5 Possible relations between Leander Quartzite and Eastern Creek Volcanics.

A–B is section east of Valhalla

C–D is section west of Calton Hills

Grimes (in prep) considers that deposition in the Carpentarian Basin ended as the sea withdrew before Late Cretaceous time. This depositional surface is not well preserved, but is probably an extension of the older part of the Tennant Creek Surface in the Northern Territory (Hayes, 1967; Grimes, 1979).

In Early Tertiary time the Karumba Basin was initiated by tectonism (Doutch, 1976); its development can be divided into three major cycles of activity (Grimes, 1979). The first cycle, the Bulimba Cycle extending from Early Tertiary into mid-Tertiary time, ended with a lateritised or silicified surface - the Aurukun Surface. This surface is equivalent to the Younger part of Hayes's (1967) Tennant Creek Surface and is well preserved in the Kennedy Gap Sheet area; it is shown as Czd.

The Kendall Surface, the terminal surface of the second cycle, the Wyaaba Cycle (which commenced in Miocene time), is not represented in the Sheet area, but is preserved farther west as a lateritised surface on the Carl Creek and Gregory Downs Limestones. Pliocene tectonism induced the present Claraville Cycle.

## Land systems

A land system is an area or group of areas throughout which there is a recurring pattern of topography, soils, and vegetation (Christian & Stewart, 1954). Stewart & others (1954) recognised five land systems in the Sheet area: the Mount Isa Land System, on steeply folded sedimentary rocks; the Waverley Land System, over granitic rocks; the Yelvertoft Land System, over dissected country without lateritic remnants; the Wonorah Land System over the Tertiary lateritic plain in the southwest corner of the Sheet area; and the Georgina Land System, which includes the channel alluvium of the major watercouses flowing into the Georgina River. Two other land systems, the Kallala Land System, developed on the black-soil plains, and the Bundella Land System, developed on the sandy plains in the west of the Sheet area are also represented, but were not mapped by Stewart & others (1954).

## CARPENTARIAN STRATIGRAPHY

Carpentarian stratigraphy is summarised in Table 2. Since the issue of the Kennedy Gap 1:100 000 Preliminary Edition map, significant changes have occurred in the nomenclature of the McNamara Group. In this report the new nomenclature is used throughout, but cross-reference is made to the equivalent symbols used in the Preliminary Edition map (Tables 2, 9). The updated stratigraphy and symbols will appear on the First Edition map of the Kennedy Gap Sheet area, currently in preparation.

### HASLINGDEN GROUP

Derrick & others (1976a) defined the Haslingden Group, which consists of the Mount Guide Quartzite and the correlative Leander Quartzite, the Eastern Creek Volcanics, and the Myally Subgroup. The Judenan Beds, possible correlatives of the Myally Subgroup, cannot be formally included in the Group until they are more precisely defined.

The Haslingden Group is the basal group of the western sedimentary succession. It unconformably overlies the basement Kalkadoon and Ewen Granites; it overlies the Argylla Formation conformably or disconformably (Bultitude & others, 1977). It is overlain unconformably by the Mount Isa and McNamara Groups, the 'Mammoth Formation', and the Carters Bore Rhyolite, and conformably or disconformably by the 'Quilalar Formation' and 'Surprise Creek Formation' (some of these units are not yet formally defined).

#### Leander Quartzite

##### Introduction

The Leander Quartzite was defined by Carter & others (1961); it is named after Leander Range, which is composed almost entirely of rocks of this formation. As suspected by Carter & others (1961) the ranges to the west of Leander Range and Calton Hills also consist of Leander Quartzite. The formation is exposed in a regional anticline surrounded by Eastern Creek Volcanics, and extends over about 560 $km^2$.

TABLE 2. SUMMARY OF STRATIGRAPHY, KENNEDY GAP SHEET AREA

| Age | Rock Unit | Symbol* | Thickness (m) | Description | Stratigraphic Relations | Remarks |
|---|---|---|---|---|---|---|
| Quaternary | | Qf | | Sheetwash, clay, silt, young alluvium | | Typically forms gilgai |
| | | Czg | About 5 | Pebble and boulder gravel | | Mostly remnants of old stream channel |
| | | Czr | | Older alluvium, red-brown sand, silt, clay, minor younger alluvium | | |
| | | Czs | | Colluvium, sand, gravel, clay, minor alluvium | | |
| | | Czd | | Ferricrete, silcrete | | Related to an old erosion surface |
| MESOZOIC | | M | About 10 | Ferruginous sandstone, conglomerate | Unconformable on Proterozoic rocks | Small outlier in S of Sheet area |
| PALAEOZOIC (CAMBRIAN) | | Є | At least 15 | Siltstone, shale, siliceous dolomite | Contacts not seen; probably unconformable on Proterozoic rocks | Small inliers in W of Sheet area |
| | | do | | Undivided dolerite | Intrudes units as young as Judenan Beds | Dykes, sills, and small stocks |
| PROTEROZOIC (CARPENTARIAN) McNamara Group | Riversleigh Siltstone(Y) | Ᵽrr (Ᵽ$x_2$?)* | Unknown | Dolomitic siltstone | Conformable on Shady Bore Quartzite | (w) Small outcrop in W of Sheet area |
| | Shady Bore Quartzite(Y) | Ᵽrs (Ᵽx,Ᵽ$x_2$) | About 200 | Quartzite, medium felds-pathic sannstone | Conformable on Lady Loretta Formation | (w) |
| | Lady Loretta Formation(Y) | Ᵽrl (Ᵽx,Ᵽ$x_1$, Ᵽ$x_2$,Ᵽv) | About 600 | Dolomitic and pyritic silt-stone, shale | Conformable on Esperanza Formation | (w) Poorly exposed |
| | Esperanza Formation (Y) | Ᵽrz (Ᵽx, Ᵽ$x_1$, Ᵽ$x_s$) | 160-500 | Stromatolitic chert, pyritic chert, dolomitic sandstone, siltstone | Conformable on Paradise Creek Formation | (w) Conophyton is most abundant stromatolite form |
| | Paradise Creek Formation (Ᵽrx) | Ᵽr$x_u$ (Ᵽx,Ᵽ$x_1$, Ᵽ$x_2$) | 200-400? | Dolomitic siltstone, minor sandstone and chert | Conformable on Ᵽr$x_c$ or Ᵽr$x_q$ | (w) |
| | | Ᵽr$x_c$ (Ᵽ$x_1$) | About 10 | Stromatolitic chert | Conformable bed in Paradise Creek Formation | (w) |
| | | Ᵽr$x_q$ (Ᵽv,Ᵽx, (Ᵽ$x_q$) | 50-200 | Cross-bedded dolomitic sandstone, quartzite | Conformable lens in Paradise Creek Formation | (w) |
| | | Ᵽr$x_1$ (Ᵽv,Ᵽx) | 200-800 | Dolomitic siltstone, minor chert | Conformable on Ᵽro | (w) |
| | Mount Oxide Chert Member(Y) | Ᵽro (Ᵽx,Ᵽ$x_1$) | 10-30 | Grey laminated chert | Conformable on Gunpowder Creek Formation | (w) |
| | Gunpowder Creek Formation | Ᵽr$w_4$ (Ᵽ$v_4$) | 0-400 | Fine micaceous sandstone, siltstone | Lens at top of Gunpowder Creek Formation, where present, conformable on Ᵽr$w_3$ | (w) |
| | | Ᵽr$w_3$ (Ᵽ$v_3$) | 100-1000 | Siltstone, shale, pyritic siltstone, dolomitic siltstone | Where present, conformable on Ᵽr$w_2$ | (w) |
| | | Ᵽr$w_2$ (Ᵽ$v_2$) | 500-2000 | Micaceous siltstone, ferrug-inous siltstone, shale. | Conformable on Ᵽr$w_1$ | (w) Minor sandstone/quartzite |
| | 'Torpedo Creek Quartzite Member'(Y) | Ᵽr$w_1$ (Ᵽ$v_1$,Ᵽx) | 100-400 | Orthoquartzite, conglomerate | Unconformable on Mammoth Form-ation, Carters Bore Rhyolite, Judenan Beds, Eastern Creek Volcanics and Leander Quartzite | (w) Known as Torpedo Creek Quartzite to north |
| | 'Mammoth Formation'(Y) | Ᵽrm (Ᵽ$v_1$) | 0-300 | Sandstone, ferruginous siltstone and shale, conglomerate | Unconformable on Carters Bore Rhyolite | (w) Small lens in N of Sheet area |

| Age | | Rock Unit | Symbol* | Thickness (m) | Description | Stratigraphic Relations | Remarks |
|---|---|---|---|---|---|---|---|
| PROTEROZOIC (CARPENTARIAN) | Mount Isa Group | Native Bee Siltstone | Ᵽin | At least 300 | Dolomitic siltstone, minor chert and tuff | Conformable on Breakaway Shale | (E) |
| | Mount Isa Group | Breakaway Shale | Ᵽlb | About 500 | Shale | Conformable on Mondarra Siltstone | (E) |
| | Mount Isa Group | Moondarra Siltstone | Ᵽlm | At least 1000 | Siltstone, dolomitic siltstone, shale | Conformable on Warrina Park Quartzite | (E) Possibly correlates with Ᵽrw$_2$. |
| | Mount Isa Group | Warrina Park Quartzite | Ᵽlw | 50-150 | Orthoquartzite, conglomerate, feldspathic quartzite | Unconformable on Myally Subgroup and Eastern Creek Volcanics | (E) Probably correlates with Ᵽrw$_1$ |
| | | Sybella Granite | Ᵽgs$_3$<br>Ᵽgs$_2$a (Ᵽga$_1$a)<br>Ᵽgs$_2$ (Ᵽgs$_1$) | | Massive microgranite<br>Massive fine granite<br>Massive porphyritic granite medium | Intrudes Eastern Creek Volcanics and Judenan Beds<br>Intrudes Eastern Creek Volcanics | (W)1537 - 40 m.y. (Rb-Sr)<br>(W)Gradational with Pgs$_3$<br>(W)1577 - 13 m.y. (Rb-Sr) |
| | | Carters Bore Rhyolite | Ᵽhr | About 200 | Quartz-feldspar porphyry, minor basalt | Slightly unconformable on Judenan Beds | (W)Top probably not exposed because of erosion. |
| | Haslingden Group | Judenan Beds | Ᵽhj | | Undivided quartzite, feldspathic quartzite and siltstone | Conformable on Eastern Creek Volcanics. Disconformably or unconformably overlain by Carters Bore Rhyolite or Gunpowder Creek Formation. | (W)Probably correlates with Myally Subgroup |
| | | | Ᵽhj$_3$ | 0-100 | Orthoquartzite, feldspathic quartzite | Discontinuous lenses at top of unit | (W) |
| | | | Ᵽhj$_2$ | 200-1200? | Feldspathic sandstone, siltstone | Conformable on Ᵽhj$_1$ | (W) A recessive unit |
| | | | Ᵽhj$_1$ | 400-1000 | Quartzite, feldspathic quartzite, minor siltstone | Conformable on Eastern Creek Volcanics | (W) |
| | Haslingden Group | Myally Subgroup | Ᵽhm | | Undivided quartzite, sandstone and grey shale | Conformable on Eastern Creek Volcanics | (E) Probably correlates with Judenan Beds |
| | | Whitworth Quartzite (Y) | Ᵽhw (Ᵽhm$_3$) | About 1000 | Feldspathic sandstone | Conformable on Ᵽhb | (E) |
| | | Bortala Formation (Y) | Ᵽhb (Ᵽhm$_2$) | About 500 | Feldspathic sandstone, siltstone | Conformable on Ᵽha | (E) A recessive unit |
| | | Alsace Quartzite (Y) | Ᵽha (Ᵽhm$_1$) | About 500 | Feldspathic quartzite | Conformable on Eastern Creek Volcanics | (E) |
| | Haslingden Group | Eastern Creek Volcanics | | | | Conformable on Leander Quartzite | |
| | | Pickwick Metabasalt Member | Ᵽhp | 100-400 | Metabasalt, flow-top breccia, tuff | Conformable on Ᵽhl | |
| | | | Ᵽhp$_q$ | | Feldspathic sandstone, epidote quartzite | Numerous lenses in Ᵽhp | |
| | | Lena Quartzite Member | Ᵽhl | 1000 maximum | Quartzite feldspathic quartzite, siltstone | Conformable on Ᵽhc | |
| | | | Ᵽhl$_s$ | 100-500 | Grey siltstone shale | Thick sequence at base of Ᵽhl | Only in N of Sheet area |
| | | Cromwell Metabasalt Member | Ᵽhc | About 3000 | Metabasalt, flow-top breccia, tuff | Conformable on Leander Quartzite | |
| | | | Ᵽhc$_q$ | 150 maximum | Feldspathic sandstone, epidote quartzite | Numerous lenses in Ᵽhc | |
| | | | Ᵽhc$_1$ | About 100 | Siltstone, calcareous or dolomitic siltstone | Lens in Ᵽhc | One exposure in E of Sheet area |
| | Haslingden Group | Leander Quartzite | Ᵽhq$_2$ | 620-2300 | Orthoquartzite | Conformable on Ᵽhq$_1$ | |
| | | | Ᵽhq$_1$ | At least 2500 | Feldspathic quartzite, micaceous metasiltstone, phyllite, tuff | Base not exposed | The oldest unit in the Sheet area |
| | | | Ᵽhq$_{1b}$ | | Metabasalt, meta-andesite | Lens in Ᵽhq$_1$ at base of exposed sequence | |

* Symbol used on Preliminary Edition geological map shown in parenthesis (see Table 9).
(W) Indicates unit only found west of Hero Fault. (E) Indicates unit only found east of Hero Fault.
(Y) Indicates new formation name not used on Preliminary Edition geological map. Commas show the unit is not formally defined.

Stratigraphic relations

The Leander Quartzite is the oldest formation in the Sheet area; its base is not exposed. It is overlain conformably by the Eastern Creek Volcanics, and is intruded by dolerite dykes along a set of joints parallel to the axial plane of folding.

Field occurrence

The Leander Quartzite has been divided into two units: a lower more recessive unit ($Ehq_1$) of feldspathic quartzite phyllite, tuff, and basalt, overlain by an upper unit ($Ehq_2$) of resistant quartzite, which forms rugged, flat-topped ranges in the east of the Sheet area.

Unit $Ehq_1$. The oldest rocks exposed vary from place to place. Deeply weathered basic rocks, possibly basalts, are interbedded with fine-grained thinly-bedded sulphide-bearing siltstone or water-laid tuffs (Fig. 6) at the bottom of the section (413 604) 9.5 km southeast of Four Mile Bore. This section passes upwards into more characteristic sediments of $Ehq_1$ - brown to grey and buff fine to medium-grained feldspathic quartzite with interbeds of grey to purple and brown metasiltstone, brown to grey thinly bedded feldspathic quartzite, orange-brown fine-grained ferruginous quartzite, and minor amounts of white to grey fine to medium-grained orthoquartzite.

Queensland Mines Ltd (1970) reported a tuff-pelite-quartzite sequence in Leander Quartzite 5 to 6 km east-northeast of Calton Hills. They considered that the tuffaceous sediment has basic or intermediate affinities, and recognized it as a distinctive member in the Warwai Uranium Lease.

In the southernmost outcrops of $Ehq_1$ fine to medium-grained, slightly feldspathic to feldspathic quartzites predominate. Most are thinly bedded, with some black laminae. The rocks are white to buff, cream or pink, and some are cross-bedded. A shale-flake conglomerate with minor slumps has been recorded.

In the range just west of Calton Hills, $Ehq_1$ consists of very fine to fine-grained, rarely medium -grained, purple to brown feldspathic quartzite interbedded with green phyllite and phyllitic quartzite. Some of the lowest beds contain rounded quartzite pebbles, which are flattened parallel to the regional fold axis. The phyllites have a strong slaty foliation. In places kink folding has developed with north-plunging fold axes.

Cross-bedding is not common in $Ehq_1$ and ranges from small to medium-scale (up to 20 cm). The major current direction seems to have been from the southeast. Ripple marks and rare scour-and-fill structures are also present.

The thickness of $Ehq_1$ is not known as its base is not exposed. Several sections are thicker than 2500 m, and one section, which may be repeated by faulting, is in excess of 5000 m.

Unit $Ehq_2$ is a fairly monotonous succession of resistant quartzites (Fig. 7). The rocks are generally white fine to medium-grained orthoquartzite and slightly feldspathic quartzite. Less common are grey to brown fine to coarse-grained feldspathic quartzite, grey pebbly feldspathic quartzite, and minor green to grey siltstone. In places the quartzite contains small angular clasts of green siliceous siltstone.

East of Calton Hills the lower part of $Ehq_2$ is coarse-grained white quartzite; this grades upwards into a fine to medium-grained quartzite which grades into coarse, and at the top, very coarse-grained quartzite. West of Calton Hills the succession is similar, but about 70 m of white siltstone underlies the topmost beds of very coarse-grained quartzite.

Typically $Ehq_2$ has regular parallel bedding and low-angle cross-beds bounded by planar surfaces; cross laminae are usually asymptotic to the bottom surface. In coarse-grained sediments cross-beds up to one metre in thickness are common, but most are in the range 10 to 60 cm. The cross-bedding indicates currents from the south for most of $Ehq_2$, but swing to the north or northwest near the top of the unit. Rare ripple marks, both symmetric and asymmetric, and some convolute bedding were also observed. The metamorphic effects seen in $Ehq_1$ are not evident in the more siliceous $Ehq_2$.

The thickness of the unit ranges from 820 to 2300 m; it is thinnest in the south.

## Petrography

Table 3 summarizes the petrography of the Leander Quartzite.

TABLE 3 ESTIMATED MODAL COMPOSITIONS, LEANDER QUARTZITE

| Rock No. | Clasts | Grains | | | | | | | | | Matrix | | Accessories | | a.g.d. | Name |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | q/se | q | p | k | mu | bi | ch | ep | ca | op | se | lm | to | zr | (mm) | |
| | | | | | | | | | | Ꞓhq$_1$ | | | | | | |
| M7685 | | 70 | | | 10 | | | | | | | 20 | | | 0.1 | Fine-grained ferruginous quartzite |
| M7686 | | 59 | | | 20 | 5 | 3 | 6 | | 5 | | | 2 | | 0.1 | Fine-grained labile quartzite |
| M7687 | | 55 | 5 | | 6 | 20 | 8 | 1 | 2 | 3 | | | | | 0.08 | Metamorphosed quartz andesite |
| M7688 | | 55 | | | 42 | | | 2 | | | | | 1 | | 0.1 | Fine-grained labile quartzite |
| M7689 | 1 | 95 | | 1 | | 3 | tr | tr | | | | | | | 0.3 | Medium-grained orthoquartzite |
| | | | | | | | | | | Ꞓhq$_2$ | | | | | | |
| M7690 | | 98 | | | 2 | | | | | | | | | tr | 0.8 | Coarse-grained orthoquartzite |
| M7692 | 1 | 65 | 34 | | | | | | | | | | | | 0.5 | Coarse-grained feldspathic quartzite |
| M7693 | | 83 | | | 2 | | | | | 1 | | | 15 | | 0.7 | Coarse-grained tourmaline quartzite |
| 0175 | 2 | 96 | | | | | | | | 2 | tr | | tr | tr | 0.4 | Medium-grained orthoquartzite |
| 0176 | 5 | 91 | 3 | | tr | | | | | | | | 1 | tr | 0.5 | Medium-grained orthoquartzite |
| 0177 | 10 | 87 | | | | | | | | | 2 | | | 1 | 1.0 | Coarse-grained sub-labile quartzite |
| 0178 | 10 | 87 | | | | | | | | 1 | | | 2 | | 0.5 | Medium-grained sub-labile quartzite |
| | | | | | | | | | | Ꞓhq (undifferentiated) | | | | | | |
| M7694 | 4 | 85 | 10 | | 1 | | | | | tr | | | | | 0.4 | Medium-grained feldspathic quartzite |
| M7695 | 5 | 94 | | | 1 | | | | | | | | | tr | 0.6 | Coarse-grained orthoquartzite |
| M7696 | | 65 | 16 | | 10 | | | | | 5 | 3 | | | 1 | 0.1 | Fine-grained feldspathic quartzite |
| M7697 | | 60 | | | 20 | 19 | | | | 1 | | | tr | tr | 0.1 | Fine-grained micaceous quartzite |
| M7698 | | 98 | | | 2 | | | | | tr | | | tr | | 0.1 | Fine-grained orthoquartzite |

Abbreviations: a.g.d. - average grain diameter, bi-biotite, ca-calcite, ch-chlorite, ep-epidote, k-potash feldspar, lm-limonite, mu-muscovite, op-opaque, p-plagioclase, q-quartz, se-sericite, to-tourmaline, tr-traces, zr-zircon

Note: M numbers are GSQ microslide numbers.

Fig. 6 Fine-grained thinly bedded sulphide-bearing siltstone or water-laid tuff? interbeds in altered quartz andesite - the lowest exposed rocks in Ehq - 9.5 km southeast of Four Mile Bore (413 604). M1721/9 TAN

Fig. 7 Typical flat-topped ridge of $Ehq_2$ with low undulating outcrops of Eastern Creek Volcanics in foreground. M1791/9 IHW

Fig. 8 Sand infillings of synaeresis cracks in a fine-grained sandstone of the basalt unit of the Judenan Beds 12 km west-northwest of 29 Mile Bore (131 495). M1710/21 IHW

The sediments of $Ehq_1$ are generally very fine to medium-grained. They mainly consist of subangular to subrounded quartz grains and very fine-grained muscovite. The muscovite in some samples is aligned, giving the rock a weak schistosity. Tourmaline and the opaques are commonly euhedral, suggesting post-depositional growth. Small lithic fragments, usually aggregates of microscopic quartz grains, are present in some rocks (e.g., M7689).

The basic rock at the base of the unit is a metamorphosed quartz andesite (M7687). The plagioclase, which forms some phenocrysts, is twinned and has a composition of about $An_{11}$; opaque minerals are mainly pyrite.

Queensland Mines Ltd (1970) reported that the tuff found 5-6 km east-northeast of Calton Hills is dark reddish brown with an irregular grainsize. It consists of 20 percent quartz, 70 percent albite, 2 percent arfvedsonite, 2 percent mica and 5 percent opaques; accessory minerals include leucoxene, apatite (forming up to 5% of the rock locally), zircon, and brannerite or rutile. Joints are coated with yellow fraucevillite, (Ba, Pb) $(UO_2)_2(VO_4)_2 \cdot 5H_2O$.

$Ehq_2$ consists mainly of medium to coarse-grained quartzite containing feldspar or lithic fragments and minor tourmaline, zircon, and opaque minerals. Quartz grains are rounded, and usually well-sorted, but grain boundaries have become granulated by later deformation. The lithic fragments are commonly aggregates of very fine-grained sericite and quartz; some appear to be shale, and others acid volcanic. Euhedral tourmaline and zircon are common.

## Discussion

Wilson & others (1977) concluded that the upward coarsening of sediments and the typical flat bedding of the Leander Quartzite with rare cross-bedding indicate deposition along a prograding linear clastic shoreline (Selley, 1970). The data collected in the Kennedy Gap Sheet area support this conclusion. The four sedimentary facies present in a prograding linear clastic shoreline, (the open marine shelf facies, the barrier sands, the lagoonal and intertidal deposits, and the continental alluvium) are represented respectively by $Ehq_1$, the well-rounded well-sorted orthoquartzite towards the base of

$Ehq_2$, and the coarse feldspathic quartzite at the top of $Ehq_2$. The last two facies are not represented in every section, especially towards the south, where $Ehq_2$ is relatively thin. This is because the base of the Eastern Creek Volcanics more closely approximates a time plane than the diachronous boundaries between facies of the Leander Quartzite (see Fig. 5).

About 60 palaeo-current directions were interpreted from cross-bedding in the Leander Quartzite. These indicate currents from the south to southeast, changing to northeast to north towards the top of the formation. These conclusions are consistent with the few cross-bedding measurements made in the Prospector Sheet area, but conflict with the ripple-mark measurements recorded by Wilson & others (1977). Further study is necessary to provide an understanding of the sedimentology of the Leander Quartzite.

The coarse to very coarse-grained feldspathic quartzite at the top of $Ehq_2$, the continental alluvium, having suffered least transportation and sorting, most accurately reflects the provenance of the sediments. It indicates a granite-acid volcanic source area - probably the Kalkadoon-Leichhardt basement block.

Carter & others (1961) correlated the Leander Quartzite with the Mount Guide Quartzite to the south as both formations underlie the Eastern Creek Volcanics, are of similar lithology, are derived probably from the Kalkadoon-Leichhardt basement, and are similarly intruded by dolerite. If the extrusion of basalts of the Eastern Creek Volcanics was broadly synchronous over the whole area of their occurrence, the end of sedimentation of both formations happened at roughly the same time. However, whether sedimentation began contemporaneously in the two formations is not known, because the base of Leander Quartzite is not exposed. Sedimentation may have started much earlier in one area than the other; and the formations may have been deposited along shorelines of separate basins.

## Eastern Creek Volcanics

### Introduction

Carter & others (1961) formally defined the Eastern Creek Volcanics, and Robinson (1968) subsequently divided then into four informal units. Derrick & others (1976a) revised the stratigraphic nomenclature of the Haslingden Group which includes the Eastern Creek Volcanics. The subdivisions of the formation, from the base, are the Cromwell Metabasalt Member, the Lena Quartzite Member, and the Pickwick Metabasalt Member. The Cromwell Metabasalt Member is exposed as low undulating ridges and broad, mainly soil-covered, plains; the Lena Quartzite forms ridges and low isolated hillocks; and the Pickwick Metabaslt Member forms low ridges and valleys.

The outcrop pattern consists of two parallel meridional bands in the east of the Sheet area, a crescent-shaped rim around the Sybella Granite to the south, and an elongate complex structural dome extending north to south, west of the Waggaboonyah Range. The Formation crops out over 390 $km^2$ in the Kennedy Gap Sheet area.

Stratigraphic relations

The Eastern Creek Volcanics conformably overlie the Leander Quartzite. The Cromwell Metabasalt Member is overlain by the Lena Quartzite Member which is overlain by the Pickwick Metabasalt Member. The Judenan Beds overlie the Eastern Creek Volcanics with apparent conformity. The Formation is intruded by two phases of the Sybella Granite and rarely by dolerite dykes.

Lithology and field occurrence

In the Kennedy Gap Sheet area the Eastern Creek Volcanics do not conform exactly with the pattern established in Sheet areas to the south and east, where (in the Mount Isa, Mary Kathleen, and Prospector Sheet areas) the broad subdivision into metabasalt-quartzite-metabasalt is characteristic. In the Pickwick Metabasalt Member in the Kennedy Gap Sheet area metabasalt predominates near the southern edge, but metasediments predominate in the north.

The subdivisions established during mapping are, from youngest to oldest;

Pickwick Metabasalt Member (Php)

Ᵽhp - Metabasalt, flow-top breccia, tuff, grey siltstone, phyllite

Ᵽhp$_q$ - Epidote quartzite, feldspathic sandstone

Lena Quartzite Member (Ᵽhl)

Ᵽhl - Quartzite, feldspathic quartzite, siltstone

Ᵽhl$_s$ - Grey siltstone, shale, minor quartzite

Cromwell Metabasalt Member (Ᵽhc)

Ᵽhc - Metabasalt, flow-top breccia, tuff, feldspathic sandstone, siltstone, quartzite

Ᵽhc$_t$ - Siltstone, calcareous or dolomitic siltstone

Ᵽhc$_q$ - Feldspathic sandstone, epidote quartzite

Description of subdivisions

The Cromwell Metabasalt Member (Ᵽhc) is mainly a dark green to dark green-grey fine-grained metabasalt. The basalt is massive to amygdaloidal and vesicular. Amygdales are mainly filled with quartz, but many are filled with calcite and chlorite-calcite mixtures, as well as some sulphides, mostly pyrite. Vesicles are in places filled with secondary chlorite, epidote, and minor pyrite. Some outcrops of basalt are highly vesicular and have a 'frothy' character. Flow-top breccias are common, comprising angular fragments of basalt, vesicular basalt, and amygdaloidal basalt, and rarely fine sandy material, in an extremely fine-grained matrix of silica and epidote. Possible basic tuffs have been identified; they are volcaniclastic rocks composed of fragments of basic rock, 1 to 5 cm across, in a fine grained matrix of basic material. Basic schists are formed in shear zones.

Sedimentary interbeds within the basalt are common. They are mainly green-grey fine-grained well-sorted epidotic sandstone, grey to buff fine-grained thinly bedded feldspathic sandstone, grey fine-grained quartzite, and brown to grey siltstone. Beds of mixed basalt and sediment are common. The sediments range in thickness from a few centimetres to several tens of metres.

$Ehc_t$ is a small outcrop of brown to grey siltstone, calcareous siltstone, and dolomitic siltstone in the southeast of the Sheet area. It is well cleaved and deeply weathered.

$Ehc_c$ comprises interbeds of arenites up to 150 m thick towards the top of the Cromwell Metabasalt section. They are mainly white to buff fine-grained thinly to thickly bedded feldspathic sandstone and quartzite, grey to brown fine-grained quartzite, minor grey laminated siltstone, and green-grey epidote quartzite. Thin black laminations define the bedding in places. Cross-bedding, ripple marks, and mud-cracks are evident in some outcrops.

The Lena Quartzite Member (Ehl) is much thinner in the Kennedy Gap Sheet area than in the Prospector or Mary Kathleen Sheet areas. Its maximum thickness of about 1000 m is in the central north of the Sheet area, but the unit more typically is less than 400 m thick. It is composed of white to brown and grey fine-grained quartzite, minor buff to grey orthoquartzite, buff fine-grained feldspathic sandstone and quartzite, and brown to grey siltstone. Thin beds of grey phyllitic slate and red-brown ferruginous siltstone also crop out. Cross-bedding and ripple marks are evident.

$Ehl_s$ is a thin zone of siltstone underlying the main Lena Quartzite Member. In the central northern portion of the Sheet area it is composed mainly of grey siltstone and shale with minor amounts of white to grey fine-grained feldspathic quartzite. Elsewhere, extending from near the Bonus Basin to the south, the quartzite component increases. Thickness ranges from less than 100 m to more than 500 m.

The Pickwick Metabasalt Member(Ehp) in the Kennedy Gap Sheet area is mainly sedimentary in character. Metabasalt with some flow-top breccia crops out along the Barkly Highway in the southeast, 5 km east-northeast of the McNamaras Road/Barkly Highway junction, and in the central portion along the northern boundary of the Sheet area. It is dark green to grey fine-grained and massive to amygdaloidal; amygdales are filled mainly with quartz, epidote, and chlorite. Chlorite schists are formed from metabasalt along shear zones.

Arenite ranges in character from grey to brown fine to medium-grained feldspathic quartzite, grey quartzite with shale partings and mud-cracks, and buff to brown fine-grained feldspathic sandstone. Cross-bedding and ripple marks are rare. Grey laminated siltstone, purple slate, reddish brown phyllitic siltstone, and minor shale are exposed at the southern end of and along the eastern margin of the Waggaboonyah Range. Some of the siltstone might be strongly sheared and weathered basic rock.

Ehp$_a$, an arenaceous sequence with minor basalt, crops out 2-3 km southeast of and 5 km north of, the Queens Gift basin. It comprises mainly white to grey fine-grained feldspathic quartzite with minor brown to grey siltstone and thin basalt interbeds.

Petrography

Estimated modal analyses of 35 specimens of the Eastern Creek Volcanics are presented in Table 4 (Cromwell Metabasalt Member), Table 5, (Lena Quartzite Member), and Table 6 (Pickwick Metabasalt Member). The Eastern Creek Volcanics have been metamorphosed to the greenschist facies throughout most of the Sheet area. In the south, adjacent to the Sybella Granite, the rocks have been contact-metamorphosed to hornblende-hornfels facies.

Metabasalts have moderately well-preserved igneous textures. For the most part they contain mineral assemblages typical of the chlorite grade of the greenschist facies. The massive parts of the basalts consist of plagioclase (mainly albite), green to blue-green amphibole (actinolite and minor hornblende), chlorite, epidote, quartz, calcite, sphene, and opaques ( mainly magnetite and ilmenite). In the amygdaloidal and vesicular parts of the flows the mineral assemblages are similar, but the amygdales contain chlorite, quartz, epidote, calcite and minor sulphides. One specimen, M7759, from the Cromwell Metabasalt Member 1.6 km north of the Lady Agnes mine, is a possible meta-andesite. In the north of the Sheet area relict clinopyroxene rimmed by actinolite within the basalt of the Cromwell Metabasalt Member (specimen 0174), indicates less intense metamorphism.

The metasediments within the Cromwell Metabasalt Member are mostly psammitic, with minor pelitic interbeds. They consist mainly of well-rounded quartz grains, with minor sericite, chlorite, actinolite, epidote, and

TABLE 4: ESTIMATED MODAL COMPOSITIONS, CROMWELL METABASALT MEMBER

| Rock No. | Minerals | | | | | | | | | | | Accessories | | | | Name |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | q | p | ep | se | bl | ch | am | cp | ca | sp | op | ap | lm | tp | zr | |
| M7699 | 2 | 20 | 30 | | 20 | | 26 | | | 1 | 1 | | | | | Metabasalt |
| M7700 | 30 | 25 | 30 | | | 2 | 12 | | | tr | 1 | | | | | Silicified metabasalt |
| M7746 | 2 | 25 | | 3 | tr | 55 | 10 | | | tr | 5 | tr | tr | | | Amygdaloidal metabasalt |
| M7748 | | 23 | | | | 70 | | | | | 7 | | tr | | | Amygdaloidal metabasalt |
| M7756 | 15 | | | | | 80 | | | | tr | 5 | | | | tr | Chlorite schist |
| M7759 | 2 | 35 | 10 | | | 40 | | | 5 | | 8 | | | | | Meta-andesite (?) |
| M7760 | 2 | 15 | 26 | | 18 | 30 | | | 2 | 2 | 5 | tr | | | tr | Metabasalt |
| M7761 | 3 | 20 | 50 | | | 10 | | | | 2 | 15 | | tr | | | Basic tuff |
| M7762 | | 15 | 55 | | 15 | 12 | | | | 1 | 2 | | | | | Amygdaloidal metabasalt |
| M7773 | 10 | | | | | 50 | | | | | 30 | | 10 | | | Amygdaloidal metabasalt |
| M7774 | | 45 | 10 | | 5 | 30 | | | 2 | 2 | 6 | | | | | Metabasalt |
| M7794 | | 25 | 26 | | | | 46 | | 2 | 1 | | | | | | Amygdaloidal metabasalt |
| M7798 | | 25 | | | | tr | 70 | | | | 5 | | | | tr | Metabasalt |
| M7805 | | 10 | 40 | | | | 45 | | | 4 | 1 | | | | | Amygdaloidal metabasalt |
| M7809 | | 16 | 20 | | | | 60 | | | 2 | 2 | | | | | Amygdaloidal metabasalt |
| M7817 | 15 | | | 40 | | 4 | 40 | | | | 1 | | | tr | | Hornfelsed stiltstone |
| M7828 | | 15 | | | 12 | | 70 | | | tr | 3 | | | | | Metabasalt |
| 0144 | 3 | 25 | | | | 65 | | | | | 7 | | | | | Metabasalt |
| 0147 | | 55 | 8 | | | | 20 | | 2 | | 15 | | | | | Vesicular metabasalt |
| 0148 | | 55 | | | 3 | 25 | | | 10 | | 7 | | | | | Metabasalt |
| 0167 | | 55 | | | | 15 | | | 5 | | 25 | | | | | Amygdaloidal metabasalt |
| 0171 | | 30 | 30 | | | | 28 | | | | 10 | 2 | | | | Metabasalt |
| 0174 | | 15 | 20 | | | | 50 | 10 | | | 5 | | | | | Basalt |
| 0179 | | 30 | 30 | | | | 35 | | | | 5 | | | | | Metabasalt |

Abbreviations: am-amphibole, ap-apatite, bl-biotite, ca-calcite, ch-chlorite, cp-clinopyroxene, ep-epidote, lm-limonite, op-opaque, p-plagioclase, q-quartzite, se-sericite, sp-sphene, to-tourmaline, tr-traces, zr-zircon

Note: M numbers are GSQ microslide numbers.

