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Record 1979/86

PRECAMBRIAN GEOLOGY OF THE SELWYN REGION, NORTHWESTERN QUEENSLAND - PRELIMINARY DATA

by

D.H. Blake, A.L. Jaques, & P.J.T. Donchak

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CONTENTS

CONTENTS (continued)

CONTENTS (continued)

ABSTRACT

The Selwyn region comprises the Selwyn and eastern half of the Mount Merlin 1:100 000 Sheet areas, and constitutes the southeastern quadrant of the Duchess 1:250 000 Sheet area, northwestern Queensland. The Precambrian rocks exposed belong to the Cloncurry Complex, and form the southeastern part of the Mount Isa Inlier. They are considered to be Early or Middle Proterozoic.

In the northwest a generally east-younging and apparently conformable succession consists of, from west to east: Argylla Formation, interlayered acid metavolcanics and metasediments; Mitakoodi Quartzite, mainly quartzose to feldspathic meta-arenites; Answer Slate; Staveley Formation, mainly fine-grained, partly calcareous metasediments; and Agate Downs Siltstone. The Staveley Formation, as mapped, includes a sequence of little metamorphosed arenites and siltstones showing well-preserved sedimentary structures. The Kuridala Formation crops out to the east; it consists mainly of mica schist, which commonly contains porphyroblasts of andalusite ± garnet ± staurolite, and schistose metagreywacke, but also includes graphitic metasiltstone, quartzite, calc-silicate rocks, acid and basic metavolcanics, and banded iron formation. The Kuridala Formation appears to be laterally equivalent to the Answer Slate and part of the Staveley Formation to the west and to part or all of the Soldiers Cap Group and Corella Formation to the east. The Soldiers Cap Group is represented mainly by schist and gneiss, which are locally migmatitic, but also includes quartzite, amphibolite, calc-silicate rocks, and banded iron formation. It may partly interfinger with and partly be overlain by Corella Formation, a unit formed largely of banded, brecciated, and massive calc-silicate rocks.

These rocks have been affected by two main deformations, during which they formed tight to isoclinal folds with steeply dipping north-trending axial planes, and were regionally metamorphosed to amphibolite and greenschist grades. They have also been intruded by many metadolerite dykes and sills, some of which postdate the earlier deformation, and by several granite plutons. Some of the granites are considered to be syntectonic (Cowie, Blackeye, and Marramungee Granites (all new names) and unnamed granite), but the larger plutons, those of Williams Granite and Gin Creek Granite, are post-tectonic. The Gin Creek Granite includes some foliated parts which are spatially associated with unnamed metamorphic rocks mainly migmatitic gneiss and schist. The youngest intrusions in the region are east-trending dolerite dykes which may be Late Proterozoic.

(b)

A major unconformity separates the Precambrian rocks from flat-lying Cambrian sediments of the Burke River Outlier succession, Mesozoic sediments of the Eromanga Basin succession, and superficial Cainozoic sediments.

Mines in the Selwyn region have produced significant amounts of copper, gold, and cobalt, and minor tungsten and silica flux. In addition, there are several copper, copper-lead-zinc, and uranium prospects. Most of the economic mineralisation occurs within the Kuridala Formation, mainly in graphitic and pyritic rocks. Recently, subeconomic deposits of copper-lead-zinc have been found in banded iron formation within the Kuridala Formation and Soldiers Cap Group.

INTRODUCTION

Scope

The Selwyn region, as described in this report, comprises the Selwyn 1:100 000 Sheet area (7054) and eastern half of the Mount Merlin 1:100 000 Sheet area (6954). It covers the southeastern part of the Duchess 1:250 000 Sheet area (SF54-6), northwest Queensland, and is bounded by latitudes 21°30'S and 22°00'S and longitudes 140°15'E and 141°00'E.

Geological fieldwork in the region was carried out between 26 June and 5 October 1978: D.H. Blake mapped most of the area east of longitude 140°22'E; A.L. Jaques mapped the area to the west and also made some observations in the area to the east; P.J.T. Donchak carried out two short traverses in the area, concentrating on structural aspects, and also visited outcrops in the southern and northwestern parts. Blake and Donchak revisited the Selwyn region in August 1979 and made some additional observations, mainly in the northwest. The results of the 1978 and 1979 fieldwork, together with preliminary laboratory data, are presented in this report, which is accompanied by the preliminary edition 1:100 000-scale geological map.

The work described is part of the Duchess project, which was started in 1975 and is being carried out jointly by the Bureau of Mineral Resources (BMR) and Geological Survey of Queensland (GSQ). The aims of the project are to investigate the Precambrian parts of the Duchess and Urandangi 1:250 000 Sheet areas and assess their mineral potential. The results will be presented mainly in the form of 1:100 000-scale geological maps and accompanying reports. Preliminary maps and reports for all the 1:100 000 Sheet areas involved are now available: Malbon (Noon, 1978, 1979), Oban (Mock, 1978), Duchess (Bultitude, Blake, & Donchak, 1978), Dajarra (Blake, Donchak, & Bultitude, 1978), Mount Angelay (Donchak, Blake, & Jaques, 1979), Ardmore (Bultitude, 1980), and Selwyn and Mount Merlin (this report).

In the following text, 1:250 000 Sheet areas are referred to by name and scale, e.g., Duchess 1:250 000 Sheet area, whereas 1:100 000 Sheet areas are referred to by name only, e.g., Mount Merlin Sheet area, Duchess Sheet area.

Access

Vehicle access to and within the Selwyn region is reasonably good. The unsealed but regularly maintained McKinlay to Boulia road crosses the SE part of the region, and provides access to the east. McKinlay, 40 km northeast

from the northeastern corner of the Selwyn region, is on the main Cloncurry to Winton road. Access in the west is via the unsealed Selwyn to Boulia, Selwyn to Hamilton River, and Selwyn to Malbon roads. Malbon, 48 km north of the northwest corner of the Selwyn region, is on the Cloncurry to Duchess road. Numerous tracks to homesteads, water-bores, and cattle yards, along fences, and to mines and mineral prospects provide access to most other parts of the region. The roads and tracks become impassable after periods of heavy rain.

Most homesteads have airstrips suitable for light aircraft nearby, and the region has almost unlimited helicopter landing sites.

Population and industry

There are no towns in the region; the only permanent habitation is at station homesteads, all but two of which are in the south and east, and at the Answer mine in the west. In 1978 and 1979 Amoco Minerals had a camp near Mount Dore, at grid reference (GR) 481038. The total permanent population in the region in 1978 was probably less than 50. Selwyn, after which the region is named, is an abandoned township in the northwest of the Selwyn Sheet area, at GR 482193.

The main industry is cattle raising. Mining is of minor importance at present, as only one mine, the Answer, is being worked. However, the region was an important mineral producer in the past, and is being prospected by several exploration companies. Of the numerous long abandoned and mostly small mines, the two largest are Mount Elliott mine, which produced 24 920 tonnes Cu and 1 854 199 g Au before it closed in 1920, and Mount Cobalt mine, which closed in 1934 after producing about 778 tonnes Co. The region also contains some tungsten, lead, zinc, and uranium mineralisation.

Climate, topography, drainage, and vegetation

The Selwyn region has a semi-arid tropical climate (Slatyer, 1964). The annual rainfall averages about 375 mm, but varies considerably from year to year, and droughts are not uncommon. Since 1970 the rainfall has been above average. Most rain falls between November and March, but substantial falls can occur at other times. In 1978, for instance, heavy rain fell on two days in July. Mean monthly maximum and minimum temperatures range from about 35 and 25°C in December to 25 and 10°C in July. Frosts occur locally in June and July.

Relative humidity is mainly in the 15 to 50 percent range. Evaporation greatly exceeds rainfall. Further climatic details are given in Carter, Brooks, & Walker (1961), and Slatyer (1964).

The northern and central parts of the region form part of the Selwyn Range, which consists of plateaus, mesas, buttes, and rocky ridges generally less than 100 m high. To the south and east are broad flat alluvial plains and undulating terrain with some low ridges. The highest point is about 470 m above sea level, on the main plateau in the north central part of the region, and the lowest is about 235 m, on the plain of the Hamilton River in the southeast. The main plateau is incised by a dendritic pattern of watercourses in deep gorges.

According to the physiographic divisions of Twidale (1964, 1966), the Selwyn Range is part of the Isa Highlands, the lowlands to the west and south are part of the Inland Plains, and the lowlands in the northeast are part of the Carpentaria Plains.

The divide separating inland drainage, flowing south towards Lake Eyre, and drainage flowing north to the Gulf of Carpentaria crosses the northeastern and central northern parts of the region. In the northeast the McKinlay River and its tributaries are part of the Cloncurry River system, as also are northward draining creeks in the central north. In the west the main watercourse is the Mort River, which drains southwest to join the Burke River in the Boulia 1:250 000 Sheet area. Limestone Creek in the northwest flows west to join the Burke River in the western half of the Mount Merlin Sheet area. The main southerly-draining watercourses east of the Mort River are the Hamilton River and two main tributaries, Sandy Creek and Bustard Creek. The Hamilton River, like the Burke River, is a tributary of the Georgina River.

The creeks and rivers in the area flow for only short periods during the year, and there is a general lack of permanent surface water. However, a few small semi-permanent waterholes occur sheltered in gorges within the Selwyn Range. Permanent supplies of water, of variable quality, are obtained only from bores.

Except on the plains in the southwest and east, where Mitchell Grass predominates, the vegetation consists mainly of spinifex with sparse low trees and shrubs. There are also some local areas of low woodland and patches of dense to open scrub formed largely of 'turpentine' bush (Acacia lysiphloia). Trees, mainly eucalpyts, grow along the main watercourses. Further details of the vegetation are given by Carter & others (1961) and Perry & Lazarides (1964).

Previous geological investigations

The Precambrian rocks of the Selwyn region form part of the Mount Isa Inlier (Geological Survey of Queensland, 1976), which was mapped at reconnaissance level by joint BMR and GSQ field parties during the 1950s. The results of this work were published as BMR Bulletin 51 (Carter & others, 1961), and relevant data were summarised in the explanatory notes for the Duchess 4-mile (1:250 000) Sheet area (Carter & Opik, 1963). Bibliographies in these two publications include the available literature on the Selwyn region to 1960. A report on the geology of an area near Selwyn township, prepared in 1957, was not published, but is available as a BMR Record (White, 1957). The only subsequent publications concerning the Precambrian of the Selwyn region have been descriptions of the Pegmont prospect by Lõcsei (1977) and Stanton & Vaughan (1979), and of the Answer and Mount Cobalt mines by Brooks (1977, 1979a). The geology of the lower Palaeozoic Burke River Outlier in the far west of the region has been described by de Keyser (1968). Mesozoic sediments in the east are described as part of the Eromanga Basin sequence by Senior, Mond, & Harrison (1978). Mineral exploration in the region to February 1976 is summarised by Noon (1976).

Present investigations

The Precambrian rocks of the Selwyn region were mapped during the 1978 and 1979 field seasons using colour aerial photographs at a scale of about 1:25 000, taken in 1971 for the Department of National Mapping. Field observations made in 1978 were plotted on transparent overlays on the aerial photographs by the authors and transferred onto photo-scale compilation sheets by G.A. Young (BMR draftswoman) in the field. Following further interpretation, checking, and corrections, the field compilation sheets were photographically reduced to 1:100 000 scale. These reductions were then redrawn as the Preliminary Edition map which accompanies this report. Copies of the field compilation sheets for the Selwyn and Mount Merlin Sheet areas, completed before the 1979 field season, can be obtained from the Australian Government Printing Office, Canberra.

Brief descriptions of the fieldwork results are included in BMR Geological Branch Summary of Activities for 1978 (Blake, 1979a; Jaques, 1979) and 1979 (Blake, 1979b).

A microprobe study of amphibolites and calc-silicate rocks from the Selwyn region has been started by A.L. Jaques. The results of this study will be presented in a later report, but some preliminary determinations of mineral compositions are included in petrographic descriptions within this data Record.

Rock nomenclature

Terms used in this report are generally as defined by Gary & others (1972).

Sandstones are classified according to Pettijohn, Potter, & Siever (1972). Grainsize definitions are as follows: fine, 0.125 to 0.25 mm; medium, 0.25 to 0.5 mm; coarse, 0.5 to 1 mm. Bedding thickness terms are laminated, less than 1 cm; thin-bedded, 1 to 50 cm; medium-bedded, 50 cm to 2 m; thick-bedded, over 2 m.

The classification recommended by Streckeisen & others (1973) is used for plutonic rocks. Grainsizes of igneous rocks, and also for metamorphic rocks, are fine, less than 1 mm; medium, 1 to 5 mm; coarse, 5 mm to 3 cm.

Terms describing metamorphic facies are as defined by Turner & Verhoogen (1960). The name 'granofels', as suggested by Goldsmith (1959), is used for granoblastic metamorphic rocks which do not have a marked foliation or lineation. The prefix 'meta' added to a rock name indicates that the rock now has a metamorphic fabric and/or mineralogy, but its original nature is readily apparent.

OUTLINE OF GEOLOGY

The Precambrian stratigraphy of the Selwyn region is summarised in Table 1. In spite of the relatively detailed field investigations in 1978 and some follow-up work in 1979, several uncertainties regarding the stratigraphy still exist. For instance, it has yet to be established which are the oldest rocks in the region, and whether or not unconformities exist within the Precambrian sequence. All the Precambrian rocks belong to the Cloncurry Complex of Carter & others (1961).

In the northwest the stratigraphy appears relatively simple, as units generally dip steeply east and appear to young east. The most westerly unit exposed is mapped as Argylla Formation, the uppermost unit of the Tewinga Group.

It consists of metamorphosed acid volcanics and associated feldspathic metasediments. To the east these rocks are overlain by and interfinger with the Marraba Volcanics, a unit of metamorphosed basic volcanics, including some amygdaloidal lava, and interlayered metasediments. The succeeding Mitakoodi Quartzite, which together with the Marraba Volcanics represents the Malbon Group in the Selwyn region, is made up mainly of quartzose to feldspathic meta-arenites. The conformably overlying Answer Slate, which consists of phyllite, schist, and metasiltstone as well as slate, passes eastwards into mostly fine-grained and variably calcareous metasediments mapped as Staveley Formation. This formation, which is thought to occupy the central part of a northerly plunging synclinorium, is tentatively taken to include sequences of interbedded arenites and siltstones (Pks_{x}) showing well-preserved sedimentary structures such as convolute bedding, cross-bedding, and ripple marks. One such sequence forming a syncline in the east appears to be less metamorphosed and less deformed (affected by one rather than two deformations) than adjacent Kuridala Formation rocks. The Staveley Formation is overlain conformably in the north by Agate Downs Siltstone, a unit of phyllitic metasiltstone and fine-grained quartzite exposed in a northerly plunging syncline. The regional metamorphism decreases from amphibolite grade in the Argylla Formation and Marraba Volcanics to mainly low or middle greenschist grade in the Staveley Formation and Agate Downs Siltstone.

The most extensive Precambrian formation in the Selwyn region, the Kuridala Formation, crops out to the east of the Staveley Formation. It is made up mainly of mica schist and schistose metagreywacke, but also includes graphitic slate, other metasediments, and minor acid and basic metavolcanics, all of which have probably been regionally metamorphosed to amphibolite grade. The mica schist commonly contains porphyroblasts of andalusite $\pm$ garnet $\pm$ staurolite.

The Answer Slate, Kuridala Formation, and at least parts of the Staveley Formation are regarded as correlatives. Facing and structural evidence and outlines of deformed basic intrusions show that all three formations are tightly to isoclinally folded on both major and minor scales. Together with the Agate Downs Siltstone and also the Corella Formation to the east, they represent the Mary Kathleen Group in the region.

Unnamed metamorphic rocks in the northwest, partly enclosed by Answer Slate and Staveley Formation, consist mainly of migmatitic muscovite-biotite-quartz-feldspar gneiss and schist veined by granite, aplite and pegmatite. They do not appear to be the more metamorphosed equivalents of adjacent metasediments, because of differences in composition, and instead may represent older rocks from deeper in the crust carried to their present position during emplacement of Gin Creek Granite. This granite, which intrudes Answer Slate, Staveley Formation, and Kuridala Formation as well as the unnamed metamorphic rocks, ranges from foliated to non-foliated, consists of biotite and tourmaline-muscovite granites, and commonly contains large inclusions of country rocks.