TABLE 5: ESTIMATED MODAL COMPOSITIONS, LENA QUARTZITE MEMBER

| Rock No. | Minerals | | | | | | Accessories | | a.g.d. (mm) | Name |
|---|---|---|---|---|---|---|---|---|---|---|
| | q | k | p | mu | ch | op | tp | zr | | |
| M7812 | 80 | 10 | 5 | 5 | | tr | tr | tr | 0.1 | Hornfelsed feldspathic sandstone |
| M7813 | 75 | | | 20 | 5 | tr | | tr | 0.2 | Sheared impure sandstone |

Abbreviations: a.g.d. - average grain diameter, ch-chlorite, k-potash feldspar, mu-muscovite, op-opaques, p-plagioclase, q-quartz, to-tourmaline, tr-traces, zr-zircon.

Note: M numbers are GSQ microslide numbers.

TABLE 6: ESTIMATED MODAL COMPOSITIONS, PICKWICK METABASALT MEMBER

| Rock No. | Clasts | | Minerals | | | | | | | | | Accessories | | Name |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | q | sh | q | ab | ep | se | ch | bi | ac | sp | op | to | zr | |
| M7710 | | | | | | 55 | | | | | 45 | | | Altered metabasalt |
| M7707 | | | 10 | | | | 65 | | | | 25 | | | Altered metabasalt |
| M7807 | | | 32 | | | | 60 | 3 | | 1 | 4 | | | Metabasalt |
| M7808 | | | | 40 | 5 | | | | 50 | 2 | 3 | | | Amygdaloidal metabasalt |
| M7747 | 15 | 5 | 30 | | | 42 | | | | | 5 | 3 | tr | Carbonaceous mudstone |
| M7750 | | | 5 | 2 | | 63 | 10 | | | | 20 | | | Metamorphosed basic tuff |
| M7751 | | 70 | 12 | | | 15 | | | | | 2 | 1 | | Shale breccia |
| M7793 | | | 95 | | | 1 | 2 | | | | 2 | | tr | Orthoquartzite |
| M7799 | | | 94 | | | 3 | | | | | 3 | | | Quartzose psammite |
| M7703 | | | 15 | | | 80 | | | | | 5 | | tr | Hematitic metasiltstone |
| M7704 | | | 15 | | | 65 | | | | | 20 | tr | | Siltstone |
| M7705 | | | 15 | | | 75 | | | | | 10 | tr | | Siltstone |
| M7706 | | | 15 | | | 55 | | 30 | | | | tr | | Siltstone |
| M7708 | | | 40 | | | 58 | | | | | 2 | tr | | Siltstone |
| M7709 | | | 52 | | | 35 | | | | | 13 | tr | | Silty sandstone |

Abbreviatuions: ab-albite, ac-actinolite, bi-biotite, ch-chlorite, ep-epidote, op-opaques, q-quartz, se-sericite, sh-shale, sp-sphene, to-tourmaline, tr-traces, zr-zircon

Note: M numbers are GSQ microslide numbers.

plagioclase, and trace amounts of zircon, sphene, and tourmaline. The pelitic bands comprise quartz, chlorite, sericite, and limonite. The presence of limonite, chlorite, and actinolite in these rocks suggests that they are in part derived from the basalts with which they interfinger.

Siltstone in the Pickwick Metabasalt Member contains rounded to well-rounded quartz grains mostly set in a fine-grained matted aggregate of sericite and opaques. Trace amounts of well-rounded zircon grains are present, and tourmaline in places is euhedral and possibly secondary. The quartzite has a similar mineralogy.

## Discussion

The Eastern Creek Volcanics represent the first major period of volcanic activity in the western succession. Their origins and associations have been discussed by several authors (Carter & others, 1961; Robinson, 1968; Glikson & others, 1976).

Carter & others (1961) noted the vast areal extent and uniform nature of the lavas. They postulated deposition in a basin which was gradually increasing in size, accompanied by normal faulting. Continued uplift of the Kalkadoon-Leichhardt basement block (Derrick & others, 1977) resulted in an increased contribution of sediments during the later stages of volcanism.

Robinson (1968) considered that the basalts were possibly of the spilite-keratophyre association of Turner & Verhoogen (1951), and displayed features typical of flood basalts of non-orogenic continental regions. Glikson & others (1976), concluded that the Eastern Creek Volcanics were continental flood tholeiites.

The sedimentary intercalations in the Eastern Creek Volcanics are mostly shallow-water sandstone and siltstone, and penecontemporaneous basic tuff. The Lena Quartzite Member marks a significant pause in basic volcanism, but thinner sedimentary interbeds in the basalt members are probably shallow-water sheet or coalescing fluvial sand masses deposited on a low-gradient platform of basalt. Sediment source areas include underlying basalts and Leander Quartzite, and the quartz-rich Kalkadoon-Leichhardt block to the east.

## Judenan Beds

### Introduction

Carter & others (1961) defined the Judenan Beds with reference to a type area in the north of the Kennedy Gap Sheet area. Our mapping has shown that in the type area the upper part of the unit is not preserved because of folding. The sequence is more complete in the south of the Sheet area, where a threefold subdivision has been established. The subunits have not been formally defined because of possible future correlations with formations in the Myally Subgroup. The main rock types in the three subunits of the Judenan Beds are from youngest to oldest:

- $Ehj_3$ - Orthoquartzite, feldspathic quartzite, chert
- $Ehj_2$ - Feldspathic sandstone, siltstone
- $Ehj_1$ - Quartzite, feldspathic quartzite, minor siltstone.

Carter & others (1961) included in the Judenan Beds a quartzite which overlies $Ehj_3$. This is now thought to unconformably overlie the Judenan Beds, and is called the Torpedo Creek Quartzite Member - at the base of the Gunpowder Creek Formation.

### Stratigraphic relations

The Judenan Beds overlie the Pickwick Metabasalt Member of the Eastern Creek Volcanics conformably, and are overlain, slightly disconformably or unconformably, by the Carters Bore Rhyolite and Gunpowder Creek Formation. The Judenan Beds probably correlate with at least the lower part of the Myally Subgroup.

Dolerite dykes intrude the Judenan Beds in a few places. The Sybella Granite intrudes the Judenan Beds in the south of the Mount Isa 1:100 000 Sheet area.

Lithology and field occurrence

The Judenan Beds are well exposed in a north-trending belt through the centre of the Kennedy Gap Sheet area. In the south they form a broad anticline around the northern part of the Sybella Granite.

The basal subunit is generally expressed as broad flat-topped strike ridges and rounded hills such as the Waggaboonyah Range. The middle unit is typically poorly exposed in broad valleys. The top unit is recognised only in the south of the Sheet area, where it is expressed as two thin strike ridges.

$Ehj_1$ consists of white to pale grey or buff, flaggy, mostly thin-bedded and cross-bedded fine-grained slightly feldspathic quartzite, white to pink medium to coarse-grained quartzite, brown to pinkish purple laminated medium-grained feldspathic sandstone, brown ferruginous micaceous and labile sandstone with mudflakes, and grey, purple or cream laminated siltstone with quartzite or sandstone interbeds. Ripple marks are locally abundant and slumping is rare. Mud-cracks, and sand infillings of synaeresis cracks, occur in some of the sandstone (Fig. 8). Pebble beds containing quartzite, acid volcanic, and siltstone clasts crop out near the base of the subunit in the north of the Sheet area. Tuff or arkose also crops out in this area.

Much of the quartzite in the south is sheared, fractured, and quartz-veined. In this area, the feldspathic sandstone and siltstone are typically phyllitic and locally schistose.

Near the base of this subunit currents appear to have come from the south or southeast but higher in the sequence they are from the north to northeast.

$Ehj_2$ contains buff mostly thin-bedded to laminated fine to medium-grained feldspathic sandstone; cream, purplish grey, or brown fine to medium-grained labile sandstone; pale grey fine-grained quartzite; cream to grey siltstone with sandstone interbeds; purple micaceous siltstone with rare pyrite casts; and red and white banded siltstone. Bedding is irregular but where it is well developed cross-bedding and ripple marks are abundant. Mudflake conglomerate beds crop out in places. Current from the north to northeast are indicated by cross-beds and ripple marks.

Where the unit is deformed a cleavage is developed and in the south-east shearing has resulted in local transposition. Silicification and quartz-veining are widely developed.

$Ehj_3$ is characteristically a white to pink or pale grey thick-bedded to massive fine-grained silicified quartzite which is locally sheared and quartz-veined. Ferruginous laminated to thin-bedded fine to medium-grained sandstone and stromatolitic chert are minor constituents.

## Petrography

Estimated modal compositions of 29 specimens from the Judenan Beds are given in Table 7.

The quartzite generally has a granoblastic texture in which the relict detrital quartz grains can mostly be recognised despite quartz overgrowths and recrystallisation at grain boundaries. A siliceous cement occurs in some specimens. The relict feldspar grains are heavily sericitised. The detritus appears to be well sorted and subrounded.

The labile sandstone has a granoblastic texture where the amount of matrix is low. The relict grains tend to have low sphericity and are subrounded to subangular. Muscovite flakes and mudflakes are aligned parallel to the bedding, but sericite in the matrix and replacing the feldspar grains tends to be randomly oriented. Weathered rocks display kaolinite veins and limonitic cement.

The siltstone is typically poorly sorted and contains subrounded quartz grains and muscovite flakes in an opaque-dusted sericitic matrix with a strongly developed foliation.

Specimens from near the southeastern corner of the Sheet area are generally highly deformed. Detrital quartz grains cannot be identified as the quartz occurs as ribbon quartz or is completely recrystallised. The labile constituents are replaced by coarser-grained partly aligned sericite. No specimens of the sandy schists which occur in this area were thin-sectioned.

TABLE 7: ESTIMATED MODAL COMPOSITIONS, JUDENAN BEDS

(Ꞓhj$_1$)

| Rock No. | Clasts qzt | Clasts sh | Clasts slt | Grains q | Grains f | Grains mu | Grains bi | Grains ch | Grains op | Grains q | Matrix se | Matrix lm | Matrix ka | Accessories | a.g.d. (mm) | Name |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0130 | | | | 85 | 12 | | | | | | 2 | | | to(1) | 1.0 | Feldspathic sandstone |
| M7711 | | | | 84 | 6 | | | | 1 | | 9 | | | to, zr | 0.2 | Feldspathic quartzite |
| M7712 | | | 3 | 97 | | | | | | | | | | to | 0.25 | Quartzite |
| M7713 | 2 | | | 98 | | | | | | | | | | to, zr | 0.6 | Quartzite |
| M7714 | | | 2 | 97 | | | tr | | | | 1 | | | to, zr | 0.2 | Quartzite |
| M7715 | 1 | | | 97 | | | | | 2 | | | | | to, zr | 0.5 | Silicified quartzite |
| M7716 | | | | 82 | 7 | | | 3 | | | 8 | | | zr | 0.2 | Feldspathic quartzite |
| M7717 | 1 | | | 84 | | 5 | | | tr | | 10 | | | ap, zr | 0.8 | Sericitic quartzite |
| M7718 | | | | 90 | | 2 | | | 2 | 6 | | | | | 0.6 | Quartzite |
| M7719 | | | | 81 | | | | | 3 | | 16 | | | zr | 0.5 | Sericitic quartzite |
| M7720 | | | | 88 | | | | | tr | | 12 | | | zr | 0.25 | Sericitic quartzite |
| M7721 | | | | 87 | | | | | | | 12 | | | to(1), zr | 0.5 | Sericitic quartzite |
| M7764 | | | | 96 | | tr | | | tr | | 4 | | | to | 0.5 | Sheared quartzite |
| M7765 | | | | 74 | | | | | tr | 24 | 2 | | | | 0.4 | Sheared quartzite |
| M7769 | | | | 70 | 3 | 5 | | | | | 15 | 7 | | zr | 0.3 | Ferruginous micaceous meta-sandstone |
| M7770 | | | | 30 | 4 | 10 | 1 | | 5 | | 50 | | | | 0.05 | Micaceous meta-siltstone |
| M7789 | | | | 95 | | | | | | | 5 | | | to | 0.5 | Quartzite |
| M7791 | | | | 55 | 30 | 1 | | | tr | | 15 | | | zr | 0.2 | Labile meta-sandstone |
| M7792 | | | | 86 | 3 | | | | 1 | 8 | 2 | tr | | to, zr | 0.3 | Quartzite |
| M7832 | | | | 65 | | tr | | | 3 | 12 | 20 | tr | | zr | 0.5 | Quartzite |

(Ꞓhj$_2$)

| Rock No. | Clasts qzt | Clasts sh | Clasts slt | Grains q | Grains f | Grains mu | Grains bi | Grains ch | Grains op | Grains q | Matrix se | Matrix lm | Matrix ka | Accessories | a.g.d. (mm) | Name |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M7722 | | | | 77 | 3 | | | | tr | | 20 | | | | 0.2 | Sub-labile meta-sandstone |
| M7723 | | | | 96 | | | | | 1 | | 2 | 1 | | zr | 0.2 | Quartzite |
| M7724 | | | | 84 | 15 | | | 1 | tr | | | | | to | 0.5 | Feldspathic quartzite |
| M7725 | | | | 75 | | | | | 20 | | 5 | | | to | 0.15 | Hematitic siltstone |
| M7786 | | | | 45 | | | | | | | | 40 | 15 | | 0.3 | Ferruginous labile meta-sandstone |
| M7788 | | | | 60 | 20 | 3 | | | | | | 15 | | | 0.3 | Labile meta-sandstone |
| M7815 | | 1 | | 42 | 52 | 2 | | | 3 | | | tr | tr | to | 0.1 | Feldspathic labile meta-sandstone |

(Ꞓhj$_3$)

| Rock No. | Clasts qzt | Clasts sh | Clasts slt | Grains q | Grains f | Grains mu | Grains bi | Grains ch | Grains op | Grains q | Matrix se | Matrix lm | Matrix ka | Accessories | a.g.d. (mm) | Name |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M7768 | | | | 40 | 2 | | tr | | | 58 | | | | zr | 0.6 | Recrystallized quartzite |
| M7800 | | | | 70 | 20 | tr | | | 1 | | 8 | 1 | | zr | 0.2 | Ferruginous sublabile meta-sandstone |

Abbreviations: a.g.d. - average grain diameter, ap - apatite, bi - biotite, ch - chlorite, f - feldspar, ka - kaolinite, lm - limonite, mu - muscovite, op - opaques, q - quartz, qzt - quartzite, se - sericite, sh - shale, slt - siltstone, to - tourmaline, tr - trace amounts, zr - zircon

Note: M numbers are GSQ microslide numbers.

## Discussion

The correlation of the Judenan Beds with part or all of the Myally Subgroup (Myally Beds) was suggested by Carter & others (1961). Detailed work by companies and the mapping reported here substantiate this correlation, though a more detailed correlation has not been possible. The three subunits in the Judenan Beds - Ꝑhj$_1$, Ꝑhj$_2$, and Ꝑhj$_3$ - may correlate with the Alsace Quartzite, Bortala Formation, and Whitworth Quartzite. It is also possible that Ꝑhj$_1$ represents a very compressed section of these three formations, Ꝑhj$_2$ then correlates with the Lochness Formation and Ꝑhj$_3$ may correlate with the 'Quilalar Formation'.

The Judenan Beds apear to thin from the southeast and the southwest, northwards towards the nose of the major fold that surrounds the Sybella Granite. This may partly be due to subsequent deformation but it probably indicates that the sediments were originally thinner in this area. This may have been caused by active uplift (intrusion of the Sybella Granite?) in this area during sedimentation, or it may be due to this area being farther from the detrital source. The thickness of the Judenan Beds in the north is not easily determined because of folding, faulting, and the probable erosion of the upper part of the Judenan Beds before the deposition of the Carters Bore Rhyolite and Gunpowder Creek Formation.

The Judenan Beds were probably deposited in a shallow-water marine environment. Some of the large cross-bed sets may indicate a deltaic environment. The presence of mud-cracks and stromatolites in the upper subunits may indicate shallower water, perhaps in a tidal or lagoonal environment.

# HASLINGDEN GROUP, Myally Subgroup

## Alsace Quartzite

### Introduction

Derrick & others (1976a) formally defined the Alsace Quartzite with reference to a type section 20 km southwest of Julius Dam in the Prospector 1:100 000 Sheet area. The unit is composed of quartzite and sandstone containing varying amounts of feldspar and clayey rock fragments. The unit resists erosion and typically forms steep-sided flat-topped ridges.

In the Kennedy Gap Sheet area the Alsace Quartzite is mapped only in one small area near the northeastern corner of the Sheet area. The total area of outcrop is about 1 $km^2$.

Stratigraphic relations

In the Prospector Sheet area, the Alsace Quartzite overlies the Pickwick Metabasalt Member of the Eastern Creek Volcanics conformably and is overlain conformably by the Bortala Formation. These relations are not readily established in the Kennedy Gap Sheet area, where the Alsace Quartzite is overlain unconformably by the Warrina Park Quartzite.

Lithology and field occurrence

In the Kennedy Gap Sheet area the Alsace Quartzite forms a series of flat-topped hills. The main rock type is a pink thin to thick-bedded medium-grained slightly feldspathic quartzite.

Discussion

The Alsace Quartzite probably correlates with the basal unit in the Judenan Beds ($Ehj_1$), which crops out widely in the central part of the Kennedy Gap Sheet area.

## Bortala Formation

Introduction

Derrick & others (1976a) formally defined the Bortala Formation with reference to a type section 17 km south-southwest of the Julius Dam in the Prospector Sheet area. The unit is composed of highly feldspathic sandstone and siltstone which form broad undulating valleys.

In the Kennedy Gap Sheet area the Bortala Formation is mapped along the eastern margin near the southeastern corner of the Sheet area. The total area of outcrop is about 0.3 $km^2$.

Stratigraphic relations

The Bortala Formation is known to overlie the Alsace Quartzite conformably and to be overlain conformably by the Whitworth Quartzite in the Prospector 1:100 000 Sheet area (Wilson & others, 1977).

Lithology and field occurrence

In the Kennedy Gap Sheet area, the Bortala Formation occurs as a fractured and locally silicified quartzite in several small fault blocks. The main rock type is a ferruginous medium-grained feldspathic sandstone with local pebble beds.

Discussion

The Bortala Formation probably correlates with the second lowest unit in the Judenan Beds ($Ehj_2$), which is mapped through the central part of the Kennedy Gap Sheet area.

## Whitworth Quartzite

Derrick & others (1976a) formally defined the Whitworth Quartzite with reference to a type section 16 km southwest of Julius Dam in the Prospector Sheet area, where the main rock types are feldspathic quartzite and sandstone which are typically cross-bedded and ripple-marked. The unit resists erosion and tends to form flat-topped plateaux, but in the Kennedy Gap Sheet area its total area of outcrop is only a few hundred square metres and it is expressed as rounded hills. The main rock types in the Sheet area are pale brown thin cross-bedded fine-grained feldspathic sandstone and buff ripple-marked very fine-grained feldspathic sandstone. Currents appear to have come from the southeast to northeast.

Because of faulting the stratigraphic relations of the Whitworth Quartzite cannot be established in the Kennedy Gap Sheet area. To the east in the Prospector Sheet area, it overlies the Bortala Formation conformably and is conformably overlain by the Lochness Formation, which is not exposed in the Kennedy Gap Sheet area. The Whitworth Quartzite may correlate with the top unit of the Judenan Beds ($Ehj_3$), which, however, is much thinner and less feldspathic.

## Undivided Myally Subgroup

A sequence of white medium-grained quartzite and sandstone, pink to brown feldspathic quartzite, grey shale, and white fine-grained quartzite occupies about 4 $km^2$ in the northeastern corner of the Kennedy Gap Sheet area. Only the ridge-forming quartzites are exposed and it has not been possible to correlate this sequence with the individual formations of the Myally Subgroup. It is probable that the lowest three formations are represented in this sequence.

## CARTERS BORE RHYOLITE

### Introduction

Derrick & others (1978) formally defined the Carters Bore Rhyolite with reference to a type section 1 km west-northwest of Six Mile Mill, in the south of the Kennedy Gap Sheet area. The type section contains about 200 m of pink, rather weathered sheared porphyritic rhyolite. This unit was included in the upper part of the Judenan Beds by Carter & others (1961), who noted rhyolite and rhyolitic tuff from several places and recorded some probable basalt and basic tuff. They also reported a rhyolitic tuff with glassy shards from south of the Barkly Highway at lat. 22°22'40"S, long. 139°14'30"E.

### Stratigraphic relations

The Carters Bore Rhyolite overlies the Judenan Beds with a slight unconformity and is overlain unconformably by the 'Mammoth Formation' and the Gunpowder Creek Formation. It correlates with the 'Fiery Creek Volcanics', a basalt-rhyolite volcanic unit which Cavaney (1975) reported from areas to the north of the Kennedy Gap Sheet area.

## Lithology and field occurrence

This unit is exposed discontinuously from near the northern boundary of the Kennedy Gap Sheet area, through the Mount Isa 1:100 000 Sheet area to the south and into the Oban Sheet area. Exposure is generally poor and the unit tends to be very weathered and soil-covered. Some bouldery tors and pavements occur to the north and east of the type section between the Sybella Granite and the Barkly Highway.

The main rock type is a pink to brown porphyritic rhyolite which rarely shows any primary foliation. It is commonly sheared and deeply weathered. Strongly foliated rhyolitic tuff and lava (Figs 10, 11) crops out in places, mainly south of the Barkly Highway for 15 km west of 29 Mile Bore. These tuffs locally contain 5 to 10 cm long fragments of grey porphyritic acid volcanics which are rounded, embayed, or angular in shape (Fig. 9). Some of these tuffs are probably ignimbritic. In the south, basic volcanic rocks are rare, but in the north of the Sheet area red heavily weathered basalt or andesite is a major component of the formation. Minor sedimentary sequences are also included in the formation: a tuffaceous medium-grained sandstone locally at the base of the unit; labile siltstone and sandstone in places above the volcanics; and a lens of mudstone with siliceous clasts within the volcanics at one locality.

The volcanics are commonly fractured and silicified. Deep weathering has produced a ferruginous capping on the formation in most exposures, and locally it is white owing to kaolinitic alteration.

## Petrography

Estimated modal compositions of five specimens of Carters Bore Rhyolite are presented in Table 8.

In the fragmental rocks, the clasts consist of a fine-grained mosaic of quartz and potash feldspar with corroded subequant quartz phenocrysts and veins of alteration containing biotite and sericite. Most of the volcanic rocks are porphyritic. The phenocrysts are from 1 to 5 mm long and are mainly rounded and embayed subhedral bipyramidal (beta) quartz grains. Potash feldspar is of similar abundance to quartz and occurs as sanidine in some specimens and microcline in others. Plagioclase phenocrysts are rare.

The groundmass is a very fine-grained mosaic of quartz and potash feldspar. The feldspar tends to occur as large anhedral clots and aggregates of finer-grained crystals. Zircon is a common accessory, forming euhedral prisms and needles. In the more deformed volcanics the feldspar is replaced by sericite and quartz. Weathering products, including kaolinite, limonite, and chlorite, have been identified.

A fresh specimen of amygdaloidal andesite (138) was kindly provided by Union Miniere Development and Mining Corp. Ltd. from a drillhole at 138819. The larger amygdales (about 10 mm across) are filled with calcite and some of the smaller amygdales contain chlorite as well. The rock consists mostly of plagioclase laths about 0.1 mm to 0.2 mm long; some laths are as long as 2 mm. Chlorite occurs as scattered large irregular masses and euhedral epidote and fine-grained sericite are present in minor amounts. Very fine-grained to submicroscopic opaque grains make up about a quarter of the rock. Specimens from outcrops of this rock type have a similar texture but are severely altered by weathering.

## Discussion

The Carters Bore Rhyolite has yielded an age of 1678 ± 1 m.y. from U-Pb zircon techniques, and about 1555 m.y. from Rb-Sr techniques (Page, 1978). Page attributes this discrepancy in ages to disturbance of the Rb-Sr total-rock system after the volcanics were deposited.

The thickest sequences of the Carters Bore Rhyolite occur south of the Barkly Highway to the west of the 29 Mile Bore. These sequences also contain the largest volcanic fragments and largest phenocrysts. It is inferred that the volcanic vent(s) were nearby. The possibility that the rhyolite is comagmatic with the northwestern phase of the Sybella Granite is being investigated.

TABLE 8: ESTIMATED MODAL COMPOSITIONS, CARTERS BORE RHYOLITE

| Rock No. | Clasts | | Phenocrysts | | | | Groundmass | | | | | | | | | | | | a.g.d. | Name |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AV | AM | q | k | p | mt | q | f | mu | bi | ca | op | ka | ch | ep | lm | to | zr | (mm) | |
| 128 | | 25 | | | 40 | | | | 2 | | 5 | 25 | | 3 | tr | | | | 0.2 | Amygdaloidal andesite |
| M7726 | | | 12 | 9 | | 1 | 45 | 34 | | | | 1 | | | | | | | 0.05 | Porphyritic rhyolite |
| M7752 | | | 7 | 8 | 1 | | 35 | 43 | tr | 3 | 2 | 1 | | tr | | | tr | tr | 0.1 | Porphyritic rhyolite |
| M7753 | 30 | | 4 | 6 | | | 30 | 30 | | | | | | | | | | | 0.05 | Rhyolitic tuff |
| M7841 | 10 | | 5 | 5 | | | 55 | | 20 | | | tr | 1 | | | tr | | | 0.01 | Weathered porphyritic rhyolite |
| M7842 | | | 12 | 8 | | | 55 | 25 | | | | tr | | | | | | tr | 0.01 | Porphyritic rhyolite |

Abbreviations: a.g.d. - average grain diameter, AM - amygdales, AV - acid volcanics, bi - biotite, ca - calcite, ch - chlorite, ep - epidote, f - feldspar, k - potash feldspar, ka - kaolinite, lm - limonite, mt - magnetite, mu - muscovite, op - opaques; p - plagioclase, q - quartz, to - tourmaline, tr - traces, zr - zircon

Note: M numbers are GSQ microslide numbers.

Fig. 9 Crystal lithic tuff in Carters Bore Rhyolite 2 km north of Six Mile Mill (084 417). M1710/1 IHW

Fig. 10 Siliceous lenticles in tuffaceous sequence of Carters Bore Rhyolite 4.5 km west of 29 Mile Bore (202 447). M1710/9 IHW

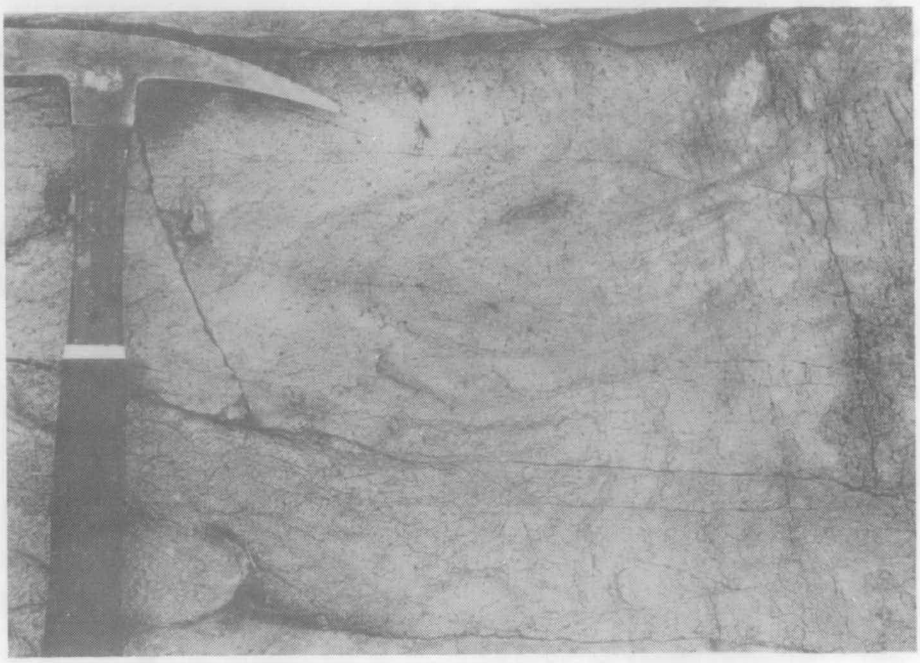


Fig. 11 Fold possibly related to flow of rhyolitic lava in Carters Bore Rhyolite 4.5 km west of 29 Mile Bore (202 447). M1710/11 IHW

The massive character and porphyritic texture of the Carters Bore Rhyolite have been regarded by some geologists as evidence of an intrusive origin. The bipyramidal quartz grains, the presence of sanidine rather than a low-temperature form of potash feldspar, the clastic texture, and the field relations indicate that most of this unit is extrusive. A possible porphyry dyke similar in appearance to the Carters Bore Rhyolite crops out in the southwest of the Sheet area 4 km southeast of the Double Event gold mine.

## MAMMOTH FORMATION

### Introduction

Cavaney (1975) proposed the name 'Mammoth Formation' in an unpublished thesis hence it is an informal name. The formal definition is in preparation. The formation as proposed corresponds to the basal part of the Gunpowder Creek Formation of Carter & others (1961). The Formation crops out over an area of 2.5 $km^2$, to the south of Judenan Creek in the central northern portion of the Sheet area. The unit is mainly arenaceous and forms low elongate strike-ridges. It ranges in thickness from zero to 300 m.

### Stratigraphic relations

The 'Mammoth Formation' unconformably overlies the Carters Bore Rhyolite and is in turn, unconformably overlain by the 'Torpedo Creek Quartzite Member' of the Gunpowder Creek Formation. It is equivalent to the 'Surprise Creek Formation' in the adjoining Sheet areas to the north and west.

### Lithology and field occurrence

The formation has not been subdivided owing to its limited exposure. It is mostly arenaceous and towards the base contains pebbly to conglomeratic bands which contain subangular to rounded pebbles and cobbles of grey medium-grained quartzite. Higher in the sequence, interbedded fine-grained quartzite, grey to brown laminated shale, and minor thin brown chert are present. The upper part of the formation is mostly buff to grey labile feldspathic sandstone and ferruginous quartzite. Brecciated quartzite and chlorite schist crop out adjacent to faults.

No rocks of the 'Mammoth Formation' were examined petrographically.

## Discussion

The field evidence in the Kennedy Gap Sheet area is not in agreement with the subdivision proposed by Cavaney (1975). He incorporated the 'Torpedo Creek Quartzite Member' into the upper part of the 'Mammoth Formation'. Evidence from the present mapping survey suggests that there was a time-break before the 'Torpedo Creek Quartzite Member' was deposited, and that this member should be included in the basal part of the Gunpowder Creek Formation.

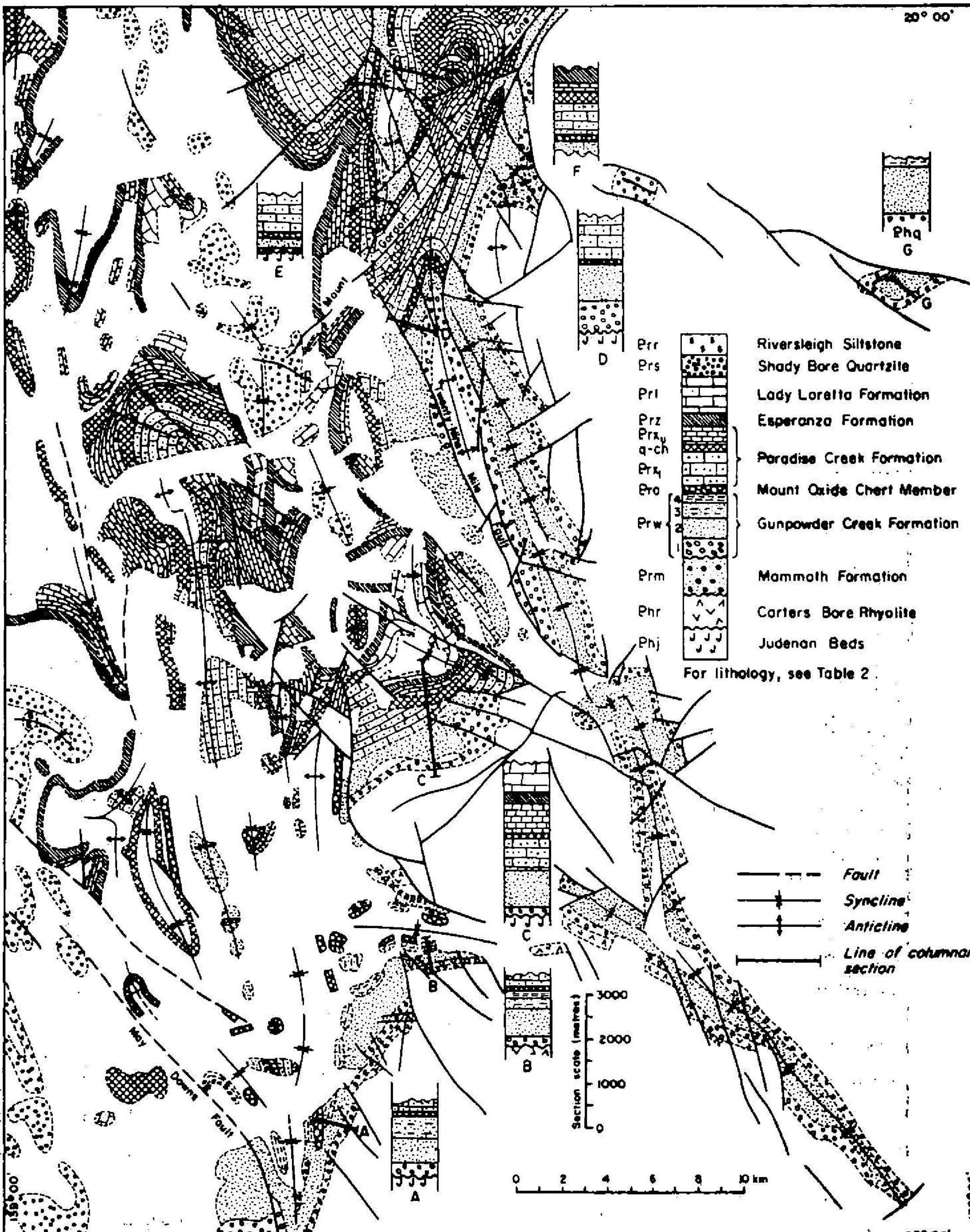
The 'Mammoth Formation' is equivalent to thin lenticular units of sandstone, siltstone, and dolomite between Haslingden Group and Mount Isa Group sediments in the Paroo Range in the Prospector 1:100 000 Sheet area. These units were previously mapped as part of the Warrina Park Quartzite (Derrick, 1974). The 'Torpedo Creek Quartzite Member' is therefore a correlative of the Warrina Park Quartzite.

Source areas for the 'Mammoth Formation' sediments are probably Judenan Beds. Derrick & others (1976b) suggest that the 'Mammoth Formation' equivalents in the Prospector Sheet area were deposited in depressions in the older Haslingden Group erosion surface during a phase of transgression after major crustal disturbance. A similar environment of deposition is suggested for the 'Mammoth Formation' in the Kennedy Gap Sheet area.

# McNAMARA GROUP

## Introduction

Cavaney (1975) named and defined the McNamara Group, for which he is preparing a formal definition (Cavaney, in prep.). He applied the name to a conformable sedimentary sequence, mainly west of the Mount Gordon Fault, and he correlated it with parts of the Mount Isa Group and the Surprise Creek Beds.

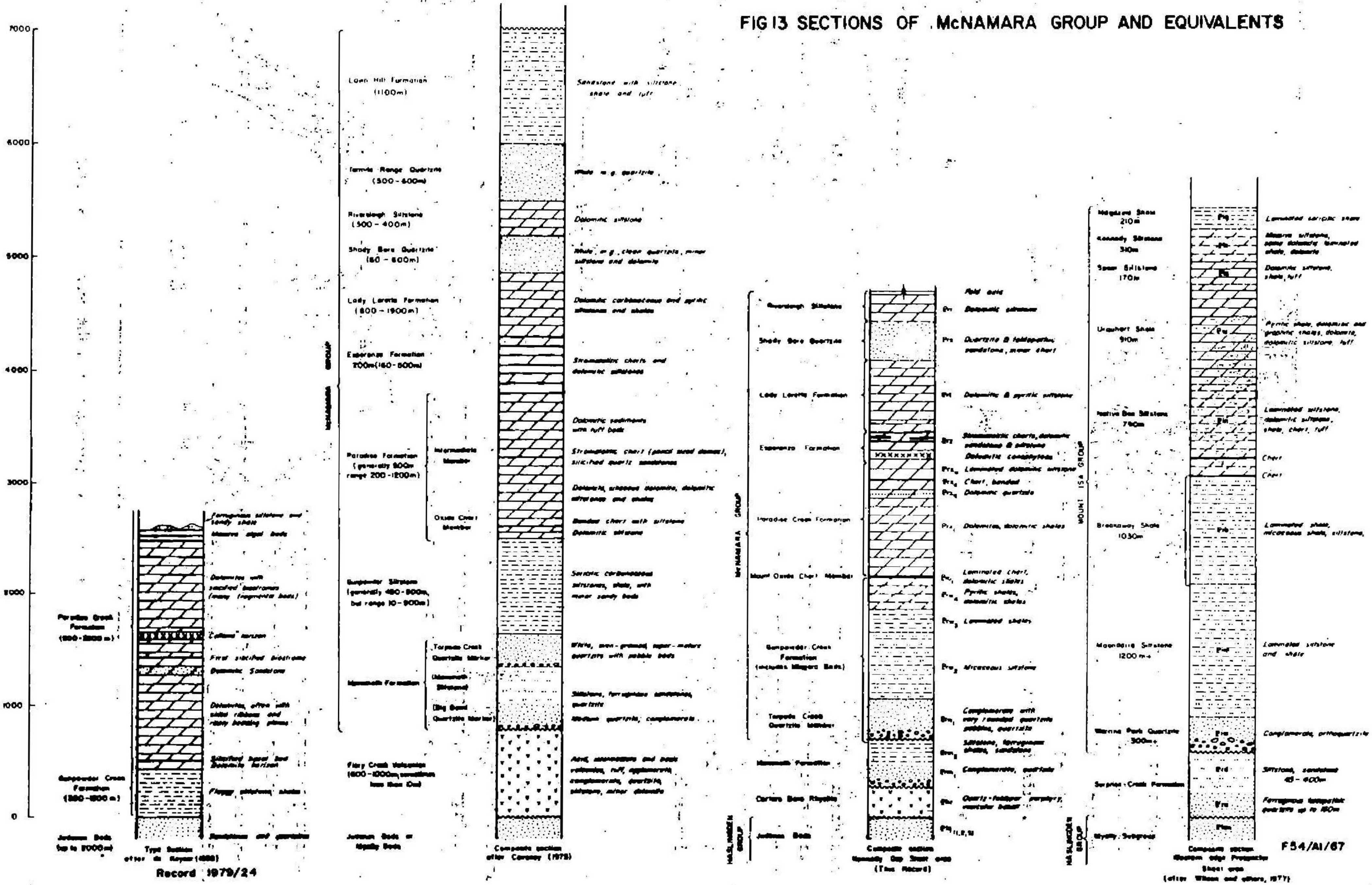



Record 1979/24

F54/A1/72

Fig. 12 The distribution, structure and stratigraphy of the McNamara Group

# FIG 13 SECTIONS OF McNAMARA GROUP AND EQUIVALENTS




Record 1979/24

The McNamara Group was named from McNamara's Road, a road built by Jack McNamara - a well known prospector and miner in the Mount Isa region - to give access to the O.P. Mine in the Upper Seymour River area, north of the Kennedy Gap Sheet area. The road is also used for access to the Lady Annie copper and phosphate deposits and the Lady Loretta zinc-lead-silver deposit. It leaves the Barkly Highway 65 km from Mount Isa and it crosses or passes close to most of the formations of the McNamara Group.

The constituent formations of the McNamara Group as proposed by Cavaney are (from top to bottom)

Lawn Hill Formation
Termite Range Quartzite
Riversleigh Siltstone
Shady Bore Quartzite
Lady Loretta Formation
Esperanza Formation
Paradise Creek Formation
Gunpowder Creek Formation
'Mammoth Formation'

All of these formations are new or revised by Cavaney except for the Lawn Hill Formation which remains as it was defined by Carter & others (1961). The highest two formations are not exposed in the Kennedy Gap Sheet area, and the Riversleigh Siltstone is of limited extent.

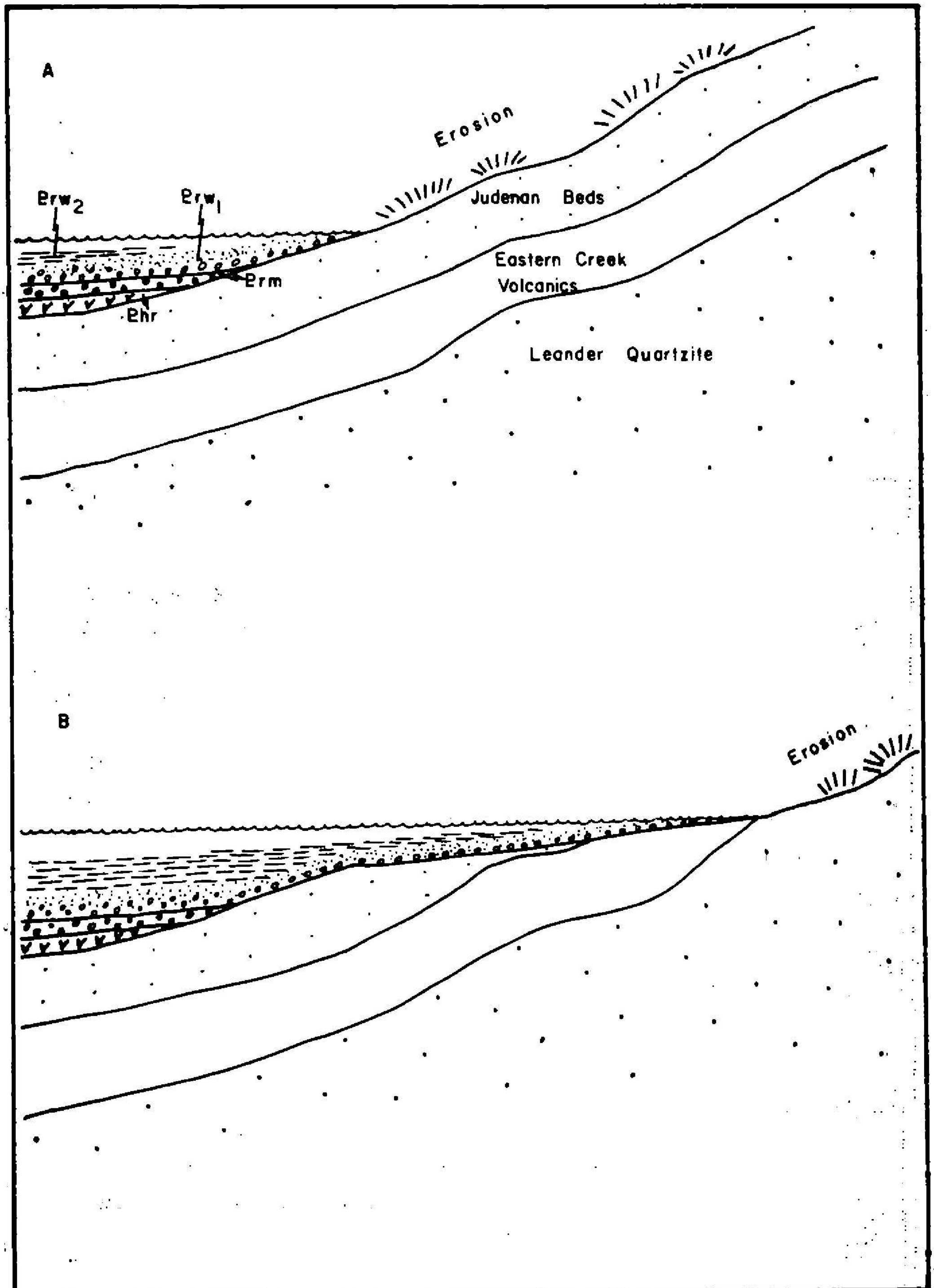
In this Record we have generally adopted the nomenclature of Cavaney (1975, personal communication 1977; Fig. 13, Table 9). However, we consider that the Torpedo Creek Quartzite Member of the 'Mammoth Formation' should be considered as part of the Gunpowder Creek Formation. Because the Gunpowder Creek Formation unconformably overlies the 'Mammoth Formation', both formations cannot be included in the same group, and we thus exclude the 'Mammoth Formation' from the McNamara Group.

We have modified Cavaney's (1975) proposed name for the important chert marker at the base of the Paradise Creek Formation from "Oxide Chert Member" to Mount Oxide Chert Member. The Redie Creek Member of Cavaney has not been named on the map because its stratigraphic position is uncertain, but the mapped units $Prx_q$ and $Prx_c$ possibly represent this member.

TABLE 9 : VARIATIONS TO STRATIGRAPHIC NOMENCLATURE IN THE McNAMARA GROUP, KENNEDY GAP SHEET AREA

| Unit described in this report | Symbol in this report | Symbol on preliminary map | Cavaney (1975 1977) | De Keyser (1958) | |
|---|---|---|---|---|---|
| - | | | Lawn Hill Formation | | |
| - | | | Termite Range (Gregory) Quartzite | | |
| Riversleigh Siltstone | Ꝑrr | Ꝑx$_{2?}$ | Riversleigh Siltstone | | |
| Shady Bore Quartzite | Ꝑrs | Ꝑx, Ꝑx$_2$ | Shady Bore (Carrier) Quartzite | ? | |
| Lady Loretta Formation | Ꝑrl | Ꝑx, Ꝑx$_2$ | Lady Loretta Formation | | |
| Esperanza Formation | Ꝑrz | Ꝑx, Ꝑx$_g$, Ꝑx$_s$, Ꝑx$_1$ | Esperanza Formation | Paradise Creek Formation | |
| Paradise Creek Formation | Ꝑrx | Ꝑx, Ꝑx$_2$ | Paradise (Creek) Formation | | Paradise Creek Formation |
| " | Ꝑrx$_u$ | Ꝑx, Ꝑx$_1$, Ꝑv$_3$, Ꝑv$_2$ | " | | |
| " | Ꝑrx$_c$ | Ꝑx, Ꝑx$_1$ | " | | |
| " | Ꝑrx$_q$ | Ꝑx, Ꝑx$_q$, Ꝑx$_1$ | " | | |
| " | Ꝑrx$_l$ | Ꝑx, Ꝑv | " | | |
| "(Mount Oxide Chert Member) | Ꝑro | Ꝑx, Ꝑx$_1$ | "(Oxide chert Member) | | |
| Gunpowder Creek Formation | Ꝑrw$_4$ | Ꝑv$_4$ | Gunpowder (Creek) Formation | | Gunpowder Creek Formation |
| " | Ꝑrw$_3$ | Ꝑv$_3$ | " | | |
| " | Ꝑrw$_2$ | Ꝑv$_2$ | " | | |
| " | Ꝑrw$_1$ | Ꝑv$_1$, Ꝑx | Mammoth Formation | Judenan Beds | Judenan Beds |
| Mammoth Formation* | Ꝑm | Ꝑv$_1$ | " | | |

* Not included in McNamara Group in this Record.




Record 1979/24

F54/A1/73

Fig. 14. Schematic representation of derivation of detritus from progressively older source areas during deposition of Gunpowder Creek Formation

The McNamara Group covers most of the western half of the Kennedy Gap Sheet area; two small outliers are also present farther east in the northern part of the Sheet area.

A number of different interpretations of the field data have been made since the Preliminary map was printed. Some of these are listed below, and summarised in Table 9 and Figure 12.

Highly ferruginous and rubbly sandstones in the southwest corner of the Sheet are shown as Paradise Creek Formation on the Kennedy Gap Preliminary map. However, they may be part of a discontinuous thin (1-10m) layer of Pilpah Sandstone covering the Paradise Creek Formation (see Carter & others, 1961). Breccia zones which have been mapped below the ferruginous sandstones in this area may be basal conglomerates, and chert grains and fragments, common in the ferruginous sandstones, are most likely derived from the Paradise Creek Formation.

2. In the areas just north and south of the Barkly Highway on the western edge of the Sheet area, a number of chert beds are now thought to be Esperanza Formation because they contain small pustular and conical pseudocolumnar stromatolitic structures. There is a possibility that the chert outcrops just to the east are also Esperanza Formation, implying that this formation is thicker than indicated on the Kennedy Gap Preliminary geological map and that the underlying siltstone does not belong to the Gunpowder Creek Formation.

3. The centre of the large domal structure (grid ref. 990670) cut by the Buckley River was mapped as Gunpowder Creek Formation on the Kennedy Gap Preliminary map, but it is now considered to belong to the Paradise Creek Formation (Fig. 12).

## Gunpowder Creek Formation

### Introduction

De Keyser (1958) proposed the name Gunpowder Creek Formation. Carter (1959) formally defined it, but excluded the conglomerate, sandstone, and quartzite sequence at the Judenan Beds-Gunpowder Greek Formation contact, which he placed in the Judenan Beds. Carter & others (1961) described the formation.

Cavaney (1975) revised the stratigraphic nomenclature in the area and included Middle Proterozoic rocks younger than the Haslingden Group in the 'McNamara Group'. He renamed the Gunpowder Creek Formation the 'Gunpowder Siltstone', which he considered overlies the 'Mammoth Formation' conformably. Recent mapping has shown that there is a time break within the 'Mammoth Formation' as proposed by Cavaney (1975); the upper part of Cavaneys' 'Mammoth Formation', the 'Torpedo Creek Quartzite Member', is considered by the present authors to be the basal part of the Gunpowder Creek Formation, and may be raised to formation status in future work.

The Gunpowder Creek Formation crops out over an area of about 160 $km^2$, mostly in the western half of the Sheet area. Two small structural basins, the Bonus Basin and Queens Gift Basin, form outliers 5 km northwest and 17 km west-northwest of Calton Hills homestead respectively.

Stratigraphic relations

The Gunpowder Creek Formation is the basal formation in the McNamara Group as we define it here. It overlies unconformably the Leander Quartzite, Eastern Creek Volcanics, the Judenan Beds, the Carters Bore Rhyolite, and, in one area centred on grid reference 130795, the 'Mammoth Formation'. The Gunpowder Creek Formation is overlain conformably by the Paradise Creek Formation. In places, it is capped by Cainozoic silcrete, and a ferruginous rubble.

Lithology and field occurrence

During the field mapping program a four-fold sub-division of the Gunpowder Creek Formation was established (Tables 2, 9). Future mapping in the Camooweal 1:250 000 Sheet area, which includes the type area of the formation, should provide enough data to allow a consistent subdivision of the formation. This could ultimately require a revision of the subdivisions proposed in the Kennedy Gap Sheet area.

The subdivisions as mapped are (from youngest to oldest)

$Erw_4$ - Fine micaceous sandstone, and siltstone

$Erw_3$ - Siltstone, shale, pyritic and dolomitic siltstone

$Erw_2$ - Micaceous siltstone, ferruginous siltstone and shale; minor feldspathic sandstone and quartzite

$Erw_1$ - 'Torpedo Creek Quartzite Member' - conglomerate, orthoquartzite, feldspathic quartzite, and sandstone.

$Erw_1$, 'Torpedo Creek Quartzite Member' ($Ev_1$ on the Preliminary map) - is a conspicuous unit throughout the Sheet area, although it rarely exceeds 400 m in thickness. In places it displays a marked angularity with underlying formations and its basal section is characterised by the presence of conglomerate bands. The conglomerate is mainly polymictic with well-rounded pebbles, cobbles, and boulders of white to grey orthoquartzite, buff to brown quartzite, and buff fine to medium-grained feldspathic quartzite (Fig. 15, 16, 17). The matrix varies from white to grey medium-grained orthoquartzite to brown fine to medium-grained quartzite, and feldspathic quartzite. Silty sandstone is a minor component. The proportion of clasts decreases from north to south: they amount to as much as 80 percent in the conglomerate bands southeast of the Mount Gordon Fault Zone, but the conglomerate is not always present south of the Barkly Highway, where the basal part comprises buff to brown fine to medium-grained graded-bedded and cross-bedded feldspathic sandstone and quartzite and minor gritty sandstone.

The shape of the clasts gives some indication as to their source areas. Clasts observed in the east, mainly overlying Leander Quartzite, are subangular to subrounded; those observed farther west are mostly subrounded to well-rounded. This may indicate that they were derived from the east and became more rounded as they were transported to the west.

Fig. 15 Well-rounded quartzite cobbles and boulders in a thick sequence of conglomerate at the base of the Gunpowder Creek Formation 3 km southwest of Six Mile Mill (064 372). M1711/15 IHW

Fig. 16 Strongly sheared conglomerate at base of Gunpowder Creek Formation in which well-rounded quartzite clasts are elongated parallel to a strong cleavage 6 km west of 19 Mile Bore. M 1722/14 IHW


Fig. 17 Angular fragments of quartzite, vein quartz, and siltstone in a polymictic conglomerate in siltstone sequence of Gunpowder Creek Formation 8 km west-northwest of 29 Mile Bore (174 482). M1722/7 IHW

Fig. 18 Alternating bands of conglomerate and siltstone in lower unit of Gunpowder Creek Formation in Bonus Basin. M2126/17 GMD

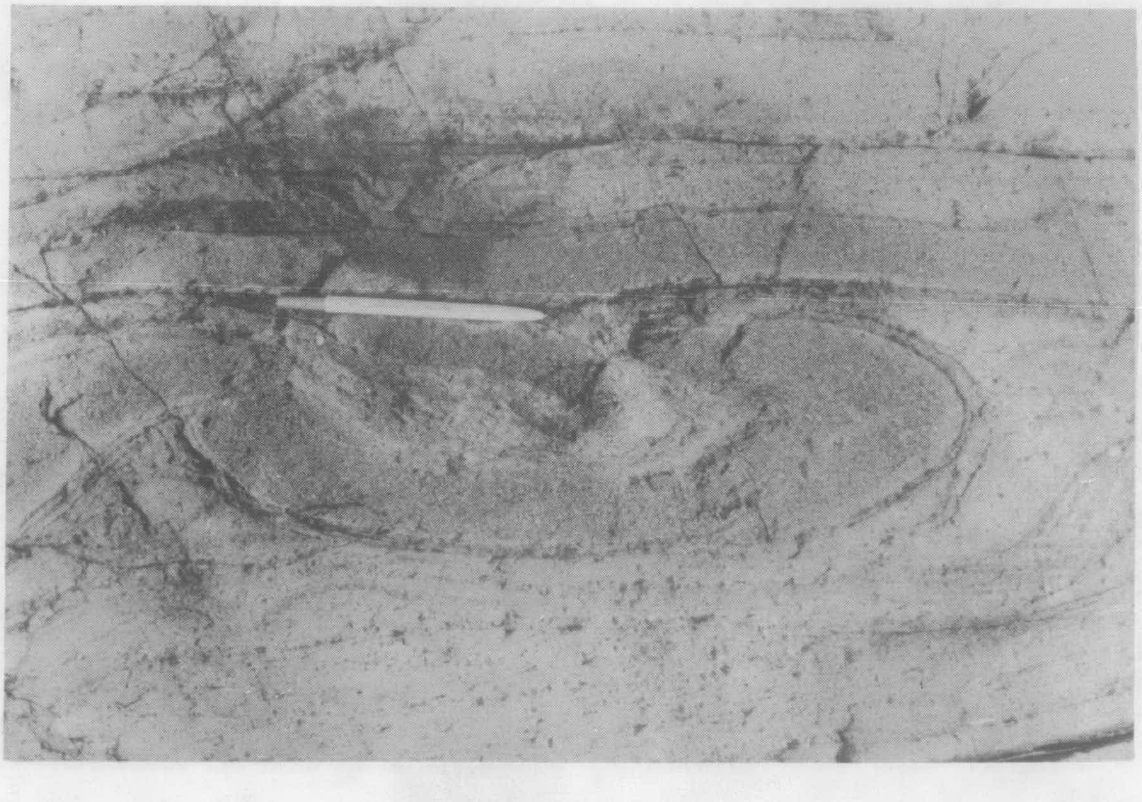


Fig. 19 Slump structure in very fine-grained sandstone near top of lower unit of Gunpowder Creek Formation in Bonus Basin. M2126/14 GMD

The upper part of $Ɛrw_1$ is mainly white to grey thinly bedded feldspathic quartzite with rare cross-bedding.

The Bonus Basin, which is centred on grid reference 300750, has a thin basal oligomictic cobble conglomerate mapped as $Ɛrw_1$. It comprises angular to subrounded clasts of grey fine to medium-grained quartzite and feldspathic quartzite in a matrix of blocky fine-grained feldspathic sandstone (Fig. 18) which is locally slumped (Fig. 19). The clasts are identical to the quartzite in the Leander Quartzite. The conglomerate bands vary in thickness: they are thin in the east and west, and up to 200 m along the southern margin of the basin.

The basal unit $Ɛrw_1$ comprises all the outcrop in the Queens Gift Basin. The basal polymictic conglomerate is unconformable on underlying rocks and contains well-rounded pebbles and cobbles of quartzite, white to grey vein quartz, and abundant grey feldspathic quartzite. The polymictic character can be attributed to source areas containing Leander Quartzite, Eastern Creek Volcanics, Judenan Beds, and possibly Myally Subgroup. The matrix is blocky thin-bedded highly feldspathic quartzite interbedded with ferruginous fine-grained sandstone. All the sandstones are sporadically pebbly, and cross-bedding and asymmetric ripple marks are present.

$Ɛrw_2$ ($Ɛv_2$ on the Preliminary map) is well represented throughout the Sheet area. To the west of the Sybella Granite, it is strongly folded red and grey laminated siltstone and creamy brown laminated micaceous siltstone; in places it is phyllitic. The contact with the underlying $Ɛrw_1$ is sharp.

To the east of the Sybella Granite, $Ɛrw_2$ is exposed in the strongly faulted core of a north-plunging syncline which extends north-northwest almost to the northern boundary of the Sheet area, just east of the Twenty-Nine Mile Fault Zone. It comprises grey laminated siltstone, shale, purple-grey laminated shale and micaceous siltstone, very fine-grained micaceous sandstone, minor buff micaceous laminated sandstone, and minor spotted shale. Some of the siltstones display convoluted bedding, and rare nodular structures may be related to slumping.

In the area west of the Twenty-Nine Mile Fault Zone and north of the Barkly Highway, most of the outcrops assigned to the Gunpowder Creek Formation, and in particular Ꝑv$_2$ on the Preliminary Geological Map, are now included in the Paradise Creek Formation. The remaining outcrops are nearly all white to grey thinly-bedded micaceous siltstone with rare buff fine-grained feldspathic sandstone interbeds.

To the west of the Mount Gordon Fault Zone red and grey laminated shales of Ꝑrw$_2$ overlie a layer of Ꝑrw$_1$ which is too thin to be represented on the map.

Throughout the Sheet area, Ꝑrw$_2$ is characterised by a highly ferruginous, locally lateritic, capping.

Unit Ꝑrw$_3$ (Ꝑv$_3$ on the Preliminary map) is now mapped mainly to the south of the Barkly Highway. Some outcrops of Ꝑv$_3$ shown on the Preliminary Geological map are now included in the Paradise Creek Formation. The unit is mainly grey laminated silicified shale, purple micaceous shale, and ferruginous siltstone.

In the northern part of the Sheet area, ellipsoidal concretionary structures are common in a narrow zone within Ꝑrw$_3$. These are apparently carbonate-rich, commonly developing a cone-in-cone structure which gives the outside surface a brain-like appearance. They are flattened parallel to the plane of bedding, and are 12 cm to 15 cm thick and 25 cm to 60 cm in diameter.

Ꝑrw$_4$ (Ꝑv$_4$ on the Preliminary map) has been mapped south of the Barkly Highway near Wilfred Creek, and, in the north, to the west of the Mount Gordon Fault Zone. It is composed of buff to grey fine-grained thinly-bedded labile sandstone and feldspathic sandstone, with minor interbeds of grey micaceous shale and white siltstone. Pyrite casts have been noted near the top of Ꝑrw$_4$ in the northern part of the Sheet area, suggesting a euxinic environment of deposition.

<u>Petrography</u>

Estimated modal analyses of 30 specimens of Gunpowder Creek Formation are presented in Table 10.

TABLE 10: ESTIMATED MODAL COMPOSITIONS, GUNPOWDER CREEK FORMATION

| Rock No. | Clasts | Minerals | | | | | | | | | Accessories | | Cement | Matrix | Unit | Name |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | q | f | mu | bl | ch | se | lm | op | py | to | zr | q | | | |
| 0166 | 20 | | | | 17 | 40 | | | 20 | | 3 | | | | Ērw$_1$ | Siltstone |
| M7727 | 2 | 62 | | | | 15 | 20 | | 1 | | | | | | " | Micaceous sandstone |
| M7728 | | 72 | | | | | 3 | 25 | | | tr | | | | " | Ferruginous sandstone |
| M7729 | | 99 | | | tr | tr | | | | | 1 | | | | " | Orthoquartzite |
| M7843 | 4 | 84 | | | | | | 2 | tr | | tr | tr | | 10 | " | Conglomerate matrix |
| M7835 | 5 | 88 | 2 | | | | | | | | | | | 5 | " | Quartzite |
| M7836 | | 75 | | 2 | | | | | 1 | | tr | | | 22 | " | Micaceous sandstone |
| M7834 | 2 | 93 | | tr | | | | | tr | | | | | 5 | " | Quartzite pebble |
| M7776 | 25 | 55 | 2 | | | | | | 3 | | tr | tr | | 15 | " | Labile psammite |
| M7833 | | 95 | | | | | 4 | | 1 | | | | | | | Quartzite pebble |
| 0165 | | 50 | | 18 | 19 | | | | 10 | | 3 | | | | Ērw$_2$ | Labile sandstone |
| M7730 | | 57 | | | | | 15 | | 28 | | tr | | | | " | Hematitic micaceous siltstone |
| M7731 | | 60 | | | | | 40 | | | | tr | | | | " | Micaceous siltstone |
| M7732 | | 40 | | | | 10 | 50 | | tr | | tr | | | | " | Micaceous siltstone |
| M7733 | | 40 | | | | 15 | 45 | | tr | | tr | | | | " | Micaceous siltstone |
| M7736 | | 30 | | 2 | | | 66 | | 2 | | | | | | " | Siltstone |
| M7777 | | 40 | | | | | 28 | 22 | 10 | | | | | | " | Ferruginous shale |
| M7742 | | 70 | | | | | 20 | 2 | 8 | | tr | tr | | | " | Meta-siltstone |
| M7790 | | 25 | | | | | 5 | 10 | 15 | | tr | tr | | 45 | " | Ferruginous siltstone |
| M7763 | | 20 | | | | | 77 | | 1 | | 2 | tr | | | " | Shale |
| M7754 | 16 | 20 | 5 | | | | | | | | | | | 59 | " | Greywacke |
| M7745 | | 30 | | | | | 66 | 2 | tr | | 2 | tr | | | Ērw$_3$ | Laminated shale |
| M7845 | | 50 | | | | | 4 | | 5 | | 1 | | | 40 | " | Micaceous siltstone |
| M7844 | | 85 | | | | | 10 | | 5 | | tr | | | | " | Graphitic silty shale |
| M7846 | 2 | 20 | | | | | 10 | | | | | | | 68 | " | Carbonaceous shale |
| M7847a | | 50 | | | | | 10 | | 5 | | | | | 35 | " | Siltstone |
| M7847b | | 50 | | | | | 5 | 3 | 5 | 20 | 2 | | | 15 | " | Pyritic sandstone |
| M7779 | | 75 | | | | | 5 | | 1 | | 1 | 1 | 17 | | Ērw$_4$ | Micaceous psammite |
| M7778 | 12 | 60 | | | | | 5 | | 1 | | 2 | tr | 20 | | " | Sub-labile psammite |
| M7743 | | 50 | | 2 | | 2 | | | 2 | | 2 | tr | 46 | | " | Silicified psammite |
| M7744 | | 42 | 5 | 5 | | | | | 1 | | 2 | tr | 45 | | " | Silicified sub-labile psammite |

Abbreviations: bl - biotite, ch - chlorite, f - feldspar, lm - limonite, mu - muscovite, op - opaque, py - pyrite, q - quartz, se - sericite, to - tourmaline, tr - traces, zr - zircon.

Note: M numbers are GSq microslide numbers.

The 'Torpedo Creek Quartzite Member' is composed mainly of quartz-rich sediments, especially near the base. The sandstone and quartzite contain subangular to well-rounded grains of quartz (0.5-3 mm) set in a finer-grained matrix of quartz with minor sericite. Tourmaline is present in nearly all the rocks; it is fine-grained and angular to subrounded. Well-rounded grains of zircon are present in some samples; they may be the result of reworking of sediments initially derived from the basement block to the east. Chlorite is present in only a few rocks; its presence suggests a low-grade greenschist metamorphism. Studies of pebbles from the conglomeratic layer show them to be very pure quartzite composed of subrounded to rounded grains of quartz with minor opaques and sericite; they are devoid of tourmaline.

The siltstone of $Erw_2$ is composed of angular to sub-rounded grains of quartz set in a matted aggregate of sericite which in most samples shows a rough parallel alignment with the bedding plane. the red and purple colouration is due to limonite, opaques, and rarely hematite. The limonite is mostly present as intergranular staining; the opaques are rounded; and the hematite occurs as small flakes. Tourmaline is a common accessory, ranging from subhedral to euhedral and displaying blue to pinkish-yellow pleochroism.

$Erw_3$ is mainly pelitic, composed of discrete angular to subangular quartz grains and ragged flakes of sericite in a finer-grained matrix of quartz and sericite grains. The laminations range in thickness from 0.5 to 3 mm. Opaques are present as a fine dust and discrete subrounded grains. Limonite is present in some rocks as an intergranular staining. Tourmaline is a common accessory mineral. One sample (M7846) contains a thin lens of pyrite-rich (20%) fine-grained sandstone. Most specimens from the northern exposures exhibit graded bedding in which bases are sharply defined by layers of quartz grains up to 0.05 mm in diameter. Some rare grains range up to 0.2 mm. The basal layer is mixed with finer material which gradually predominates towards the top. This type of graded bedding is formed by settling from still water rather than the type formed by a sediment-laden current, which deposits well-sorted material. The graded beds range from 0.5 to 3 mm thick. The grading is usually from silt to clay.

The sediments of $Erw_4$ are mostly psammitic. They comprise angular to subrounded grains of quartz, sericite, minor muscovite and chlorite, and opaques set in an extremely fine-grained siliceous and sericitic cement. Tourmaline is present in relatively large amounts up to 2 percent. Zircon is a common accessory mineral. Chlorite is evident in some specimens.

## Discussion

Petrographic evidence suggests that the bulk of the Gunpowder Creek Formation has been metamorphosed to the chlorite grade of the greenschist facies.

The formation has probably been deposited in a transgressive sedimentary environment. Source areas are considered to be quartzite terrains composed of Judenan Beds, Eastern Creek Volcanics, and Leander Quartzite. Deposition of the formation commenced in a slowly subsiding basin, following a period of instability accompanying the intrusion of the Sybella Granite (Fig. 14A). Transgression of the basin eastwards resulted in progressively older units being eroded (Fig. 14B); this is reflected in the composition of the pebbles and cobbles in the basal conglomerate. To the west the clasts are derived from Judenan Beds, whereas to the east - for example, in the Bonus Basin - the clasts are almost exclusively orthoquartzite of the upper Leander Quartzite. Towards the centre of the basin silts were being deposited and indicate greater distance from source areas and possibly a more mature topography in the source areas.

After the deposition of the conglomeratic basal member the depositional basin must have been stable for a long time. The sediments of $Prw_2$ and $Prw_3$ display features typical of a low-energy environment. For the most part they are fine-grained and are monotonously thinly bedded and laminated; micro-crossbeds appear to be uncommon. The rhythmic graded bedding described in specimens from $Prw_3$ also attests to a low-energy environment. A broad shallow shelf is envisaged as the most likely environment of deposition.

$Prw_4$ was deposited in more restricted environments. A slightly higher-energy environment than $Prw_2$ and $Prw_3$ is indicated by the presence of cross-bedding and graded bedding of a style usually associated with turbidity current action. Both these features are small-scale. Restricted circulation in the basin at this time is indicated by the presence of pyrite in the sediments.

Units previously mapped as Mingera Beds in the Mount Isa Sheet area (Hill & others, 1975) are now considered to be Gunpowder Creek Formation.