The Soldiers Cap Group, which crops out to the east of the Kuridala Formation, has not been subdivided into individual formations in the Selwyn region. It consists mainly of schist and gneiss representing metamorphosed and partly migmatitic quartzofeldspathic and greywacke-type sediments. Subordinate rock types include amphibolite, some of which is considered to represent basalt lavas; quartzite; calc-silicate rocks; and banded iron formation. In the south, coarse mica schist mapped as Soldiers Cap Group appears to grade westwards into rocks typical of the Kuridala Formation. To the north the relationship of the group to the adjacent Corella Formation, which is formed mainly of banded to brecciated calc-silicate rocks, is uncertain because of structural complexities and lack of facing evidence; the presently favoured interpretation is that the two units form a conformable and locally interfingering sequence of which probably the Corella Formation part is generally the younger.

The Soldiers Cap Group and Corella Formation, and also the Kuridala Formation to the west, are intruded by Williams Granite, the main types of which are porphyritic and non-porphyritic biotite and hornblende-biotite granites. The Williams Granite is generally not foliated, and it cuts across fold structures in adjacent rocks; hence it is considered to be post-tectonic. Soldiers Cap and Corella rocks are also intruded by foliated granites (Cowie, Marramungee, and Blackeye Granites, and unnamed granite) which are probably syntectonic.

Northerly trending metadolerite and amphibolite sills, dykes, and pod-like bodies intrude all the Precambrian units except Agate Downs Siltstone, Staveley unit Pks$_x$, and the granites. These intrusions have been regionally metamorphosed, and most, if not all, pre-date the main folding event; all are older than Williams Granite. The youngest basic intrusions are post-tectonic,

east-trending dolerite dykes which cut Williams Granite and older rocks; these dykes are strongly oblique to the regional northerly trends, but are aligned roughly parallel to the southwestern body of Williams Granite.

The Phanerozoic rocks of the region comprise Cambrian sediments of the Burke River Outlier sequence, which overlie Precambrian rocks in the west; flat-lying Mesozoic sediments, correlated with the Eromanga Basin sequence to the east, which are widespread on summit surfaces; and unconsolidated Cainozoic sediments, most extensive in the south and east.

The Selwyn region contains copper, cobalt, gold, tungsten, lead, zinc, and uranium mineralisation. Total production amounts to over 26 000 tonnes of copper, 778 tonnes of cobalt, nearly 2 000 kilograms of gold, and less than 250 kilograms of tungsten. Most of the copper mineralisation occurs within the Kuridala Formation, mainly in graphitic slate. The largest copper deposit, at the Mount Elliott mine near Selwyn, also produced most of the gold recovered from the area. Cobalt ore has been mined at the Mount Cobalt mine, situated in the Kuridala Formation adjacent to a metadolerite intrusion. Minor tungsten mineralisation is known in the same general area. Uranium prospects are located 5 km and 16 km to the north, in the Kuridala and Staveley Formations respectively Banded iron formation at Pegmont prospect, in Kuridala Formation, and at prospects to the northeast, in Soldiers Cap Group, contain subeconomic concentrations of lead, zinc, and copper. Stratabound quartz-hematite-magnetite bodies, present within all of the Precambrian units in the northwest, are locally anomalously rich in copper and gold. Because of the known mineralisation, some of which was previously economic, and also because of geological similarities with the Broken Hill area of western New South Wales, the region has a considerable economic potential for mining.

Table 1. Summary of Precambrian stratigraphic and intrusive units, Selwyn region

Rock unit (and max. thickness in metres)	Main rock types (and map symbols)	Relations
Dolerite dykes (50)	Dolerite, not metamorphosed (unlabelled dyke symbol)	Trend E to ENE; cut Kuridala and Corella Formations, Williams and Maramungee Granites, and Soldiers Cap Group
Williams Granite	Biotite and hornblende granite, porphyritic ($\mathcal{E}gl$) to non-porphyritic ($\mathcal{E}gl_a$); greisen ($\mathcal{E}gi_g$)	Intrudes Soldiers Cap Group, Kuridala and Corella Formations, metadolerite, and Cowie Granite
Gin Creek Granite	Foliated and non-foliated biotite granite, locally porphyritic, and tourmaline-muscovite granite ($\mathcal{E}gg$); schistose and gneissic inclusions common.	Intrudes unnamed metamorphics, Answer Slate, Kuridala and Staveley Formations, and metadolerite
Unnamed granite	In NE: Foliated leucocratic granite, granodiorite, and tonalite; biotite granite; SE of Selwyn: hornblende-biotite tonalite ($\mathcal{E}g$)	Intrudes Corella Formation and Soldiers Cap Group in NE, and Kuridala Formation SE of Selwyn
Cowie Granite	Leucocratic biotite granite, granodiorite, tonalite, and pegmatite ($\mathcal{E}gc$); locally migmatitic	Intrudes Soldiers Cap Group and Corella Formation
Blackeye Granite	Leucocratic granodiorite, commonly foliated ($\mathcal{E}ge$)	Intrudes Corella Formation
Marramungee Granite	Leucocratic biotite granite, granodiorite, tonalite, and pegmatite ($\mathcal{E}gr$)	Intrudes Soldiers Cap Group
Metadolerite (300 +)	Metadolerite, amphibolite (dl, and unlabelled dyke symbol)	Forms northerly trending dykes, sills, and pod-like bodies intruding all units except granites, Agate Downs Siltstone, and Pks_x part of Staveley Formation.
MARY KATHLEEN GROUP		
Agate Downs Siltstone (500 ?)	Phyllitic metasiltstone ($\mathcal{E}kg$), fine-grained quartzite ($\mathcal{E}Kg_q$)	Conformable on Staveley Formation.
Staveley Formation (1000+)	Calcareous and non-calcareous phyllite, slate, arenite, and siltstone ($\mathcal{E}ks$); mica schist cut by granitic veins ($\mathcal{E}ks_g$); calcareous arenite and phyllite, calc-silicate rocks, marble ($\mathcal{E}ks_c$); calcareous, ferruginous, and feldspathic arenites, siltstone, and phyllite ($\mathcal{E}ks_x$); amygdaloidal metabasalt ($\mathcal{E}ks_{xb}$)	May overlie unnamed metamorphics. Pks appears to merge laterally into, and generally overlie, Answer Slate Pks_g appears to merge laterally with Kuridala Formation; Pks_x is inferred to overlie Kuridala Formation.

Rock unit (and max. thickness in metres)	Main rock types (and map symbols)	Relations
Answer Slate (1000 +?)	Slate, phyllite, metasiltstone, mica schist (Pka)	Conformable on Mitakoodi Quartzite; merges laterally with Kuridala Formation; may overlie unnamed metamorphics
Kuridala Formation (1000 +)	Interbedded mica schist (commonly porphyroblastic) and schistose metagreywacke (P_{kr}); graphitic slate and phyllite (P_{kr_g}); phyllite, slate, and mica schist (P_{kr_s}); calc-silicate rocks (P_{kr_p}); chert (P_{kr_c}); quartzite ($P_{kr_{ch}}$); meta-arkose (P_{kr_q}); metamorphosed acid volcanics (P_{kr_f}); mixtures of the above lithologies (P_{kr_a})	Appears to merge laterally with Soldiers Cap Group to E and Answer Slate and part of Staveley Formation to W; base not exposed
Corella Formation (1000 +)	Amphibolitic to siliceous banded calc-silicate granofels (Pkc) and breccia ($P_{kc_{br}}$); metarhyolite (P_{kc_a})	May interfinger with and partly overlie Soldiers Cap Group
SOLDIERS CAP GROUP (1000 +)	Schist and gneiss, migmatitic in part (Po); amphibolitic metabasalt and paraamphibolite (P_{o_d}); mica schist (P_{o_s}); calc-silicate rocks (P_{o_c}); also quartzite, banded iron formation, and pegmatite	Merges laterally with Kuridala Formation in S; may interfinger with Corella Formation; base not exposed
MALBON GROUP Mitakoodi Quartzite (1000 +?)	Quartzite, feldspathic quartzite, metasiltstone, phyllite, and schist (Pnm)	Appears to be conformable on both Marraba Volcanics and Argylla Formation
Marraba Volcanics (1000 +?)	Metabasalt, amphibolite, meta-arenite, schist (Pna)	Overlies and appears to interfinger with Argylla Formation
TEWINGA GROUP Argylla Formation (1000 +)	Felsic granofels and gneiss representing metamorphosed acid volcanics; feldspathic quartzite (Pea)	Appears to interfinger with Marraba Volcanics; base not exposed
Unnamed metamorphics (1000 +?)	Quartz-feldspar-mica gneiss and schist, migmatitic gneiss, amphibolite (Plm)	Intruded by Gin Creek Granite.

DESCRIPTIVE NOTES ON PRECAMBRIAN STRATIGRAPHIC UNITS

Unnamed metamorphic rocks

Map Symbol. Blm.

Distribution. Crop out in west, in general vicinity of Gin Creek Bore (GR 378998); also occur as unmapped inclusions in Gin Creek Granite.

Reference area. About 1 km southeast of Gin Creek Bore, at GR 378986.

Thickness. Unknown.

Airphoto characteristics. Form undulating terrain and low hills with mainly medium tones.

Rock types. Mainly biotite ± muscovite + quartz + feldspar gneiss and schist, migmatitic gneiss, and amphibolite; also quartzite, feldspathic quartzite, banded quartz-tourmaline rock, 'slate', quartz-hematite rock, quartz + feldspar ± tourmaline pegmatite, and leucogranite veins; quartz veins common; sample of acid gneiss examined in thin section consists of quartz, microcline, sericitised plagioclase (some myrmekite), muscovite, poikiloblastic scapolite, equant Fe-Ti oxides and associated sphene, and minor zircon, apatite, and tourmaline; some gneiss and schist contain porphyroblasts and augen of feldspar, and some contain quartz blebs. Pegmatite forms migmatitic sweats, boudins, and cross-cutting veins.

Structure and metamorphism. Gneiss and schist show tight to isoclinal minor folds and a prominent generally steep to vertical foliation trending between N and NE. Migmatitic rocks are widespread, and indicate amphibolite grade regional metamorphism.

Relations. Intruded by and intimately associated with Gin Creek Granite; relations with adjacent Answer Slate and Staveley Formation are uncertain, at least partly because of poor exposures in contact areas. Contacts with granite are generally highly irregular, locally gradational, and in places are of lit-par-lit type.

Age. Middle or Early Proterozoic.

Correlations. Some of acid gneiss is similar to that thought to represent metamorphosed acid volcanics of Tewinga Group in Dajarra and Duchess Sheet areas to west (Blake & others, 1978; Bultitude & others, 1978). The metamorphic rocks are generally similar to those of Soldiers Cap Group to E, and are more recrystallised than those of Argylla Formation to NW.

Mineralisation. None known.

Remarks. The unnamed metamorphic rocks are of higher grade than rocks of the adjacent Staveley Formation and Answer Slate, and, because of their predominantly quartzofeldspathic rather than pelitic compositions, they are unlikely to be more metamorphosed equivalents of these units. One possiblity is that they represent rocks from deeper in the crust carried to their present position during emplacement of Gin Creek Granite.

TEWINGA GROUP

Named and defined by Derrick & others (1976a); includes oldest rocks exposed between Mount Isa and Cloncurry. In Selwyn region only one constituent unit, Argylla Formation, crops out.

Argylla Formation

Map symbol. Bea.

Nomenclature. Named after Argylla Creek, Cloncurry 1:250 000 Sheet area; defined by Carter & others (1961); revised by Derrick & others (1976a); mapped in Selwyn region as Argylla Formation by Carter & Opik (1963).

Distribution. Confined to NW, where it crops out as N-trending belt up to 5 km wide; extends N into Malbon Sheet area (Noon, 1978).

Type section. In Mary Kathleen Sheet area.

Table 2. Unnamed metamorphic rocks, Argylla Formation, Marraba Volcanics, and Mitakoodi Quartzite petrographic data

Sample no. (prefix 7853)	Location (GR)	Quartz	K-feldspar	Plagioclase	Muscovite	Biotite	Amphibole	Clinopyroxene	Scapolite	Sphene	Apatite	Zircon	Tourmaline	Opaques	Epidote	Calcite	Chlorite	Sericite	Other minerals; rock types
Unnamed metamorphic rocks																			
4709	385993	X	X	X	x	x			x	x	†		†	x					Gneiss
Argylla Formation																			
4339	247085	X	X	X			X			x				†	†		†		Metavolcanic
4340	251085	X	X	X			X			x				†	x		†		Metavolcanic
4485	256152	X	X	X							†			x					Meta-arenite
4485A	256152	X	X	X	†									x					Meta-arenite
4487	243155	X	X											†					rutile?, †; metavolcanic
4640	252073	X		X			x	†		x					x				Metavolcanic
4650	244116	X	X	x		†							†						Meta-arenite
4653	252120	X	X		x		(†)			†				†					Metavolcanic
4654	244128	X	X	x							†	†		x			†		Meta-arenite
4659	232133	X	X	X	†	†				†									Meta-arenite?
Marraba Volcanics																			
4327	267112	x	X		x	x							†						Schist
4334	266071	X	X	X	X	x					†		†	x					Schist
4346A	259105			X			X				†			x	†		†		Metabasalt
4465	273218			X		x	X							x			†		Metabasalt
4664	237155	x	x	X			X							†	x				Metabasalt amygdaloidal
4664A	251155	x	x	X		x	X								X	†			Metabasalt, amygdaloidal
Mitakoodi Quartzite																			
4324	269112	x			?	X							†	x				X	Schist
4460	239211	X		X	X									x					Meta-arenite
4462A	288221	x		X	x	x							x	X					Metachert
4463A	283218			x			X				x			x	†	†	†		Metabasalt
4466A	278209	X		x	X	X								†					Metasiltstone
4469	280203	x		x	X	X								x					Metasiltstone

X, major constituent (>10% of rock)
x, minor constituent (1-10% of rock)
†, trace constituent (<1% of rock) or alteration product

( ), pseudomorphed
=, as porphyroblasts
___, some as porphyroblasts

Reference area. At GR 250090, near Wangaratta Bore/Double Crossing Bore track, where typical rock types of formation are well exposed.

Thickness. Possibly over 3000 m, but uncertain, as formation may be tightly folded.

Airphoto characteristics. Forms low hills and undulating terrain with mainly pale tones.

Rock types. Metamorphosed acid volcanics and feldspathic arenite, subordinate quartz-feldspar-biotite schist, and minor metabasalt (e.g., at GR 259153); local quartz veins.

Acid volcanics: Pinkish to pale purplish green, recrystallised to medium to fine-grained granulitic to gneissic rocks; generally contain phenocrysts/megacrysts/augen, commonly in clusters (glomeroporphyritic?), of feldspar; commonly streaky; rhyolitic to dacitic, and considered to represent lava, tuff (including ignimbrite), and agglomerate; meta-agglomerate in N contains fragments of reddish brown 'dacite' up to 2 cm across. In 3 feldspar 'porphyries' examined in thin-section, 'phenocrysts' of sodic plagioclase and/or microcline are anhedral, and their margins are intergrown with groundmass of quartz + microcline + sodic plagioclase ± dark blue-green amphibole ± muscovite ± epidote ± sphene ± Fe oxide; in 1 sample (76534653), small euhedral pseudomorphs after amphibole? are present, and much of the quartz appears to be pseudomorphing vesicle-filling zeolites. Another volcanic rock (78534487) is made up essentially of alkali feldspar euhedra about 0.1 mm across poikilitically enclosed in quartz.

Feldspathic arenite: recrystallised to feldspathic quartzite; pinkish; medium to fine-grained; cross-bedding recognisable in places; consists of quartz (60-80%) + microcline + sodic plagioclase ± accessory Fe oxide, biotite, muscovite, zircon, and apatite; lithic grains represented by fine-grained quartz-feldspar aggregates.

Structure and metamorphism. Foliation and bedding dip consistently E at moderate to steep angles, and only facing determined indicates younging to E; however, tight folding cannot be ruled out. Degree of recrystallisation, development of gneissic foliation, and mineral assemblages indicate probable amphibolite grade metamorphism.

Relations. Appears to interfinger with and be conformably overlain by Marraba Volcanics; also appears to be overlain conformably by Mitakoodi Quartzite; overlain unconformably by Cambrian Mount Birnie Beds and Mesozoic Gilbert River Formation?; intruded by metadolerite.