## Paradise Creek Formation

### Introduction

De Keyser (1958) defined the Paradise Creek Formation with reference to a composite section in the Mammoth Mines 1:100 000 Sheet area, north of the Kennedy Gap Sheet area. The lower part of the formation is represented by a section along Paradise Creek for about 11 km from near its junction with Gunpowder Creek; the upper part is exposed along a line that extends from latitude 19°48'20"S, longitude 138°59'20"E (about 5 km west of Lady Annie copper mine) northwest for about 5 km (Carter & others, 1961). Cavaney (1975) has revised the definition of this formation, and has divided the upper part of his McNamara Group (Tables 2, 9; Figs. 12, 13).

The revised Paradise Creek Formation underlies much of the western half of the Kennedy Gap Sheet area and has a total outcrop area in the Sheet area of about 200 $km^2$. Except for a small area of excellent, fresh exposure in the central northern part of the Sheet area, the formation is deeply weathered and poorly exposed. This has made differentiation between the Gunpowder Creek Formation, Paradise Creek Formation, and the Pilpah Sandstone difficult, particularly in the southwestern corner of the Sheet area.

### Stratigraphic relations

The Paradise Creek Formation conformably overlies the Gunpowder Creek Formation; its base is marked by a thin distinctive laminated chert, the Mount Oxide Chert Member (cf. Cavaney, 1975; Fig. 20). It is overlain conformably by the Esperanza Formation and unconformably by Cambrian and Mesozoic sediments.

Carter & others (1961) reported that the thickness of the Formation ranges from 3000 to 4500 m in the type areas, but may be less farther south. De Keyser (1958) showed sections which range in thickness from less than 800 m to about 3000 m, but only part of this sequence is now included in the Paradise Creek Formation. Cavaney (1975) reported that his Paradise (Creek) Formation is generally 500 m thick (range 200-1200 m). Partial sections measured on the Kennedy Gap Sheet area (Figs. 12, 13) are generally less than 1000 m.

Lithology and field occurrence

Throughout much of the Sheet area the mainly dolomitic rocks are white, deeply leached, and kaolinitic. Remnants of the Tertiary weathering surface are preserved on low rises only a few metres high. Towards Judenan Creek less altered dolomitic rocks have a thin red to yellow ochreous coating over fresh grey to black dolomite.

Poor exposure and incomplete sections have made consistent subdivision of the formation difficult. The following informal units have been mapped (from youngest to oldest):

$Prx_u$ - dolomitic siltstone, minor sandstone and chert
$Prx_c$ - stromatolitic (pustular) chert
$Prx_q$ - cross-bedded dolomitic sandstone, quartzite
$Prx_l$ - dolomitic siltstone, minor chert
Pro - grey laminated chert

Pro, the Mount Oxide Chert Member (cf. Cavaney, 1975), consists of white to grey, resistant chert beds each about 3 to 5 mm thick, broken into platelets 2 to 3 cm long. These chert beds are generally in groups of about six, and several such groups make up the unit, which may vary from 0.1 to 10 m in thickness. Unlike cherts throughout the rest of the Paradise Creek Formation, the basal chert generally does not display any stromatolitic structures. The chert was included in units Px and $Px_1$ on the Preliminary map (Tables 2, 9).

Associated with the chert beds are black dolomitic laminated siltstone and shale, which become white and kaolinitic or silicified when weathered. Unit Pro has a total area of outcrop in the Kennedy Gap Sheet area of about 6 $km^2$.

$Prx_1$ (Pv and Px on the Preliminary map) consists of dolomite, dolomitic siltstone and shale, minor sandstone, and some chert beds. It covers about 75 $km^2$ in the Kennedy Gap Sheet area. The dolomitic sediments are laminated to thickly bedded; the bedding is commonly disrupted by load casts (Fig. 22). Minor cross-beds, some mud-cracks, and scours are present in fine-grained sandy beds. Our limited evidence supports de Keyser's (1958) observation that towards the south the Paradise Creek Formation tends to become less dolomitic and more silty and has intercalations and tongues of sandstone.

$\underline{Prx_q}$ ($Pv$, $Px_q$, $Px$ on the Preliminary map) forms low ridges of porous well-sorted medium to coarse-grained sandstone. It has a total outcrop in the Kennedy Gap Sheet area of about 30 $km^2$. The porous nature is probably due to the leaching of dolomite cement. This unit is probably the dolomitic sandstone marker which de Keyser (1958) notes is stratigraphically below his Collenia horizon. The sandstone is locally overlain by a thin chert labelled Prxc.

$Prx_c$ ($Px_1$ on the Preliminary map) is a thin stromatolitic chert marker which overlies $Prx_q$. The stromatolites typically have a pseudocolumnar or columnar-layered structure. This unit has a total outcrop of about 10 $km^2$ in the Kennedy Gap Sheet area.

$\underline{Prx_u}$ ($Px$, $Px_1$, $Px_2$ on the Preliminary map) is the top unit of the Paradise Creek Formation as defined here. It is typically grey dolomitic siltstone, dolomite, laminated dolomitic or siliceous shale, laminated fine-grained dolomitic sandstone, and black and white chert. The dolomitic rocks typically weather to white or cream friable siltstone or shale. The sandstone is locally ferruginous. The unit has a total outcrop in the Kennedy Gap Sheet area of about 80 $km^2$.

## Petrography

Pro, the basal chert (samples M7839, 138), consists of microcrystalline quartz layers containing minor amounts of opaque minerals, mica, and, in the subsurface sample (138), up to 15 per cent carbonate. The chert layers are separated by graphite-rich dolomitic shales (sample 138, shown in Fig.21). Although the chert has recrystallised to microcrystalline quartz, no replacement textures have been observed and it appears that the original beds were chert.

$\underline{Prx_1}$. The presence of dolomite in the sediments of this unit has been confirmed by X-ray diffraction techniques (D. Barnes, BMR, personal communication 1977). The sediments in the lower part of $Prx_1$ (e.g., sample 139, Fig. 22) consist of dolomite with less than a total of two percent quartz, muscovite, plagioclase, and opaque minerals. Graphite-rich laminae and variation in the grainsize of the dolomite define bedding. Sample 158 contains subrounded quartz grains 0.2 mm in diameter, rounded lithic fragments and very fine-grained opaques set in a dolomitic groundmass. Quartz overgrowths are common on the quartz grains and the lithic fragments are of banded cherty stromatolites and massive chert.

Fig. 20 Surface expression of grey laminated chert (Mount Oxide Chert Member) at base of Paradise Creek Formation 10 km north of Chalky Bore M1670/10 IHW.

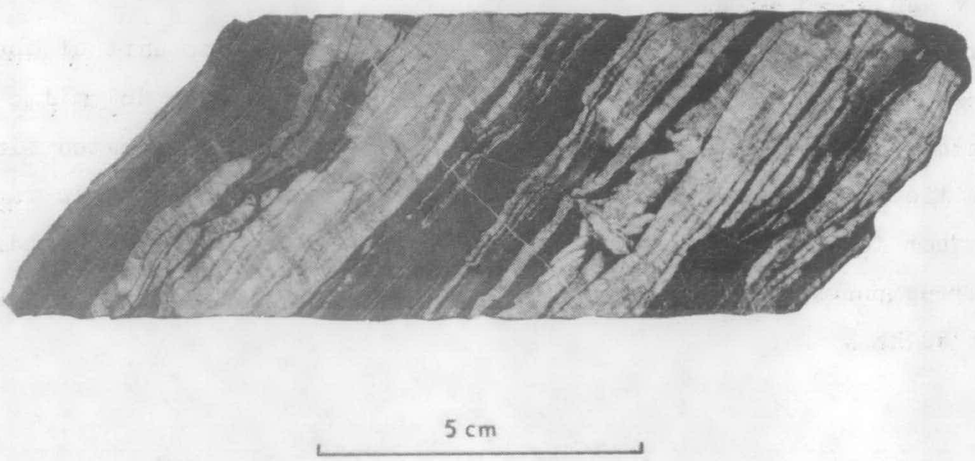



Fig. 21 Drill core of Mount Oxide Chert Member (203 m, Kelly DDH 33); the light bands are chert and the dark bands are graphitic shale. Specimen by courtesy of Union Miniere Development and Mining Corp. Ltd GB/86 RMH

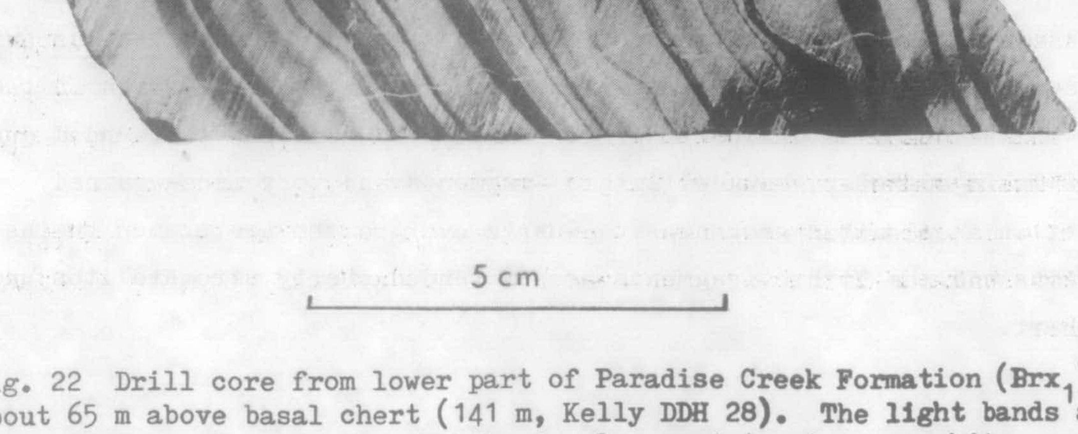



Fig. 22 Drill core from lower part of Paradise Creek Formation ($Brx_1$) about 65 m above basal chert (141 m, Kelly DDH 28). The light bands are almost pure carbonate; the dark bands also contain minor graphite, quartz, muscovite and opaques. Note the load casts. Specimen by courtesy of Union Miniere Development and Mining Corp. Ltd GB/87 RMH

The siltstone in $Prx_1$ (samples M7682, 150, 151) is laminated; individual laminae range in grainsize from very fine-grained to fine-grained. The siltstone is similar to the main rock type in the underlying Gunpowder Creek Formation. The main constituents are quartz and micas, mainly sericite, with minor opaque minerals (iron oxides, graphite, and pyrite), tourmaline, and plagioclase. Some samples have a poorly defined graded bedding but irregular alternations of siltstone and mudstone are more common.

$\underline{Prx}_q$ is characterised by sandstone composed of rounded, well sorted, and highly spherical quartz and chert grains in a dolomite matrix. Other specimens are almost entirely siliceous, possibly because fine-grained quartz has replaced the dolomite. Estimated modal analyses of six specimens are presented in Table 11. In some specimens (e.g., 140) grains are rimmed by authigenic quartz; in others the grains have irregular boundaries and are less rounded. The grain boundaries are commonly granulated and the quartz has undulose extinction, indicating post-depositional deformation. The main accessory minerals in these sandstones are tourmaline, zircon, and plagioclase. Needles within some of the quartz grains may also be tourmaline. One specimen (M7755) contains small clasts of acid volcanic rock.

$\underline{Prx}_c$ is typically a banded chert with small columnar stromatolites. In thin section (M7680, M7681, M7683, and M7841) the banding is defined by variations in the chert grainsize and in the amount of fine-grained opaque material. the stromatolites are also banded and the intercolumnar material consists of fine-grained clay mineral aggregates. Some of the chert bands are disrupted, and slightly rounded tabular fragments and muscovite flakes are cemented in a cherty matrix. Poorly defined spherical structures in one specimen may represent oolites. Fractures in the chert are filled with coarser-grained quartz veins.

$\underline{Prx}_u$. Only one specimen of this unit has been thin-sectioned (164). It is a laminated fine-grained siliceous siltstone containing minor amounts of muscovite, biotite, and opaque minerals. Dolomitic siltstone and dolomite in this unit appear to be similar in hand specimen to specimens from $Prx_1$.

Discussion

De Keyser (1958) considered that the Paradise Creek Formation sediments belong to the 'orthoquartzite and carbonate association' described by Pettijohn (1957), which 'appears to be the product of sedimentation marginal to a very low-lying stable land surface'. As de Keyser has pointed out, the ripple marks, cross-bedding, stromatolites, sharpstone breccias, and oolites indicate that the sediments were deposited in shallow water.

The chert beds in the Formation, however, indicate two conflicting environments of deposition. The Mount Oxide Chert Member most closely resembles Pettijohn's (1957) 'geosynclinal chert'; these are cherts characterised by rhythmic layering, and chert layers up to a few centimeters thick separated by thinner bands of siliceous black shales, commonly pyritic; they are thought to have been precipitated in deep water. The younger cherts of the formation resemble 'cratonic cherts' - replacement cherts associated with shallow-water limestone and quartz arenite. This may indicate regression, or at least shallowing of the basin, during the deposition of the Paradise Creek Formation. The observation of shallow-water sedimentary structures only in the upper part of the formation, and the increase of sandstone in the upper part of the Formation, support this conclusion.

The stromatolites also reflect the changing depositional environments of the Paradise Creek Formation. In the lower part of the Formation they are absent; the bottom of the basin was probably below the biotic zone, and highly reducing. The first stromatolites to appear in the basin formed large domed bioherms with columns up to 15 cm in diameter and 50 cm high. this type of stromatolite (Conophyton) probably grew in the intertidal to subtidal zone. these columns are branched, however, and become smaller in diameter and more numerous towards the top of the bioherm, which indicates a change from deeper to shallower water (M. Walter, BMR, personal communication, 1977).

Younger stromatolites form small individual unbranched columns. Hoffmann (1976) found that in Shark Bay(Western Australia) such stromatolites developed on a shallow sublittoral shelf offering partial protection from wave attack. The Paradise Creek stromatolites have been replaced by chert; a penecontemporaneous, diagenetic replacement of carbonate by chert is favoured.

In the shallow restricted basin, which is thought to have existed at this time, the water would have been highly saline, and contained fairly high concentrations of silica. This type of silicified stromatolite is also typically developed in the Esperanza Formation.

The very mature sands, cemented by dolomite, may have been washed into the basin from the beach during storms. The graded bedding in the fine-grained sands and siltstones may have formed also as the result of storms. Kelling (see Ager, 1973, p. 39) has suggested the term 'tempestites' for graded beds of shallow-water sediment that may have been churned up by storms and allowed to settle again.

Transport of sediment from the southeast is consistent with the observed facies changes from mainly sandy in the south to silty and carbonate-rich sediments in the north.

Cavaney (1975) notes the presence of potash feldspar-rich tuff beds from a few millimetres to one metre thick throughout the Paradise Creek Formation. The tuffs locally contain sequences of graded shards. Dolomite rhombs occur in some specimens and zircon is a common accessory mineral. these acid tuffs may be the source of the clasts found in specimen M7755. Alternative sources could be exposures of Carters Bore Rhyolite, possibly at the south-eastern margin of the basin, or acid volcanics in the Tewinga Group 50 km to the east.

Cavaney (in prep.) proposes the Redie Creek Member for a sequence of stromatolitic chert and cross-bedded partly silicified sandstone and quartzite near the middle of the Paradise Creek Formation. this member probably corresponds to our units $Prx_c$ and $Prx_q$.

## Esperanza Formation

### Introduction

Cavaney (1975) proposed the name Esperanza Formation (Prz; $Px$, $Px_1$, $Px_s$ on Preliminary map) was for a sequence of stromatolitic chert and dolomitic siltstone in the Lady Annie/Paradise Creek area. This sequence had previously been regarded as the upper part of the Paradise Creek Formation (de Keyser, 1958; Carter & others, 1961). The type area is in the Paradise Creek/Redie Creek area in the Mammoth Mines 1:100 000 Sheet area, north of the Kennedy Gap 1:100 000 Sheet area.

Outcrop of the Esperanza Formation covers about 45 $km^2$ in the Kennedy Gap Sheet area. It is typically exposed as low ridges of dolomitic sandstone and chert bands projecting several centimetres to almost a metre above the generally sand-covered surface. In the north of the Sheet area this formation forms broad pavements of dolomitic sandstone and siltstone, and dolomitic stromatolites (Figs. 23-26).

Stratigraphic relations

The Esperanza Formation conformably overlies the Paradise Creek Formation and is overlain conformably by the Lady Loretta Formation (Tables 2, 9; Figs. 12, 13). Cavaney (1975) reported that the Esperanza Formation ranges from 160 to 500 m in thickness, but is most commonly about 200 m thick.

Lithology and field occurence

This formation is characterised by chert beds. The cherts are typically stromatolitic, consisting of well-developed unbranched columnar structures up to 3 cm in diameter and 15 cm high. Hill & others (1975, figs. 15 and 16) and Robertson (1960, plates 6, 7, and 9) have illustrated these structures. Each chert bed overlies a sequence of cross-bedded medium-grained sandstone which probably had a dolomitic cement before weathering. Minor dolomite and dolomitic siltstone with sporadic pyrite and chalcopyrite casts occur between the sandstone-chert units.

In the north of the Sheet area to the east of McNamaras Road, two areas of large columnar dolomitic stromatolites occur in domed bioherms (north and south of grid ref. 110850). In plan these stromatolites are round to polygonal and in section they have steeply convex laminae (Figs. 23, 24, 25, and 26). Columns are 10 to 15 cm in diameter and at least 50 cm high. the columns branch, becoming smaller in diameter and more numerous upwards, but they remain parallel (Fig. 25). Laminated fine-grained dolomitic siltstone overlies the stromatolites and infills the spaces between the bioherms. This sequence was referred to as the 'Collenia' horizon by de Keyser (1958), and is identified as $Px_s$ on the Kennedy Gap Preliminary geological map. The stromatolite form is now generally called Conophyton.

Fig. 23 Cross-section of dolomitic columnar stromatolites in domed bioherm 4 km southeast of Blackstar copper mine. M2021/6 RMH.

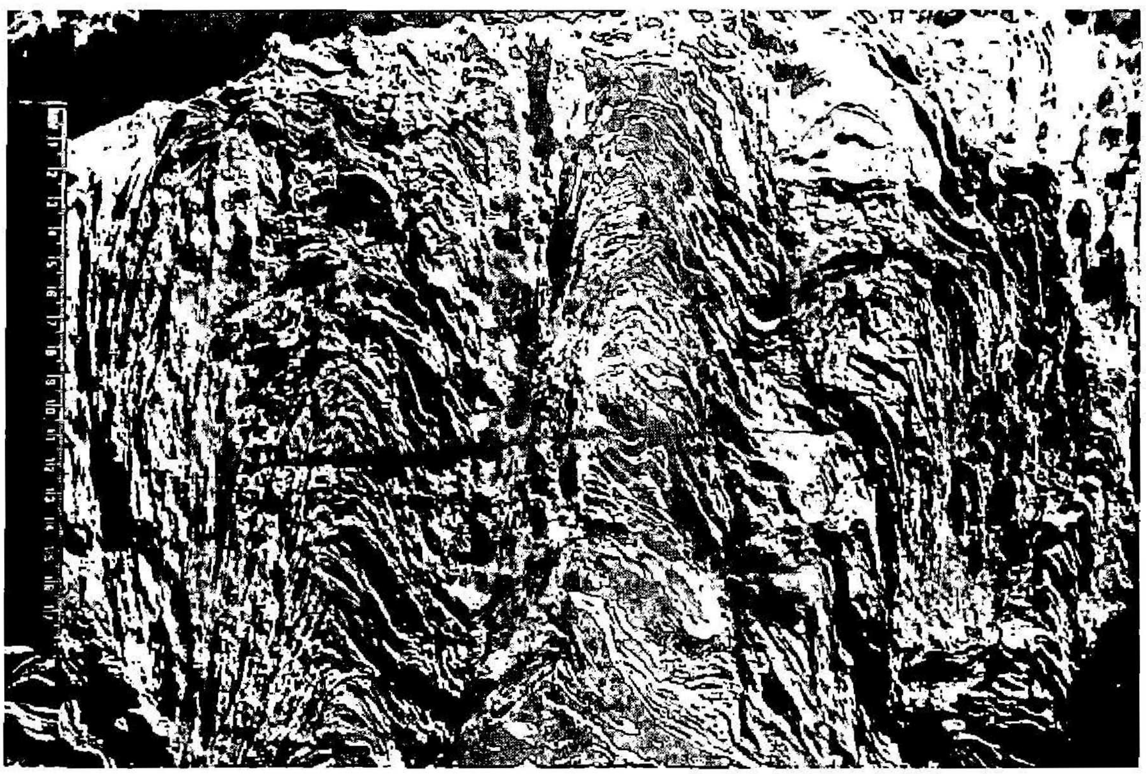


Fig. 24 Vertical section of dolomitic columnar stromatolites (<u>Conophyton</u>) showing details of laminae 4 km southeast of Blackstar copper mine. M2021/13 RMH.

Fig. 23 Cross-section of dolomitic columnar stromatolites in domed bioherm 4 km southeast of Blackstar copper mine. M2021/6 RMH.

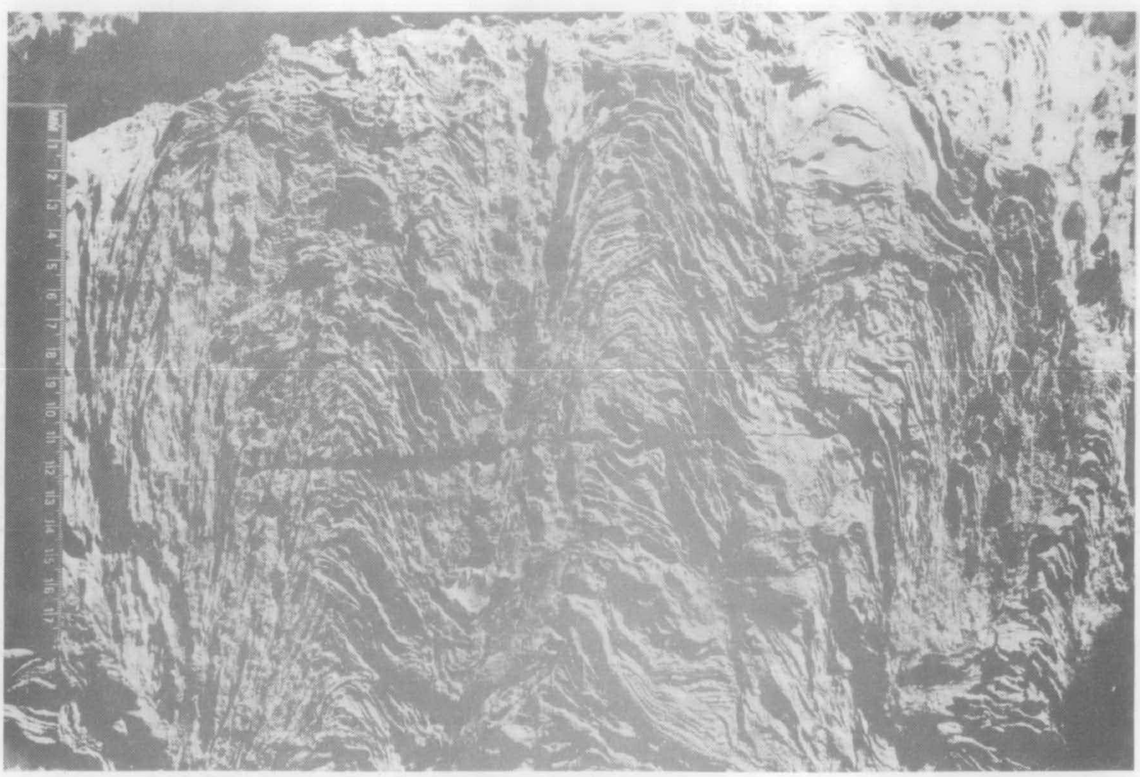
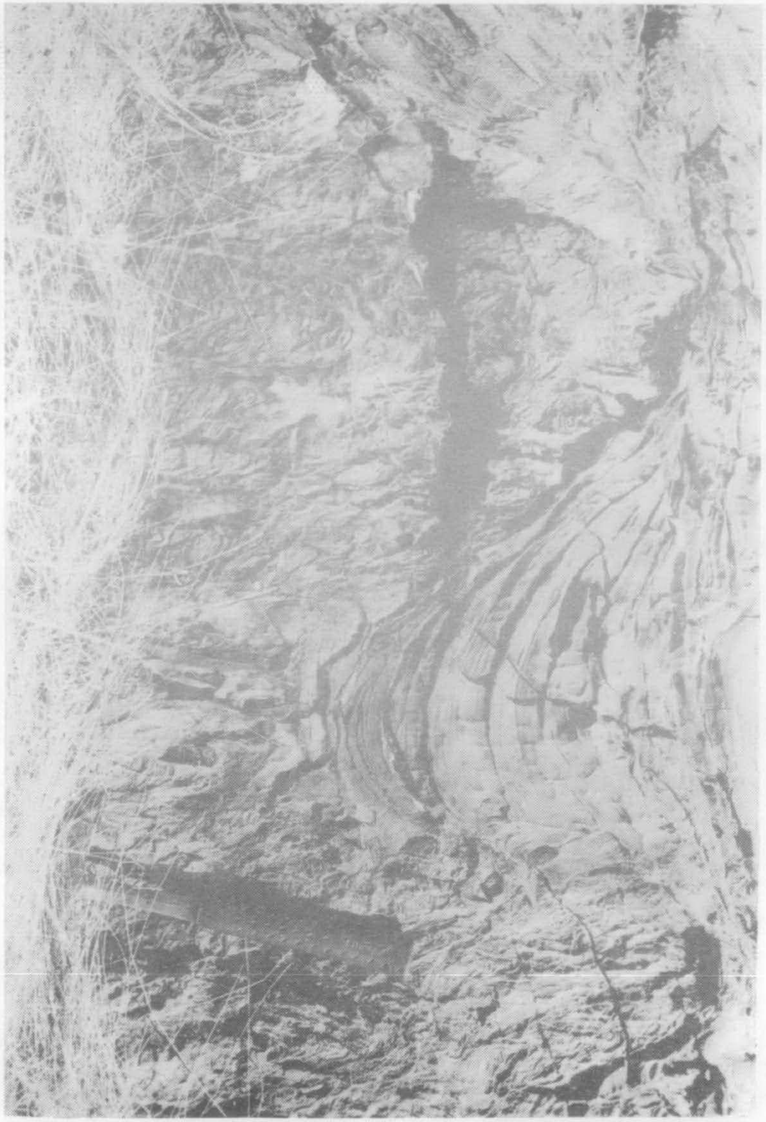


Fig. 24 Vertical section of dolomitic columnar stromatolites (Conophyton) showing details of laminae 4 km southeast of Blackstar copper mine. M2021/13 RMH.



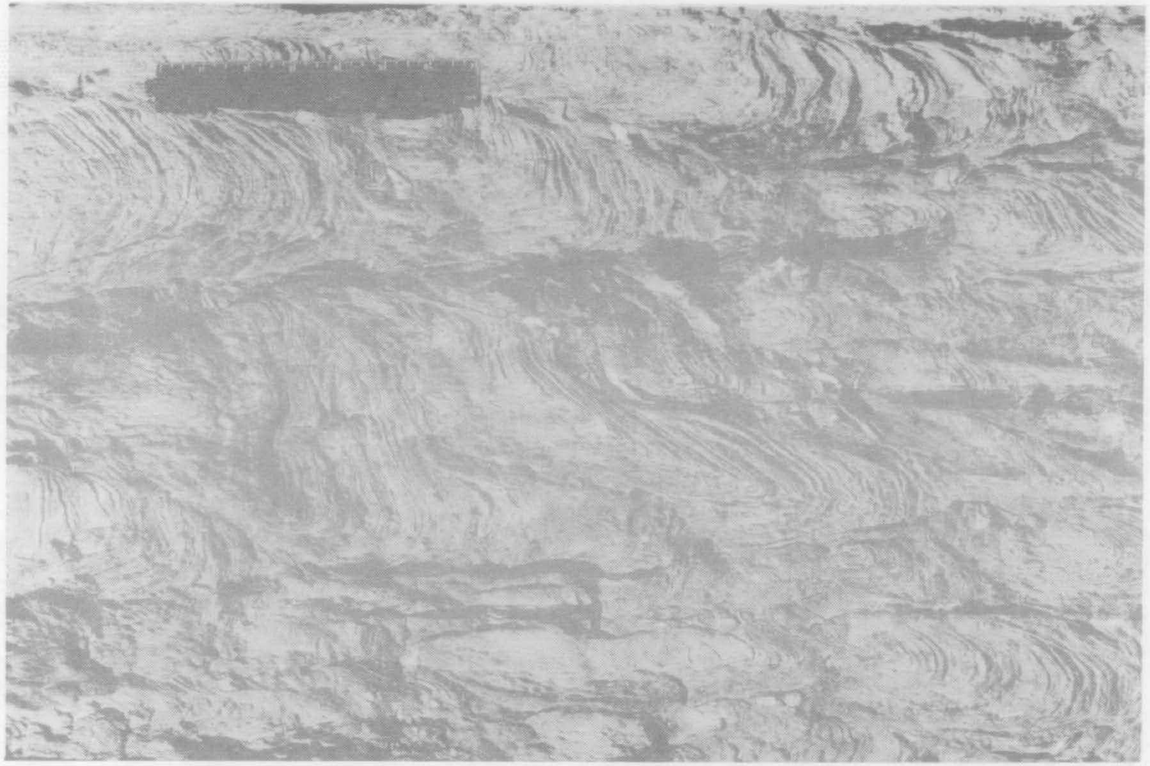


Fig. 25 Vertical section of stromatolitic bioherm - showing parallel columns that branch and become smaller in diameter and more numerous upwards. M2021/33 RMH.

Fig. 26 Vertical section of stromatolitic bioherms - showing domed shape, internal structure, and the overlying dolomitic siltstone; 4 km southeast of Blackstar copper mine. M2021/34 RMH.

TABLE 11: ESTIMATED MODAL COMPOSITIONS, PARADISE CREEK FORMATION, UNIT Ꞓrx$_q$

| Rock No. | Clasts | Grains | | | | Matrix | | Accessories | | a.g.d. | Name |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | AV | q | p | c | op | dm | se | to | zr | (mm) | |
| 140 | | 85 | 1 | | 5 | 9 | | | | 0.4 | Dolomitic quartzite |
| 160 | | 85 | 5 | | 3 | | 3 | 2 | 2 | 0.1 | Quartzose sandstone |
| 161 | | 85 | | 5 | 4 | | | 5 | 1 | 0.2 | Quartzose sandstone |
| M7755 | 1 | 84 | 5 | | | | 10 | | | 0.2 | Sublabile sandstone |
| M7801 | | 90 | | tr | tr | | 9 | 1 | tr | 0.15 | Quartzose sandstone |
| M7802 | | 90 | | 8 | tr | | 1 | tr | 1 | 0.05 | Quartzose sandstone |

Abbreviations: a.g.d. - average grain diameter, AV - acid volcanics, c - chert, dm - dolomite, op - opaques, p - plagioclase, q - quartz, se - sericite, to - tourmaline, tr - traces, zr - zircon.

Note: M numbers are GSQ microslide numbers.

TABLE 12: ESTIMATED MODAL COMPOSITIONS, ESPERANZA FORMATION

| Rock No. | Grains | | | | Matrix | | Accessories | | a.g.d. | Name |
|---|---|---|---|---|---|---|---|---|---|---|
| | q | c | mu | op | se | lm | to | zr | (mm) | |
| 142 | 65 | | 7 | | 10 | 15 | 2 | 1 | 0.05 | Labile sandstone |
| 143 | 80 | 5 | | | 15 | | | | 0.25 | Quartzose sandstone |
| M7684 | 72 | 2 | | 1 | 25 | | tr | | 0.1 | Labile sandstone |

Abbreviations: a.g.d. - average grain diameter, c - chert, lm - limonite, mu - muscovite, op - opaques, q - quartz, se - sericite, to - tourmaline, tr - traces, zr - zircon.

Note: M7684 is a GSQ microslide number.

## Petrography

The chert in the Esperanza Formation is essentially microcrystalline quartz. Stromatolitic structures are defined by changes in grainsize and by laminae rich in clay minerals or opaque minerals. One specimen (141) of an unsilicified stromatolite, possibly from the 'Collenia' horizon of de Keyser (1958), consists almost entirely of fine-grained dolomite with minor amounts of quartz, mica, and opaquies. The laminations are defined by changes in grainsize and concentrations of graphite.

Estimated modal compositions of three specimens of sandstone from the Esperanza Formation are presented in Table 12. The sandstone typically contains well-sorted subangular to subrounded grains of quartz showing undulose extinction, minor fractures, and many small inclusions. Granular chert fragments, iron oxides, and rounded tourmaline grains are present in small quantities. Sericite, clay minerals, and fine opaque dust are the main matrix constituents.

## Discussion

The stromatolites within the Esperanza Formation most probably formed in a very shallow-water marine environment, possibly on a sublittoral shelf. The reason some stromatolites are siliceous while others are not may be related to volcanic (hot-spring) environments favouring silica-depositing biota (Walter, Bauld, & Brock, 1976).

# Lady Loretta Formation

## Introduction

Cavaney (1975) proposed the name Lady Loretta Formation (Prl; Pr, Pr$_1$, Pr$_2$, Pr on the Preliminary map) was for a sequence of dolomitic, carbonaceous, and locally pyritic siltstone and shale which overlies the stromatolitic chert and *Conophyton* of the Esperanza Formation. The proposed type section is in the syncline which contains the Lady Loretta zinc-lead-silver deposit in the Mammoth Mines 1:100 000 Sheet area; Loudon & others (1975) have described it in detail. Outcrop of this formation covers about 10 km$^2$ in the Kennedy Gap 1:100 000 Sheet area.

### Stratigraphic relations

The Lady Loretta Formation overlies the Esperanza Formation conformably and is overlain conformably by the Shady Bore Quartzite.

Cavaney (1975) reported that the thickness of the formation ranges from 600 m in the south to 1900 m in the Gregory River area.

### Lithology and field occurrence

The formation is typically poorly exposed. It underlies broad alluvial plains in the north of the Sheet area, but outcrop is restricted to low rises adjacent to resistant chert or sandstone beds of the surrounding formations. The most common surface expression of the Lady Loretta Formation is ferruginous or limonitic siltstone; some white thin-bedded dolomitic siltstone is also exposed. No specimens of this formation were thin-sectioned.

## Shady Bore Quartzite

### Introduction

The Shady Bore Quartzite (Ꝑrs;Ꝑx, Ꝑx$_2$ on the Preliminary map) was originally proposed by Cavaney (1975), who called it the Carrier Quartzite - a name since found to be invalid. The type section is along the track from the Thorntonia/Gregory Downs road to Shady Bore in the southwestern corner of the Mount Oxide 1:100 000 Sheet area. The unit forms a prominent meridional range near the western limit of Precambrian outcrop, and covers about 40 km$^2$ in the Kennedy Gap Sheet area.

### Stratigraphic relations

The Shady Bore Quartzite conformably overlies the Lady Loretta Formation and is overlain conformably by the Riversleigh Siltstone. Cavaney (1975) reported that the Shady Bore (Carrier) Quartzite is 300 to 600 m thick in the north and about 60 to 100 m thick near the Lady Loretta prospect.