Age. Early to Middle Proterozoic. Less metamorphosed acid volcanics mapped as Argylla Formation in Cloncurry 1:250 000 Sheet area have been dated at 1777 ± 7 m.y. (U-Pb age on zircon; Page 1978).

Correlations. Equivalent to Argylla Formation in Malbon and S half of Marraba Sheet areas to N; may not be at same stratigraphic level as isotopically dated acid volcanics mapped as Argylla Formation to NW, in a geographically different part of the Cloncurry Complex.

Mineralisation. Cu occurs in a N-trending shear at GR 247113, site of a small prospect pit in chloritised acid metavolcanics.

Remarks. Facing evidence in the Selwyn region and in the Malbon and Marraba Sheet areas to the N (Noon, 1978; Derrick & others, 1971) indicate that in general the Argylla Formation underlies Marraba Volcanics. The lensoid metabasalt sequence mapped as Marraba Volcanics and enclosed by Argylla Formation in the NW could be regarded as a basaltic part of the Argylla Formation, like unit Pea_b in the Duchess Sheet area (Bultitude & others, 1978), or alternatively, it may represent a synclinal keel and hence overlie, rather than be within, the Argylla Formation.

MALBON GROUP

Named and defined by Derrick & others (1976b); represented by two units, Marraba Volcanics and Mitakoodi Quartzite, in Selwyn region, where it appears to lie conformably between Tewinga Group (below) and Mary Kathleen Group (above).

Marraba Volcanics

Map symbol. Pma.

Nomenclature. Defined by Carter & others (1961); redefined, and subdivided into 3 members (not identified in Selwyn region) by Derrick & others (1976b).

Distribution. 3 lensoid outcrops up to 1.7 km wide in NW; extends N into Malbon Sheet area. As mapped, not as extensive as indicated by Carter & Opik (1963).

Type section. In Marraba Sheet area.

Reference area. E of Double Crossing Bore, at GR 263063.

Thickness. 0 to probably over 1000 m.

Airphoto characteristics. Forms undulating terrain and low hills and ridges; dark tones on metabasalt, pale tones on meta-arenite; trend lines visible in places.

Rock types. Metabasalt, amphibolite, and interlayered meta-arenite and schist; also minor laminated chert.

Metabasalt: dark bluish to greenish grey; fine-grained; schistose to massive; commonly amygdaloidal, especially at margins of flows; other igneous textures, such as phenocrysts and groundmass laths of plagioclase, preserved locally; consists of plagioclase (An_{19-30}) + bluish green to pale green hornblende (commonly tschermakitic) + ilmenite ± sphene ± biotite ± chlorite ± calcite ± epidote ± actinolite ± quartz; epidote commonly occurs as relatively coarse grained clots probably representing amygdale fillings .

Amphibolite: foliated fine-grained plagioclase-green hornblende-Fe-Ti oxide rock; may be intrusive or extrusive.

Meta-arenite: generally identical to that in overlying Mitakoodi Quartzite; white to pink; medium to fine-grained; variable quartzose, feldspathic, and micaceous; heavy-mineral laminae common; cross-bedding in S indicates younging E.

Schist: fine-grained; consists of biotite + quartz ± muscovite ± chlorite ± sodic plagioclase ± microcline ± Fe oxide.

Structure and metamorphism. Bedding is steeply dipping to vertical, and has northerly trends; foliation, where present, appears to parallel bedding; no folds identified, and formation may young consistently east. Mineral assemblages in mafic rocks indicate amphibolite grade metamorphism; presence of chlorite and actinolite indicates some subsequent retrogressive metamorphism.

Relations. Appears to conformably overlie, and also interfinger with, Argylla Formation; overlain conformably by Mitakoodi Quartzite to E and unconformably by Cambrian Mount Birnie Beds to S; intruded by metadolerite.

Age. Middle or Early Proterozoic.

Correlations. Equated with Marraba Volcanics in N part of Malbon and S part of Marraba Sheet areas (Noon, 1978; Derrick & others, 1976b).

Mineralisation. Some Cu minerals present in basic rocks at GR 264118.

Remarks. May be partly or entirely shallow marine. Western outcrop as mapped is assumed to represent a local early phase of basaltic volcanism related to the Marraba Volcanics, but it could be regarded as a basaltic part of the Argylla Formation, like unit Pea_b in the Duchess Sheet area (Bultitude & others, 1978); alternatively it may represent a keel of an isoclinal syncline.

Mitakoodi Quartzite

Map symbol. Pnm.

Nomenclature. Defined by Carter & others (1961); definition revised by Derrick & others (1976b); not subdivided in Selwyn region.

Distribution. Crops out in north-trending belt, up to 2.5 km wide, in NW; extends north into Malbon Sheet area, where it has been divided into 5 stratigraphic subunits by Noon (1978); outcrops in Selwyn region are more or less as mapped by Carter & Opik (1963).

Type section. In Marraba Sheet area.

Reference area. NE of Double Crossing Bore, at GR 285080.

Thickness. Probably over 1000 m.

airphoto characteristics. Forms low strike ridges, hills, and undulating terrain; outcrops have pale to medium tones; bedding trends are generally visible.

Rock types. Quartzite and feldspathic quartzite (meta-arenites); subordinate interbedded metagreywacke, metasiltstone, phyllite, and schist; minor meta-basalt, amphibolite, jaspilite, and chert; some ridge-forming quartz-hematite rock, commonly brecciated, in south; quartz veining common throughout.
Quartzites: metamorphosed (recrystallised) quartz arenite, feldspathic arenite, and minor lithic arenite; white, buff, pale pink and pale brown; mainly fine-grained; some beds contain up to 10% muscovite; thick to thin-bedded; many beds show lamina banding; poorly displayed cross-bedding at several localities suggest younging to E.
Metagreywacke: grey or brown; mainly fine-grained; medium bedded; typical samples consist mainly of quartz, feldspar, biotite, iron oxide, and porphyroblastic muscovite.
Metasiltstone: occurs mainly as thin interbeds; brownish to greenish grey; generally micaceous; Fe and Mn staining common.
Phyllite and fine-grained mica (biotite and/or muscovite) schist: occur mainly as thin interbeds; small altered porphyroblasts (garnet?) present in places.
Metabasalt; (single flow?) present in N (at GR 283218) composed of blue-green amphibole, sodic plagioclase, quartz, opaque minerals, and minor sphene and K-feldspar.
Amphibolite: present at several localities; schistose, and generally coarser than metabasalt; represents basic lavas and/or basic intrusions.
Jaspilite and chert: thin bands present in N (at GR288221); some are laminated; one chert sample (acid tuff?) examined in thin section (7854462A) - contains scattered clots and single grains of microcline, albite, muscovite, and biotite, and small hieroglyphic-like aggregates of fine-grained opaque material, enclosed in a very fine-grained homogeneous felsic groundmass.

Structure. Bedding is steep to vertical and trends north; cleavage/schistosity is parallel to bedding; no minor folds recorded and no major isoclinal folds (like those in overlying Answer Slate) mapped; several shears and faults present, mainly subparallel to bedding.

Metamorphism. Mineral assemblages and degree of recrystallisation indicate probable upper greenschist or lower amphibolite facies.

Relations. Overlies Marraba Volcanics and Argylla Formation; overlain by Answer Slate; contacts appear to be conformable where not faulted. Intruded by metadolerite. Overlain unconformably in south by Cambrian Mount Birnie Beds.

Age. Middle or Early Proterozoic.

Correlations. Correlated with Mitakoodi Quartzite exposed in northern part of Malbon and southern part of Marraba Sheet areas to N (Noon 1978; Derrick & others, 1971); may be partly equivalent to Overhang Jaspilite of Malbon Sheet area.

Mineralisation. Cu mineralisation occurs in a fault zone at GR 267125.

Remarks. The Mitakoodi Quartzite is presumed to represent mainly shallow-water sediments.

SOLDIERS CAP GROUP

Map symbols: Po, Po_d, Po_c, Po_s

Nomenclature. Named after Soldiers Cap, a mesa capped by flat-lying Mesozoic sediments 40 km SE of Cloncurry. Defined as a formation by Carter & others (1961); redefined as Soldiers Cap Group by Derrick & others (1976c), who subdivided the group in Cloncurry Sheet area into three formations. In Selwyn region subdivided into lithologic units, but not into individual formations; previously described by Carter & others (1961) and Carter & Opik (1963).

Distribution. Extensive exposures in NE and E and sparse exposures in SE and S; probably underlies much of area in E covered by thin veneer of Mesozoic and Cainozoic sediments. Crops out E of, and as belts and lenses within and to W of, main outcrop of Corella Formation. Most westerly outcrop is in far S, where schist and gneiss mapped as Soldiers Cap Group appear to grade westwards into meta-arenite and schist mapped as Kuridala Formation. Outcrops mapped include some areas previously shown as Corella Formation. Extends N into Mount Angelay (Donchak & others, 1979) and Cloncurry (Glikson & Derrick, 1970; Derrick & others, 1976c) Sheet areas.

Type Section. Defined by Carter & others (1961): extends from 20°56'40"S, 140° 39'50"E, to 20°55'10"S, 140°45'30"E, Cloncurry Sheet area (Derrick & others, 1976c).

Thickness. Several thousand metres. At least 6000 metres in Cloncurry Sheet area, according to Derrick & others (1976c); base not exposed and top equivocal in Selwyn region.

Airphoto characteristics. Forms hills and ridges, generally rounded and less than 100 m high, and undulating terrain; a few hills have mesa cappings of flat-lying Mesozoic sediments. Generally less resistant to erosion, and hence more subdued, than adjacent Corella Formation. On aerial photographs: mainly medium tones, except for mafic rocks, which have dark tones; bedding and foliation trend lines evident in places, as are cross-cutting pale pegmatite veins.

Rock types. Po: gneiss and schist, migmatitic in part, mainly representing quartzofeldspathic and greywacke-type metasediments; subordinate quartzitic and feldspathic meta-arenites (including quartzite), some of which are garnetiferous, and banded iron formation, pegmatite, and amphibolite. Po_d: mainly amphibolitic metabasalt and para-amphibolite. Po_c: calc-silicate rocks. Po_s: mica schist.

Lithologic units

Po. Main unit of group; contains some small 'inclusions' of other lithologic units. Reference area: along creek section from GR 924120 to GR 935120.

Gneiss and schist: pink, pale grey, pink and grey, and medium to dark grey; medium to coarse-grained, locally pegmatitic; generally show medium to thin compositional banding which in most cases probably represents original bedding; no structures indicating way-up identified; geneissic to schistose foliation mainly parallel to compositional banding except in axial zones of folds; crenulations and minor folds common; consist of mica (muscovite and/or biotite) or hornblende + quartz + feldspar (sodic plagioclase and/or microcline) ± accessory apatite, tourmaline, Fe-Ti oxides, and zircon; locally also contain porphyroblastic garnet and andalusite (as at GR 832180), fibrolitic sillimanite (as at GR 933118), and cordierite (as at GR 855215); common secondary minerals are chlorite after biotite, and sericite after feldspar.

Meta-arenites: white, pink or grey; medium to fine-grained; thin to thick bedded; commonly occur as continuous bands or as lines of boudins, generally less than 1 m thick, in sequences consisting mainly of schist; only weakly foliated except where mica-rich; no sedimentary facing criteria found; range from quartzose (quartzite) to feldspathic (meta-arkose and feldspathic quartzite); contain variable amounts of biotite and/or muscovite, and in places are poorly to richly garnetiferous, especially where associated with banded iron formation.

Banded iron formation: mainly dark brown to black, cherty to medium-grained, and finely laminated; generally less than 1 m thick; host to subeconomic Zn, Pb, and Cu mineralisation. Well developed at Cowie prospect (GR 862890), where it forms upstanding manganese-stained gossans showing complex minor folding; less well developed at Marramungee and Black Rock prospects (GR 905145 and 910078). May be confined to one stratigraphic level, forming marker bed within Soldiers Cap Group.

Pegmatite: forms cross-cutting to concordant veins and lenses, some several metres thick, consisting of quartz + feldspar ± tourmaline ± muscovite; ranges from massive to sheared and schistose; is relatively resistant to erosion, so is exposed preferentially to gneiss and schist.

Amphibolite: dark grey to black; fine to medium-grained; strongly to weakly foliated; occurs as concordant to subconcordant bands a few metres thick, most of which probably represent basic intrusions; consists of plagioclase + green hornblende + sphene ± quartz + opaque minerals.

$\underline{Bo}_d$. Amphibolitic metabasalt and interlayered para-amphibolite and other metasediments; may also include some basic intrusions; main outcrop is in NW, between Corella Formation to W and Marramungee Granite to E; occurs as lensoid masses, in places apparently over 500 m thick, which interfinger along strike

with metasediments of Po; two main outcrop areas may represent different stratigraphic levels, hence Po_d is regarded as a lithologic, rather than a stratigraphic, unit. Reference area: near GR 902106.

Metabasalt: dark bluish to greenish grey; fine to medium-grained; moderately to strongly foliated; central parts generally homogeneous, but margins characteristically streaky to blotchy - these probably represent amygdaloidal and scoriaceous flow margins; consists of green to brownish green, commonly tschermakitic, hornblende (30-50%) + plagioclase (20-50%, oligoclase to bytownite (up to An_{74}), commonly partly sericitised or saussuritised) ± quartz (more than 10% in some samples) ± andradite garnet (up to 30%) ± salitic clinopyroxene (up to 20%) ± ilmenite (generally less than 5%); minor constituents include sphene, apatite, epidote, and rarely biotite. Garnet occurs as red-brown euhedral porphyroblasts, some over 1 cm across, in quartz-bearing metabasalt, and is probably restricted to metabasalt which previously contained zeolites and/or other secondary minerals in amygdales and vesicles; it is not known in 'normal' amphibolites of the Cloncurry Complex, which are essentially hornblende-plagioclase rocks.

Metabasalt is distinguished from intrusive amphibolite by : 1, presence of streaky and blotchy marginal zones a metre or more wide, commonly with patchy concentrations of white spots of various shapes and sizes (interpreted as amygdale and vesicle fillings); 2, common presence of garnet porphyroblasts and abundant quartz in marginal zones; and 3, common association with banded para-amphibolite, interpreted as bedded basaltic tuff, and with hornblende-bearing quartzite and calc-silicate rocks, interpreted as sediments containing some basaltic detritus.

Para-amphibolite: shades of grey; mainly medium-grained; thin-banded to laminated; consists of green tschermakitic hornblende + plagioclase (An_{30-80} measured) ± quartz ± salitic clinopyroxene ± garnet ± sphene ± ilmenite ± apatite.

Other metasediments: include quartzite, meta-arkose, mica schist, mica-quartz-feldspar gneiss, hornblende-bearing feldspathic quartzite, and calc-silicate rocks.

Po_c. Lensoid masses, generally less than 100 m thick, consisting predominantly of calc-silicate rocks similar to those of the Corella Formation; most masses occur within 1 km of contacts between Soldiers Cap Group and Corella Formation. Reference area: GR 877208.

Calc-silicate rocks: shades of pink, grey, and green; mainly medium to fine-grained; laminated to thin banded, or brecciated, banding commonly contorted; consist of plagioclase (commonly albitic) ± microcline ± quartz ± calcite ± green amphibole (commonly Cl and K_2O-rich hastingsite) ± salitic clinopyroxene ± scapolite ± sphene ± epidote ± garnet (andradite-grossular) ± opaque minerals (including magnetite) ± chlorite ± mica; cross-cutting coarse to pegmatitic actinolite-feldspar veinlets common.

Bo$_s$. Medium to coarse mica (muscovite ± subordinate biotite) schist cropping out adjacent to Corella Formation calc-silicate breccia; partly veined and migmatitic near GR 915990, 6 km NW of Glenholme homestead. Reference area at GR 895108.

Structure. As in Mount Angelay Sheet area (Donchak & others 1979), the Soldiers Cap Group has been affected by two major folding episodes. In the Selwyn region tight to isoclinal minor folds are common, but no major folds have been mapped, although some are probably present. In most cases the minor folds deform the dominant schistosity/foliation (S_1), and hence are F_2 folds; in places the minor F_2 folds appear to refold earlier isoclinal folds (F_1), the limbs of which are parallel to S_1.

No faults are shown within Soldiers Cap Group outcrops, but some, especially strike faults, are present, and many outcrops are at least partly bounded by faults.

Metamorphism. Rock types and mineral assemblages indicate regional metamorphism of amphibolite grade: migmatitic gneiss and schist containing quartz + sodic plagioclase + microcline + biotite + muscovvite + garnet + andalusite ± sillimanite; amphibolite containing green hornblende + oligoclase/andesine ± clinopyroxene ± garnet; calc-silicate rocks containing amphibole + clinopyroxene ± garnet. Overall the metamorphic grade appears to increase eastwards, the highest grade rocks identified being medium-grained garnet-clinopyroxene amphibolites exposed 5.5 km NW of Answer Downs HS and 5.5 km W of Dingading HS. Some retrogressive metamorphic effects such as biotite replaced by chlorite, and feldspar and andalusite replaced by 'sericite', are common. The main regional metamorphism probably took place during the F_1 and S_1 structural event, whereas the retrogressive metamorphism may be related to the F_2 folding event and/or to intrusion of Williams Granite.

Table 3. Soldiers Cap Group: petrographic data

Sample no. (prefix 7853)	Location (GR)	Quartz	K-feldspar	Plagioclase	Muscovite	Biotite	Amphibole	Clinopyroxene	Garnet	Andalusite	Sillimanite	Cordierite	Staurolite	Scapolite	Sphene	Apatite	Zircon	Tourmaline	Opaques	Epidote	Calcite	Chlorite	Sericite	Other minerals, remarks
Gneiss																								
0466	855215	X	X	X	x	x						X				†	†							
0482	877187	X	?	X	x	x						X				†	†							
1106	978196	X	x	X		X											†							
1122	933117	X	X	X	x	X					x													
1203	934994	X		X	x	X											†							
1226	856923	X		X			X									†	†		x					
1245	866952	X	X	X	x	x													x				†	
1245A	866952	X	?	X	†	X										†	†		†				†	Rutile?†
1261	888918	X	†	X	x	X										†			†					
Schist																								
0939	820209	X	x	x	X	X										†	†							
0972	830179	X	X	X	X	X				†	†					†	†	†	x				†	
1036	861007	X	X	X	X	x										†	†	†	x					
1130	936102	X				X										†								
1180	914901	X		X	X	X													x					
1442	665733	X			X	X											†							
Meta-arenite																								
0476	878209	X	x	X	†	x										†			†				†	
0490A	893148	X	†	X	†	x										†	†		†					
1139A	940060	X		(?)						X					x	†				X	x		†	Garnetiferous quartzite
1673B	897101	X		X			x	x							x	†				†		†		
Calc-silicate rocks																								
0475A	875209			x			X	X						X	x	†			†	†				Breccia
0477	883208	X	X				X								x	†	†		†	†	†	†	†	Banded
0527A	909123	X	X			X	X			X				X	X	†			†	X				Lamina banded
1204	937998		x				x	X						X	x	†								Breccia
Metabasics																								
0490	893148	X		X			X		x							x			x					Scoriaceous metabasalt
0491	829148	x		X			X								x	x			x					Metabasalt?
0492	890146			X			X	x							†				†	†			†	Amygdaloidal metabasalt
0524	911130	x		X			X								x				x	†	†	†	†	Prehnite, †; amygdaloidal metabasalt

Table 3 cont. Soldiers Cap Group: petrographic data

Sample no. (prefix 7853)	Location (GR)	Quartz	K-feldspar	Plagioclase	Muscovite	Biotite	Amphibole	Clinopyroxene	Garnet	Andalusite	Sillimanite	Cordierite	Staurolite	Scapolite	Sphene	Apatite	Zircon	Tourmaline	Opaques	Epidote	Calcite	Chlorite	Sericite	Other minerals, remarks
0539A	902106	x		X		x	X		x							†			x					Amygdaloidal metabasalt
0946A	819207			(X)			X	x							x	†			x	†			†	Prehnite? †; amygdaloidal metabasalt
0946B	819207	x		X			X								x	†			x					Metabasalt?
1099	881962	†	†	X			X									†			x	x				Metabasalt?
1112	930155	x		X			X								x				x					Banded para-amphibolite
1123	935117	x		X			X									x			x					Banded para-amphibolite
1136	940089	X		X			X		X							x			x					Scoriaceous metabasalt
1139	940060	X		X			X	X	x						x	†								Banded para-amphibolite
1144	925081			X			X	X											†					Amygdaloidal metabasalt
1226A	856923	x		X			X	(x)							x				†	†				Amphibolite
1240B	855950			(X)			X	X							†	†			†				†	Amphibolite
1673A	897101	x		X											x				x					Metabasalt
1673C	897101	X		(x)		†	X	(x)	X							x			x			†	†	Scoriaceous metabasalt

X, major constituent (>10% of rock)
x, minor constituent (1-10% of rock)
†, trace constituent (<1% of rock) or alteration product
( ), pseudomorphed
-, porphyroblast

Relations. Base not exposed; in S merges laterally westwards with Kuridala Formation; relation with Corella Formation uncertain; intruded by Marramungee Granite, Cowie Granite, Williams Granite, unnamed granite, amphibolite (mainly mapped as part of Soldiers Cap Group), and dolerite; overlain unconformably by flat-lying Mesozoic and Cainozoic sediments.

In the S, W of the Selwyn/Hamilton River road, coarse mica schist, felsic gneiss, and pegmatite - typical rocks of the Soldiers Cap Group - grade imperceptibly westwards into thinly interlayered finer-grained mica schist and meta-arenite of the Kuridala Formation. Similarly, NW of Cowie prospect, near GR 845940, schist and gneiss appear to grade westwards into thin-bedded meta-arenite more typical of the Kuridala Formation than the Soldiers Cap Group, though mapped as the latter. In neither area is there any evidence of a stratigraphic break between Soldiers Cap and Kuridala rocks. For this reason, the Soldiers Cap Group and Kuridala Formation are considered to be part of the same stratigraphic sequence, and are regarded as probably lateral equivalents.

Contacts between the Soldiers Cap Group and Corella Formation are exposed at several localities. In all cases examined, Soldiers Cap schists, generally showing no obvious signs of shearing or brecciation, are exposed adjacent to brecciated calc-silicate rocks of the Corella Formation. In several places, as along the McKinlay River, the contact zone consists of interlayered schist and calc-silicate breccia. This contact may represent a thrust zone, as suggested by Honman (1939), or it may be an essentially sedimentary feature representing an interfingering of different but laterally equivalent lithologies.

In the Cloncurry Sheet area to the N, according to Carter & others (1961), Glikson & Derrick (1970), Glikson (1972), and Derrick & others (1976c, 1977), the Soldiers Cap Group is overlain unconformably by the Corella Formation. However, in the Selwyn region, as in the adjoining Mount Angelay area (Donchak & others 1979), the Soldiers Cap and Corella rocks appear to have been affected by the same structural and metamorphic events, and there is no good evidence to indicate that they are separated by a major unconformity. Also, because of a lack of facing evidence in the contact areas, the Soldiers Cap Group cannot be shown to be older than the Corella Formation.

The favoured interpretation, on present evidence in the Selwyn region and Mount Angelay Sheet area, is that the Corella Formation and Soldiers Cap Group are part of an essentially conformable and locally interfingering stratigraphic sequence, the Corella Formation in general being the younger unit.

Contacts between the Soldiers Cap Group and Marramungee Granite, Cowie Granite, and unnamed granite are generally highly irregular, with concordant (lit-par-lit) to cross-cutting veins of granite penetrating the Soldiers Cap rocks. Contacts between Soldiers Cap Group and Williams Granite are more regular, and in the north may be partly marked by a fault. Stoped blocks of Soldiers Cap schist and gneiss are enclosed in granite at an exposed roof contact of Williams Granite on the east side of a mesa W of Cowie prospect at GR 815903.

Basic intrusions cutting the Soldiers Group comprise northerly trending concordant to subcordant amphibolite bodies and easterly trending dolerite dykes.

Age. Probably Middle or Early Proterozoic; no isotopic data available.
Correlations. Considered to be stratigraphically equivalent to part of the Kuridala Formation; banded-iron formation in Soldiers Cap Group at Cowie, Murramungee, and Black Rock prospects is almost identical to banded iron formation in Kuridala Formation at Pegmont prospect, and may well be at the same stratigraphic level. The Soldiers Cap Group may also be correlated with part of the Corella Formation (see 'Relations').
Mineralisation. Banded iron formation is host to subeconomic Zn, Pb, and Cu mineralisation at Marramungee, Black Rock, and Cowie prospects; similar mineralisation has been reported, probably at a similar stratigraphic level, at 'Tombstone Flats' (GR 935995). Minor Cu mineralisation occurs in schist and amphibolite (probably metabasalt) at White Cliffs prospect in north (GR 819208), and also in metabasalt of unit Po_d.
Remarks. The Soldiers Cap rocks probably represent a sequence of mainly proximal turbidite-type sediments - greywacke, siltstone, and shale. The overall high feldspar content of the rocks is attributed to a high acid volcanic and/or granitic component in the original sedimentary detritus. Evidence of contemporaneous basaltic volcanism is given by intercalated amphibolite thought to represent metabasalt lava; associated para-amphibolites are interpreted as waterlaid basic tuffs, indicating that the basic volcanism may have been subaqueous. Contemporaneous acid volcanism may be represented by :1, massive garnetiferous gneiss, exposed in the northeast (at GR 972223), which like petrographically similar Potosi gneiss of the Broken Hill area, NSW (Stevens & others, 1979), may be a metamorphosed acid tuff; 2, some of the quartz-feldspar rocks ('meta-arkose'), which may be metamorphosed acid tuffs; and

3, metarhyolite lava flows within the Corella Formation, close to Soldiers Cap rocks, at GR 890146. The banded iron formation may also be related to contemporaneous volcanism, as it is thought to be a chemical sediment of exhalative type, like that in the 'mine sequence' at Broken Hill (Barnes, 1979). The calc-silicate rocks of the Soldiers Cap Group appear identical to those of the Corella Formation, and were presumably deposited in a similar sedimentary environment.

D.H. Blake was greatly impressed by the close similarity between rocks of the Soldiers Cap Group and those of the Willyama Complex of the Broken Hill Block (noted previously by Derrick, 1976) when he attended an excursion to the Broken Hill area run by the NSW Geological Survey in April 1979 (Stevens & others, 1979). The occurrence of similar rocks, including banded iron formation, in both areas indicates that the Soldiers Cap Group is a potential host for a major ore body of the Broken Hill type.

MARY KATHLEEN GROUP

Named and defined by Derrick & others (1977). In Selwyn region: represented by Corella Formation, Answer Slate, Kuridala Formation, Staveley Formation, and Agate Downs Siltstone; conformable on Malbon Group, and inferred to be stratigraphically equivalent, at least in part, to Soldiers Cap Group to E.

Corella Formation

Map symbols. Pkc, Pkc_{br}, Pkc_{a}.

Nomenclature. Formation originally defined by Carter & others (1961), revised by Derrick & others (1977). Outcrops in Selwyn region are as mapped by Carter & others (1961) and Carter & Opik (1963) except for small areas now mapped as Soldiers Cap Group.

Distribution. Crops out in E as N to NNW-trending belt up to 6 km wide; this belt extends N from latitude 21°30"S through Mount Angelay Sheet area (Donchak & others, 1979) into Cloncurry and Marraba Sheet areas (Glikson & Derrick, 1970; Derrick & others, 1971).

Type section. In Marraba Sheet area (Carter & others, 1961; Derrick & others, 1977).

Reference areas McKinlay River at GR 898053 for Pkc, Marramungee Creek at GR 876187 for Pkc_{br}, and at GR 883144 for Pkc_{a}.

Thickness. Probably several thousand metres in Selwyn region; base and top uncertain.

Air-photo characteristics. Outcrops consist mainly of relatively rugged hilly terrain with medium to dark tones; bedding trends discernible locally.

Rock types. Pkc: mainly banded calc-silicate granofels; Pkc_{br}: mainly calc-silicate breccia; Pkc_{a}: metarhyolite.

Lithologic units

Pkc. Calc-silicate granofels and minor calc-silicate breccia (of Pkc_{br} type), marble, chert, mica schist, and amphibolite.

Calc-silicate granofels: shades of pink, grey, and green; mainly medium to fine-grained; massive to more commonly thin-banded, laminated, or streaky; banding generally reflects original bedding; no sedimentary structures indicating facing found; open medium-scale folds and tight to isoclinal minor folds present locally; variably rich in carbonate, amphibole (actinolite and/or hornblende), feldspar (albite/oligoclase $\pm$ microcline), quartz, epidote, and salitic clinopyroxene; rarely scapolitic;

Calc-silicate breccia: forms irregular layers and lenses within outcrops of mainly banded calc-silicate granofels; always present at contacts with Soldiers Cap rocks.

Marble: medium to coarse, forms small lenses a few metres thick; may consist of dolomite as well as calcite; commonly has fetid smell when hit with hammer.

Chert: pale greyish; thin banded; commonly contorted.

Mica schist: grey; medium to fine-grained (not as coarse as typical Soldiers Cap schist); contains muscovite and biotite/phlogopite; forms rare bands a few metres thick interlayered with banded calc-silicate granofels (e.g., at GR 885083).

Amphibolite: dark grey to greenish grey (epidotic); fine to medium-grained; includes amygdaloidal metabasalt, some possible para-amphibolite, and small, mainly pod-like intrusive bodies of locally porphyritic metadolerite.

Marble, chert, and amphibolite appear to be more common in $\underline{Pkc}_{br}$ than in Pkc.

$\underline{Pkc}_{br}$. Consists mainly of calc-silicate breccia, but also includes banded calc-silicate granofels like that in Pkc, and, in SE, at GR 896929, some fine-grained acid gneiss that may represent a metamorphosed volcanic rock.

Breccia: formed of angular blocks of rock types found in Pkc and also rare jasper and, at GR 906912, gossanous banded ironstone, enclosed in a fine to coarse, calc-silicate matrix; blocks range from less than 1 cm to over 100 m across; no fragments of schist or gneiss are present, even where breccia is in contact with Soldiers Cap Group rocks; blocks were clearly consolidated before being incorporated in the breccia; in different outcrops boundaries of blocks range from sharp (?main metamorphism took place before brecciation) to diffuse over a few millimetres (?main metamorphism took place after brecciation); occurs as belts and lensoid masses, some over 1 km wide; ranges from homogeneous, with blocks of one rock type enclosed in a matrix of similar composition, to heterogeneous, with several types of calc-silicate rocks and in some places amphibolite, chert, and jasper, present as blocks enclosed in a calc-silicate matrix; typically massive and chaotic, but commonly shows a crude layering on a large scale, the layering being more or less parallel to bedding and layering in adjacent Pkc or Soldiers Cap Group. In places (e.g., at GR 900910), also occurs in beds or layers a metre or so thick interlayered with massive breccia. Locally, mainly near bodies of Williams Granite, the breccia is red, probably due to presence of very fine-grained hematite.

Table 4. Corella Formation: petrographic data

Sample no. (prefix 7853)	Location (GR)	Quartz	K-feldspar	Plagioclase	Muscovite	Biotite	Amphibole	Clinopyroxene	Scapolite	Sphene	Apatite	Zircon	Tourmaline	Opaques	Epidote	Calcite	Chlorite	Sericite	Other minerals; remarks
Banded calc-silicate rocks																			
0500	879139			X															Phlogopite, t; albitite
0500A	878139	X	X	X			X	X		†	†			×	×	†			
0558	884083	X	X	X							†		†	×					Phlogopite? x
0563	865105	X	X	X			X			×	†			×	†	†			
0577	914940	X	X	X		×	X		×	×	†			×		†			
0956	824222	X	X	X			X			†	†			×	×				
1055	871033		X	X			×	X		×	×		†	×	×	X	†		
1185	905986	X		X			×	X		×							†		
Calc-silicate breccia																			
1032	845111	X	X	X		×				×	†	†		×		×	†		Fluorite, t; inclusion in Pgl
1075	874005		×	X		(x)	X			×	†			×	†	×	†		
1076	871004	×	X	×			×	X		×	†			×	×	×			
1163	904046		X	X			X	X		×	†			†		×			
1217	899907	X		X				X		†	†			×		X	†		Phlogopite
1221	918878			X			×	X		×	†	†		×		×			
1222	856868	×		X			×	X		×	×				†				
Marble																			
1044	860087				×						†			×		X	×		Marble
Metarhyolite																			
0494	888145	X	X	X		(†)						†		†		×	†		Phenocrysts 15% of rock
0496	883144	X	X	X		(†)								×		†	†		Phenocrysts 15% of rock
Acid gneiss																			
1676	896929	X	X	X		×						†		×					Metavolcanic?