Lithology and field relations

The Shady Bore Quartzite consists mainly of white to pale pink, grey, or buff thinly cross-bedded medium-grained quartzite which typically forms low rounded strike ridges. Fine-grained ferruginous sandstone with interbeds of pale grey to white fine-grained orthoquartzite and minor stromatolitic chert are common in the southwestern part of the Sheet area. Orthoquartzite interbedded with feldspathic quartzite is dominant in the central part of the Sheet area. Cavaney (1975) reported siltstone and dolomite from northern exposures of this formation. Ripple marks and cross-beds are widely developed and indicate currents mostly from the south and southeast.

Petrography

The sandstones consist of subangular to well-rounded, well-sorted quartz grains, some chert grains, and highly altered feldspar grains in a very fine-grained sericite and chloritic matrix. Authigenic quartz overgrowths are common. Oolites have been recognised in one specimen (M7838). A fine dusting of opaques is common. Slightly rounded zircon and subangular fragments of tourmaline are the main accessory minerals.

Estimated modal compositions of two specimens are presented in Table 13.

The chert in this formation occurs mostly as discs 2 to 5 cm in thickness and up to 15 cm across. Very fine-grained limonite-dusted chert is cut by veins of fine-grained quartz mosaics.

Discussion

Much of what we have called Shady Bore Quartzite possibly belongs to the Esperanza Formation (R.J. Cavaney, personal communication 1977). Our main reasons for calling the western outcrops Shady Bore Quartzite are the apparent continuity from the type section in the north, and the similarity in airphoto pattern with the type section. The eastern outcrops of Shady Bore Quartzite are distinguished from the Esperanza Formation because they are separated from the main stromatolitic cherts by a wide zone of poor outcrop which possibly contains

TABLE 13: ESTIMATED MODAL COMPOSITIONS, SHADY BORE QUARTZITE

| Rock No. | Grains q | c | p | o | op | Matrix k | lm | se | Accessories to | zr | agd mm | Name |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M7740 | 80 | 10 | | | 1 | | | 9 | tr | tr | 0.15 | Quartzose sandstone |
| M7838 | 65 | 15 | 10 | 3 | 2 | 3 | 2 | | tr | tr | 0.1 | Sublabile sandstone |

Abbreviations: a.g.d. - average grain diameter, c - chert, k - kaolinite, lm - limonite, o - oolites, op - opaques, p - plagioclase q - quartz, se - sericite, to - tourmaline, tr - traces, zr - zircon

Note: M numbers are GSQ microslide numbers

TABLE 14: ESTIMATED MODAL COMPOSITIONS, MOONDARRA SILTSTONE

| Rock No. | Grains q | mu | op | Matrix ch/se | lm | Accessories to | zr | a.g.d. mm | Name |
|---|---|---|---|---|---|---|---|---|---|
| M7783 | 40 | 30 | 3 | 20 | 7 | | | 0.04 | Micaceous siltstone |
| M7784 | 20 | 10 | 10 | 60 | | tr | tr | 0.02 | Carbonaceous siltstone |
| M7785 | 20 | 3 | 12 | 65 | | tr | | 0.02 | Carbonaceous siltstone |

Abbreviations: a.g.d. - average grain diameter, ch - chlorite, lm - limonite mu - muscovite, op - opaques, q - quartz, se - sericite, to - tourmaline, tr - traces, zr - zircon

Note: M numbers are GSQ microslide numbers as much as 2000 m of stratigraphic sequence. If this is all included in the Esperanza Formation the formation would approach 5000 m in thickness. We have included only the well-exposed stromatolitic sequence in the Esperanza Formation and infer that the zone of poor outcrop represents Lady Loretta Formation. The overlying sandstone units thus belong to the Shady Bore Quartzite.

The Shady Bore Quartzite was probably deposited in a shallow-water marine environment.

## Riversleigh Siltstone

### Introduction

Cavaney (1975) proposed the name Riversleigh Siltstone (Prr;$Px_2$ on the Preliminary map) with reference to a type area north of the Riversleigh homestead in the Lawn Hill 1:100 000 Sheet area. It is composed mainly of dolomitic siltstone, but also contains sandy siltstone, shale, and tuff beds. The formation is 300 to 400 m thick (Cavaney, 1975).

### Stratigraphic relations

The Riversleigh Siltstone conformably overlies the Shady Bore Quartzite and is conformably overlain by the Termite Range Quartzite (a formation not exposed in the Kennedy Gap Sheet area).

### Lithology and field occurrence

Only one small outcrop (about 0.3 $km^2$) of this formation occurs in the Kennedy Gap Sheet area. It is a weathered ferruginous dolomitic siltstone which crops out in the axis of a refolded syncline just south of the Barkly Highway near the western border of the sheet area. No specimens were thin-sectioned.

Discussion

The Riversleigh Siltstone is the stratigraphically highest formation of the McNamara Group recognised in the Kennedy Gap sheet area.

## MOUNT ISA GROUP

Introduction

Bennett (1965) defined the Mount Isa Group, in which he named seven formations. Derrick & others (1976b) have defined an eighth formation, the Warrina Park Quartzite, at the base of the group. Only the lowest four formations in this group are exposed in the Kennedy Gap Sheet area. They are (from youngest to oldest):

Native Bee Siltstone (Ƥin) - Dolomitic siltstone, minor chert and tuff
Breakaway Shale (Ƥib) - Shale, minor siltstone
Moondarra Siltstone (Ƥim) - Dolomitic siltstone, siltstone, shale
Warrina Park Quartzite (Ƥiw) - Orthoquartzite, feldspathic quartzite, conglomerate.

The Mount Isa Group crops out in the southeastern corner of the Sheet area, 10 km to the northwest in the Hero leases area, and in the northeastern corner. The western limit of the Mount Isa Group is defined by the Mount Isa Fault in the south and the Hero Fault to the north. West of these faults, McNamara Group rocks are correlated with the Mount Isa Group. These two groups are separated by older rocks belonging to the Haslingden Group (and the Judenan Beds). The Mount Isa Group rests unconformably on the Haslingden Group, eg. near the Hero leases.

### Warrina Park Quartzite

Introduction

Derrick & others (1976b) defined the Warrina Park Quartzite with reference to a type section near the kiosk at Lake Moondarra in the Mary Kathleen 1:100 000 Sheet area. This quartzite sequence had previously been mapped as the Quartzite Marker in the Myally Beds (Bennett, 1965). The unit typically forms high ridges with a characteristic dip slope.

Outcrop of the Warrina Park Quartzite in the Kennedy Gap Sheet area covers about 5 $km^2$.

## Stratigraphic relations

The Warrina Park Quartzite unconformably overlies the Eastern Creek Volcanics and the Myally Subgroup. It is overlain conformably by the Moondarra Siltstone. In the Prospector 1:100 000 Sheet area the Warrina Park Quartzite unconformably overlies rocks which are correlative of the 'Mammoth Formation'.

## Field occurrence and lithology

In the Kennedy Gap Sheet area the Warrina Park Quartzite mostly crops out as a narrow steep-sided ridge of white thin-bedded cross-bedded and locally ripple-marked fine-grained quartzite. Conglomerate bands are common near the base of the unit and typically contain well-rounded quartzite clasts ranging from 10 to 30 cm in diameter (Fig. 27). Fractures, quartz veins, and silicification occur in the more deformed zones.

In the Hero leases the quartzite is highly ferruginous. It overlies sheared basic volcanics, and at the base a brown thin to thick-bedded medium-grained pebbly sandstone contains flattened clasts of quartzite, siltstone, shale, and basic volcanics. This sequence is overlain by brown ferruginous fine-grained labile sandstone which grades upward into siltstone. The labile sandstone contains some pebble bands and is locally graded; bedding is mostly lenticular. Some ferruginous impure calcareous sandstone has also been recorded from this area.

No specimens of the Warrina Park Quartzite from the Kennedy Gap sheet area were thin-sectioned.

## Discussion

The abundance of well-rounded quartzite clasts in most of the conglomerate beds in this unit is evidence of erosion of an older quartzite. The probable source is Myally Subgroup, which has evidently been eroded from

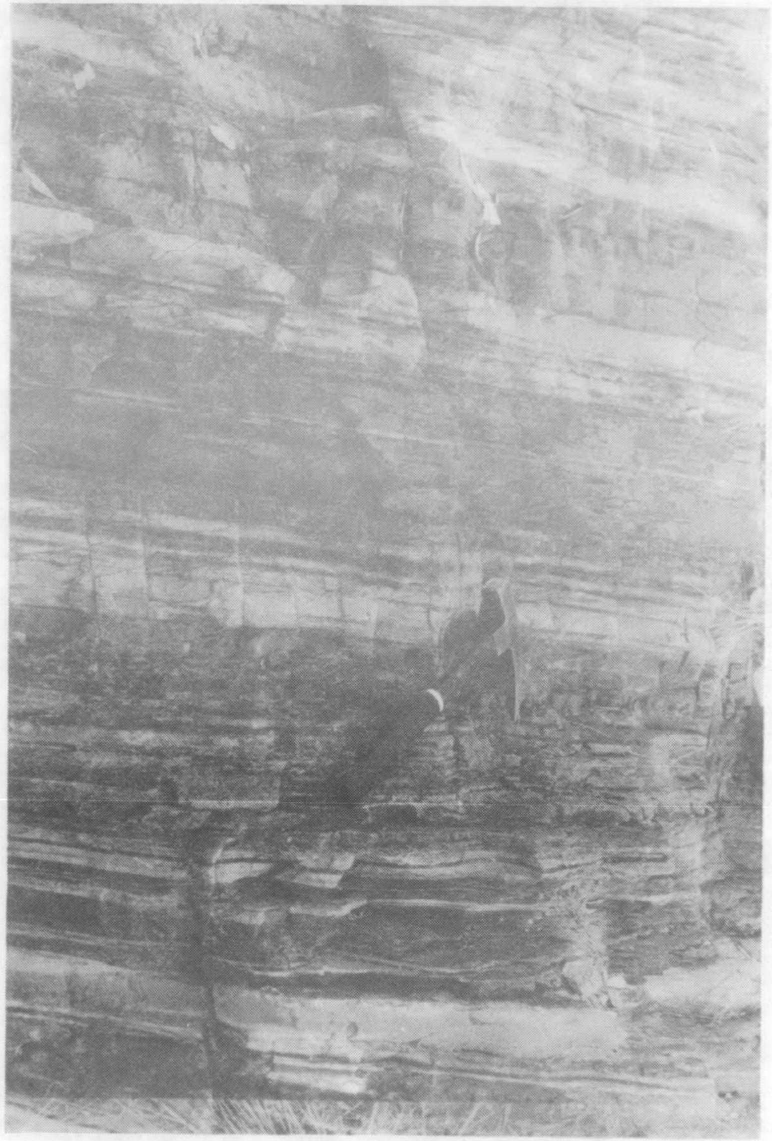


Fig. 27 Laminated labile sandstone with quartz pebble beds and intraformational shale breccia in Warrina Park Quartzite 2 km northeast of 19 Mile Bore (361 374). M1791/16 IHW.

Fig. 28 Typical red and white banded laminated siltstone in Moondarra Siltstone 10 km east-northeast of 19 Mile Bore (435 385); cleavage is parallel to hammer handle. M1791/1 IHW.

Myally Subgroup, which has evidently been eroded from the sequence in the southeast of the KennedyGap Sheet area where the Warrina Park Quartzite rests unconformably on the Eastern Creek Volcanics. Erosion of the Judenan Beds from above the Sybella Granite may also have contributed quartzite detritus.

The size of the quartzite clasts appears to decrease from east to west, but, because of wide local variations, a more detailed study would be required to verify this trend. The few palaeocurrent directions that have been inferred from cross-bed orientations indicate currents from the southeast to northeast.

The basic volcanic and siltstone detritus in the Hero lease area probably was derived locally from erosion of the Eastern Creek Volcanics although intraformational brecciation may have produced some of the siltstone and shale fragments. The ferruginous component in the conglomerate and sandstone is probably related to erosion of these basic volcanics. Some tectonism may have caused instability near the Hero fault and contributedto the diverse lithologies in the Hero lease area.

The depositional environment envisaged for most of the Warrina Park Quartzite is fluviatile coastal plain and shoreline marginal to a transgressive sea. Detritus generally fines upwards within the Warrina Park Quartzite, a feature which continues into the overlying formations - apparently marine shelf facies deposits.

## Moondarra Siltstone

### Introduction

Bennett (1965) and more recently Mathias & Clark (1975) have described the Moondarra Siltstone. The type section is southeast of Lake Moondarra (Derrick & others, 1976b) in the Mary Kathleen 1:100 000 Sheet area. The dolomitic siltstone and shale in this formation typically form broad flat valleys in which exposure is poor.

In the Kennedy Gap Sheet area this formation covers about 15 $km^2$, mostly in the southeastern corner.

## Stratigraphic relations

The Moondarra Siltstone overlies the Warrina Park Quartzite conformably and is overlain conformably by the Breakaway Shale.

## Lithology and field occurrence

Although exposure is generally poor, some moderately good exposure occurs in the stream channels and on the interfluves. The main rock type is laminated siltstone which locally is micaceous. Limonite pseudomorphs after pyrite are common. The siltstone grades into sandy siltstone, silty shale, and shale; calcareous siltstone is also evident. Minor slumping and micro-crossbedding occur locally. In outcrop the siltstone is cream, pale grey, pale brown, buff or purple, but when fresh it is generally mid-grey. Alternations of purple and pale grey or cream bands are common and in some areas concentric concretionary colour banding is developed. Cleavage is well developed in the siltstone (Fig. 28), and, in some highly deformed areas, intersecting cleavages cause the rock to fracture into long pencils.

## Petrography

Estimated modal analyses of three specimens of Moondarra Siltstone are presented in Table 14. The coarser specimens contain granular subangular quartz, muscovite flakes oriented parallel to the bedding planes, and opaque grains set in a chlorite/sericite matrix. Tourmaline is the main accessory, forming subhedral to euhedral crystals.

## Discussion

The Moondarra Siltstone overlies the Warrina Park Quartzite with a sharply defined but gradational boundary. The transition is thought to represent continued transgression of a marine environment over an eroded land surface which was first covered by the fluvial? Warrina Park Quartzite. The abundant muscovite may have been derived from schists in the Tewinga Group or from pegmatite-rich cupolas, perhaps above the Sybella Granite. The tourmaline crystals may also have been derived from similar pegmatites.

# Breakaway Shale

## Introduction

Bennett (1965) described the Breakaway Shale near Mount Isa; more recently Mathias & Clark (1975) have described this formation to the north near the Hilton mine. The type section is about 4 km north-northeast of Mount Isa, partly in each of the Mary Kathleen and Mount Isa 1:100 000 Sheet areas (Derrick & others, 1976b). The siliceous shale and minor siltstone in this formation typically form a chain of rounded hills or ridges. In the Kennedy Gap Sheet area the Breakaway Shale is exposed over about 5 $km^2$, almost entirely in the southeastern corner.

## Stratigraphic relations

The Breakaway Shale overlies the Moondarra Siltstone conformably and is overlain conformably by the Native Bee Siltstone.

## Lithology and field occurrence

The ridges and rounded hills of this formation provide good exposures of grey, pale brown, or buff thin-bedded to laminated shale, slate, and siltyshale. Limonite pseudomorphs after pyrite, and pyrite casts, are common. In the Lady Agnes copper mine area the shale is altered to a kaolinitic sericite schist. In other areas the rocks are fractured and quartz-veined. A ferruginous chert has been recorded from the top of the formation in the southeastern corner of the Sheet area.

## Petrography

Estimated modal compositions of two specimens of Breakaway Shale are presented in Table 15. Grains of quartz, opaques, and tourmaline, and rare flakes of muscovite, are set in a matrix of sericite and kaolinite. The sericite defines a slaty cleavage oblique to the bedding.

TABLE 15: ESTIMATED MODAL COMPOSITIONS, BREAKAWAY SHALE

| Rock No. | Grains | | | | | Matrix | | Accessories | | a.g.d. | Name |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | q | mu | ep | op | se | ka | ch | to | zr | mm | |
| M7757 | 30 | | | 1 | tr | 64 | 5 | tr | | 0.02 | Kaolinite siltstone |
| M7758 | 35 | 2 | tr | 3 | 60 | | | tr | tr | 0.02 | Slate |

**Abbreviations:** a.g.d. - average grain diameter, ch - chert, ep - epidote, ka - kaolinite, mu - muscovite, op - opaques, q - quartz, se - sericite, to - tourmaline, tr - traces, zr - zircon.

**Note:** M numbers are GSQ microslide numbers.

Discussion

The Breakaway Shale probably represents a deeper-water marine environment than the Moondarra Siltstone; it is finer-grained, lacks carbonates, and commonly contains pyrite casts.

## Native Bee Siltstone

Introduction

Bennett (1965) described the Native Bee Siltstone near Mount Isa; Mathias & Clark (1975) presented additional data from the Hilton mine area. The type section is east of the Mount Isa golf course, to the south of the town (Derrick & others, 1976b). This formation typically forms valleys with low rubbly outcrops. In the Kennedy Gap Sheet area outcrop of this formation covers about 4 $km^2$.

Lithology and field occurrence

This formation crops out poorly on sandy plains in the southeast of the Kennedy Gap Sheet area. The plains are typically littered with ferruginous laminated siltstone and brown chert fragments. Fresher outcrops in gullies are of cream, white, or grey laminated, mostly dolomitic, siltstone containing pyrite casts. No specimens of this formation from the Kennedy Gap Sheet area were thin-sectioned.

Discussion

The Native Bee Siltstone possibly represents deposition on a marine shelf. It is correlated with the Paradise Creek Formation in the McNamara Group to the west.

# CARPENTARIAN INTRUSIVE ROCKS

## Sybella Granite

### Introduction

The Sybella Granite was formally defined by Carter & others (1961) who recognised four distinct types of granite - a weathered granite, a foliated porphyritic granite, a massive porphyritic granite, and a microgranite -as well as pegmatite, aplite, and albitite. The current mapping program has shown that the weathered granite is not a distinct type as it is texturally the same as the massive porphyritic granite: its different appearance is due only to extreme weathering. The foliated porphyritic granite, common in the Mount Isa Sheet area to the south, is not recorded in the Kennedy Gap Sheet area.

In the Kennedy Gap Sheet area the massive porphyritic granite is exposed over about 50 $km^2$ and is shown as $Ꝑgs_2$ on the Kennedy Gap 1st edition geological map ($Ꝑgs_1$ on the Preliminary geological map). A finer-grained, less porphyritic variant with a total outcrop of about 2 $km^2$ occurs in the northwest of the Sybella Granite. This variant is shown as $Ꝑgs_{2a}$ ($Ꝑgs_{1a}$ on the Preliminary map). The microgranite is restricted to about 3 $km^2$ in the eastern part of the Sybella Granite and is shown as $Ꝑgs_3$.

Shepherd (1932), Joplin (1955), Joplin & Walker (1961), Carter & others (1961), Wilson (1972) and Hill & others (1975) have described the Sybella Granite; most of these descriptions refer to areas south of the Kennedy Gap Sheet area. The Sybella Granite was called the Templeton Granite by earlier workers.

### Stratigraphic relations

Field relations in the Mount Isa 1:100 000 Sheet area indicate that the massive porphyritic granite is younger than the foliated porphyritic granite. The microgranite is thought to be younger than the massive porphyritic granite, but contacts between these granite types are not exposed. Isotopic age determinations using Rb-Sr techniques support these relative ages; the foliated porphyritic granite is 1646 ± 15 m.y., the massive porphyritic granite is 1577 ± 13 m.y., and the microgranite is 1537 ± 40 m.y. (R.W. Page, BMR, personal communication 1974). These ages are regarded as minimum ages in view of the U-Pb-Th ages of 1160 m.y. for the massive porphyritic granite (Richards & others, 1966) and 1555 m.y. to 1576 m.y. for the microgranite (Farquharson & Richards, 1970).

In the Kennedy Gap Sheet area the massive porphyritic granite intrudes the Eastern Creek Volcanics, and the microgranite intrudes the Eastern Creek Volcanics and the Judenan Beds. Rare dolerite dykes intrude the massive porphyritic granite.

The relation between the Sybella Granite and the Gunpowder Creek Formation cannot be verified because the two units are not in contact. The presence of some clasts of massive porphyritic microgranite and quartz-tourmaline pegmatite in the conglomerate at the base of the Gunpowder Creek Formation is taken as evidence that this formation is younger than the northwestern phase ($Egs_2$) of the Sybella Granite. The possibility that the northwestern phase is comagmatic with the Carters Bore Rhyolite, which underlies the Gunpowder Creek Formation, appears to substantiate this relation. Further zircon dating is in progress to test these correlations. This relation also suggests that the Mount Isa Group, partly equivalent to the Gunpowder Creek Formation, is also younger than the Sybella Granite.

Lithology and field occurrence

$Egs_2$, the massive porphyritic granite is generally deeply weathered and sand-covered. The weathered granite is typically a blocky white to pale pink kaolinitic and chalcedonic rock which tends to retain the porphyritic texture of the fresh rock, especially preserving the discrete equant quartz phenocrysts which characterise the massive porphyritic granite. Remnants of an old laterite profile remain over parts of the area underlain by this granite type, and even in the ferricrete which marks the top of this laterite profile the quartz grains retain their form and size distribution.

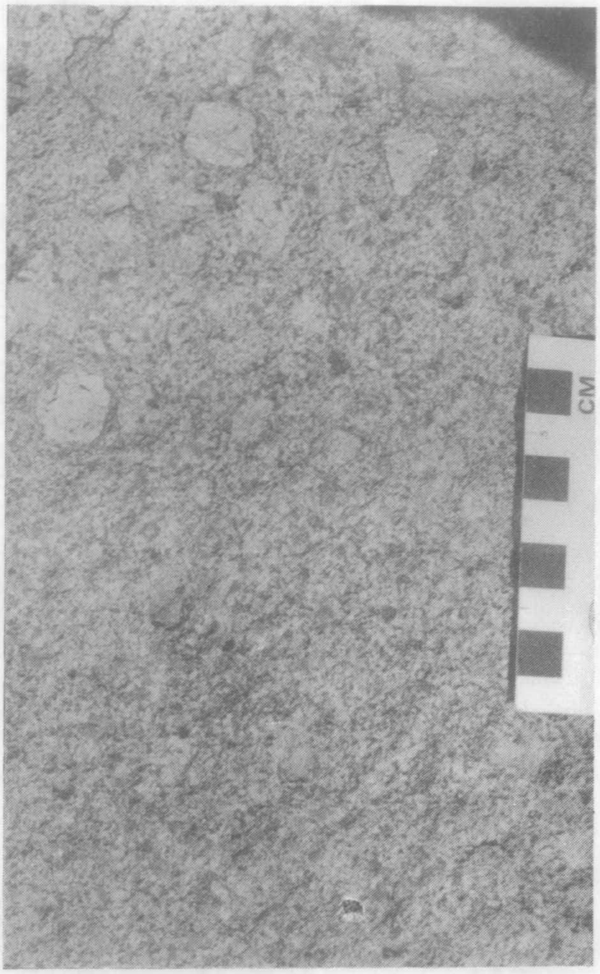



Fig. 29.

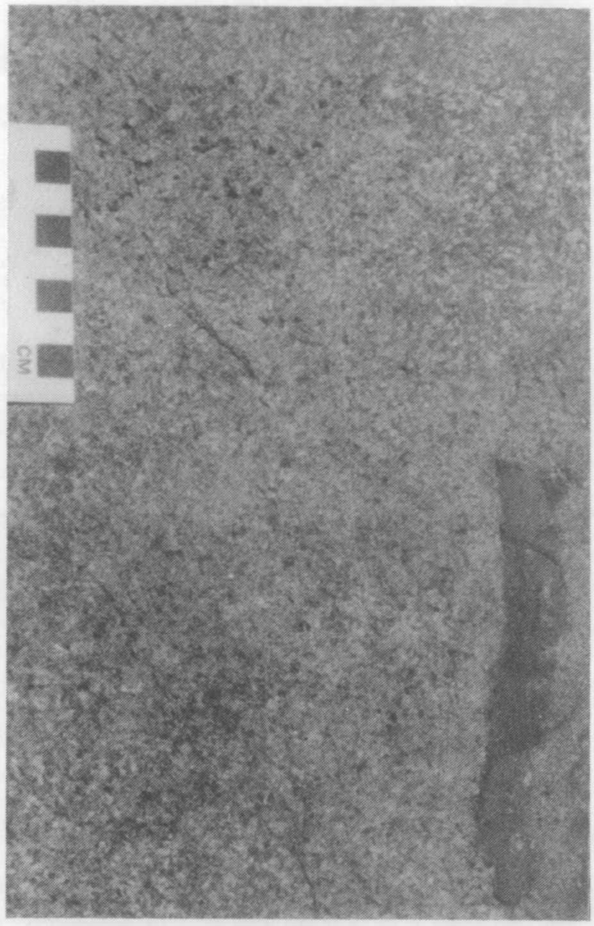



Fig. 30.

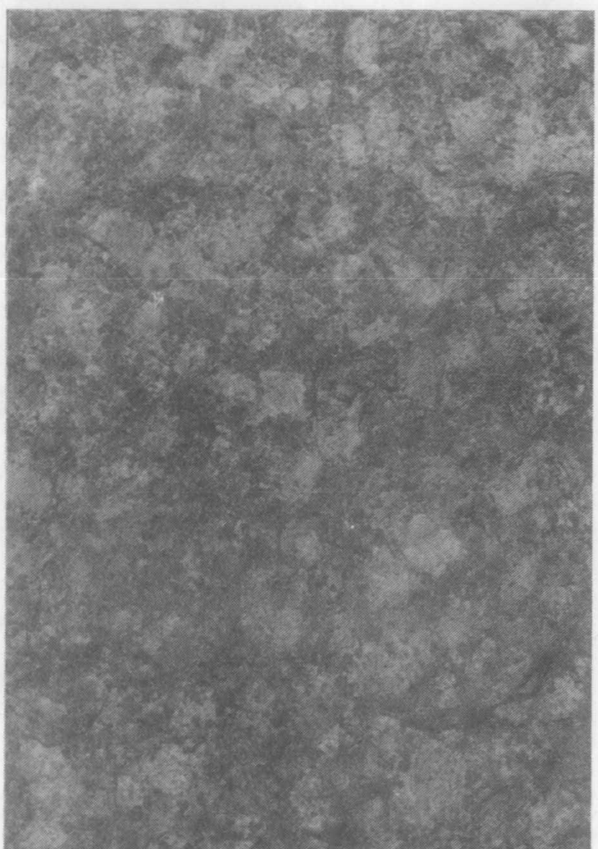



Fig. 31.

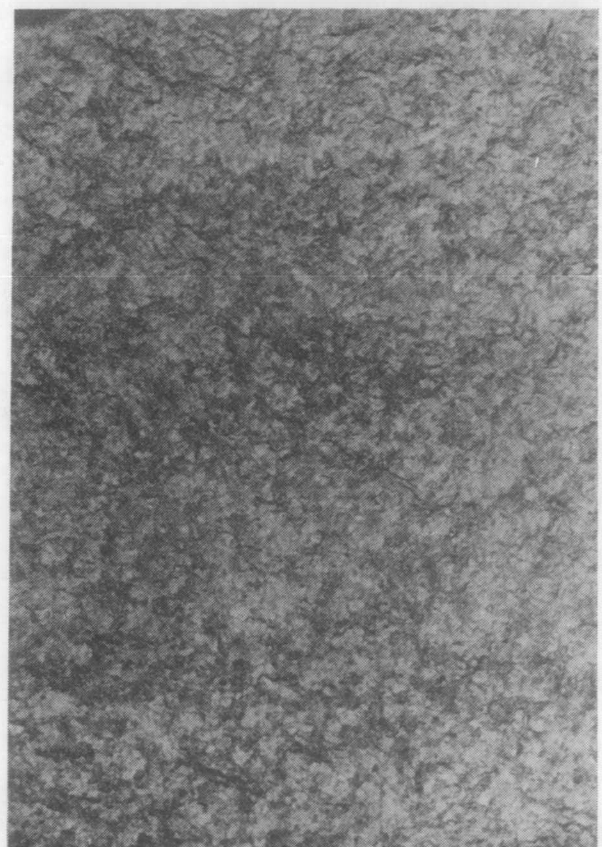



Fig. 32.

The fresh outcrops of the massive porphyritic granite occur as tors and whaleback pavements. Remnants of blocky weathered granite are frequently exposed above the bouldery fresh granite. The fresh rock is a pink, medium-grained slightly porphyritic granite with equant rounded quartz grains and larger (10 mm) subhedral potash feldspar phenocrysts in a fine-grained xenomorphic granular groundmass. Locally the potash feldspar is rimmed by plagioclase producing a rapakivi texture (Fig. 29). In other areas the porphyritic granite grades into a finer-grained non-porphyritic variety (Figs. 31, 32). Dark clots of biotite, opaques, and purple fluorite are distributed throughout the porphyritic granite and locally are elongated, defining a weak foliation. The potash feldspar phenocrysts also tend to be aligned. Near the contacts, the granite contains some xenoliths of basic volcanic and hybrid igneous rock and less frequently grey schist and quartzite. The latter have strongly developed reaction rims.

The contact of the granite with the Eastern creek Volcanics is sharp and subconcordant. In a few places, veins of granite extend a few metres into the country rock. Grainsize in the granite only decreases slightly towards the contact although fine-grained granite or microgranite locally forms a narrow chilled margin.

Aplite veins up to 1 m thick are common in the massive porphyritic granite. Most are even-grained and fine-grained but some are slightly porphyritic; other veins are medium-grained towards their centres. The aplite veins can be distinguished even in the weathered outcrops. Quartz veins are common within the granite and are mostly related to shears or faults.

---

Fig. 29 Rapakivi-textured microcline phenocrysts in northwestern phase of Sybella Granite, $Egs_2$, 8 km southeast of Six Mile Mill (146 350). M1670/27 IHW.

Fig. 30 Even-grained texture typical of Sybella Granite, $Egs_3$ (microgranite), 4.5 km southwest of 19 Mile Bore (317 324). M1711/2 IHW.

Fig. 31 Typical porphyritic northwestern phase of Sybella Granite, $Egs_2$, 7.5 km east of Six Mile Mill (159 391). M1711/10 IHW.

Fig. 32 Non-porphyritic fine-grained granite, $Egs_{2a}$, which is gradational with the porphyritic northwestern phase of Sybella Granite (Fig. 31) about 10 km to the north. M1711/12 IHW.

$\underline{Pgs}_{2a}$ : This phase of the granite is poorly exposed as boulder and cobble-covered areas and a few extensive flat pavements. The fine-grained granite is generally slightly weathered. It is similar in appearance to much of the aplite in the massive porphyritic granite.

$\underline{Pgs}_{3}$. This phase is exposed as boulders on a slightly elevated plateau. The rocks are generally fresher than the granite phases ($Pgs_2$ and $Pgs_{2a}$) to the west. The main rock type is a pink even-grained fine-grained granite (previously called a microgranite; Fig. 30). The potash feldspar grains tend to be euhedral and slightly porphyritic (5 mm to 10 mm long). Biotite, fluorite, and sphene can be identified in some hand specimens. Near the contacts, this granite is finer-grained and contains sparse basic xenoliths. Narrow aplite veins have been recognised in this granite type.

Closely spaced (about 5 m apart) shear zones with a southeasterly trend occur throughout the microgranite. These shear zones locally contain quartz-tourmaline veins.

Petrography

Estimated modal analyses of 15 samples of the Sybella Granite are presented in Table 16.

$\underline{Pgs}_{2}$.The texture of this granite phase is porphyritic: potash feldspar, quartz, and minor plagioclase phenocrysts occur in a fine-grained hypidiomorphic granular groundmass. The potash feldspar phenocrysts are mostly subhedral to euhedral slightly corroded tabular microcline crystals 3 to 20 mm long. The quartz phenocrysts are subhedral, slightly rounded, equant, moderately to very strongly strained grains, some of which have been recrystallised, especially near the margins, which commonly consist of very fine-grained granulated quartz mosaics. The quartz probably crystallised as bipyramidal (beta-quartz) grains; these discrete equant grains are a characteristic of this granite phase. Plagioclase does not occur as phenocrysts in all specimens of this phase, but commonly is present as subhedral laths which are extensively altered and partly replaced by quartz.

TABLE 16: ESTIMATED MODAL COMPOSTIONS, SYBELLA GRANITE

| Rock No. | Phenocrysts | | | Groundmass | | | | | | | | | | | Accessories | | | | a.g.d. | Name |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | q | k | p | q | k | p | mu | bl | ch | ka | op | al | ap | ca | f | lm | sp | to | zr | mm | |
| **Ꞓgs₂** | | | | | | | | | | | | | | | | | | | | | |
| M7816 | 40 | | | 10 | 30 | | | | | 15 | tr | | | | | 5 | | | tr | 1 | Weathered porphyritic granite |
| M7820 | 20 | 10 | | 10 | 35 | | 5 | | | 20 | | | | | | tr | | | | 0.5 | Weathered porphyritic granite |
| M7822 | 5 | 2 | | 25 | 53 | 5 | | 5 | tr | | tr | tr | tr | | tr | | | | tr | 1 | Granite |
| M7823 | 15 | 40 | 10 | 10 | 15 | 6 | | 4 | | | tr | | tr | | | | | | tr | 1.5 | Porphyritic granite |
| M7825 | 8 | 6 | 1 | 30 | 50 | 1 | | 4 | | | tr | | | tr | tr | | | | tr | 0.5 | Porphyritic granite |
| M7818 | | | | 30 | 46 | 20 | | 3 | | | | tr | | | | | | 1 | tr | 0.2 | Aplite |
| M7824 | | | | 20 | 70 | 2 | 5 | 3 | | tr | tr | tr | | | | | | | tr | 0.3 | Aplite |
| M7826 | 15 | 5 | 1 | 10 | 50 | 17 | | 2 | | | tr | | | | tr | | | | tr | 0.5 | Aplite |
| **Ꞓgs₂ₐ** | | | | | | | | | | | | | | | | | | | | | |
| M7797 | | | | 25 | 60 | 10 | | 3 | | | tr | | | | tr | | | | | 1.55 | Granite |
| M7829 | | | | 33 | 60 | 5 | tr | 1 | | | tr | | | | tr | tr | | | tr | 1 | Granite |
| M7830 | 2 | | 6 | 20 | 60 | 8 | tr | 4 | | | tr | | | | tr | | | | | 0.5 | Porphyritic micro granite |
| M7831 | | | | 30 | 55 | 9 | tr | 5 | | | tr | | | | tr | | | | tr | 2 | Granite |
| **Ꞓgs₃** | | | | | | | | | | | | | | | | | | | | | |
| M7810 | | 10 | | 30 | 50 | 5 | tr | 3 | 1 | | 1 | | tr | | tr | | tr | | tr | 2 | Porphyritic granite |
| M7811 | | 5 | | 25 | 60 | 7 | tr | 1 | 1 | | | | | | tr | tr | tr | | tr | 2 | Sheared granite |
| M7814 | | 5 | | 25 | 60 | 5 | 1 | | 3 | | 1 | | | | tr | | tr | | | 2 | Granite |

Abbreviations: a.g.d. - average grain diameter, al - allanite, ap - apatite, bl - biotite, ca - calcite, ch - chlorite, f - fluorite, k - microcline, ka - kaolinite, lm - limonite, mu - muscovite, op - opaques, p - plagioclase, q - quartz, sp - sphene, to - tourmaline, tr - traces, zr - zircon.