X, major constituent (>10% of rock)
x, minor constituent (1–10% of rock)
†, trace constituent (<1% of rock) or alteration product

( ) Pseudomorphed
— Some as phenocrysts/megacrysts

Pkc$_a$. Two lensoid metarhyolite bodies up to 200 m thick in NE; mainly massive, but banded or brecciated to agglomeratic at contacts with calc-silicate breccia.

Metarhyolite: pale pink to pale grey; fine to very fine-grained except for small phenocrysts, less than 5 mm across, forming about 15% of rock; flow banding and/or bedding (in bedded tuff?) locally discernible; some cross-cutting veins of epidote and actinolite also present. Phenocrysts: rounded to subhedral; have fretted outlines (intergrown with groundmass minerals), and are partly recrystallised into composite grains; comprise about equal proportions of quartz, microcline, and sodic plagioclase. Groundmass; mosaic of quartz and albite (and K-feldspar?), with minor chlorite (after biotite?), opaque granules, calcite (in vesicles?), and zircon.

Most of the rhyolite is probably extrusive lava, but some may represent associated bedded tuffs.

Structure. Bedding generally has steep to vertical dips and N to NNW trends, similar to layering in adjacent Soldiers Cap Group. Folds with amplitudes of several tens of metres are present in places, as along the McKinlay River at GR 895053, where a recumbent fold is exposed, and thin banded calc-silicate granofels locally shows complex minor folding. Some calc-silicate breccia may be a sedimentary feature, especially where the breccia appears to be bedded, but most is probably related to tectonism (folding, faulting, and igneous intrusion), when pressure and temperature conditions were such that the calc-silicate rocks fractured and brecciated rather than deforming into tight folds (cf. Glikson, 1972).

In the Selwyn region, as in Mount Angelay Sheet area (Donchak & others, 1979) two major tectonic events have affected the Corella Formation. These appear to be the same events as those which affected the adjacent Soldiers Gap Group. Both caused brecciation as well as folding, and were accompanied by regional metamorphism and igneous intrusion.

Metamorphism. The main metamorphism is thought to be related to the earlier tectonic event, as with the Soldiers Cap Group. Calc-silicate rocks containing clinopyroxene are widespread, and together with the associated hornblende-bearing amphibolites, indicate regional metamorphism of amphibolite grade. Actinolite, epidote, and chlorite are also widespread in calc-silicate rocks,

and may be related, at least in part, to retrogression during later tectonism and/or igneous intrusion. In Corella Formation of the Selwyn region, in contrast to calc-silicate rocks in Soldiers Cap Group and Kuridala Formation, scapolite appears to be rare (recorded only at GR 914940) and no garnet has been identified.

Relations. Intruded by Cowie Granite, unnamed granite, Williams Granite, metadolerite, and dolerite; unconformably overlain by flat-lying Mesozoic sediments; relation to Soldiers Cap Group equivocal.

Contacts with Cowie Granite and unnamed granite bodies are highly irregular, and numerous granite veins and apophyses cut calc-silicate rocks in contact zones; contacts with Williams Granite are generally sharp and clear-cut; associated thermal metamorphic effects are rarely apparent.

The formation is intruded by numerous basic sheets and pod-like bodies. These range from subconcordnt amphibolites, in which no relict igneous textures are apparent, to metadolerites in which subophitic textures and plagioclase phenocrysts are partly preserved. Some amphibolite bodies are tightly folded and cut by granite veins. The formation is also cut by E-trending dolerite dykes, the youngest intrusions in the area.

Contacts with the Soldiers Cap Group may be partly tectonic and partly depositional. No direct evidence has been found in the Selwyn region to indicate that the Corella Formation unconformably overlies the Soldiers Cap Group, as reported in Cloncurry Sheet area (Carter & others, 1961; Glikson & Derrick, 1970; Glikson, 1972; Derrick & others, 1976c, 1977) - see also section on Soldiers Cap Group in this report.

Age. Middle or Early Proterozoic; in Marraba Sheet area the formation is intruded by Burstall Granite, which has been dated at 1720 m.y. (Page, 1979).

Correlations. May be stratigraphically equivalent to parts of Soldiers Cap Group, Kuridala Formation and Staveley Formations.

Mineralisation. None known in Selwyn region; host to copper mineralisation in areas to W and N.

Remarks. Prior to metamorphism and brecciation, the formation consisted mainly of medium to fine-grained, thinly bedded to laminated, impure calcareous sediments. These were probably deposited in a shallow marine (lagoonal?), environment, as in the Duchess Sheet area to the west (Bultitude & others, 1978). Sedimentation was accompanied by local basic and acid volcanism, as is indicated by the presence within the sequence of basalt and rhyolite. Such volcanism and associated earthquake activity may have caused some brecciation of penecontemporaneous calcareous sediments and the formation of local talus slopes.

Kuridala Formation

Map symbols. Ekr, and Ekr with suffixes a, c, ch, f, g, p, q, and s.

Nomenclature. Named after Kuridala township (now abandoned), in Malbon Sheet area. Formally defined by Carter (1959); described in more detail by White (1957), Carter & others (1961), and, in Malbon Sheet area, by Noon (1978); also described by Carter & Opik (1963). Subdivided by White (1957) into three parts: Mount Elliott Slate Member (named after Mount Elliott mine at Selwyn) at base, an unnamed middle unit of mainly interbedded schist and quartzite, and Hampden Slate Member (named after Hampden group of mines at Kuridala) at top. This subdivision was followed by Noon (1978) but is not used in this report, for reasons discussed in 'Remarks' below; the formaton is subdivided here into lithologic rather than stratigraphic units.

Distribution. Crops out in broad belt running from N to S through the central part of area; extends northwards into adjoining Malbon and Mount Angelay Sheet areas (Noon, 1978; Donchak & others, 1979) and southwards into Boulia 1:250 000 Sheet area (Casey, 1968).

Type section. From a point one mile (1.6 km) north of Kuridala, west for two miles (3.2 km) (Carter, 1959), Malbon Sheet area.

Thickness. Probably several kilometres, base not exposed.

Air-photo characteristics. Rocks range from highly resistant to readily eroded, and give rise to variety of landforms, from steep-sided hills and strike ridges, some up to 100 m high (e.g., on quartzite), to broad and narrow strike valleys (e.g., on phyllite). Pale to dark tones on aerial photographs reflect wide variety of rock types present. Bedding trend-lines, locally outlining fold structures, are generally prominent.

Rock types. Predominately metamorphosed sedimentary rocks; mainly schistose (micaceous) to massive (feldspathic or quartzitic) meta-arenites (including metagreywacke), mica schist (commonly porphyroblastic), phyllite, and carbonaceous metasiltstone (commonly with andalusite porphyroblasts); also chert, calc-silicate rocks, metamorphosed acid volcanics, banded iron formation, hornfels, and banded quartz-hematite rock. Petrographic data summarised in Table 5. Schistosity is generally parallel or subparallel to bedding, except in fold hinge areas, and is commonly crenulated.

Lithologic units

Pkr$_a$. Pink to maroon metarhyolite, meta-agglomerate, and metatuff forming strike ridges in west, near Stuart copper mine (GR 453917). Cut by quartz, feldspar, and aplite veins; intruded by granite in south. Maximum thickness about 100 m. Reference area at GR 451910.

Metarhyolite: medium to fine-grained, porphyritic and non-porphyritic; weakly cleaved; generally shows vague, commonly contorted, fine banding (flow-banding); margins brecciated; merges into agglomerate; consists of mosaic of quartz and alkali feldspar or quartz and muscovite, and abundant yellow-brown to blue tourmaline (thermal metamorphic effect).

Meta-agglomerate: marginal to metarhyolite; consists of angular clasts, many over 2 cm across, of rhyolite, turbid 'clay' possibly representing altered pumice, and metasiltstone (tuff?), and also fragmentary crystals of quartz and alkali feldspar (at least partly microcline) and some tourmaline (as in metarhyolite).

Meta-tuff: medium to fine-grained; thin-bedded to laminated; consists of variably turbid and ironstained alkali feldspar, quartz, and subordinate muscovite and tourmaline.

Pkr$_c$. Calc-silicate rocks and, in NW, subordinate dark grey slate, phyllite, fine-grained mica schist, pink feldspathic quartzite, and thin-banded cherty

Table 5 Kuridala Formation: petrographic data

Sample no. (prefix 7853)	Location (GR)	Quartz	K-feldspar	Plagioclase	Muscovite	Biotite	Amphibole	Clinopyroxene	Garnet	Andalusite	Sillimanite	Cordierite	Staurolite	Scapolite	Sphene	Apatite	Zircon	Tourmaline	Opaques	Epidote	Calcite	Chlorite	Sericite	Other minerals remarks
Schistose and Phyllitic Rocks																								
0185A	470214	X	X		†					X								†	×				†	
0185B	470214	X	(X)		X	X				X														
0201	509153	X	X			X				(?)												†	†	
0203B	517155	X	×	X	X	X				X								×						
0219	497182	X	X	(X)	×	X				(?)								†	†					
0254	474132	X		×	X ×					X														Sample from Lady Ella? Cu mine
0254A	474132	X		X	X	X				X						†		†				†		Sample from Lady Ella? mine
0257A	479136	X			X	×			(x)										†					
0257B	479136	X			X	×			(x)									†	†					
0266	483128	X		X	X	×				(X)							†	†	†					
0267	482131	X			X	×			x	X										†				
0286	458130	X																					X	
0286A	458130	?			X													†	X				X	
0296	468099				×											†	†		×		X			phlogopite, x
0303	469082	X	X		×	×				X		X							×					
0311	453075	X		X	†	†										†			×					hematitic; conglomeratic?
0351	517033	X			X	X										†		†	×					
0353	516022	X			X	X				(x)						†		†	×					
0369A	612029	X		†	X	X										†								
0387	609033	X		†	X	X			†	†		(?)						†	†					Mt Carol Cu mine
0387A	609033	X	†	×	×	×			†													†		Mt Carol Cu mine
0387B	609033	X			X	X			†	X								†						Mt Carol Cu mine
0388	605032	X		†	X	X			x	x						†	†	†						
0421	559082	X			X					(X)		(?)												
0422	613010	X	?	X	X	X																		
0639	598920	X			×	X			†	x						†			†					
0670A	618966	X		(X)	X					x								†	†					graphite?
0676A	600936	X			X	×			(x)															
0682	612935	X	X	X	×	×				x														
0685	619924	X	×	X	X	X												†						
0689	593924	X			X	X			(x)															graphite,x

Table 5 (contd) Kuridala Formation: petrographic data

Sample no. (prefix 7853)	Location (GR)	Quartz	K-feldspar	Plagioclase	Muscovite	Biotite	Amphibole	Clinopyroxene	Garnet	Andalusite	Sillimanite	Cordierite	Staurolite	Scapolite	Sphene	Apatite	Zircon	Tourmaline	Opaques	Epidote	Calcite	Chlorite	Sericite	Other minerals remarks
Schistose and Phyllitic Rocks (contd)																								
0741	450016	X		X	X	X										†		†				†		
0741A	450016	X	x		X	X			(†)									†						
0741B	450016	X		x	X											†		†	x					phlogopite, x
0747	450005	X			X														X					hematitic
0767	465013	X			X				(x)										x					
0768	447990	X			X														X					hematitic
0781	443994	X			X	X				(?)								†	x					
0784	474960	X			X	X			(†)															
0788	478966	X			X	X							X					†				†		
0808	457918	X			X	X				x			x					†						graphite, x
0879	477971	X			X	X			X				X					†	x					
0880	478972	X			X	X				(?)						†		†	†					
0924	569958	X			X	X				X						†		†	†					
1320	676835	X	X		X	X												†						Pegmont prospect
1320B	676835	X			X	x										†		†						Pegmont prospect
1403	550832	X			X	x			(x)	(x)								†	†					
1403A	550832	X			X	(x)			(x)															
1403A	550832	X			X	(x)			(x)	(x)								†						
1564	520811	X			X	(x)			(x)	x									†					
1567	507807	X			X	(?)				X								†						
1602	590066	X		X	†	X												†	†					
1608	605064	X	†		X	X			(†)	X		?	?			†		†	x					
1695	670810	X			X	X				(?)														
Non-schistose medium to coarse-grained rocks																								
0185	471214	X		(?)	X													†	x					Meta-arenite
0203A	517155	x	X		X	x												x	x					Laminated granofels
0204	519157	X	X	?	x	x											†	†	†					Meta-arkose
0343	520044	X	X	X	†	†													x					Feldspathic quartzite
0357	515032	X	X	X															†				†	

Table 5 (contd) Kuridala Formation: petrographic data

Sample no. (prefix 7853)	Location (GR)	Quartz	K-feldspar	Plagioclase	Muscovite	Biotite	Amphibole	Clinopyroxene	Garnet	Andalusite	Sillimanite	Cordierite	Staurolite	Scapolite	Sphene	Apatite	Zircon	Tourmaline	Opaques	Epidote	Calcite	Chlorite	Sericite	Other minerals remarks
Non-schistose medium to coarse-grained rocks (contd)																								
0369	612021	X		X	x	X										†	†					†		Feldspathic metagreywacke
0635	611970	X	?	X	x	x											†	†	†					Meta-arkose
0664	532974	X	X	x	†																			graphite? X; banded granofels
0713	562894	X			x																			Quartzite, marker bed
0759	471009	x	X		†	x																		Granofels (metavolcanic?)
0817	495961	X	X	X	†	†										†			x					Meta-arkose
0831	490999	X		X		x	x		x						†	†			x	x	†		†	Metagreywacke
0832	492995	X	X	X	x											†			x					Meta-arkose
0838B	511998	x		X															†					Albitite
0855	511923	X			x													†				?		Quartzite
1344A	654836	X		(?)	x	x												†					†	Graphite? x; quartzite
1346	659833	X	X														†		†			†		Phlogopite, x; rutile? †; granofels
1348	650843	X	?	X	†										†		†		†		†			Granofels
1349	648844	X	X	(X)	x	x										†		†	x					Laminated granofels
1369	661844	X	X	(?)		x														†				Rutile?†; feldspathic quartzite
1404	544826	X		X	x	(x)										†	†		†	x		†		Micaceous feldspathic quartzite
1733	513877	x	x		x	x			†							†			†			†		Quartzite
Acid volcanics																								
0745A	446013	X	X		†				(?)															Metarhyolite
0801	453915	X	X		X													†				†	†	Fluorite? †; bedded 'tuff'
0803	425913	X	X		x													†						Agglomerate
0804	451910	X	(?)		X													x	†					Metarhyolite

Table 5 (contd) Kuridala Formation: petrographic data

Sample no. (prefix 7853)	Location (GR)	Quartz	K-feldspar	Plagioclase	Muscovite	Biotite	Amphibole	Clinopyroxene	Garnet	Andalusite	Sillimanite	Cordierite	Staurolite	Scapolite	Sphene	Apatite	Zircon	Tourmaline	Opaques	Epidote	Calcite	Chlorite	Sericite	Other minerals remarks
Non-schistose fine-grained rocks																								
0186	469212	X		(x)	†																	?		graphite, x; slate
0186A	469212	X		(x)	X	X											†	†						metasiltstone
0198A	499175	x		X	X				(X)								†							graphite, X; metasiltstone
0198B	499175		x		X				X															graphite, X; metasiltstone
0224	481179	?	?		X				X															graphite, X; slate; Mt Elliott mine
0360	695042	†			X				X															graphite, X; slate
0431	620992	X																					†	graphite, x; metachert
0448	619005		X		†																			graphite, x; 'chert'
0670	618966	X		?				X	X															graphite, X; metasiltstone
0683	613928	X	X	x		†									†					x		†		granofels
0877	470968	x			x															X				graphite, X; malachite, x; metasiltstone
1320A	676835																		X					BIF, Pegmont prospect
1334	677836	X														†	†	X						banded rock, Pegmont prospect
1751A	446037	X																	X			†	†	banded hematitic rock
Calc-silicate granofels																								
0270	475133			X			x	X							x				x	x	x			Laminated
0298	468098		X				X	x							x	†	†		†	x	†			Laminated
0309	459075			X											x	†			†		†	†		Fluorite, †
0367	608031	X		X			X		X						x				x	x			x	Banded
0380	468038	x	x	X			X	x							x									Laminated
0380A	468038		x	X			X	X							x									Laminated
0618	625923	X	?	x	†		x	.x							†				x		x			Hydrogarnet? x; prehnite X; laminated
1344	654836			x			X	X						X	x									Thin-banded
4136	469038	x	X				X								†	†			x					Laminated

Table 5 (contd) Kuridala Formation: petrographic data

Sample no. (prefix 7853)	Location (GR)	Quartz	K-feldspar	Plagioclase	Muscovite	Biotite	Amphibole	Clinopyroxene	Garnet	Andalusite	Sillimanite	Cordierite	Staurolite	Scapolite	Sphene	Apatite	Zircon	Tourmaline	Opaques	Epidote	Calcite	Chlorite	Sericite	Other minerals remarks
Metabasics																								
0821	508963			X			X								x			†	x					Probably metabasalt
0821A	509963		x	X			X								x				x	†				Para-amphibolite
Hornfels																								
0209	528163	X	X	X	X	X				x	x	X							x					Metapelite
0837A	505003	X	X	X	†	x										†	†		x		†	†		Rutile? †; fluorite, †; meta-arkose
0904A	528913	X	X	x	X	X				x							†		x					Metagreywacke
0904B	526914	X	X	x	x	x				x	x	X					†		x					Metapelite
1724	527888	X	X		X	x				x	x	x				†			x					Metapelite
4607	547126	X	X		x	X				X	x	x				†			†					Metapelite

X, major constituent (> 10 % of rock)
x, minor constituent (1-10% of rock)
†, trace constituent (< 1% of rock) or alteration product

( ), pseudomorphed
___, as porphyroblasts
≡, some as porphyroblasts

quartzite; some possible metabasalt and metatuff E of Mt Cobalt. Reference area at GR 475133.