Note:- M numbers are GSQ microslide numbers.

The groundmass consists of mostly anhedral quartz, microcline, and plagioclase which range in diameter from 0.3 to 2 mm. Local patches of myrmekite invade some of the larger microcline grains. Biotite is the main ferromagnesian mineral; it occurs as ragged ophitic books clustered into intergranular aggregates which also contain opaque granules and most of the accessory minerals. The accessory minerals are euhedral zircon (about 1 mm across), patches of fluorite (up to 0.2 mm long), and minor amounts of euhedral metamict allanite (up to 0.1 mm long). Apatite has been recorded as narrow prisms (up to 0.1 mm long) in the microcline.

The weathered granite specimens retain the porphyritic texture and characteristic quartz form. The microcline is replaced by quartz and dusted with kaolinite. Patches of kaolinite and muscovite probably represent altered plagioclase phenocrysts and groundmass grains. Leaching of ferromagnesian elements has removed biotite, and only traces of limonite and fine opaque dust remain. Zircon retains its euhedral form.

The aplite is moderately even-grained and very fine-grained (0.2 to 0.5 mm average grain diameter). Microcline is the main constituent. It occurs as anhedral grains and locally is slightly porphyritic with the largest grains about 2 mm across. The quartz grains are generally anhedral, with typically smoothly curved interlocking boundaries. Anhedral to subhedral plagioclase grains are the other main constituent. Biotite and muscovite are commonly present in amounts of a few percent and tend to form clusters of ragged subhedral books which also contain most of the accessory minerals. Zircon is present in all specimens as subhedral rounded grains up to 0.1 mm long; subhedral tourmaline prisms only about 0.03 mm long are locally abundant; intergranular fluorite occurs near some biotite clusters; and allanite occurs as subhedral metamict grains up to 0.1 mm long.

$\underline{Pgs}_{2a}$ has a typically even-grained, fine-grained xenomorphic granular texture, although some specimens are slightly porphyritic and other specimens are hypidiomorphic granular. Microcline is the main constituent occurring as slightly altered subhedral grains 1 mm to 5 mm across. Quartz forms anhedral grains and rarely discrete composite grains. It is also present in patches of myrmekite with a radial structure. The plagioclase occurs as anhedral to subhedral grains about 1 mm across and is generally sericitised. Biotite, muscovite, and opaques occur in small clusters of subhedral books or anhedral granules. Fluorite is an abundant accessory and euhedral zircon grains are common.

$Pgs_3$ is an even-grained, fine-grained granite which locally has microcline and relict plagioclase phenocrysts. Microcline is the main constituent and typically occurs as subhedral to euhedral tabular grains from 2 to 5 mm long. The phenocrysts rarely exceed 10 mm in length. Myrmekitic intergrowths occur at the margins of some of the microcline grains. The plagioclase is mostly sericitised albite occurring in subhedral grains from less than 1 to 5 mm long. these grains are partly replaced by microcline. Euhedral to subhedral books of biotite and muscovite occur in clusters, especially along microshears. The biotite is almost entirely altered to chlorite. Opaques are present as anhedral grains and aggregates of small grains. Fluorite and sphene are the main accessory minerals; they occur together, in and adjacent to the biotite clusters. The fluorite is intergranular and the sphene is subhedral. Zircon and apatite have also been recorded.

Discussion

The northern phases of the Sybella Granite are thought to be epizonal granites (Buddington, 1959) because of their sharp contacts with the country rock, the presence of beta-quartz grains (in $Pgs_2$), and the generally finer grain size near contacts. Other features such as the general concordance of the contacts, some evidence of assimilation of country rocks, the (poorly developed) foliation, and evidence of a metamorphic aureole are more typical of deeper-seated (mesozonal) granites.

The intrusive history of the Sybella Granite is not easily resolved because of textural variations within each phase and a lack of meaningful field relations. The oldest phase of the Sybella Granite ($Pgs_1$) is not recorded in the Kennedy Gap Sheet area; the oldest mapped phase within this Sheet area is thought to be the massive porphyritic granite $Pgs_2$. In a few outcrops this phase contains xenoliths of a medium to coarsely porphyritic microgranite with a texture similar to the bulk of $Pgs_2$. This microgranite may represent an older phase or it may be a remnant of a finer-grained variant of $Pgs_2$ which solidified at or near the contact soon after intrusion and was later engulfed by the main variety of $Pgs_2$. The fine-grained, even-grained granite phase, $Pgs_{2a}$, appears to be younger than $Pgs_2$; it could also be related to $Pgs_3$, the microgranite in the northeast of the Sybella pluton.

TABLE 17: ESTIMATED MODAL COMPOSITIONS, DOLERITES

| Rock No. | | | | | Minerals | | | | | | | | | a.g.d. | Name | Country Rock |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | q | p | ep | ch | bi | se | am | ca | op | hm | ap | al | sp | mm | | |
| M7737 | 1 | 39 | 14 | | | | 40 | 1 | 4 | tr | | | 1 | 1.0 | Metadolerite | Leander Quartzite |
| M7738 | | 64 | 1 | 25 | 3 | | | 4 | 3 | | tr | | | 1.0 | Metadolerite | Leander Quartzite |
| M7771 | 25 | 10 | | | 7 | 50 | | | 8 | | tr | | | 0.03 | Metadolerite | Judenan Beds |
| M7787 | | 40 | | 7 | 50 | | | tr | 1 | | 1 | tr | 1 | 0.3 | Metadolerite | Leander Quartzite |
| M7806 | | 30 | 10 | | tr | | 54 | | 6 | | | | | 1.0 | Metadolerite | Judenan Beds |

Abbreviations: a.g.d. - average grain diameter, al - allanite, am - amphibole, ap - apatite, bi - biotite, ca - calcite, ch - chlorite, ep - epidote, hm - hematite, op - opaques, p - plagioclase, q - quartz, se - sericite, sp - sphene, tr - traces

Note: M number is GSQ microslide number.

# Dolerite

## Introduction

Dolerite dykes and sills are abundant in the eastern part of the Kennedy Gap Sheet area where they form a north-northwest-trending swarm cutting the Leander Quartzite. Fewer dolerites are recognised in the Eastern Creek Volcanics and the Judenan Beds; dolerites are rare in the Sybella Granite; and no dolerites have been recorded from the Mount Isa Group or the McNamara Group in this Sheet area.

At least two distinct periods of dolerite intrusion are indicated in the Kennedy Gap Sheet area: the older period antedates the Sybella Granite and the younger period postdates it. A detailed study of the dolerites has not been undertaken because of weathering and poor exposure.

## Lithology and field occurrence

In the quartzitic units the dolerite bodies are poorly exposed in narrow, elongate valleys. Outcrops are typically very weathered but some very fresh bouldery outcrops have been located. In the Eastern Creek Volcanics the dolerite is difficult to distinguish from basic volcanics, because both are covered by ferricrete remnants and thin red-brown soils.

The fresher dolerite is typically medium-grained and may have an ophitic texture.Metamorphism and shearing has transformed some dolerite to chlorite-biotite schist. Some schists contain relict plagioclase phenocrysts.

## Petrography

Table 17 presents estimated modal compositions of five dolerite dykes. The least metamorphosed specimens (M7737 and M7806) contain amphibole crystals, showing relict ophitic textures, in a relatively equigranular medium-grained hypidiomorphic granular groundmass of plagioclase laths, skeletal intergranular and granular opaques, and a variety of alteration products such as sphene, calcite, and epidote. The other specimens are schistose or contain randomly oriented chlorite and biotite replacing the original ferromagnesian minerals. Specimen M7771 has been extensively silicified and contains mainly sericite and quartz but still retains an ophitic texture.

## CAMBRIAN STRATIGRAPHY

Two small outcrops of Cambrian strata are located on the east bank of Cattle Creek about 10 km north of the Barkly Highway near the western boundary of the Sheet area (grid ref. 925 686). The main rock type is a laminated siliceous limestone which is partly covered by caliche. Õpik & others (1961) recorded a section 15 m thick of dark bituminous unfossiliferous limestone in this area, and mapped this limestone, a pale limestone, and gypsum over a total area of about 30 $km^2$. However, much of this area is now known to contain outcrops of Paradise Creek Formation and Esperanza Formation, which are overlain by thin remnants of this limestone unit.

The Cambrian rock types present are similar to the Thorntonia Limestone to the west of the Sheet area, and to part of the Beetle Creek Formation, which occurs at the base of the Middle Cambrian sequence to the south. A Middle Cambrian age is suggested for the outcrops in the Kennedy Gap Sheet area.

## MESOZOIC STRATIGRAPHY

One small outcrop of possibly Mesozoic age crops out in the Sheet area at grid reference 241 404, about 4.5 km south of 29 Mile Bore. It consists of flat-lying ferricreted sediments which form the capping of a small butte rising above the generally low-lying outcrops of $Phj_2$ in the Judenan Beds. These rocks are probably of Early Cretaceous age and may correlate with the Polland Waterhole Shale.

## CAINOZOIC UNITS

Five Cainozoic units have been mapped in the Kennedy Gap Sheet area. A sixth unit, alluvium, was recognised but its narrow sinuous development along the watercourses did not allow it to be mapped. This unit has been included in

Czr, and to a lesser extent, in Qf and Czs. The six units are listed below in roughly increasing age, although considerable overlap in age occurs between most units.

Qf - Sheetwash, clay, silt, alluvium
Czr - Older alluvium, red-brown sand, silt, clay, minor younger alluvium
Czg - Pebble and boulder gravel
Czs - Colluvium, sand, gravel, clay, minor alluvium
Czd - Ferricrete, silcrete

Calcrete has also developed on a small scale in the Cainozoic.

Czd is a duricrust which is widely represented by ferricrete cappings on psammitic, pelitic, and basic volcanic rocks. The ferricrete contains angular quartz and minor highly altered feldspar grains and fragments of the underlying rock type in a generally botryoidal limonitic cement. Many of the dolomitic units in the McNamara Group are overlain by a locally limonite-stained silcrete which consists of angular quartz, quartzite, altered feldspar, and chert fragments in a very fine-grained chalcedonic cement containing some kaolinite and a fine-grained dusting of opaque iron oxides.

Czs is mainly a brown sandy colluvium which has developed by weathering of various psammitic and granitic rocks. A dark clayey soil is developed over the basic volcanics and some pelitic units. Gravel has accummulated locally; it contains clasts of the underlying rock types, especially vein quartz. Czs is the most widespread Cainozoic unit mapped in the Kennedy Gap Sheet area, where it covers about 500 $km^2$.

Czg is a gravel deposit which forms several rounded slightly elevated areas mostly in the headwaters of Wilfred Creek, 5 to 10 km southeast of 29 Mile Bore. The gravel is characterised by well-rounded pebbles and boulders (to 50 cm in diameter) in a quartzose matrix which is locally ferruginous. The gravel beds locally exceed 5 m in thickness. The linear distribution of the gravel beds along a shallow valley possibly indicates that the gravels represent a previous course of Wilfred Creek.

The clasts appear to have been mostly derived by reworking of the conglomerate a the base of the Gunpowder Creek Formation.

Czr covers about 200 $km^2$. It consists mainly of red-brown sand, silt, and clay which are older flood-plain deposits along the main watercourses in the area.

Qf is typically a thick black clayey soil and minor silt which develops on flat plains or shallow depressions through the action of sheetwash. These areas are characterised by gilgai vegetation, and a bluish/green colour on the colour air photographs. The black soil typically develops above dolomitic sediments of the McNamara Group and to a lesser extent over the Eastern Creek Volcanics. A lacustrine limestone deposit of early Cainozoic age commonly underlies the black soil plains.

## STRUCTURE

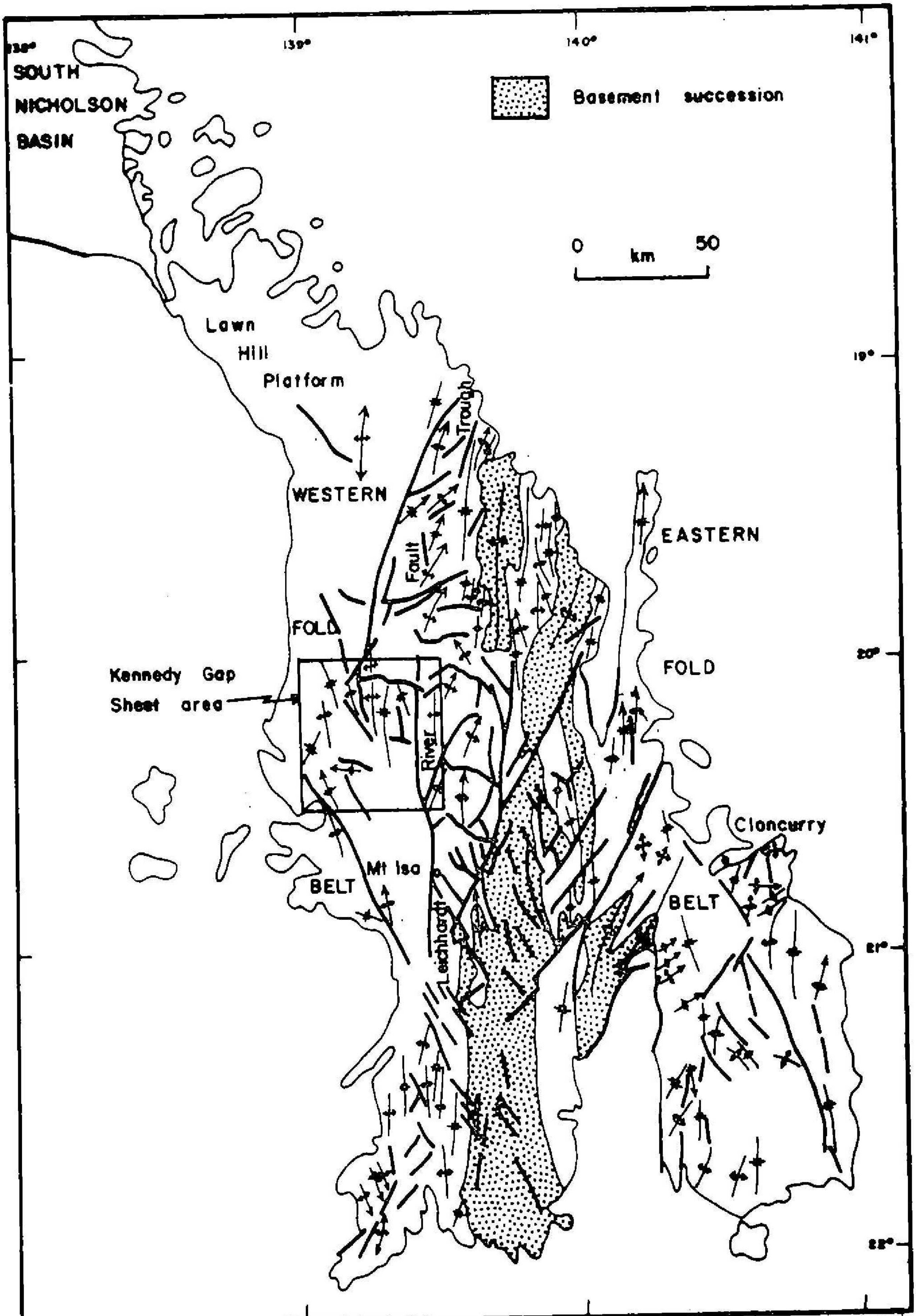
### Introduction

The Kennedy Gap Sheet area is in the Western Fold Belt of the Mount Isa Inlier (Fig. 33). Most of the area is considered to be in the Mount Isa Orogenic Domain but the northwestern part, west of the Mount Gordon Fault Zone, is assigned to the Lawn Hill Platform (Plumb & Derrick, 1975), where the deformation is less intense. The Sheet area generally has less complicated structure than other Sheet areas to the south and east.

Most of the rocks in the Kennedy Gap Sheet area are Carpentarian and were folded, faulted, and intruded by granite before Adelaidean sediments were deposited to the west. Subsequently this area has been only slightly deformed. The main structures are tight meridional folds which have been disrupted by at least three systems of faults. West of the Mount Gordon Fault Zone, folding has produced broad basins and domes, and faulting is less conspicuous.

### Previous work

De Keyser (1958) described the structure of the Paradise Creek Formation and related rocks. He noted the strong north-trending folding and indicated the abundance of strike-slip and vertical displacement faults, and




Record 1979/24

F54/A1/74

Fig. 33. Structural setting of the Kennedy Gap Sheet area

commented on shearing, silicification, quartz-veining, and phyllonite zones along faults. He postulated a long period of deformation caused by east-west compression or a northwest-trending sinistral shear couple.

Carter & others (1961) noted the different structural styles on either side of the Mount Gordon Fault Zone, and commented on the general northerly plunge of folds to the east of the fault zone and the wrapping of structures around the northern end of the Sybella Granite in the south of the Sheet area. In the older strata they recognised two deformations, both consistent with east-west stress. Faults, especially those with a northerly trend, were thought to have been active during sedimentation, but they related most of the faults to a conjugate strike-slip system. They recognised some east-trending faults with large vertical displacements, and described the north-trending Mount Isa Fault as a high-angle reverse fault. They commented on jointing in the Sybella Granite and the Leander Quartzite where the joints are filled by metadolerite. Cleavage was reported from the Eastern Creek Volcanics and the older rocks.

The only published detailed structural studies which deal with rock units found in the Kennedy Gap Sheet area are by Wilson (1975), in an area west of Mount Isa, and by Alcock & Lee (1974), at Lady Loretta, north of the Kennedy Gap Sheet area. The Mount Isa study revealed four generations of folds but only three could be identified in any one part of the stratigraphic sequence. The Lady Loretta study revealed four groups of folds - the earliest being interpreted as slumping which occurred no later than diagenesis of the sediments. The final generation of folds in both areas are represented by small folds or large open folds which have little effect on regional structural trends. Both studies indicate that the first generation of folds with regional significance plunge moderately to steeply to the north. A later generation of folds generally has a shallow plunge to the north,northeast, southeast, or rarely southwest. Both studies revealed a complicated pattern of faulting.

## Structural elements

Only two foliations have a wide distribution in the Kennedy Gap Sheet area. The oldest foliation, $S_o$, is bedding which is clearly evident throughout the stratigraphic sequence. A primary layering is only locally defined in the basic lavas but interbedded sediments displaying primary sedimentary structures adequately define the large-scale structure of these rocks. $S_0$ dips are generally steeper than 70° in the east of the Sheet area, but dips of 30° to 50° are more common in the west. The main structural trends of $S_0$ are shown in Figure 34 and displayed as stereographic projections in Figure 35.

A younger foliation, $S_1$, is an axial-plane structure to folds in $S_0$. This foliation is recognised in all stratigraphic units which have favourable lithologies, but it is poorly developed in units above the Gunpowder Creek Formation. In the Leander Quartzite, $S_1$ develops as widely spaced joints which are commonly filled by dolerite dykes. In the Judenan Beds in the southeastern corner of the Sheet area, intense folding is accompanied by partial transposition of bedding ($S_0$)into the axial-plane foliation ($S_1$). Equal-area projections of $S_1$ are presented in Figure 35.

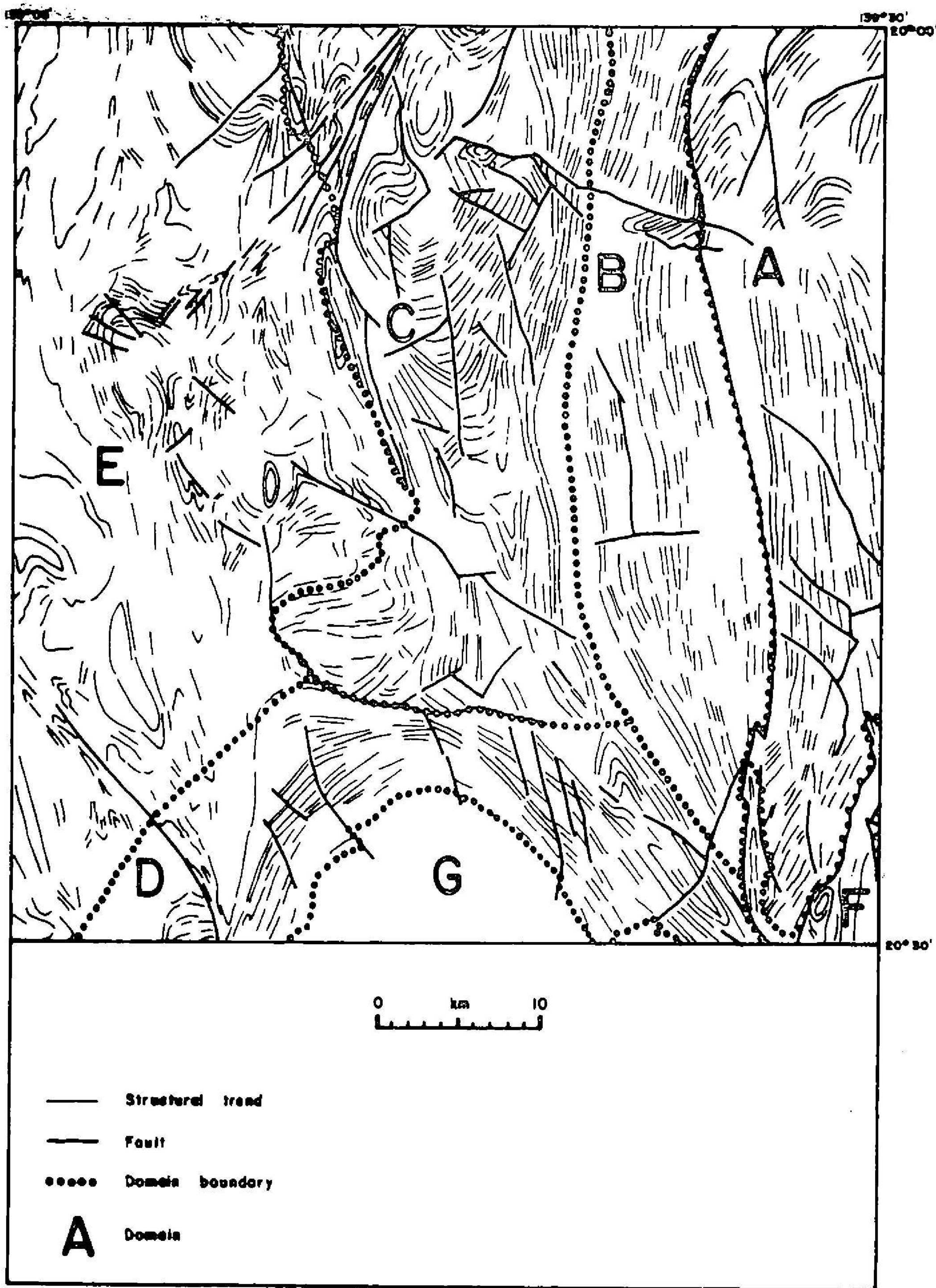
Later penetrative foliations are evident locally, especially near major faults. These foliations are mostly kink bands or crenulation cleavages.

Most lineations are defined by the intersection of $S_0$ and $S_1$. Other lineations are defined by mineral elongation (amphiboles in the basic rocks and quartz grains in the most highly metamorphosed quartzites). In the Sybella Granite a poor lineation is defined locally by elongation of potash feldspar phenocrysts and by elongated basic xenoliths. Equal-area projections of lineations are presented in Figure 35.

## Macroscopic structures

### Folds

The macroscopic fold closures and the strike of bedding ($S_0$) on the limbs of folds are readily apparent over most of the Kennedy Gap Sheet area. The major folds are tight to isoclinal and have a northerly trend.These folds are referred to below as the $F_1$ fold generation, the main examples being the Leander Anticline and the Waggaboonyah Syncline, which both extend for almost the entire length of the Sheet area in the east. The fold axes are nearly horizontal, but tend to have a slight northerly plunge.




Record 1979/24

F54/A1/76

Fig. 34. Structural domains and trends in the Kennedy Gap Sheet area

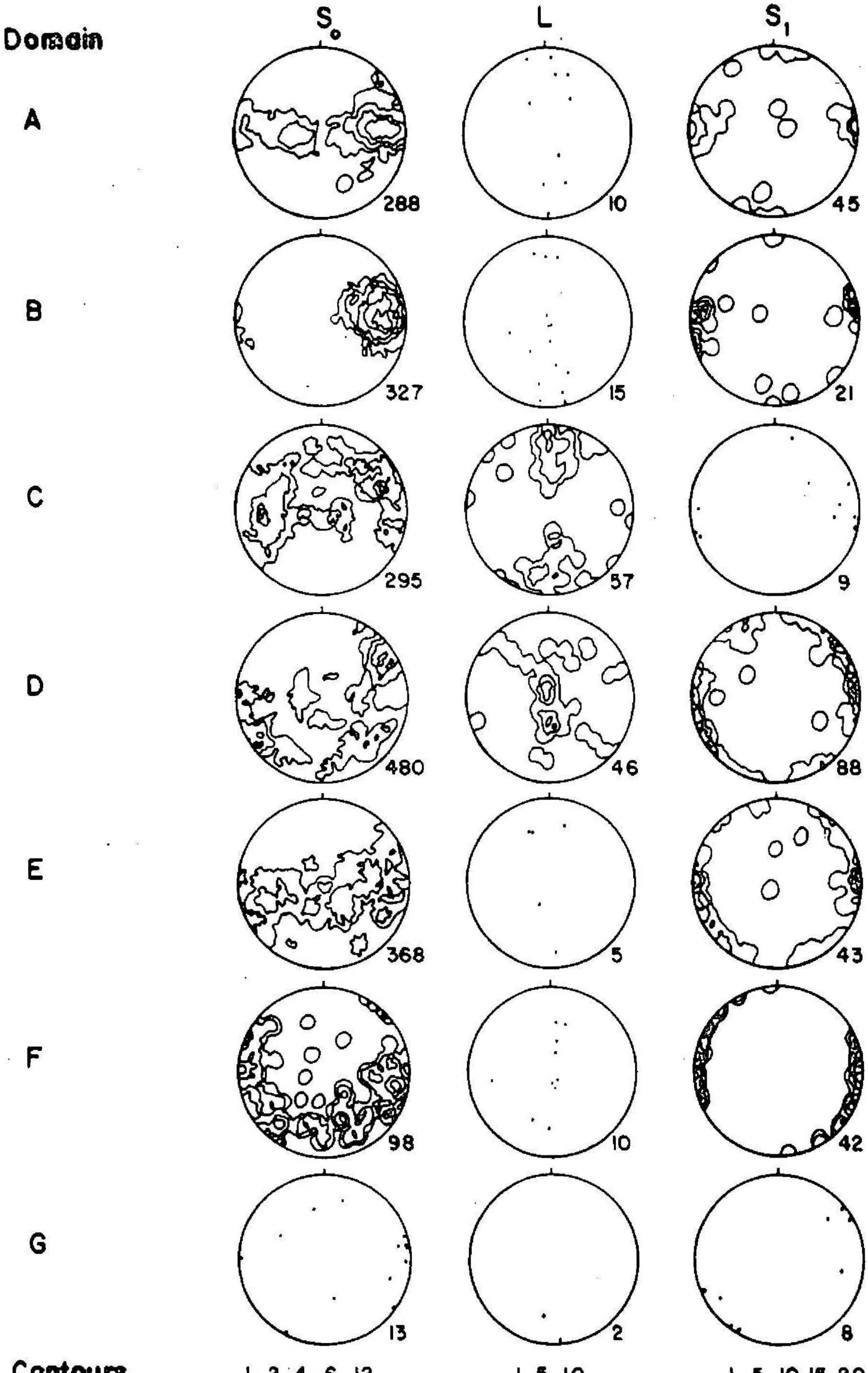



Fig. 35. Equal-area lower-hemisphere projections of $S_0$, L, and $S_1$ in domains A to G shown in Figure 34



F54/A1/76

These folds have been fragmented by numerous oblique, transverse and strike faults; for example, a major strike fault with large vertical movement (the Hero Fault) and several smaller parallel faults repeat the western limb of the Leander Anticline and a combination of strike-slip and normal faults terminate the southern end of this anticline. Numerous east-trending faults repeat the stratigraphic sequence along the north-plunging folds. In the south of the Sheet area, the southern extension of the Waggaboonyah Syncline is deflected to the southeast so that it trends roughly parallel to the contact of the Sybella Granite, and in the southwest of the Sheet area other fold axes are deflected to the west to parallel the granite contact.

In the northwest of the Sheet area the folding is more open and basin-and-domes are common, with generally north-trending long axes. Faulting is less conspicuous, and is limited to small displacements of folds on strike-slip and/or normal faults. Despite the apparent refolding implied by basin-and-dome structures, this folding was attributed to inhomogeneous strain by Duff & Wilson (1975). Their main argument for only one phase of folding is the development of only one axial-plane foliation.

Faults

Three types of faults have been recognised in other parts of the Mount Isa Inlier (Carter & others, 1961; Derrick & others, 1971, 1977; Wilson & Derrick, 1976). These are:

1) a generally north-trending set of major faults which may show reverse movements, and which may have been active during as well as after sedimentation;

2) an east-west trending set of normal faults with large vertical movements;

3) a conjugate set of northeast (dextral) and southeast (sinistral) strike-slip faults, the largest of which have lateral displacement of tens of kilometres.

The first type is represented by the Mount Isa Fault and Hero Fault in the east of the sheet area and possibly by the Mount Gordon Fault Zone in the northwest. The May Downs Fault in the southwest of the sheet area may also belong to this set. These faults are the major faults in the Sheet area and trend northerly, northwesterly, and northeasterly. Evidence of activity during sedimentation is not abundant, but the unusual conglomeratic sequence at the base of the Mount Isa Group in the Hero lease area may be evidence of movement during Mount Isa Group time. Similarly, the thick conglomerate on the western side of the May Downs Fault may be evidence of movement on this fault during Gunpowder Creek Formation time. The Gunpowder Creek Formation is known to thin against the Mount Gordon Fault Zone to the north of Kennedy Gap Sheet area (G. Moore, personal communication, 1977), possibly indicating uplift during sedimentation. Faults of this type also show evidence of major movements during or after the folding.

The second type of faults are represented by the unnamed west-northwest-trending fault near the Barkly Highway at grid reference 105473; the similar-trending splays of 29 Mile Fault Zone in the middle of the Sheet area; and the unnamed fault along the northern boundary of the Bonus Basin farther north at grid reference 300760. Vertical movements on these faults displace the southern blocks downward. The earliest movements on the two northern faults appear to have occurred during deposition of the Gunpowder Creek Formation, because conglomerate sequences at the base of this formation are generally thicker and more labile in areas adjacent to these faults. The main movements on these faults have occurred since the deposition of the McNamara Group, probably after the major folding episode.

The majority of the small faults in the Sheet area are thought to be of type 3. They trend northeast and northwest, and generally have a strike-slip displacement of at most several hundred metres. Strike-slip movements are also probable in the Mount Gordon Fault Zone and along the May Downs Fault. In the south of the sheet area most of the strike-slip faults trend northwest, roughly parallel to the May Downs Fault to which they may be related. Displacements on these minor faults are mostly post-folding, although some of the larger faults, for example Smith's Fault and the southern end of the 29 Mile Fault Zone, may have been active during deposition of the basal unit in the Gunpowder Creek Formation.

Igneous contacts and unconformities

The Sybella Granite contacts are mostly concordant with the stratigraphy in the Haslingden Group, which the granite intrudes. The semicircular northern boundary of the main Sybella Granite pluton in the south is one of the most conspicuous structures in the Sheet area. The smaller pluton of microgranite ($Egs_3$) to the southeast has a partly discordant contact with the Haslingden Group. Neither pluton has a pronounced deformational foliation parallel to $S_1$ in the adjoining strata, possibly indicating that the granite was intruded after $F_1$ folding. The absence of a foliation is also explicable if the granite did not deform during folding of the strata. The only penetrative foliation in the granites (especially prevalent in $Egs_3$) is a vertical cleavage parallel to, and mostly located along, a set of northwest-trending shears. This deformation appears to be related to the northwest-trending strike-slip faults which cut the granite and displace the granite contact (for example Smith's Fault).

Dolerite dykes are of at least two ages. The older swarm trends north to north-northwest in the Leander Quartzite, where it follows a joint pattern consistent with an axial-plane foliation in the $F_1$ folds. These dolerite dykes and related sills and bosses of dolerite are metamorphosed. The younger dolerite dykes are unmetamorphosed. They generally trend west-northwest to west, and may lie in tensional fractures related to the east-west faults. they may, however, be much younger, as dykes of similar orientation and petrology in the Mary Kathleen Sheet area ($do_6$) may be Adelaidean in age (Derrick & others, 1977; Wilson & Derrick, 1976).

Three unconformities are thought to be present in the Carpentarian sequence exposed in this Sheet area. The oldest is at the base of the Carters Bore Rhyolite, the next is at the base of the 'Mammoth Formation', and the youngest is at the base of the Mount Isa and McNamara Groups. Strong angularity is evident in only a few localities, but the presence of unconformities are evident when the features are considered regionally. The youngest unconformity shows the most angularity, mainly because of its more extensive distribution. The 'Mammoth Formation' is recognised in only one locality, and does not show any mappable discordance with the underlying Carters Bore Rhyolite. The only evidence that the Carters Bore Rhyolite is unconformable on the Haslingden Group is the local disappearance of the upper part of the Judenan Beds from the underlying sequence.

The three unconformities all occur in the interval between the final deposition of the Haslingden Group and the start of deposition of the Mount Isa and McNamara Groups. They are best regarded as diastems in sedimentation during a period of significant tectonism, which was probably related to intrusion of at least part of the Sybella Granite, the earliest folding in the Haslingden Group, and uplift and erosion. It has not been possible to separate this tectonism and folding from the later $F_1$ folding which affected the groups above and below the unconformities.

The tectonism appears to have been most intense near the present outcrop of the Sybella Granite. This tectonic event has been studied over a large area to the north and east of the Sheet area by Holyland (1975), who defined monoclines on either side of a northeast-trending uplifted area by changes in the stratigraphic level immediately underlying the base of the McNamara Group and its equivalents. These monoclines are also the loci of maximum angularity (usually about $30^{o}$) at the unconformity. The relatively small angularity between the Haslingden Group and the McNamara Group and its equivalents indicates that only broad open folding of the Haslingden Group occurred during this interval.

## Discussion

The domains indicated in Figure 34 were selected to test if structures differ in units above and below the zone of three unconformities. Domains containing only Haslingden Group rocks (A and B) were separated from areas containing only McNamara Group (E), Mount Isa Group (F) and granite (G). In the two other domains (C and D), it was not feasible to separate Haslingden Group rocks from McNamara Group rocks.

The distribution of $S_1$ is similar in all domains (Fig. 35). $S_0$ is also consistent in all domains except in C, where the unusual south-plunging anticline exposing Eastern Creek Volcanics is depicted by a characteristic girdle. Lineations (L) also show a consistent pattern except in domain D, where the lineations defined by the intersection of $S_0$ and $S_1$ are rotated to maintain parallelism with the fold axes which are deflected around the Sybella Granite contacts.

The east and west of the sheet area display structural homogeneity, and are dominated by the west limbs of north-plunging folds with a well-developed, near-vertical axial-plane foliation. This pattern is not well displayed in the middle of the sheet area (domains C and D), and the differences in style are attributed either to intrusion of the Sybella Granite, or to folding of strata in which the Sybella Granite was already emplaced; the latter alternative is favoured here. A further possibility is that the granite intruded the Haslingden Group before the McNamara Group was deposited, but later rose diapirically, refolding the $F_1$ folds. No major shears parallel to the granite contact have been located except for the north to northwest-trending faults in the Judenan Beds to the east of the pluton.

The sequence of structural events in the Kennedy Gap Sheet area appears to be as follows (from oldest to youngest):

1. During Haslingden Group sedimentation - possible minor faulting on north-trending faults.

2. Intrusion of dolerite.

3. Post-Haslingden Group sedimentation - intrusion of the Sybella Granite with minor uplift, warping, and erosion.

4. Extrusion of Carters Bore Rhyolite - minor uplift, associated subsidence, and continuing erosion.

5. After restricted deposition of Mammoth Formation - minor tectonism, followed by general subsidence.

6. During deposition of McNamara and Mount Isa Groups - slow subsidence, minor activity on some faults.

7. Post-deposition of McNamara and Mount Isa Groups - major folding episode ($F_1$).

8. East-west faulting disrupted major folds and reactivated north-south faults.

9. Strike-slip faulting.

10. Intrusion of dolerite

## METAMORPHISM

The Carpentarian rocks in the Kennedy Gap Sheet area have undergone low-grade regional metamorphism. The grade, mainly greenschist facies, is fairly uniform throughout the Sheet area but tends to decrease westward. Superimposed on this regional metamorphism is a narrow aureole of hornblende hornfels facies contact metamorphism adjacent to the Sybella Granite. In this Record the description and classification of metamorphic rocks is based on the concepts of Winkler (1967, 1974).

The regional metamorphism is characterised by the development of albite-epidote-actinolite and albite-chlorite assemblages in the basic volcanic rocks. Biotite is also present in many specimens. The pelitic rocks in the Leander Quartzite and the Judenan Beds are mostly phyllitic and contain fine-grained sericite and minor chlorite or biotite. Younger pelitic rocks in the McNamara and Mount Isa Groups also contain sericite and chlorite, but kaolinite is present in some of the shales near the top of the McNamara Group (for example, in the Esperanza Formation and the Shady Bore Quartzite).

On the evidence of these assemblages it is not possible to assign these metamorphic rocks to the Abukuma, Barrovian, or Intermediate facies series. Evidence from areas to the south and east of the Sheet area indicate a low-pressure (Abukuma) facies series (Hill & others, 1975). The common assemblages are typical of the lower part of the greenschist facies - the quartz-albite-muscovite-biotite-chlorite subfacies of the Abukuma facies series (Winkler, 1967).

The presence of minerals such as kaolinite in the younger sediments may indicate that either temperature or pressure were not high enough to initiate metamorphism high in the stratigraphic column, or that the sediments near the top of the stratigraphic sequence were deposited after the regional metamorphism. The latter argument is not considered likely because these units conformably overlie units which are metamorphosed to the greenschist facies. Some areas of apparently unmetamorphosed igneous rock may be a result of equilibrium during metamorphism not being attained, for example, the presence of primary clinopyroxene in the cores of large phenocrysts in a metabasalt in the Eastern Creek Volcanics (specimen 174) just north of the Bonus Basin. The margins of these phenocrysts are altered to actinolite.

Many of the dolerite dykes in the Leander Quartzite, Eastern Creek Volcanics, and Judenan Beds also contain mineral assemblages that do not appear to be in equilibrium with their country rock. For example, hornblende is the common ferromagnesian mineral in the dolerite dykes, whereas actinolite, chlorite, or biotite tend to occur in the country rocks. The hornblende-bearing assemblages contain albite-epidote and so they also belong to the greenschist facies rather than the amphibolite facies, and hence the controlling factor is possibly composition rather than grade of metamorphism.

Figure 36 indicates the distribution of the most diagnostic metamorphic minerals. Figure 37 shows approximate temperatures and pressures of metamorphism in the Kennedy Gap Sheet area. The low pressures shown in the stippled field of Figure 37 are indicated from cordierite and andalusite-bearing rocks in the contact zone of the Sybella Granite in the Mount Isa Sheet area, to the south (Hill & others, 1975).

## GEOLOGICAL HISTORY

### Introduction

The Kennedy Gap Sheet area contains almost the entire depositional record of the western succession - that is the Haslingden Group (except for the basal part), the Carters Bore Rhyolite, part of the 'Mammoth Formation', and the Mount Isa and McNamara Groups (except for the uppermost formations). As neither the base of the western succession nor older basement rocks are exposed in the Sheet area, very early history of the Sheet area and the shape of the initial sedimentary basin must be extrapolated from adjoining Sheet areas.

## Haslingden Group time

In the Mary Kathleen Sheet area (Derrick & others, 1977) the basal beds of the Haslingden Group contain conglomerate and labile sandstone (lower unit of the Mount Guide Quartzite) which overlie acid volcanics which are assigned to the Argylla Formation. This contact is considered to be an unconformity by Derrick & others (1977) but work further south in the Duchess Sheet area indicates that this contact may be conformable and that the major unconformity lies below the acid (and locally basic) volcanics (Bultitude & others, 1977). Detritus in the conglomerate appears to have been derived from an elevated area to the east consisting of acid volcanics and granite. It is assumed that during the deposition of the Haslingden Group in the Kennedy Gap Sheet area a similar landmass existed to the east in the Prospector Sheet area (Wilson & others, 1977).

The oldest unit of the Haslingden Group in the Kennedy Gap sheet area is the Leander Quartzite which probably represents a similar time interval to the Mount Guide Quartzite in the south. Sedimentary transport directions indicated by cross-bedding in the lower unit of the Leander Quartzite are mainly from the southeast and the detritus is highly feldspathic, indicating a nearby source area of feldspathic rocks - possibly acid volcanics and granite. In the upper unit of the Leander Quartzite the transport directions show a considerable scatter but are mainly from the southeast to northeast, except near the top of the unit where currents from the north appear to predominate. These sediments are more mature, indicating a more distant source, a more mature topography, or the reworking of earlier deposited detritus.

From this evidence the lower Haslingden Group appears to have been deposited on a broad continental shelf or intracratonic basin bounded to the southeast and east by an elevated crystalline landmass. The Leander Quartzite was probably deposited as a prograding linear clastic shoreline and the minor slumping and volcanism near the base may indicate some tectonism during early

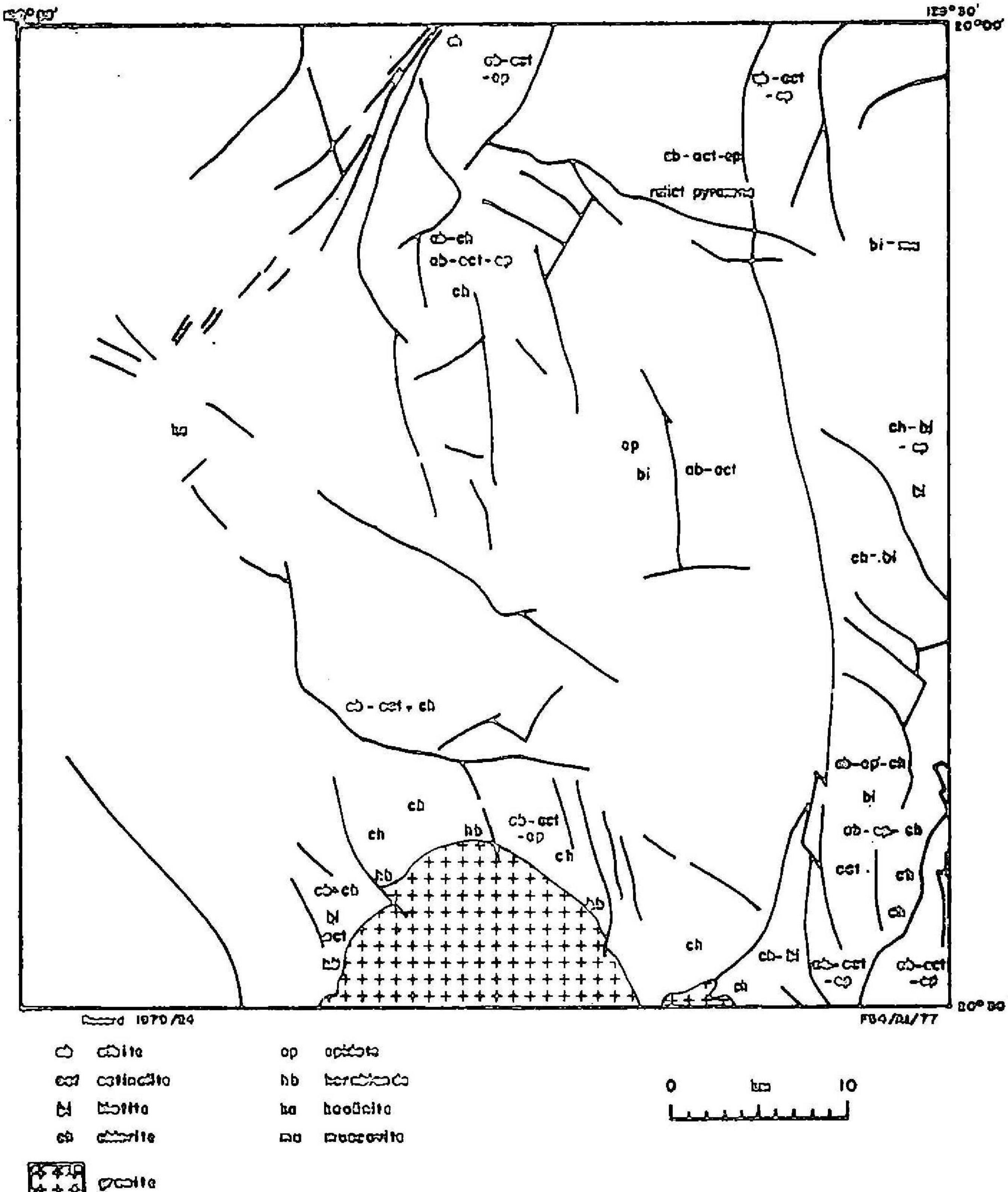



Fig. 36. Distribution of metamorphic minerals in the Kennedy Gap Shoot area

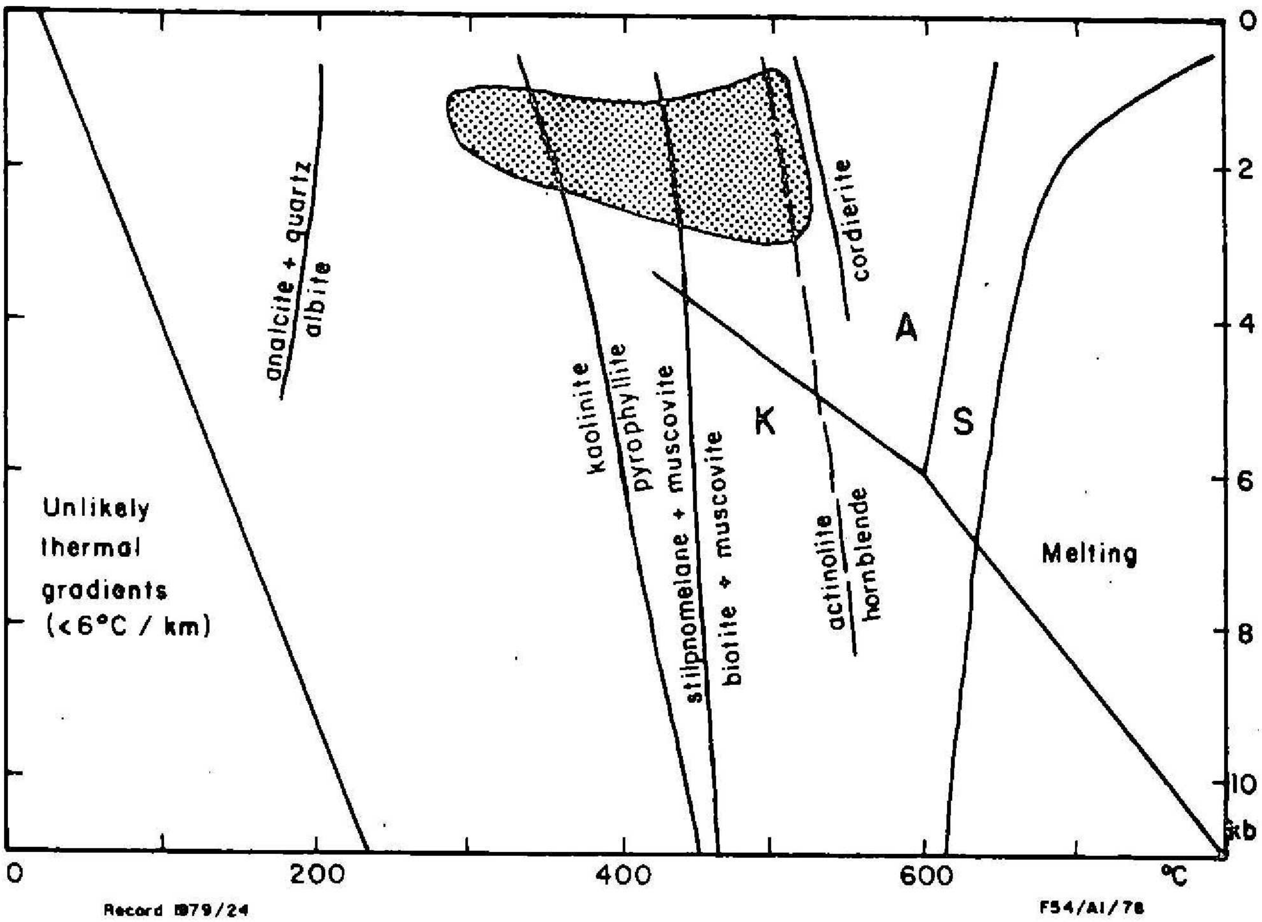



Fig. 37. Possible temperature – pressure conditions (stippled) during metamorphism in the Kennedy Gap Sheet area. Stability curves after Winkler (1974).

sedimentation. As the sedimentary basin filled and the source area was eroded, the palaeoslope probably would have decreased, and streams would have tended to meander producing wide scatter in the transport directions.

The sedimentation was followed by extensive outpourings of basic lava - the Eastern Creek Volcanics. The lavas appear to have moderately uniform thickness over the Sheet area and this indicates a relatively flat land surface. The absence of pillow structures and the abundance of amygdales in the basalt flows indicate subaerial extrusion. This is supported by the interbedded sediments which appear to be terrestrial or shallow-water marine. Geochemically, the basic volcanics from the Eastern Creek Volcanics in the Mary Kathleen Sheet area resemble continental tholeiites (Glikson & others, 1976).

Minor folding may have accompanied the basalt extrusion and resulted in north-trending axial-plane tension gashes forming in the Leander Quartzite. These gashes may have been intruded by dolerite dykes.

The ratio of intercalated sediment to basalt increased with time, either as a result of longer periods of time between basalt flows or an increase in the rate of sedimentation as the sedimentary basin subsided further. At the close of the basic volcanism the whole Sheet area was submerged, allowing marine deposition of the Myally Subgroup and the Judenan Beds. These units contain numerous mud-cracks and some stromatolites which indicate a shallow-water depostional environment.

The apparent thinning of the Judenan Beds in the south may have been caused by uplift in this area, possibly in response to the intrusion of early phases of the Sybella Granite. Uplift of the crystalline Kalkadoon-Leichhardt block to the east may also have occurred at this time, providing a rejuvenated source area of quartzo-feldspathic detritus. Evidence of tectonic activity is also provided by faulting which affected the deposition of the Judenan Beds.

Termination of Haslingden Group deposition

The uplift in the south and possibly to the east of the Sheet area during the deposition of the Judenan Beds became more widespread and effectively terminated deposition of the Haslingden Group in the sheet area. During this time deposition may have continued in areas to the north and northeast where additional sedimentary units such as the Surprise Creek Beds units W, X, Y, and Z (Wilson & others, 1977) were deposited. The Haslingden Group was gently folded, and eroded, especially in the southeast of the Sheet area.

After this period of slight tectonism, the Carters Bore Rhyolite was extruded. Petrological similarity between this unit and one of the youngest phases of the Sybella Granite, suggests the two units may be comagmatic. The minor tectonism which preceded the extrusion of the Carters Bore Rhyolite may have been caused by, or related to, the intrusion of the earlier phases of the Sybella Granite. Contact metamorphism of the Haslingden Group rocks accompanied the granite intrusion.

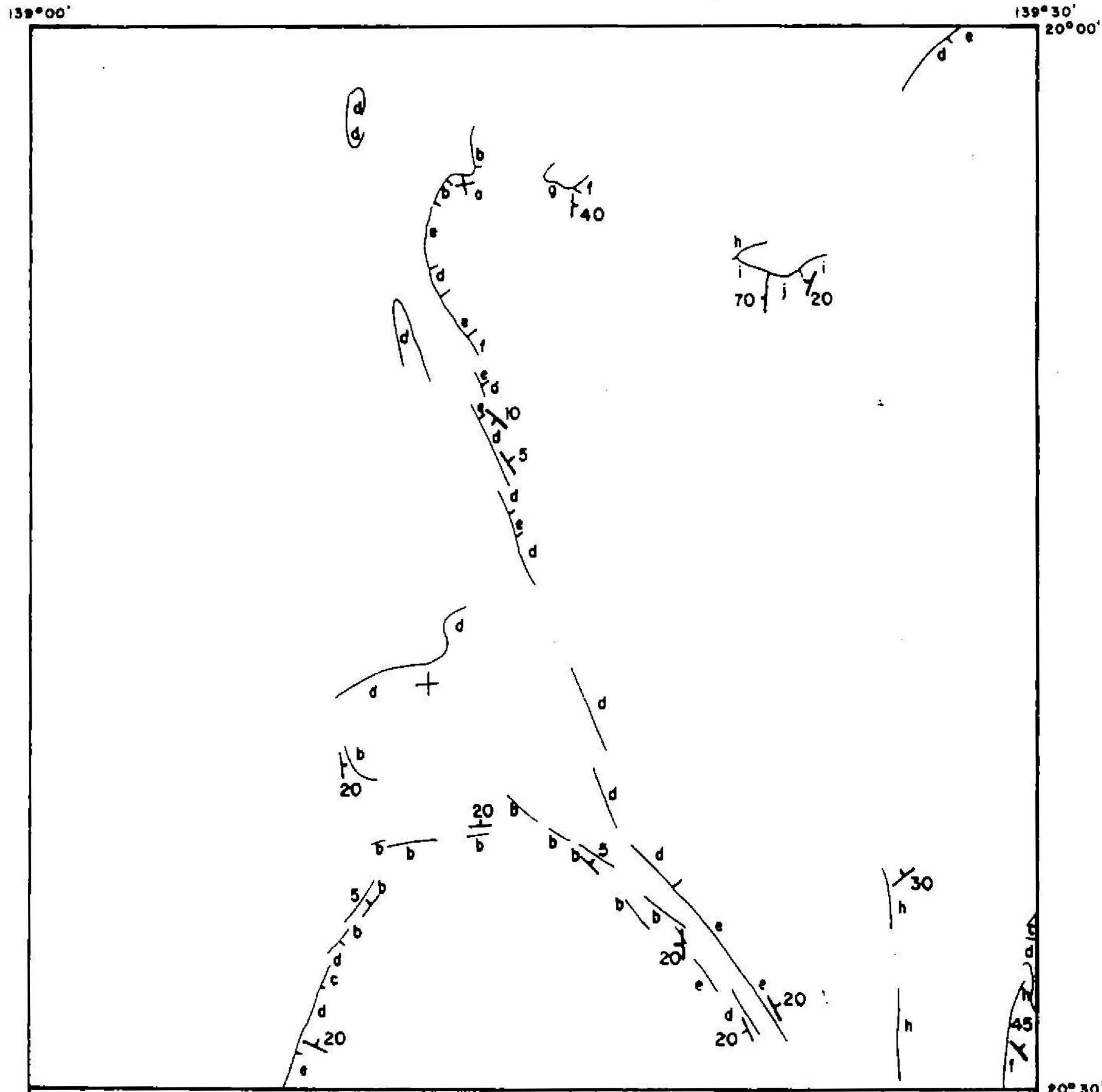
Mild tectonism continued after the extrusion of the Carters Bore Rhyolite. The sea transgressed into small depressions in the north of the sheet area probably at about this time. This transgression is marked by the 'Mammoth Formation' sediments in the Sheet area. More continuous sedimentation of about this age is represented by the 'Mammoth Formation equivalents' and the Surprise Creek Beds, units A, B, C and D, in the Prospector Sheet area (Wilson & others, 1977).

Another period of mild tectonism followed this deposition and resulted in a slight unconformity, with very local angularity, between older rocks and the McNamara Group.

An assessment of the configuration of Haslingden Group rocks before the McNamara and Mount Isa Groups were deposited is presented in Figure 38. This diagram has been prepared by assuming that the sediments above and below the unconformity were originally deposited horizontally, then rotating the youger beds to the horizontal about hypothetical horizontal fold axes, and observing the attitude of the underlying rocks. This figure also shows the unit below the unconformity, which reflects the undulating nature of the pre-McNamara Group erosion surface developed on the Haslingden Group.

McNamara Group and Mount Isa Group time

The McNamara and Mount Isa Groups contain sediments which are thought to represent a major transgression of the seas over an older landmass of the 'Mammoth Formation', Carters Bore Rhyolite, Haslingden Group, and possibly the Sybella Granite. The basal beds are most commonly conglomeratic, containing




McNamara Group unconformity

dip of Haslingden Group at time of unconformity

| Unit below unconformity | |
|---|---|
| a | Mammoth Formation |
| b | Carters Bore Rhyolite |
| c | Judenan Beds, unit 3 |
| d | " " " 2 |
| e | " " " 1 |
| f | Pickwick Metabasalt Member |
| g | Lena Quartzite Member |
| h | Cromwell Metabasalt Member |
| i | Leander Quartzite, unit 2 |
| j | " " " 1 |

Record 1979/24

F54/A1/79

Fig. 38. Possible configuration and exposure of Haslingden Group at commencement of McNamara Group time

highly rounded clasts of quartzite, feldspathic sandstone, and vein quartz that could have been derived from the Judenan Beds and the Sybella Granite aureole. Current transport directions in the basal unit of the Gunpowder Creek Formation ($Prw_1$) and the Warrina Park Quartzite are mainly from the east and southeast, although some northeasterly, northwesterly, and westerly current sources have been identified.

Small-scale slumping is widespread in the second lowest unit of the Gunpowder Creek Formation ($Prw_2$), indicating some instability during sedimentation, but the younger units are finely laminated and appear to have been deposited in a stable environment. This environment was probably a broad continental shelf or epicontinental basin, and much of the sediment appears to have accumulated below wave base.

A grey laminated unfossiliferous chert at the base of the Paradise Creek Formation and the Native Bee Siltstone may have formed because of volcanic activity in or near the basin. The succeeding units contain some acid tuff and tuffaceous material, but the sequence comprises mainly fine-grained dolomitic detrital sediments. Pyritic shale and siltstone and stratiform silver-lead-zinc sulphides were deposited in the Mount Isa area. Some pyritic sediments occur in the Kennedy Gap sheet area but most of the deposition in this area appears to have been in very shallow water, as indicated by extensive stromatolitic units in the Paradise Creek Formation and Esperanza Formation. Thick sandstone and siltstone developed near the top of the McNamara Group represent some rejuvenation in source areas adjacent to the sedimentary basin. Current directions interpreted from cross-bedding in the Shady Bore Quartzite indicate currents from the south and southeast.

## Post-McNamara Group deformation

The main folding episode ($F_1$; see STRUCTURE) affected the McNamara Group rocks. Regional metamorphism of low-greenschist facies possibly accompanied this folding; it was followed by reactivation of some faults, and finally by strike-slip faulting. This was succeeded by intrusion of a few dolerite dykes and general uplift and erosion.

Post-Carpentarian developments

During the Adelaidean the Pilpah Sandstone was deposited to the west of the sheet area (and possibly within the sheet area) as shallow-water platform-cover sediments. Middle Cambrian sedimentation is recorded in the west of the sheet area, but its full extent is not known. A shallow Middle Cambrian sea probably covered most of the western half of the Sheet area and may have been continuous with the sea in which the Cambrian sediments were deposited near Beetle Creek in the Mount Isa Sheet area, to the south. A thin veneer of Mesozoic sediments may also have covered part of the Sheet area but only one small remnant of it remains.

Tertiary lateritisation indicates a stable erosional environment. A subsequent uplift, which appears to have been more pronounced in the east of the Sheet area, has controlled the Recent erosional and depositional patterns.

## ECONOMIC GEOLOGY

### History of prospecting and mining

Early this century gold was discovered near May Downs homestead, near the southern boundary of the Kennedy Gap Sheet area. The May Downs Gold Field was established but prospecting activity declined. There was an increase in activity in the 1920s and again in 1931 and 1932 when most of the ground was repegged (Shepherd, 1934). All shows were located on a north-northwest-trending belt of conglomerate, phyllite-schist, and quartzite, mainly in the Mount Isa 1:100 000 Sheet area. Development work was hampered by the lack of treatment facilities on the field; all stone had to be carted to the Bower Bird Battery in the Prospector 1:100 000 Sheet area for treatment. Work was carried out at Pioneer, New Pioneer, and Double Event, which are located near the headwaters of Mine Creek. There is no record of any stone being sent for treatment from these workings.

Some copper ore was also mined in this period, and up to 1953 18 tonnes of ore were reported from the Calton Hills area.

In 1954 the lifting of the ban on uranium exports and the offer of rewards for discovery of uranium by the Commonwealth Government prompted a surge in exploration activity. The first significant uranium deposit found in Queensland was Skal, located in the southeastern part of the Kennedy Gap Sheet area. This deposit was prospected initially by Mount Isa Mines Ltd and subsequently by Queensland Mines Ltd. Drilling has shown reserves to be 1600 tonnes $U_3O_8$ at 1.2 kg/tonne (Brooks, 1972). The deposit is in sheared basic volcanics and associated calcareous sediments and quartzite of the Eastern Creek Volcanics. The mineralisation, - primary brannerite with minor carnotite - is in brecciated quartzite and feldspathic siltstone in a zone of strike shearing; calcite, magnetite, hematite, and minor chalcopyrite have also been introduced (Brooks, 1960). The only other deposit which has been intensively prospected is Valhalla, which was initially prospected by United Uranium NL and subsequently by Queensland Mines Ltd. Costeaning and drilling indicated uranium mineralisation over an area of 720 m by 15 m, and confined to a 60 m thick vertically dipping ferruginous tuff bed interbedded with metabasalt of the Eastern Creek Volcanics (Brooks, 1972). In 1969, reserves were estimated to be 1850 tonnes $U_3O_8$ at 1.2 kg/tonne.

Numerous other small deposits occur in the Eastern Creek Volcanics. They have been investigated by many companies, including Mount Isa Mines Ltd, United Uranium NL, Queensland Mines Ltd, and to a lesser extent Mineral Deposits Ltd and Ausminda Pty Ltd. These deposits include Warwai, Watta, and Narpajin in the Leander Quartzite; and Bikini, Drum, Future, Jurraveel, Left-over, Marraroo, Minga, Murioola, Pile, Printi, Tjilpa, Queens Gift, Mount Inter, Rich John, Neutron, Woomera, Isotope, Hopeful, Gamma-ray, and Proton in the Eastern Creek Volcanics. Brooks (1972) has summarised the results of exploration of many of these deposits.

A comprehensive summary of mining company exploration carried out under Authorities to Prospect in the Mount Isa 1:250 000 Sheet area until December 1976 is provided in Wilson (1977). A list of Authorities to Prospect in the Kennedy Gap Sheet is presented in Table 17. The first Authority to Prospect in the Sheet area was granted in 1956. Since then the main target has been base metals, initially small high-grade deposits, and more recently stratiform deposits mostly in the Gunpowder Creek and Paradise Creek Formations. The search for uranium, which commenced in 1954, has been concentrated in the Eastern Creek Volcanics and to a lesser extent in the Leander Quartzite and Judenan Beds. Since 1966 mining company activity has included the search for phosphate and associated uranium.

TABLE 18. AUTHORITIES TO PROSPECT IN THE KENNEDY GAP SHEET AREA

| A.P. No. | Company | Open file company reports* |
|---|---|---|
| 30 | Mount Isa Mines Ltd | - |
| 94 | United Uranium N.L., King Island Scheelite (1947) Ltd, Loloma (Fiji) Gold Mines Ltd | 166, 170 |
| 128 | Rio Tinto Australian Exploration Pty Ltd | 253, 357, 358, 380, 391, 2228 |
| 136 | Queensland Mines Ltd | 537 |
| 141 | Rio Tinto Australian Exploration Pty Ltd | 358, 380, 391, 2228 |
| 149 | Queensland Mines Ltd | 537 |
| 169 | Rio Tinto Southern Pty Ltd | 645, 874, 1039 1181, 1182, 1183, 1213 |
| 183 | Carpentaria Exploration Co. Pty Ltd | 943 |
| 204 | Carpentaria Exploration Co. Pty Ltd | 1620 |
| 232 | CRA Exploration Pty Ltd | 1289, 1528 |
| 235 | Mount Isa Mines Ltd | - |
| 283 | Placer Prospecting Pty Ltd, Ausminda Pty Ltd | 2063, 2273 |
| 292 | Carpentaria Exploration Co. Pty Ltd | 2558, 2832 |
| 296 | Kern County Land Co. | 2082, 2083, 2577 |
| 361 | Kennecott Explorations (Aust.) Pty Ltd | 2696 |
| 375 | Continental Oil Co. Aust. Ltd | 2735, 2770, 2997, 3102 |
| 388 | Queensland Mines Ltd | 2524, 2602 |
| 401 | Kern County Land Co. | 2241, 2281 |
| 411 | Carpentaria Exploration Co. Pty Ltd | 2821 |
| 467 | Queensland Mines Ltd | 2818, 2886 |
| 472 | Queensland Mines Ltd | - |
| 485 | Mineral Deposits Ltd | 3112, 3943, 4419, 4420 |
| 582 | Mount Isa Mines Ltd | 4091 |
| 588 | Carpentaria Exploration Co. Pty Ltd | 3516, 3517 |

| A.P. No. | Company | Open file company reports* |
|---|---|---|
| 589 | Queensland Mines Ltd | 2979 |
| 614 | Eastern Copper Mines N.L., Union Miniere Development & Mining Corp. Ltd | 3985, 3986 |
| 615 | Eastern Copper Mines N.L., Union Miniere Development & Mining Corp. Ltd | 3909, 3982 |
| 616 | Anaconda Australia Inc., Newmont Pty Ltd | 3648, 3786, 4191 |
| 617 | Anaconda Australia Inc., Newmont Pty Ltd | 3558, 3778, 4191 |
| 618 | Eastern Copper Mines N.L. | 3789 |
| 619 | Eastern Copper Mines N.L. | 3758 |
| 635 | Queensland Mines Ltd | 3289 |
| 656 | Tasman Minerals Pty Ltd | 3983 |
| 660 | Placer Prospecting (Aust.) Pty Ltd | 3327 |
| 668 | Anaconda Australia Inc. | 3529, 3706, 4608 |
| 684 | Mineral Deposits Ltd | 3693, 3943, 4419, 4420 |
| 727 | Pioneer Mining & Exploration Pty Ltd | 4122 |
| 966 | Esso Australia Ltd | 4156 |
| 1058 | Eastern Copper Mines N.L. | 5088 |
| 1154 | Falconbridge (Australia) Pty Ltd, CRA Exploration Pty Ltd | 4775, 5103, 5104, 5626 |
| 1191 | Savage Exploration Pty Ltd | 4649, 4751, 5304, 5305 |
| 1234 | AGIP Nucleare Australia Pty Ltd | 5168 |
| 1264 | Mines Exploration Pty Ltd | 5179, 5446 |
| 1271 | Carpentaria Exploration Co. Pty Ltd | 5442 |
| 1339 | Consolidated Gold Fields Australia Ltd | 5191 |
| 1343 | Anaconda Australia Inc. | 5197 |
| 1392 | Mines Exploration Pty Ltd | 5489, 5967, 6213 |
| 1439 | International Nickel Australia Ltd | 5270, 5626 |
| 1442 | Carpentaria Exploration Co. Pty Ltd | 5464 |
| 1571 | CRA Exploration Pty Ltd | 5625 |
| 1650 | Union Miniere Development & Mining Corp. Pty Ltd | 6097, 6241 |
| 1652 | Union Miniere Development & Mining Corp. Pty Ltd | 6097, 6241 |

* Held at Queensland Mines Department

## Mining Activity

Mining activity in the Kennedy Gap sheet area has been of limited extent. Carter & others (1961) and Krosch & Sawers (1974) have provided details of production, mostly from copper shows, up to the end of 1972. Only three listings of production figures are given for the Kennedy Gap Sheet area. They are

| Mine | Ore (tonnes) | Copper (tonnes) |
|---|---|---|
| a. Calton Hills (locality) | 18 | 5.4 (estimated) |
| b. King George (Royal George) | 91.1 | 2.6 |
| c. Lady Agnes | 352.7 | 13 |

During the period of field mapping it was reported that a gouger was operating a small gold 'show' in the northern part of the May Downs Gold Field. A review of Wardens Reports for the Mount Isa district published in the Queensland Government Mining Journal indicated that no production was recorded from any mine in the sheet area for the period January 1973 to March 1978.

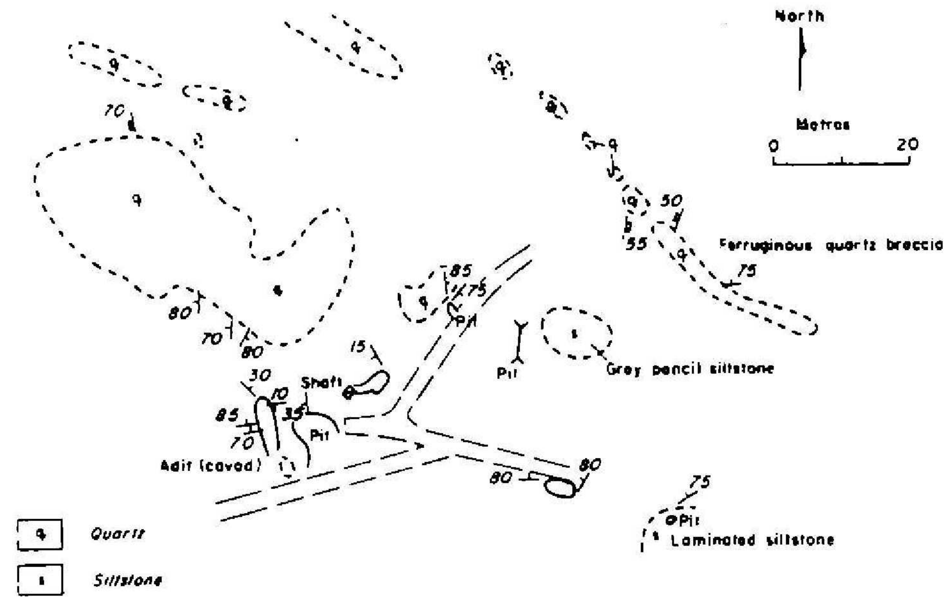
## Mine description

### Lady Agnes (after Syvret, 1966):

The mine is 10 km northeast of Nineteen Mile bore which is adjacent to the Barkly Highway at grid reference 422 420, 20.5 km north of Mount Isa.