Calc-silicate rocks: pink, green, and grey; thin-banded to laminated; some small-scale cross-bedding and slump structures give local facing; variably siliceous, epidotic, feldspathic, calcareous, and amphibolitic; main minerals recorded are actinolitic amphibole, calcite, salitic clinopyroxene, epidote, garnet, dark blue-green hornblende, K-feldspar, pale to colourless mica (phlogopite?), prehnite, quartz, scapolite, albite, and sphene. At GR 508962 heterogeneous calc-silicate rock, consisting mainly of plagioclase and green hornblende, is associated with fine-grained amphibolite containing small partly recrystallised phenocrysts; these rocks may represent metamorphosed basaltic tuff and lava, respectively.

$\underline{\text{Pkr}}_{ch}$. Metamorphosed chert, represented by quartzite, quartz-albite rock, and albitite; minor calc-silicate rocks, marble, mica schist, and schistose meta-arenite; mapped as separate unit only near Mount Ulo (GR 621982), where it forms part of prominent ridge. Reference area at GR 620992. Metachert is pale grey; fine to very fine-grained; medium to thin-bedded; weathered surfaces pitted in places; commonly contorted and quartz-veined; may represent silicified carbonate, or acid tuff, or chemical sediment.

$\underline{\text{Pkr}}_{f}$. Meta-arkose and, locally, minor interbedded mica schist, metagreywacke, and quartzite similar to those in unit Pkr_{g}; ridge-forming, as more resistant to erosion than adjacent units; crops out in north-northeast-trending belt 12 km long and up to 2.5 km wide east of Mount Cobalt mine, and in smaller area about 8 km southeast of this mine; probably interfingers laterally with Pkr_{g}. Outcrops generally paler in tone on aerial photographs than those of Pkr_{g}. Reference area at GR 485960.

Meta-arkose: pale grey to pinkish grey; medium to fine-grained; moderately well-sorted; thick to thin-bedded; friable to silicified; massive to cleaved; locally cut by quartz veins; partly to completely recrystallised; composed of quartz + sodic plagioclase $\pm$ microcline $\pm$ minor mica (biotite and/or muscovite).

Pkr$_g$. Most widespread unit in area. Consists predominantly of schistose meta-arenite and mica schist representing metamorphosed greywacke, siltstone, and shale, but also includes interbeds of quartzite, meta-arkose, carbonaceous metasiltstone, calc-silicate rocks, banded iron formation, and, at some granite contacts, hornfels. Reference area near Selwyn/Hamilton River road, at GR 545995.

Interbedded schistose meta-arenite and mica schist: pale to dark grey, or ironstained to shades of brown; mainly medium to fine-grained; medium to thin-bedded; variable micaceous, feldspathic, and quartzose, rarely calcareous; consist mainly of muscovite ± biotite + quartz ± feldspar (microcline and/or sodic plagioclase) ± opaque minerals ± green amphibole ± poikilitic porphyroblasts (mainly in schist) of andalusite ± garnet ± muscovite ± staurolite (rare); common accessories are zircon, tourmaline and apatite. Most porphyroblasts appear to have formed before or during development of the schistosity, which is wrapped around them; those of andalusite are mostly euhedral, range up to 5 cm long and 1 cm across, and in places form over 25% of the total rock; those of garnet are equant, less than 5 mm across, and in places contain sigmoidal trails of inclusions ('snowball' texture); muscovite porphyroblasts are ellipsoidal and may be pseudomorphs; staurolite porphyroblasts, found only in mica schist near Mount Cobalt mine, are euhedral. Meta-arenites show rare bedding-plane laminations and very rare cross-bedding; schists locally show laminar banding.

Quartzite: generally white or grey, also glassy; locally ironstained to brown; medium to fine-grained, commonly sugary-textured; silicified to friable; massive or medium to thin bedded; sheared and schistose in places; bedding plane laminations apparent locally but no sedimentary structures indicating facing preserved; quartz veining common; resistant to erosion, and forms some prominent strike ridges; consists of interlocking quartz mosaic with sparse muscovite and biotite flakes and tourmaline grains. Ridge-forming quartzite several metres thick in central part of outcrop area forms prominent marker beds.

Banded iron formation: medium to fine-grained; finely laminated to thin-banded; exposed at Pegmont prospect (GR 676835), where it is 4-6 m thick, and SE of Mount Cobalt, at GR 509922, where it is about 1 m thick. At Pegmont (Lőcsei, 1977; Stanton & Vaughan, 1979) it is complexly folded, with overall gentle easterly dip; fresh drill core consists mainly of galena, sphalerite, pyrite, magnetite, gahnite, fayalitic olivine, garnet, apatite, graphite, amphiboles, clinopyroxene, and quartz; manganese minerals, including pyrolusite, are commonly present in oxidised material.

Meta-arkose: similar to that forming most of unit $\underline{P}kr_f$.

Carbonaceous metasiltstone: similar to that characteristic of unit $\underline{P}kr_s$.

Calc-silicate rocks: similar to those characteristic of unit $\underline{P}kr_c$.

$\underline{P}kr_p$. Phyllite, slate, fine-grained mica schist, and minor thin interbeds of meta-arenite; also some bands of quartz-hematite rock, some of which appear conglomeratic; quartz-veining common; mapped as separate unit only in W; mainly forms linear topographic depressions, but includes some resistant ridge-forming beds. Reference area at GR 461983.

Phyllite: shades of grey and buff, or ironstained to brown; soft and friable, or silicified to slate; in places shows lamina banding; contains andalusite and staurolite porphyroblasts in SW.

Slate: silicified phyllite and laminated metasiltstone, locally graphitic.

Mica schist: grey; fine-grained; locally contains small porphyroblasts of garnet and/or andalusite.

$\underline{P}kr_q$. Ridge-forming quartzite in W; minor interbedded phyllite, mica schist, and black slate in places. Reference area W of Mount Dore Cu mine, at Gr 472040.

Quartzite: metamorphosed (recrystallised) quartz arenite; white to pale grey, or ironstained; medium to fine-grained; massive, or thin-bedded to laminated; no sedimentary facing structures found; locally sheared and brecciated; quartz-veining common.

Pkr$_s$. Mainly carbonaceous siltstone metamorphosed to graphitic slate, phyllite, and granofels; minor interbeds of rocks typical of units Pkr$_g$, Pkr$_p$, and Pkr$_c$; characteristic dark tone on air photographs; includes Mount Elliott Slate Member of White (1957); cut by quartz veins and intruded by granite. Reference area at Mount Elliott mine, GR 481179.

Carbonaceous metasiltstone: dark grey to black, or partly bleached; fine to very fine-grained; thin bedded to finely laminated; tight to isoclinal minor folds evident locally; copper minerals and/or pyrite present in many places; consists essentially of graphite + quartz and/or feldspar and/or calcite + muscovite ± biotite, and commonly contains irregularly oriented porphyroblasts of 'match-stick' andalusite/chiastolite up to 5 cm long, and anhedral poikiloblasts of muscovite.

Pkr. Mixture of lithologic units, but mainly schist; in W includes pink metarhyolite containing small quartz and feldspar phenocrysts, calc-silicate rocks, and bands of medium-grained to conglomeratic quartz-hematite rock; 2 km W of Pegmont prospect, at GR 657840, it includes thin-banded to massive, medium to fine-grained quartzofeldspathic granofels which may represent felsic tuff.

Structure. Two major folding episodes evident - F_1 and F_2. Few faults mapped, but probably many present, especially strike faults: those mapped appear to postdate the folding.

First folding episode, F_1: represented by tight to isoclinal large, medium, and small-scale folds having steep to vertical limbs. An associated axial-plane schistosity (S_1), especially well developed in pelitic rocks, is generally parallel to bedding except in fold-hinge zones. Trends are mainly N, but swing to NW in N and to NNE in S. F_1 folds identified include a major isoclinal structure outlined by ridge-forming quartzite in Pkr$_g$ at GR 525840; a tight major fold outlined by ridge-forming quartz-hematite bands in Pkr at GR 445988; recumbent folds a few metres across near Pegmont prospect (e.g., at Gr 670822), where the general dip of bedding/schistosity appears to be gentle to north; and isoclinal minor folds present at many exposures, especially those of Pkr$_s$ and Pkr$_{ch}$.

Second folding episode, F_2: represented by more open, mainly upright major folds; fold axes generally trend N; fold plunges are gentle to steep; no associated axial-plane schistosity developed. The earlier schistosity, S_1, is commonly crenulated by F_2, especially in axial zones of F_2 folds. Examples of F_2 folds include a broad synformal structure partly outlined by a thick sill-like body of metadolerite at GR 615005, and a major steeply plunging open fold, closure to N, about 7 km NW of Pegmont prospect, at GR 625895.

Metamorphism. Mineral assemblages indicate regional metamorphism to amphibolite grade: quartz + muscovite + biotite ± porphyroblasts of andalusite and/or garnet and/or staurolite in pelitic rocks; clinopyroxene in calc-silicate rocks; hornblende rather than actinolite in associated metadolerite intrusions (except in W). Porphyroblasts are generally deformed or cut by S_1, but were probably formed during same tectonic event at F_1 and S_1. Minor retrogressive metamorphism evident in many rocks, especially in W, may have resulted from F_2 tectonism.

In general, rocks of Kuridala Formation do not appear to be thermally metamorphosed at granite contacts. However, thermal aureoles up to 100 m wide, consisting of hornfels, are present locally; e.g., around a small intrusion of Williams Granite (Pgi_a) at GR 508760, adjacent to Williams Granite (Pgi) 5 km SE of Selwyn (at GR 528168) and 7 km SE of Mount Cobalt mine (at GR 30914), and adjacent to Gin Creek Granite at GR 443037. Mineral assemblages in the aureoles include fibrolitic sillimanite + andalusite + cordierite + muscovite + biotite + quartz + microcline + sodic plagioclase, indicating hornblende hornfels facies rocks.

Relations. Appears to merge laterally with schist and gneiss of Soldiers Cap Group in SE and with Answer Slate and part of Staveley Formation (Pks_g) in W: Kuridala schists become generally coarser-grained to east and finer-grained to west; banded ironstone interbedded with schist in Pkr_g at Pegmont prospect (GR 676835) may be at the same stratigraphic level as that in Soldiers Cap schist and gneiss at Cowie prospect (GR 862890) and other prospects to E and NE. Inferred to be overlain, possibly unconformably, by sediments mapped as part of Staveley Formation (Pks_x) SW of Selwyn. Overlain unconformably at several localities by flat-lying Mesozoic sedimentary rocks. Intruded by Williams Granite, Gin Creek Granite, unnamed granite (at GR 572082), numerous metadolerite dykes and sills, and east-trending dolerite dykes. Contacts with granite, well exposed at many localities, are sharp but commonly irregular in detail.

Age. Probably Middle or Early Proterozoic.

Correlations. Considered to be stratigraphically equivalent to Soldiers Cap Group rocks to E and Answer Slate to W; may also be equated with part of Corella Formation to E and some Staveley rocks in NW (especially Pks and Pks$_g$).

Mineralisation. Cu mineralisation common, especially in black slates of Pkr$_s$; e.g., at Mount Elliott, Mount Dore, and Marilyn mines. Co and minor Cu occur at Mount Cobalt mine and nearby. Some W, as scheelite, has been produced from a small mine near Mount Cobalt. Minor U mineralisation occurs in black slate and quartzite at Mariposa mine/prospect. Pb-Zn mineralisation occurs in banded iron formation at Pegmont prospect. Small amounts of Au have been recorded in quartz-hematite bodies W of Mount Dore.

Remarks. Rocks of Kuridala Formation may represent mainly deep-water sediments, as turbidite-type rocks (greywackes, etc.) predominate. Black slate represents carbonaceous siltstone/shale which, presumably, was deposited during very quiet sedimentation.

Complex tight to isoclinal folding, and a scarcity of facing evidence make it impossible to determine which are the oldest or youngest parts of the formation, or the stratigraphic positions of the various constituent lithologic units. For example, black slate of unit Pkr$_s$ may occur at only one or at several stratigraphic levels, and the Mount Elliott and Hampden Slate Members may be stratigraphic equivalents rather than marking the base and top of the formation, as suggested by White (1957).

Answer Slate

Map symbol. Pka.

Nomenclature. Defined by Carter (1959) and Carter & others (1961); name proposed by White (1957); named after Answer Mine, at GR 340035, Selwyn region.

Distribution. Crops out in north-trending belt up to 7 km wide in NW of Selwyn region; extends north into adjoining Malbon Sheet area, where it is subdivided into two parts by Noon (1978). In Selwyn region outcrops are more or less as mapped by Carter & Opik (1963); Noon's subdivisions have not been recognised.

Type section. S of Limestone Creek, from 21°33'S (not 21°23'S, as given in Carter, 1959, and Carter & others, 1961), GR 337150, for 5 km W, to GR 289150.

Thickness. Uncertain, because of tight to isoclinal folding; may be more than 1000 m.

Airphoto characteristics. Forms undulating terrain and low strike ridges with medium to pale tones; bedding/cleavage trends generally clearly visible.

Rock types. Interbedded slate, phyllite, micaceous metasiltstone, and fine-grained mica schist (mainly in south); minor quartzite, chert (especially in north), and ridge-forming quartz-hematite bands; quartz veins generally abundant. Slate, phyllite, and chert are pale to dark grey, or bleached to ironstained; graphitic and/or pyritic in part; thin-bedded to laminated; locally show tight minor folds and/or crenulations. Schist is mainly iron-stained to shades of brown. Interbedded quartzite is generally pale pink, fine-grained, and probably feldspathic. Chert sample from GR 318125 consists of a fine-grained mosaic of quartz and albite and accessory hematite, sphene, and muscovite. Fine-grained schist at GR 294087 consists of quartz, biotite, feldspar, and accessory tourmaline; lenticles of coarser-grained material may represent incipient porphyroblasts.

Structure. Dolerite sills in sequence outline several tight to isoclinal major folds, closed to S; no way-up indications found, so not known if folds are synclines or anticlines. Cleavage appears to be generally parallel to bedding except in fold noses; bedding/cleavage is vertical to steeply dipping, trends are mainly between N and NW.

Metamorphism. Difficult to determine because of general weathered nature and fine grain-size of rocks exposed; mineralogy of metadolerites in sequence indicates upper greenschist or lower amphibolite facies.

Table 6. Answer Slate and Staveley Formation: petrographic data

Sample no. (prefix 7853)	Location (GR)	Quartz	K-feldspar	Plagioclase	Muscovite	Biotite	Amphibole	Clinopyroxene	Garnet	Andalusite	Cordierite	Staurolite	Scapolite	Sphene	Apatite	Zircon	Tourmaline	Opaques	Epidote	Calcite	Chlorite	Sericite	Rock type
Answer Slate																							
4310	318125	X		X	†												†	†					Metachert
4748	294087	X	x			X									†								Schist/phyllite
Staveley Formation:	unit Pks																						
4150	423137	x	(X)															X					Weathered schist
4183	348066	X	?	X	x	x										†		x					Meta-arenite
4280	352105	x		X			X										X			X			Laminated calc-silicate rock
4280A	352105	X		X	†												X						Metasiltstone (hornfels?)
4291	348130	X	X	X	†											†	†						Meta-arenite
4430	404163	X															†	x				X	Schist/phyllite
4433	389182	X		X	†												†	x					Metasiltstone
4434	382181	X																†				X	Schist
4736	446109	X	X			X					(?)							x					Phyllite
Staveley Formation:	unit Pks_c																						
4162	364092	x	x^c	x	†													†		X			Calcareous metasiltstone
4162A	364092	z	x	X	X													x		X			Calcareous metasiltstone
4172	380079	?	x	X	X												†	†		X	†		Calcareous metasiltstone
4173A	378068	X	X				X													X	x		Calc-silicate rock
Staveley Formation:	unit Pks_g																						
4168	402083	X		X										†	†			x					Schist
4176A	369069	X		X	X						X		X				†	†			x	†	Schist

Sample no. (prefix 7853)	Location (GR)	Quartz	K-feldspar	Plagioclase	Muscovite	Biotite	Amphibole	Clinopyroxene	Garnet	Andalusite	Cordierite	Staurolite	Scapolite	Sphene	Apatite	Zircon	Tourmaline	Opaques	Epidote	Calcite	Chlorite	Sericite	Rock type
Staveley Formation: unit $\mathbb{B}ks_x$																							
0235	447000	X		X	X													x					Meta-arenite
0284A	457124	X		x	X												†	X				X	Hematitic schistose conglomerate
0286B	458130	X															†					X	Meta-arenite
4113	443150	x		X	†	x	(X)											x			†		Porphyry 'dyke'
4142	457116	?	X		x	X												x				X	Phyllitic mudstone
4142A	457116	x			x	x												X	X				Calcilutite
Staveley Formation: unit $\mathbb{B}ks_{xb}$																							
0240A	452141			X			X		X										X				Amygdaloidal meta-basalt
0240A	452141			X			X		X										X				Amygdaloidal meta-basalt
0244	452139	x		X										x				x	X				Metabasalt

X, major constituent (>10% of rock)
x, minor constituent (1-10% of rock)
†, trace constituent (< 1% of rock) or alteration product
(), pseudomorphed
=, as porphyroblasts
_, some as phenocrysts

Relations. Overlies Mitakoodi Quartzite to W, apparently conformably; merges laterally with Kuridala Formation in S; overlain by Staveley Formation to E, apparently conformably, but with local unconformity according to White (1957); overlain unconformably by Mesozoic Gilbert River Formation. Intruded by numerous sills of metadolerite, including multiple bodies in which individual sills are separated from one another by thin screens of Answer Slate. Inferred to be intruded by Gin Creek Granite (contacts concealed); strongly sheared, rodded (vertically), and quartz-veined near concealed contact with unnamed metamorphics of W Gin Creek Bore.

Age. Middle or Early Proterozoic.
Correlations. Stratigraphically equivalent to Kuridala Formation to E, and according to Noon (1978), to part of Marimo Slate in Malbon Sheet area.

Mineralisation. Several occurrences of Cu mineralisation known, the most important being at the Answer Mine.

Remarks. The Answer Slate may represent distal facies equivalents of turbidites and associated sediments in the Kuridala Formation, and is presumed to represent relatively deep-water deposits. Presence of pyrite and graphite may indicate restricted circulation and local reducing conditions.

Staveley Formation

Map symbols. Pks, Pks_g, Pks_x, Pks_{xb}.

Nomenclature. Defined by Carter (1959); named after Parish of Staveley, in which most of the outcrop area of the formation lies (White, 1957), Duchess 1:250 000 Sheet area. In this report it excludes the Agate Downs Siltstone Member of White (1957), Carter & others (1961), and Carter & Opik (1963).

Distribution. Crops out in north-trending belt up to 14 km wide in NW part of Selwyn region; extends north into Malbon Sheet area, where it is mapped by Noon (1978) as part of Corella Formation. Outcrops in Selwyn region are generally as mapped by White (1957) and Carter & Opik (1963) except for part, now mapped as Kuridala Formation, E of Gin Creek Granite.

Type section. In Malbon Sheet area, from 21°24'50", 140°27'20", a point 1.6 km N of the Tip-top mine, west for about 6.4 km (Carter, 1959; Carter & others, 1961); includes section through Agate Downs Siltstone.

Thickness. Probably more than 2 000 m.

Airphoto characteristics. Forms undulating terrain and some strike ridges; mainly medium tones; bedding trends prominent locally.

Rock types. Mainly sedimentary rocks showing only low-grade regional metamorphic effects. Five lithologic units distinguished: Pks, interbedded calcareous to non-calcareous phyllite, slate, arenite, and siltstone; minor chert, limestone/marble, and calc-silicate rocks; Pks_g, mica schist, minor calcareous rocks, and numerous granite and pegmatite veins; Pks_c, calcareous arenite and phyllite, calc-silicate rocks, and marble; Pks_x, interbedded arenite, siltstone, and phyllitic shale/mudstone showing well-preserved sedimentary structures; minor conglomerate, calcilutite, calc-silicate rocks, and limestone/marble; Pks_{xb}, metabasalt. Banded quartz-hematite rocks occur in all units except Pks_{xb}.

Lithologic units

Pks: most extensive unit, but generally poorly exposed; reference area along Limestone Creek, near GR 380182; rocks exposed mostly much weathered and ironstained to bleached.

Arenite-siltstone-shale/mudstone sequence: variably calcareous, siliceous, micaceous, and feldspathic; thin-bedded to laminated; arenites include some greywacke types; fine-grained rocks are phyllitic to finely schistose; no sedimentary structures found to indicate facing; arenite at GR 348130 contains clasts of quartz, microcline, plagioclase, and myrmekite, derived from a granitic terrain, enclosed in a matrix of chlorite, sericite/muscovite, and iron oxide.

Calc-silicate rocks: finely laminated at GR 352105, where they consist of quartz, plagioclase, calcite, and subordinate iron oxide, yellow-brown to blue-green amphibole, muscovite, and sphene.

$\underline{Pks}_{g}$: restricted to within 1.5 km of Gin Creek Granite, and characterised by abundant cross-cutting granite and pegmatite veins; reference area is vicinity of Belgium mine (GR 431120); generally less calcareous and more metamorphosed and recrystallised than unit Pks; consists mainly of fine-grained mica (muscovite and/or biotite) + quartz ± feldspar schist. Pre or syn-foliation porphyroblasts of staurolite and andalusite largely replaced by sericite are present in chlorite-muscovite-biotite-quartz schist close to Gin Creek Granite at GR 369059. Diopside and other calc-silicate minerals have been recorded in metamorphosed limestone near GR 386062 by White (1957).

$\underline{Pks}_{c}$: mapped as separate unit SE of Selwyn/Boulia road; reference area at GR 365092; consists mainly of well-bedded calcareous rocks, some of which contain porphyroblastic tremolite/actinolite.

$\underline{Pks}_{x}$. crops out in E and NW of Staveley outcrop area; reference area SSW of Selwyn, at GR 455130.
Interbedded arenite, siltstone and shale/mudstone: buff to brownish or shades of grey; variably micaceous, calcareous, feldspathic, andferruginous; generally quartz-poor; arenites are medium to fine-grained, recrystallised in part; shale/mudstone is commonly phyllitic. Sedimentary structures, especially convolute bedding (recumbent folds of Allen & Banks, 1972) and small-scale cross-bedding outlined by heavy-mineral laminae, are common, generally well-preserved and provide good facing criteria; also present are some ripple marks, graded bedding, and possible halite casts (at GR 452148) similar to those recorded in unit $\underline{Pkc}_{x}$ in the NW of Mount Angelay Sheet area (Donchak & others, 1979). Mn dendrites are common on bedding planes. Arenites examined in thin-section consist of quartz + feldspar + sericite + iron oxide ± biotite/phlogopite ± muscovite (porphyroblastic in some samples) ± calcite + accessory tourmaline (some in E as elongate euhedra).

Conglomerate: present in sequences in southeast (e.g., at GR 457124), near contact with Kuridala Formation; typically porous and hematitic; contains lensoid clasts up to 3 cm across of fine-grained muscovite/sericite schist (containing possible altered porphyroblasts) and other fine-grained rocks.

$\underline{Pks}_{xb}$: small outcrop in east, reference area at GR 452139, surrounded by Pks_{x}; consists of non-foliated metabasalt lava which is massive in centre and amygdaloidal, scoriaceous, and agglomeratic at margins; epidote and garnet occur in vesicles. Socriaceous metabasalt examined in thin section consists mainly of epidote + actinolite + albite ± garnet.

Structure. Beds generally dip vertically or steeply east, and strike between NNE and NNW. Tight to isoclinal minor folds are exposed in places, and larger folds are outlined locally by metadolerite intrusions in Pks. Unit Pks$_x$ in east is folded into a major isoclinal syncline which has an overturned eastern limb and is presumed to plunge steeply north. Bedding in NW outcrop of Pks$_x$ is locally disrupted by a penetrative cleavage probably related to isoclinal folding.

Metamorphism. Most of formation, and especially units Pks$_x$ and Pks$_{xb}$, appear little metamorphosed, though partly recrystallised, and are probably greenschist grade rocks. Typical metamorphic mineral assemblages are chlorite + biotite + sericite/muscovite + quartz + feldspar, and quartz + plagioclase + actinolitic amphibole in rocks in Pks; quartz + sericite/muscovite in Pks$_x$; and epidote + actinolite + albite in Pks$_{xb}$. Unit Pks$_g$ appears to be more metamorphosed, and presence of andalusite and staurolite porphyroblasts in muscovite-biotite schist indicates at least local metamorphism to amphibolite grade. Elongate tourmaline euhedra in arenite of Pks$_x$ in E is attributed to thermal metamorphism associated with granite intrusions.

Relations. Inferred to overlie Answer Slate to W and Kuridala Formation to E; may overlie unnamed metamorphics (Plm) to S; overlain by Agate Downs Siltstone in N; intruded by Gin Creek Granite; units Pks and Pks$_g$ are intruded by metadolerite, and unit Pks$_x$ is intruded by feldspar porphyry. Relations between units Pks, Pks$_g$, Pks$_c$, and Pks$_x$ are equivocal.

Contacts with Answer Slate appear to be conformable, as in Malbon Sheet area to north (Noon, 1978), and gradational, but have been reported as locally unconformable south of Limestone Creek by White (1957).

Unit Pks$_g$ may merge laterally with Kuridala Formation to E.

Unit Pks$_x$ in E is at least partly faulted against, and may be unconformable on, Kuridala Formation: at GR 45130 well-bedded, little metamorphosed Pks$_x$ rocks overlie, apparently conformably, Kuridala phyllite and fine-grained mica schist, but the latter show microscopic crenulations, and sericite/muscovite schist immediately below the contact is cut by highly contorted (ptygmatic) veinlets of quartz which do not continue up into Pks$_x$ - the Kuridala rocks here show evidence of two deformations which do not appear to have affected the Pks$_x$ rocks; also, about 1 km to S, conglomerate bands in Pks$_x$ contain clasts of schist which could be derived from nearby Kuridala Formation.

To W of Pks$_{xb}$, Pks$_{x}$ is intruded by one or more sheets of feldspar porphyry 1-2 m thick. The porphyry has an igneous texture, and consists of euhedral plagioclase phenocrysts, up to 7 mm long and altered to epidote and albite, set in a fine-grained groundmass of albite laths, calcite, greenish-brown hornblende, iron oxide, and interstitial quartz.

Age. Middle or Early Proterozoic.

Correlations. Units Pks and Pks$_{g}$ may be stratigraphically equivalent to parts of the Answer Slate and Kuridala Formation and hence with part of the Corella Formation, as suggested by Noon (1978). Unit Pks$_{x}$ is strikingly similar in lithology and grade of metamorphism to units in areas to north - to part of Corella Formation mapped as Pkc$_{x}$ in NW corner of Mount Angelay Sheet area (Donchak & others, 1979) and part of Marimo Slate mapped as Pkm$_{2}$ in Marraba Sheet area (Derrick & others, 1971). Unit Pks$_{c}$ may be equivalent to Pks and/or Pks$_{x}$.

Mineralisation. Cu ore has been produced from the Belgium mine (GR 431120), and U has been recorded at the Utah prospect (Brooks, 1960) about 0.8 km to SE (not located during 1978 survey), both in unit Pks$_{g}$ close to Gin Creek Granite. Quartz-hematite bodies within the formation have been prospected for base metals and gold by several companies, but no economic concentrations have been reported.

Remarks. Relations and correlations of Staveley Formation rocks have yet to be satisfactorily resolved, and there is some doubt, at least as far as Blake is concerned, that the whole formation can be correlated directly with the Corella Formation, as suggested by Noon (1978). An alternative interpretation is that the Staveley Formation as mapped is a composite unit comprising some parts (Pks, Pks$_{g}$, and possibly Pks$_{c}$) which are correlatives of the Answer Slate/Kuridala/Corella sequence, and other much younger parts (Pks$_{x}$ and Pks$_{xb}$) separated from Pks and Pks$_{g}$ by an unconformity representing a time break during which a major tectonic event was followed and/or accompanied by uplift and erosion. If this latter interpretation is correct, the exposed younger Staveley rocks occupy partly fault-bounded keels of synclines like Stanbroke Sandstone and Surprise Creek Beds in Dajarra and Duchess Sheet areas to the west (Blake & others, 1978; Bultitude & others, 1978).

The convolute bedding/recumbent folds found in unit $\mathcal{P}ks_x$ are similar to structures considered by Allen & Banks (1972) to be mainly formed by current drag on a wet sand bed liquified or fluidised as a result of earthquake shock. In the case of unit $\mathcal{P}ks_x$, earthquakes could have been associated with contemporaneous volcanism, evidence for which is given by metabasalt of $\mathcal{P}ks_{xb}$.

Agate Downs Siltstone

Map symbol. $\mathcal{P}kg$, $\mathcal{P}kg_q$.

Nomenclature. Named as member of Staveley Formation and described by White (1957) and Carter & others (1961). Regarded in this report as a separate unit rather than as part of Staveley Formation.

Distribution. Crops out in N-trending synclinal belt up to 2 km wide in NW, N of Limestone Creek; extends northwards into Malbon Sheet area, where it is described by Noon (1978) as a member of Corella Formation. Outcrops in Selwyn region were mapped as Agate Downs Siltstone by White (1957) and as undivided Staveley Formation by Carter & Opik (1963).

Type section. In Malbon Sheet area (Carter & others, 1961 - part of type section for Staveley Formation).

Reference section. From GR 388205 to GR 399205.

Thickness. Probably about 500 m.

Airphoto characteristics. Forms strike-ridges showing bedding trends; pale ($\mathcal{P}kg_q$) to medium ($\mathcal{P}kg$) tones.

Rock types. Mainly phyllitic metasiltstone ($\mathcal{P}kg$) and quartzite ($\mathcal{P}kg_q$).

$\mathcal{P}kg$: pale grey or ironstained to brown or maroon phyllitic metasiltstone, locally silicified; minor dark grey slate; some calcareous and ferruginous arenite and siltstone, in places showing cross-bedding and ripple marks, near base, underlying $\mathcal{P}kg_q$.

Pkg$_q$: white to pale grey fine-grained quartzite; well-developed bedding plane lamination present, but no cross-bedding; brecciated and hematitic in places; forms marker bed outlining fold structures.

Structure and metamorphism. Facing given by cross-bedding indicates that the Agate Downs Siltstone forms a major isoclinal syncline. This fold plunges N at about 50°, and its axial plane dips steeply E. Tight to isoclinal small and medium-scale subsidiary folds are common, especially at closure of main fold in S. The rocks in the syncline appear to be regionally metamorphosed to only low or middle greenschist grade.