The country rock is siltstone of the Breakaway Shale of the Mount Isa Group. The workings are on the southern side of a southeast-trending quartz-filled fault ridge. they consist of a shaft 20 m deep, one small open-cut, five pits, and one costean (Fig. 39). About 15 m west-southwest of the main shaft, workings believed to be an adit are now caved in. Development crosscuts in the shaft have been at the 7.8-m level.

Mineralisation consists of malachite and azurite associated with minor faulting and fracturing. The fracturing has allowed permeation and erratic distribution of carbonate near the fault.




Record 1979/24

F54/A1/80

Fig. 39 Sketch map of Lady Agnes copper mine (after Syvret, 1966)

Royal George

The mine is about 7 km northeast of Nineteen Mile bore, (grid ref. 401403). The country rock is altered basic schist of the Cromwell Metabasalt Member of the Eastern Creek Volcanics. The workings consist of one shaft, one pit, one costean, and an inclined adit which dips at $30^{\circ}$ to $040^{\circ}$.

## ACKNOWLEDGEMENTS

The co-operation of Mr J. Banning of Calton Hills and Mr T. Stretton of May Downs greatly assisted the fieldwork on which this report is based. We extend our thanks to Mary Kathleen United Ltd for allowing our base camp to be situated beside Lake Corella. During the field season numerous useful discussions were held with geologists of many mining companies, in particular Anaconda Australia Inc., Carpentaria Exploration Co. Pty Ltd, Falconbridge (Australia) Pty Ltd, Mines Exploration Pty Ltd, Mount Isa Mines Ltd, and Union Miniere Development and Mining Corp. Ltd. Further discussions, especially with Mr R. Cavaney of Carpentaria Exploration Co. Pty Ltd have contributed greatly to our understanding of the geology of the Sheet area. Several BMR and GSQ staff members have assisted in the preparation of this report.

BIBLIOGRAPHY

AGER, D.V., 1973 -THE NATURE OF THE STRATIGRAPHIC RECORD. Macmillan, London.

AGIP NUCLEARE AUSTRALIA PTY LTD, 1975 -Authority to Prospect 1234 M, final report (on relinquished area).

AGIP Nucleare Australia Pty Ltd (unpublished CR 5168).

ALCOCK, P.J., & LEE, M.F., 1974 -Aspects of the geology and exploration of the Lady Loretta lead-zinc-silver deposit, north west Queensland. In Recent technical and social advances in the north Australian minerals industry. Australasian Institute of Mining and Metallurgy, North West Queensland Branch, Regional Meeting, 207-15.

ATKINSON, W.J., 1962 - Hero Leases area -North Mt. Isa - PRP/1/110, report on detailed mapping, 1962 season (AP 169M). Rio Tinto Southern Pty Ltd (unpublished CR 1181).

BARRATT, R.M., 1975a - Report on exploration, year ended 31st December, 1974, Authority to Prospect No. 1264M. Mines Exploration Pty Ltd (Unpublished CR 5179).

BARRATT, R.M., 1975b - Final report on Authority to Prospect No. 1264M, Queensland. Mines Exploration Pty Ltd (unpublished CR 5446).

BARRATT, R.M., 1976 - Authority to Prospect 1392M, final report on areas relinquished on July 1st, 1975. Mines Exploration Pty Ltd (unpublished CR 5489).

BEATTIE, R.J., 1972 - Authorities to Prospect Nos. 484M, 485M and 684M (Areas 1 & 2) Mount Isa and Cloncurry Gold & Mineral Fields, Report on exploration to 31st December, 1971. Mineral Deposits Ltd (unpublished CR 3943).

BEATTIE, R.J., & GRENNING, P.J., 1971 - Annual report, Authority to Prospect No. 684M 'Calton Hills', for the period 1st January to 31st December, 1970. Mineral Deposits Ltd (unpublished CR3693)

BEATTIE, R.J., and GRENNING, P.J., 1973 -Final report on Authorities to Prospect Nos. 485M and 684M - Calton Hills. Mineral Deposits Ltd (unpublished CR 4419 & 4420).

BENNETT, E.M., 1965 - Lead-zinc-silver and copper ore deposits of Mount Isa. In McANDREWS, J. (Editor) - GEOLOGY OF AUSTRALIAN ORE DEPOSITS (2nd edition), 8th Commonwealth Mining and Metallurgical Congress 1, 233-46.

BENNETT, E.M., 1970 - Authority to Prospect No. 588M "Eastern Creek". Report for the year ended 31st December, 1969. Carpentaria Exploration Co. Pty Ltd

BROOKS, J.H., 1960 - The uranium deposits of northwestern Queensland. Geological Survey of Queensland, Publication 297.

BROOKS, J.H., 1972 - Uranium exploration in Queensland 1967-71. Geological Survey of Queensland, Report 69.

BROWN, C.H., 1977 - Final report, Authority to Prospect 1392M. Mines Exploration Pty Ltd (unpublished CR 6213).

BRUNKER, R., 1972 - Final report on exploration of Authority to Prospect No. 616M, Buckley River area and Authority to Prospect No. 617M, Johnson Creek area, northwest Queensland. Newmont Pty Ltd (unpublished CR 4191).

BUDDINGTON, A.F., 1959 - Granite emplacement, with special reference to North America. Bulletin of the Geological Society of America, 70, 671-47.

BULTITUDE, R.J., GARDNER, C.M., & NOON, T.A., 1977 - A recently discovered unconformity near the base of the Proterozoic Cloncurry Complex south of Mount Isa, northwestern Queensland. BMR Journal of Australian Geology & Geophysics, 2, 311-14.

BURGDORF, P.G., 1966a - Surprise Creek Project 39, Report No. 2 (AP 296M). Kern County Land Co. (unpublished CR 2082B).

BURGDORF, P.G., 1966b - Progress report Surprise Creek Project, Authority to Prospect 296M, Report No. 4. Kern County Land Co. (unpublished CR 2082C).

BURGDORF, P.G., 1967 - Final report, Surprise Creek Project 39, Report No. 6, Authority to Prospect 401M. Kern County Land Co. (unpublished CR 2241).

BURGDORF, P.G., & HANSEN, W.A., 1967 -Final report, Surprise Creek Project 39, Authority to Prospect 296M. Kern County Land Co. (unpublished CR 2577).

CAMPBELL, M.D., 1968 - Progress notes on 1968 drilling operations (first half) for phosphate, Authority to Prospect Nos. 354M & 375M, Undilla Basin, Queensland, Australia. Continental Oil Co. Aust. Ltd (unpublished CR 2770).

CAMPBELL, M.D., 1969 - Final report on relinquished areas of Authority to Prospect Nos. 354M-375M, Undilla Basin area and Whistler Creek area, northwest Queensland. Continental Oil Co. Aust. Ltd (unpublished CR 2997).

CARPENTARIA EXPLORATION CO. PTY LTD, 1968 -North Stone Axe - No. 4 D.D.H. (AP 292M). Carpentaria Exploration Co. Pty Ltd (unpublished CR 2558B).

CARPENTARIA EXPLORATION CO. PTY LTD, 1971 - Final report, Authority to Prospect No. 588M "Eastern Creek". Carpentaria Exploration Co. Pty Ltd (unpublished CR 3517).

CARPENTARIA EXPLORATION CO. PTY LTD,1975a - Authority to Prospect No. 1271M "Judenan Creek", final report. Carpentaria Exploration Co. Pty Ltd, Mining Tenement Progress Report 149 (unpublished CR 5442).

CARPENTARIA EXPLORATION CO. PTY LTD, 1975b - Authority to Prospect No. 1442M "Mingera West", Final report. Carpentaria Exploration Co. Pty Ltd Mining Tenement Progress Report 152 (unpublished CR 5464).

CARTER, E.K., 1959 - New stratigraphic units in the Precambrian of north-western Queensland. Queensland Government Mining Journal, 60, 437-41.

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

CAVANEY, R.J., 1975 - Stratigraphic and structural controls to copper mineralisation in the Mount Isa -Lawn Hill district, north west Queensland. M.Sc. Thesis, James Cook University of North Queensland (unpublished).

CAVANEY, R.J., in prep. - The stratigraphy of the Mount Isa Group equivalents in the Mount Isa-Lawn Hill area.

CHRISTIAN, C.S., & STEWART, G.A., 1954 -The land-use groups of the Barkly region. In Survey of the Barkly region 1947-48. CSIRO Land Research Series, 3, 150-182.

COLORADO SCHOOL OF MINES RESEARCH FOUNDATION INC., 1969 - Report on beneficiating Australian phosphate ore (AP 354M & 375M). Continental Oil Co. (unpublished CR 2735).

COMPTON, P.R., 1962 - MANUAL OF FIELD GEOLOGY. Wiley, New York.

CONTINENTAL OIL CO. AUST. LTD, 1969 -Annual report, Authorities to Prospect 354M & 375M, Undilla Basin, northwest Queensland. Continental Oil Co. Aust. Ltd (unpublished CR 3102).

CRA EXPLORATION PTY LTD, 1963a - Final report on Authority to Prospect 169M, north Queensland, from 1st October, 1960 to 30th September, 1963. CRA Exploration Pty Ltd (unpublished CR 1181).

CRA EXPLORATION PTY LTD, 1963b - Cloncurry - Mt Isa investigations A. to P. 169M, quarterly report for period ended 31st March, 1963. CRA Exploration Pty Ltd (Unpublished CR 1182)

CRA EXPLORATION PTY LTD, 1964 - A. to P. 232M - N.W. Queensland, Final Report. CRA Exploration Pty Ltd (unpublished CR 1528)

CROOK, K.A.W., 1960 - Classification of arenites. American Journal of Science, 258, 419-28.

DE KEYSER, F., 1958 - Geology and mineral deposits in the Paradise Creek area, north-west Queensland. Bureau of Mineral Resources, Australia, Record 1958/100 (unpublished).

DERRICK, G.M., 1974 - Stratigraphic and paleogeographic evolution and revolution in the Mount Isa area. In Recent technical and social advances in the north Australian minerals industy. Australasian Institute of Mining and Metallurgy, Northwest Queensland Branch, Regional Meeting, 177-87.

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

DERRICK, G.M., WILSON, I.H., & HILL, R.M., 1976b - Revision of stratigraphic nomenclature in the Precambrian of northwestern Queensland. III Mount Isa Group. Queensland Government Mining Journal, 77, 402-6.

DERRICK, G.M., WILSON, I.H., & HILL, R.M., 1978 - Revision of stratigraphic nomenclature in the Precambrian of northwestern Queensland. VIII : Igneous Rocks. Queensland Government Mining Journal, 79, 151-56.

DERRICK, G.M., WILSON, I.H., HILL, R.M., GLIKSON, A.Y., & MITCHELL, J.E., 1974 - Geology of the Mary Kathleen 1:100 000 Sheet area, northwestern Queensland. Bureau of Mineral Resources, Australia, Record1974/90 (unpublished).

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

DERRICK, G.M., WILSON, I.H., HILL, R.M., & MITCHELL, J.E., 1971 - Geology of the Marraba 1:100 000 Sheet area, Qld. Bureau of Mineral Resources, Australia, Record 1971/56 (unpublished)

DIMO, G., 1975 - Combined annual and final report, Authority to Prospect 1343 (Lochness South). Anaconda Australia Inc. IR-F54/1/-(unpublished CR 5197).

DOBLE, K.W., 1974 - Final report on exploration of A. to P. 1058M, N.W. Queensland to June 1974. Eastern Copper Mines N.L. (unpublished CR 5088).

DOUTCH, H.F., 1976 - The Karumba Basin, northeastern Australia and southern New Guinea. BMR Journal of Australian Geology and Geophysics, 1, 131-40.

DUFF, B.A., & WILSON, I.H., 1975 -Basin and dome deformation in the Mount Isa Geosyncline. In Proterozoic geology, abstracts of 1st Australian Geological Convention, Adelaide, 12-16 May 1975. Sydney, Geological Society of Australia, 56.

DUKE, J.H., 1975a - Annual report, exploration year 2 - 1974, Authority to Prospect 1154M, May Downs, Queensland. Falconbridge (Australia) Pty Ltd (unpublished CR 5103).

DUKE, J.H., 1975b - Authority to Prospect 1154M, May Downs, Queensland. Report on land released - January 1975. Falconbridge (Australia) Pty Ltd (unpublished CR 5104).

EASTERN COPPER MINES N.L., 1971 -Authority to Prospect 614M, Mt Isa, Queensland, Annual report for 1970. Eastern Copper Mines N.L. (unpublished CR 3985).

EIPE, M.V., 1973 - Authority to Prospect No. 1191M, Mount Isa area, Queensland, quarterly reports for 3 months ended June 30, 1973 and for 3 months ended September 30, 1973. Savage Exploration Pty Ltd (unpublished CR 4649).

EIPE, M.M., 1974 - Authority to Prospect No. 1191M, Mount Isa area, Queensland, annual report for 1973. Savage Exploration Pty Ltd (unpublished CR 4751).

EIPE, M.V., 1975a - Authority to Prospect No. 1191M, Mount Isa area, Queensland, annual report for 1974. Savage Exploration Pty Ltd(unpublished CR 5304).

EIPE, M.V., 1975b - Authority to Prospect 1191M, Mt Isa, Relinquishment report. Savage Exploration Pty Ltd (unpublished CR 5305).

FARQUHARSON, R.B., & WILSON, C.J.L., 1971 -Rationalization of geochronology and structure at Mount Isa. Economic Geology,60,574-82.

FARQUHARSON, R.B., & RICHARDS, J.R., 1970 -Whole-rock U-Th-Pb and Rb-Sr ages of the Sybella microgranite and pegmatite Mount Isa, Queensland. Journal of the Geological Society of Australia, 17, 53-8.

FLACK, D.S., 1967 - Final report on Authority to Prospect number 283M. Queensland. Ausminda Pty Ltd (unpublished CR 2273).

FOLK, R.L., 1968 - PETROGRAPHY OF SEDIMENTARY ROCKS. Hemphill's Bookstore, Austin.

GEOCONTRACT PTY LTD, 1970 - Interim report on work carried out on A to P 656M in the period 1st July, 1970 to 30th September, 1970. Tasman Minerals Pty Ltd (unpublished CR 3983C).

GEOCONTRACT PTY LTD, 1971a - Final report on work carried out on A.P. 656M. (Calton Hill area) in the period July 1969 to December 1970. Tasman Minerals Pty Ltd (unpublished CR 3983A)

GEOCONTRACT PTY LTD, 1971b - Final report on reconnaissance phase work carried out on Authorities to Prospect 656M and 830M (Calton Hills area) in the period August 1969 to August 1970. Tasman Minerals Pty Ltd (unpublished CR 3983b)

GEOCONTRACT PTY LTD, 1971c - Interim report on work carried out on A.P. 656M in the period 1st October to 31st December, 1970. Tasman Minerals Pty Ltd (unpublished CR 3983c).

GEOCONTRACT PTY LTD, 1971d - Interim report on work carried out on A. to P. 656M in the period 4th July, 1970 to 31st March, 1971. Tasman Minerals Pty Ltd (unpublished CR 3983c).

GESSNER, R.H., 1966 - Authority to Prospect 283M, report of activities, May 1, 1965 to April, 30, 1966. Placer Prospecting Pty Ltd (unpublished CR 2063)

GIFFORD, W.G.R., 1971 - Progress report, Authority to Prospect 616M (Buckley), Queensland, to December, 1970. Anaconda Australia Inc. (unpublished CR 3648)

GIFFORD, W.G.R., & BEATTIE, R.D., 1971 - Final report, Authority to Prospect 616M (Buckley), Northwest Queensland, to July, 1971. Anaconda Australia Inc. (unpublished CR 3786)

GILFILLAN, J.F., 1974 - Annual report, exploration year 1 - 1973, Authority to Prospect 1154M, May Downs, Queensland. Falconbridge (Australia) Pty Ltd (unpublished CR 4775).

GLASSON, K.R., 1971 - Annual report on Authority to Prospect No. 615M, Mt Isa, Queensland, 1970. Eastern Copper Mines N.L. (unpublished CR 3909).

GLIKSON, A.Y., & DERRICK, G.M., 1970 -The Proterozoic metamorphic rocks of the Cloncurry 1:100 000 Sheet area, (Soldiers Cap Belt) northwestern Queensland. Bureau of Mineral Resources, Australia, Record 1970/24 (unpublished).

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

GREEN, P.W., 1975 - Annual report, 1974 and final report, Authority to Prospect 1339M, Northwest Queensland. Consolidated Gold Fields Australia Ltd, Report 2/1975 (unpublished CR 5191).

GRIMES, K.G., 1972 - The Mesozoic and Cainozoic geology of the Cloncurry 1:250 000 Sheet area, Queensland. Bureau of Mineral Resources, Australia, Record 1972/57 (unpublished).

GRIMES, K.G., 1974 - Mesozoic and Cainozoic geology of the Lawn Hill, Westmoreland, Mornington and Cape van Diemen 1:250 000 Sheet areas, Queensland. Bureau of Mineral Resources, Australia, Record 1974/106 (unpublished).

GRIMES, K.G., 1979 - The stratigraphic sequence of old land surfaces in northern Queensland. BMR Journal of Australian Geology Geophysics,4, 33-46.

GUY, B.B., 1977 - Authority to Prospect Nos. 1650 M, 1651 M, and 1652 M. Mount Isa area, Queensland, Final report. Union Miniere Development & Mining Corp. Ltd (unpublished C.R. 6241).

HANSEN, W.A., 1966 - Surprise Creek Project 39, Report No. 1. (AP 296 M). Kern County Land Co.(unpublished CR 2082A).

HANSEN, W.A., 1966 - Progress report Surprise Creek project. Authority to Prospect 296 M. Report No. 3. Kern County Land Co. (unpublished CR 2083).

HANSEN, W.A., & TESTER, D.K., 1966 - Progress report, Surprise Creek project, Authority to Prospect 296 M, Report No. 5. Kern County Land Co.(unpublished CR 2082D).

HARDY, I.M., 1968 - A.P. 388 M (1) and (2). Report on area surrended. Queensland Mines Ltd (unpublished CR 2524).

HARTLEY, J.S., 1965 - Silver Ridge prospect (A.P. 204 M). Carpentaria Exploration Co. Pty Ltd, Technical Report No. 62 (unpublished CR 1620).

HAYES, J., 1967 - Land surfaces and laterites in the north of the Northern Territory. In JENNINGS, J.N., & MABBUTT, J.A. (Editors) - LANDFORM STUDIES FROM AUSTRALIA AND NEW GUINEA. Australian National University Press, Canberra. 182-210.

HILL, J.H., 1975 - Authority to Prospect 1439 M, Annual report 1974. International Nickel Australia Ltd (unpublished CR 5270).

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

HOFFMAN, P.F., 1976 - Stromatolite morphogenesis in Shark Bay, Western Australia. In WALTER, M.R., (Editor) - STROMATOLITES Elsevier, Amsterdam, 261-71.

HOLYLAND, P.W., 1975 - Regional evaluation of the western basin, Northwest Queensland. Consolidated Gold Fields Australia Ltd, Report 8/1975 (unpublished).

HORTON, H., 1976 - Around Mount Isa, a guide to the flora and fauna. University of Queensland Press, St Lucia.

HOWE, B.A., 1970 - Calton Hills total-count scintillometer survey, survey data (AP 635 M). Adastra Surveys Group (unpublished CR 3289)

HRUSKA, D.C., 1970 - Report on areas relinquished from Authority to Prospect 668 M (Paroo) as from October 1, 1970. Anaconda Australia Inc. (unpublished CR 3706)

HRUSKA, D.C., 1971a - Progress report, Authority to Prospect 668 M (Paroo) Queensland, to December 1970. Anaconda Australia Inc. (unpublished CR 3529).

HRUSKA, D.C., 1971b - Final report, Authority to Prospect 668 M (Paroo). Anaconda Australia Inc.(unpublished CR 4608).

HRUSKA, D.C., & ROBERTS, H.G., 1971 - Progress report, Authority to Prospect 617 M (Johnson), northwest Queensland, to December 31, 1970. Anaconda Australia Inc.(unpublished CR 3558).

JENSEN, H.E., 1961 - N.W. Queensland Investigations-PRP/1/110 - A to P 169 M. Quarterly report for period ended 30th June, 1961. Rio Tinto Southern Pty Ltd(unpublished CR 645).

JOPLIN, G.A., 1955 - A preliminary account of the petrology of the Cloncurry Mineral Field. Proceedings of the Royal Society of Queensland,66(4), 33-67.

JOPLIN, G.A., 1968 - A PETROGRAPHY OF AUSTRALIAN METAMORPHIC ROCKS. Angus & Robertson, Sydney.

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

KENNECOTT EXPLORATIONS (AUSTRALIA) PTY LTD, 1968 - Authority to Prospect 361 M, Quarterly report 1 October-31 December 1967 and Final report of prospecting for areas retained since 1 August 1967. Kennecott Explorations (Australia) Pty Ltd(unpublished CR 2696)

KERN COUNTY LAND CO., 1967a - Authority to Prospect 401 M, progress report for the three months ended June 30, 1967. Kern County Land Co.(unpublished CR 2281)

KERN COUNTY LAND CO., 1967b - Authority to Prospect 401 M, progress, report for the three months ended September, 30th 1967. Kern County Land Co. (unpublished CR 2281).

KROSCH, N.J., & SAWERS, J.D., 1974 - Copper mining in the Cloncurry and Mount Isa mining fields, 1971. Geological Survey of Queensland, Report 85.

LOUDON, A.G., LEE, M.K., DOWLING, J.F., & BOURN, R., 1975 - Lady Loretta silver-lead-zinc deposit. In KNIGHT, C.L., (Editor) - ECONOMIC GEOLOGY OF AUSTRALIA AND PAPUA NEW GUINEA : 1 METALS. Australasian Institute of Mining and Metallurgy, Monograph Series 5,377-82.

McBRIDE,B., 1958 - Final geological report A.P. 94 M Mt Isa area. United Uranium N.L.(unpublished CR 166).

McCARTHY, E., & PINNEY, R., 1959a - Geophysical surveys - North Mt Isa area. (AP 128, 141) Rio Tinto Australian Exploration Pty Ltd(unpublished CR 380)

McCARTHY, E., & PINNEY, R., 1959b - N.W. Queensland investigations - PRP/1/100, review report of geophysical surveys, 1959 field season (AP 128, 141). Rio Tinto Australian Exploration Pty Ltd (unpublished CR 391)

McKENNA, D., 1963 -Summary report, geological investigations and diamond drilling, North Mt Isa, PRP/1/110 (Hero Leases) to March, 1963. (A.P. 169M). Conzinc Rio Tinto Australia Ltd (unpublished CR 1039).

MATHESON, R.S., 1959a -Cloncurry - Mt Isa district, Queensland PRP/1/100. Quarterly Report for period ending 31st March, 1959. (A.P. 128). Rio Tinto Australian Exploration Pty Ltd (unpublished CR 253).

MATHESON, R.S., 1959b -Quarterly report on A.P. 128M Cloncurry district, period 1st July -30th September, 1959. Rio Tinto Australian Exploration Pty Ltd (unpublished CR 357)

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

MINERAL DEPOSITS LTD, 1968-70 -Authority to Prospect No. 485M, Calton Hills, Interim Reports Nos. 1-9and Annual Reports, 1968-69. Mineral Deposits Ltd(unpublished CR 3112)

MINOPS PTY LTD, 1970 -Geological report of Calton Hills Uranium Project, Authority to Prospect 635M, Mount Isa District - Queensland. Queensland Mines Ltd (unpublished CR 3289).

MOUNT ISA MINES LTD, 1970 -Authority to Prospect 292M "Valley Extended", Final Report. Mount Isa Mines Ltd (unpublished CR 2832)

MOUNT ISA MINES LTD, 1972 -Authority to Prospect 582M, report on areas excluded from lease applications. Mount Isa Mines Ltd (unpublished CR 4091)

MUCENIEKAS, E., 1959 -N.W. Queensland investigations - PRP/1/100 Report on geochemical investigations during 1959. (A.P. 128, 141) Rio Tinto Australian Exploration Pty (unpublished CR 391)

MUCENIEKAS, E., 1963 -Hero Lease area - North Mt Isa - PRP/1/110 geochemical report. (A.P. 169M) C.R.A. Exploration Pty Ltd (unpublished CR 1213)

MUCENIEKAS, E., 1964 -Hero Lease area - North Mt Isa - Eastern Limb, geochemical report (A.P. 232M) C.R.A. Exploration Pty Ltd (unpublished CR 1289).

MULLINS, W.J., & CALAITZIS, P., 1971a - Final report to the Department of Mines, Queensland, on the area of Authority to Prospect 619M, relinquished. Eastern Copper Mines N.L. (unpublished CR 3758)

MULLINS, W.J., & CALAITZIS, P., 1971b - Final report to the Department of Mines, Queensland, on the area of Authority to Prospect 618M relinquished. Eastern Copper Mines N.L.(unpublished C.R. 3789)

MURRAY, W.J., 1963 -Final report, Gregory Authority to Prospect 183M. Carpentaria Exploration Co. Pty Ltd Report No. 15 (unpublished C.R. 943)

NEWPORT, R., 1976 -Authority to Prospect 1439M, Judenan - Queensland, annual report - 1975 and final report. International Nickel Australia Ltd (unpublished C.R. 5626)

OPIK, A.A., CARTER, E.K., & NOAKES, L.C., 1961 - Mount Isa - 4 mile geological series Bureau of Mineral Resources, Australia, Explanatory Notes, 20.

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

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

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

PETTIJOHN,F.J., 1957 - SEDIMENTARY ROCKS (2nd edition). Harper, New York.

PETTIJOHN, F.J., 1975 - SEDIMENTARY ROCKS (3rd edition). Harper and Row, New York.

PLUMB, K.A., & DERRICK, G.M., 1975 - Geology of the Proterozoic rocks of the Kimberley to Mount Isa region. In KNIGHT, C.L., (Editor) - ECONOMIC GEOLOGY OF AUSTRALIA AND PAPUA NEW GUINEA: 1. METALS Australasian Institute of Mining and Metallurgy, Monograph Series, 5, 217-52.

POHL, D.C., 1972 - Relinquishment report, Mingera Creek project, Authority to Prospect 966M Queensland. Esso Australia Ltd (unpublished CR 4156).

QUEENSLAND MINES LTD, 1968a -Authority to Prospect 388M. Annual Report - 1967. Queensland Mines Ltd (unpublished CR 2602).

QUEENSLAND MINES LTD, 1968b -Authority to Prospect 467M(3). Surrender report. Queensland Mines Ltd (unpublished CR 2886).

QUEENSLAND MINES LTD, 1969 - Authority to Prospect 467M(2). Surrender report. Queensland Mines Ltd (unpublished CR 2818).

QUEENSLAND MINES LTD, 1970 - Surrender report A.P.589M. Queensland Mines Ltd (unpublished CR 2979).

RENNIE, C.C., 1970 - Final report on Authority to Prospect No. 660M north-western Queensland. Placer Prospecting (Aust.) Pty Ltd.(unpublished CR 3327).

RICHARDS, J.R., BERRY, H., and RHODES, J.M., 1966 - Isotopic and lead alpha ages of some Australian zircons. Journal of the Geological Society of Australia,13, 69-96.

RIDGEWAY, J.E., 1960- Final report -Authority to Prospect 136M and 149M. Queensland Mines Ltd (unpublished CR 537).

RILEY, R.J., 1968 - The preliminary geological and geochemical appraisals of the Calton Hills Authority to Prospect No. 411M. Carpentaria Exploration Co. Pty Ltd, Technical Report No. 153 (unpublished CR 2821).

RIO TINTO AUSTRALIAN EXPLORATION PTY LTD, 1959 - Exploration programme, Cloncurry - Mt Isa district, N.W. Queensland PRP/1/100, Review of activities, 1959. (A.P. 128, 141). Rio Tinto Australian Exploration Pty Ltd (unpublished CR 391).

RIO TINTO AUSTRALIAN EXPLORATION Pty Ltd, 1960 - Final report on Authorities to Prospect Nos. 128M & 141M, Nth Queensland, from 1.10.58 to 30.9.60. Rio Tinto Australian Exploration Pty Ltd (unpublished CR 2228).

RIO TINTO SOUTHERN PTY LTD, 1962 -N.W. Queensland Investigations - PRP/1/110, A. to P. 169M. Quarterly report for period ended 30th June, 1962. Hero Leases, North Mt Isa. Rio Tinto Southern Pty Ltd (unpublished CR 874).

RIO TINTO SOUTHERN PTY LTD, 1963 -Cloncurry - Mt Isa investigations A. to P. 169M, quarterly report for period ended 31st December, 1962. Rio Tinto Southern Pty Ltd (unpublished CR 1183).

ROBERTSON, W.A., 1960 - Stromatolites from the Paradise Creek area, northwestern Queensland. Bureau of Mineral Resources, Australia, Report 47.

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

ROGERS, J.K., 1977 - Authority to Prospect 1392M Buckley River area, Northwest of Mount Isa, annual report for 1976. Mines Exploration Pty Ltd (unpublished CR 5967).

SEARL, R.A., 1959a - Cloncurry - Mt Isa district, Queensland - PRP/1/100. Quarterly report for period ending 30th September, 1959 (AP 128, 141). Rio Tinto Australian Exploration Pty Ltd (unpublished CR 358).

SEARL, R.A., 1959b - Exploration programme Cloncurry - Mt Isa district - PRP/1/100, Review of geological activities October 1958-November 1959 (AP 128, 141). Rio Tinto Australian Exploration Pty Ltd (unpublished CR 391).

SELLEY R.C., 1970 - ANCIENT SEDIMENTARY ENVIRONMENTS. Chapman and Hall, Norwich.

SHEPHERD, J.H., 1957 - Work accomplished on A.P. 94M. Mt Isa area. United Uranium N.L., King Island Scheelite (1947) Ltd, & Loloma (Fiji) Gold Mines Ltd (unpublished CR 170).

SHEPHERD, S.R.L., 1932 - Mount Isa silver-lead-zinc deposits, the Black Rock lode. Queensland Government Mining Journal,33, 377-83.

SHEPHERD, S.R.L., 1934 - Gold prospects at May Downs, Cloncurry Gold and Mineral Field. Queensland Government Mining Journal, 35, 40-3.

SISE, J.R., & GIFFORD, W.G.R., 1971 -Final report, Authority to Prospect 617M (Johnson) north west Queensland to June 1971. Anaconda Australia Inc. (unpublished CR 3778).

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

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

SMART, J., GRIMES, K.G., DOUTCH, H.F., and PINCHIN, J., in prep. - The Mesozoic Carpentaria Basin and the Cainozoic Karumba Basins, north Queensland. Bureau of Mineral Resources Australia, Bulletin 202.

STEWART, G.A., 1954 - Geomorphology of the Barkly region. In Survey of the Barkly region 1946-48. CSIRO Land Research Series, 3, 42-58.

STEWART, G.A., CHRISTIAN, C.S., & PERRY, R.A., 1954 - The land systems of the Barkly region. In Survey of the Barkly region 1947-48. CSIRO Land Research Series, 3, 113-49.

STRECKEISEN, A.L., 1967 - Classification and nomenclature of igneous rocks. Neues Jahrbuch fur Mineralogie, Abhandlugen 107, 144-239.

SYVRET, J.M., 1966 - Copper mining in the Cloncurry and Mount Isa Fields, 1965. Geological Survey of Queensland, Report 14.

TOWNDROW, P., 1972 - Final report, Authority to Prospect 727M, Mt Isa northwest Queensland. Pioneer Mining & Exploration Pty Ltd (unpublished CR 4122).

TURNER, F.J., & VERHOOGEN, J., 1951 - IGNEOUS AND METAMORPHIC PETROLOGY. McGraw-Hill, New York.

TWIDALE, C.R., 1964 - Geomorphology of the Leichhardt-Gilbert area. In PERRY, R.A. (Editor) - General report on lands of the Leichhardt-Gilbert area, Queensland, 1953-54. CSIRO, Land Research Series, 11, 115-24.

TWIDALE, C.R., 1966 - Geomorphology of the Leichhardt-Gilbert area of north-west Queensland. CSIRO Land Research Special Report 6.

UNION MINIERE DEVELOPMENT & MINING CORP. LTD, 1972a - Annual report, Authority to Prospect 615M, north western Queensland, January 1 to December 1, 1971. Union Miniere Development & Mining Corp. Ltd (unpublished CR 3982).

UNION MINIERE DEVELOPMENT & MINING CORP. LTD. 1977 - Authorities to Prospect 1650M, 1651M & 1652M, Mount Isa area, NW Queensland, Annual report 1976. Union Minere Development & Mining Corp. Ltd (unpublished CR 6097).

WALTER, M.R., BAULD, J., & BROCK, T.D., 1976 - Microbiology and morphogenesis of columnar stromatolites (Conophyton, Vacerrilla)from hot springs in Yellowstone National Park. In WALTER, M.R. (Editor) - STROMATOLITES, Elsevier, Amsterdam, 273-310.

WILLS, K.J., 1976 - Exploration at May Downs (A. to P. 1154M) and Mine Creek (A. to P. 1571M) during the period October, 1975 to March,1976. CRA Exploration Pty Ltd, Report 8510 (unpublished CR 5625).

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

WILSON, C.J.L., 1975 - Structural features west of Mount Isa. Journal of the Geological Society of Australia, 22, 457-76.

WILSON, I.H., 1977 -Mineral exploration under Authorities to Prospect in the Mount Isa 1:250 000 Sheet area, northwestern Queensland. Queensland Government Mining Journal, 78, 222-33.

WILSON, I.H., & DERRICK, G.M., 1976 -Precambrian geology of the Mount Isa region, northwest Queensland. 25th International Geological Congress - Guidebook, Excursions 5A and 5C.

WILSON, I.H., DERRICK, G.M., HILL, R.M., DUFF, B.A., NOON, T.A., & ELLIS, D.J., 1977 - Geology of the Prospector 1:100 000 Sheet area, Queensland. Bureau of Mineral Resources, Australia, Record 1977/4 (unpublished).

WINKLER, H.G.F., 1967 -PETROGENESIS OF METAMORPHIC ROCKS (2nd ed.). Springer-Verlag, Berlin.

WINKLER, H.G.F., 1974 -PETROGENESIS OF METAMORPHIC ROCKS (3rd ed.). Springer-Verlag, Berlin.