Relations. Conformably overlies Staveley Formation; not intruded by metadolerite.

Age. Middle or Early Proterozoic.

Correlations. May be equivalent to part of Staveley Formation to S.

Mineralisation. None known in Sheet area.

Remarks. Overlies Staveley Formation, rather than forming the lower part of this formation, as was suggested by White (1957).

DESCRIPTIVE NOTES ON PRECAMBRIAN INTRUSIVE UNITS

Metadolerite

Map symbols. dl, and unlabelled dyke symbol.

Nomenclature. Mapped as intrusive pre-granite metadolerite by White (1957) and Carter & Opik (1963). Previously thought earlier to be mainly extrusive flows (Honman, 1941; Searl, 1952).

Distribution. Widespread in area, most extensive in NW; forms sills, dykes, and pod-like bodies intruding all Precambrian formations except Agate Downs Siltstone, does not intrude granite.

Thickness. Variable; many dykes (or sills) in Kuridala Formation are only a metre or so wide, whereas some bodies are several hundred metres thick. Many large bodies in NW are multiple sills in which individual intrusions are separated by thin screens of country rock.

Airphoto characteristics. Mainly forms depressions, as generally less resistant to erosion than adjacent rocks, but craggy outcrops are present in places (e.g., at GR 608991, near Mount Ulo); has characteristic smooth dark tone.

Rock types. Metadolerite commonly showing some relict igneous features, especially ophitic texture and small plagioclase phenocrysts; schistose to massive amphibolite; minor 'aplite' (granophyre?) veins in places (e.g., at GR 496040).

Metadolerite: mainly dark bluish or greenish grey where fresh, and black on weathered surfaces; fine-grained (at margins) to medium-grained or gabbroic (in centres of large intrusions); some compositional banding (pale and dark layers) in gabbroic metadolerite in some of large sills in NW and near Mt Ulo (at GR 613995); foliated to schistose, especially at margins, to massive; locally brecciated and/or epidotic where intruding Corella Formation. Most samples examined in thin section (Table 7) consist of plagioclase (oligoclase/andesine, commonly partly altered) + green amphibole (mainly hornblende, but commonly actinolite in W) $\pm$ minor relic clinopyroxene (mainly in W) and accessory biotite, quartz, and opaque minerals; secondary epidote and chlorite are common; scapolite is present in some metadolerite intruding calc-silicate rocks, mainly in place of plagioclase (e.g., in small metadolerite body, not shown on map, at GR 465075); some pale bands in large sill W of Mt Ulo (at GR 613995) consist of hornblende granodiorite.

Structure and metamorphism. Metadolerite forms mainly steeply dipping to vertical intrusions. The larger bodies are generally pod-like in Corella Formation, but elsewhere are mostly sheet-like. Some sills outline fold closures. Mineral assemblage of oligoclase/andesine + hornblende in central and eastern part of region and in far NW indicates regional metamorphism to amphibolite grade; predominance of actinolite with some relic clinopyroxene in W, mainly in metadolerite intruding Answer Slate and Staveley Formation, indicates some metamorphism to only greenschist grade.

Relations. Intrudes Soldiers Cap Group and Corella Formation in E, and unnamed metamorphics, Argylla Formation, Marraba Volcanics, Mitakoodi Quartzite, Answer Slate, Staveley Formation, and Kuridala Formation (but not Agate Downs Siltstone or unit Pks$_x$ of Staveley Formation) to W; intruded and locally hornfelsed by Williams Granite and Gin Creek Granite; overlain by Mesozoic sediments. Some metadolerite bodies intruding Corella Formation have irregular cumulose contacts, indicating possible emplacement in soft, unconsolidated sediments. An intricately 'brecciated' contact between metadolerite and Kuridala calc-silicate rocks exposed at GR 460073, NW of Mount Dore, resembles that of metadolerite and Corella calc-silicate rocks in Mount Philp Breccia in Duchess Sheet area (Bultitude & others, 1978).

Mineralisation. Co and minor Cu, W, and U occur in a shear zone along a metadolerite/schist contact at Mount Cobalt Mine (GR 473960). Many of the mineral deposits in the region occur close to metadolerite intrusions but none are contained within metadolerite.

Remarks. Metadolerite intrusions pre-date emplacement of Williams Granite and at least part of Gin Creek Granite. Most appear to have been intruded before the enclosing country rocks were folded and metamorphosed (i.e., pre-date F_1 and S_1).

Cowie Granite
(new name)

Map symbol. Pgc.

Nomenclature. Named after Cowie prospect, GR 862890, 10 km ESE of Squirrel Hills homestead, Selwyn region. Previously mapped as part of Williams Granite (Carter & Opik, 1963).

Distribution. Crops out in belt up to 3 km wide trending NNE for 11.5 km from a point 4.5 km W of Cowie prospect, centred on GR 855940.

Type area. 5 km NNW of Cowie prospect, at GR 850937, where the characteristic features of the granite are well displayed.

Table 7. Metadolerite, amphibolite, and dolerite: petrographic data

Sample no. (prefix 7853)	Location (GR)	Quartz	K-feldspar	Plagioclase	Muscovite	Biotite	Amphibole	Clinopyroxene	Scapolite	Sphene	Apatite	Tourmaline	Opaques	Epidote	Calcite	Chlorite	Sericite	Other minerals; rock name
Metadolerite, amphibolite																		
0307A	464075	x				x	X		X	x			x					Scapolitic metadolerite
0309	459075			X		x	x	X		†			x	†			†	Metadolerite
0309A	459075			X		x	X						x	†				Metadolerite
0365	481037	x		X		X												Hornfels (metadolerite?)
0413A	562055			X		†	X			x	†		x	†				Amphibolite
0435	616995			X		†	X			x			†	†		†	†	Metadolerite
0435A	613995	X	x	X			X			x			x		†	†		Granodiorite band in sill
0462	861221	X	x	X			X			x								Tonalitic amphibolite
0462A	861221						X	x	X	†	†		†	†			†	Scapolitic amphibolite
0838	511998	x		X		x	X	x					x					Orthopyroxene metadolerite
1070	881023			X			X	X					x		†			Metadolerite
1111	928155	x		X			X	x		†			†				†	Amphibolite
1207	977928	x		X			X	x	X		†	†	x					Scapolitic amphibolite
1240B	855950			(X)			X	x		†	†		†				†	Amphibolite
1343	657838			X			X			x	†		†					Metadolerite
1405	547825	x		X			X	†		x	x		x	x				Metadolerite
4322	278112			X			X			†			†					Metadolerite
4462	288221			X		†	X						x	†		†		Metadolerite
Dolerite																		
0526	905124	x	x	X			†	X					x					Orthopyroxene x; olivine? (†);
1670A	822087	X	X	X		x	x	X			†		x					

X, major constituent (>10% of rock) ( ), pseudomorphed
x, minor constituent (1-10% of rock)
†, trace constituent (<1% of rock) or alteration product

Airphoto characteristics. Gives rise to undulating terrain with a few rocky knolls (does not form spheroidal boulders); has pale to medium tones.

Lithology. Consists of heterogeneous, biotite-bearing leucocratic granitic rocks - granite, granodiorite, and tonalite - forming blockly to rubbly and friable exposures. Contains numerous irregular inclusions of Soldiers Cap-type rocks, some many metres across, and in places appears migmatitic.

Granitic rocks: pale pinkish, brown weathering; fine-grained to pegmatitic; massive to moderately foliated; not porphyritic; samples (Table 8) examined in thin section consist mainly of strained quartz (30-50%), albite/oligoclase (30-60%, some myrmekite), microcline (30-40% in 2 samples), biotite (up to 5%), and opaque minerals (less than 1%).

Structure and metamorphism. Foliation, when present, appears concordant with that of enclosed and adjacent Soldiers Cap rocks. Local alteration such as bleaching of biotite and sericitisation of feldspar probably related to post-emplacement regional metamorphism.

Relations. Intrudes and forms migmatitic complexes with Soldiers Cap Group; also intrudes Corella Formation; inferred to be intruded by Williams Granite (Pgi) to W as it is cut by small bodies of porphyritic microgranite considered to be related to Williams Granite.

Age. Middle or Early Proterozoic.

Correlations. Probably related to Blackeye Granite to E and to Marramungee Granite and unnamed granite to N.

Mineralisation. None known.

Remarks. Probably a syntectonic granite intruded during the main metamorphic event affecting the Corella Formation and Soldiers Cap Group, and therefore older than Williams Granite to W.

Blackeye Granite

(new name)

Map symbol. Pge.

Nomenclature. Named after Blackeye Creek, a tributary of which drains outcrop area. Blackeye Creek joins the McKinlay River near Answer Downs homestead, close to the eastern edge of the Selwyn region (at GR 995045). Previously mapped as Williams Granite (Carter & Opik, 1963).

Distribution. N-trending outcrop 1.8 km long and 0.4 km wide located 6 km WNW of Glenholme homestead, centred at GR 908978.

Type area. Central part of outcrop area.

Airphoto characteristics. Forms low hilly terrain with some spheroidal boulders and small tors; pale tones, in contrast to adjacent Corella Formation.

Lithology. Consists of fine-grained leucocratic granodiorite and minor quartz-feldspar pegmatite.

Granodiorite: pale pink to grey; not porphyritic; vertical N-trending foliation and jointing generally prominent; samples examined in thin section (2, see Table 8) consist of quartz (30%), orthoclase (15%), sodic plagioclase (50%), ferromagnesian minerals (5%, biotite + hornblende in one sample, clinopyroxene + secondary amphibole in other), and minor sphene, epidote, chlorite (secondary after biotite), and opaque minerals.

Structure and metamorphism. Foliation is parallel to banding/bedding in adjacent Corella Formation. Secondary chlorite after biotite and amphibole after clinopyroxene probably formed during a metamorphic event postdating emplacement of the granite.

Relations. Intrudes Corella Formation; intrusive contact irregular in detail, lit-par-lit in part, and numerous granitic and pegmatitic veins penetrate adjacent calc-silicate rocks.

Table 8. Cowle, Blackeye, and Marramungee Granites and unnamed granite: petrographic data

Sample no. (prefix 7853)	Location (GR)	Quartz	K-feldspar	Plagioclase	Muscovite	Biotite	Amphibole	Clinopyroxene	Sphene	Apatite	Zircon	Tourmaline	Opaques	Epidote	Calcite	Chlorite	Sericite	Other minerals; rock name	C
Cowle Granite																			
1093	881972	X	?	X		(x)					†		x	†				Granite?	2
1101	876963	X		X		x							x					Tonalite	10
1103	873977	X	X	X		x							x					Granite	3
1228	851939	X	X	X	†	†												Granite	1
1240A	855950	X		X													†	Tonalite	0
Blackeye Granite																			
1185A	906987	X	X	X			†	x	†				†	†		†		Granodiorite	7
1187	904982	X	X	X		x	x		†				†	†		†		Granodiorite	8
Marramungee Granite																			
0515	902146	X	X	X	†	x				†	†		†	†		†	†	Granite	3
0516	901149	X		X		X				†			x	†		†		Tonalite	12
0518	907141	X	X	X	†	(x)			†	†	†			†	†	†		Rutile?,t; Granodiorite	5
0541	906104	X	X	X	†	x				†			x	†		†		Granite	5
Unnamed Granite																			
0426B	572082	X		X		x	x			†	†		x					Tonalite SE of Selwyn	15
0462A	861221	X	X	X		x				†			†					Aplite vein cutting dl	2
0565	870109	X	†	X		†	x			†	†		†	†			†	Tonalite	5
0577	914940	X	X	X	†				†				†	†	†	†		Granite vein cutting Pkc	1
0992	851168	X	x	X		x	x	†	x	†	†		†	†		†		Granodiorite	8
1108	974196	X	X	X	†	x				†			x			†		Granite	10

X, major constituent (>10% of rock)
x, minor constituent (1-10% of rock)
†, trace constituent (<1% of rock) or alteration product
(), pseudomorphed

Age. Middle or Early Proterozoic.

Correlations. Probably similar in age to Cowie and Marramungee Granites.

Remarks. Considered to be a syntectonic granite related to main metamorphic event affecting adjacent Corella Formation.

Marramungee Granite

Map symbol. Pgr.

Nomenclature. Named after Marramungee Creek, branches of which drain northern part of outcrop area, Selwyn region. Previously mapped as part of Williams Granite (Carter & Opik, 1963).

Distribution. NNE-trending outcrop 5 km long and up to 1 km wide in NE of Selwyn region, centred at GR 905130, 12 km NW of Answer Downs homestead.

Type area. Central part of outcrop area.

Airphoto characteristics. Forms low hills and some prominent tors; outcrop area has pale tones, much paler than adjacent Soldiers Cap Group.

Rock types. Heterogeneous leucocratic granite, granodiorite, and tonalite; pegmatite; local migmatite (at margins of intrusion).

Leucocratic granitic rocks: white, pale pink, and pale grey; mainly medium to fine-grained, also pegmatitic; massive to strongly foliated; commonly exposed as spheroidal and ellipsoidal boulders; locally sheared and generally somewhat recrystallised; small 'rust' spots (after pyrite?) common; xenoliths of Soldiers Cap rocks common near margins. Samples examined in thin section (Table 8) consist largely of quartz (30%), sodic plagioclase (30-60%) and microcline (0-30%) showing some alteration to sericite, muscovite, epidote, and biotite (3-10%) partly altered to chlorite ± epidote ± muscovite.

Structure and metamorphism. Foliation in granite is grossly concordant with that of adjacent Soldiers Cap rocks; alteration of biotite and feldspar and partial recrystallisation are attributed to post-emplacement metamorphism.

Relations. Intrudes Soldiers Cap Group; contacts smooth and concordant to irregular, and are lit-par-lit in N; abundant granite and pegmatite veins and pods occur within adjacent country rocks. Cut by E-trending dolerite dyke, adjacent to which the granite is reddened.

Age. Middle or Early Proterozoic.

Correlations. Probably related to Cowie and Blackeye Granites.

Mineralisation. None known; granite is spatially (but probably not genetically) related to Zn and Cu mineralisation in banded iron formation of Soldiers Cap Group at Marramungee prospect.

Remarks. Probably a syntectonic body emplaced during the main folding and metamorphic event affecting the Soldiers Cap Group, hence pre-F_2.

Unnamed granite

Map symbol. Pg.

Distribution. Several small outcrops in NE, to E of Williams Granite, and one to W, 12 km SE of Selwyn, at GR 572082. Main outcrops previously mapped as Williams Granite (Carter & Opik, 1963).

Airphoto characteristics. Forms mainly low hilly terrain, lower than that of adjacent Precambrian units; exposed in places as spheroidal boulders; pale to very pale tones.

Rock types (Table 8). In NE: mainly heterogeneous leucocratic granite, granodiorite, tonalite, and quartz-feldspar pegmatite; biotite granite at GR 974196. SE of Selwyn: medium to fine-grained hornblende-biotite tonalite and minor aplitic to pegmatitic veins; not foliated.

Leucocratic granitic rocks: white, pale pink, pale grey; fine to coarse-grained and pegmatitic; moderately to strongly foliated and recrystallised; include abundant blocks ('rafts') many metres across of Corella calc-silicate rocks.

Structure and metamorphism. Foliation in unnamed granite in NE is more or less concordant with that of adjacent rocks; subconcordant veins of unnamed granite in banded calc-silicate rocks of Corella Formation locally show tight to isoclinal folds (e.g., at GR 852180); recrystallisation of granitic rocks in NE is probably related to the main metamorphic event affecting the Corella Formation.

Relations. Intrudes Corella Formation and Soldiers Cap Group in NE, and Kuridala Formation SE of Selwyn; overlain by flat-lying Mesozoic sediments. Contacts with Corella Formation are highly irregular to lit-par-lit, and numerous veins and apophyses of granite and pegmatite cut adjacent calc-silicate rocks; as mapped, contacts represent approximate boundaries between areas consisting mainly of granite and those consisting mainly of calc-silicate rocks. Contacts with Kuridala Formation SE of Selwyn are not exposed.

Age. Middle or Early Proterozoic.

Correlations. Unnamed granite in NE is probably related to Marramungee, Cowie, and Blackeye Granites; that SE of Selwyn may be related to Williams Granite.

Mineralisation. None known.

Remarks. Unnamed granite in NE is presumed to be syntectonic, emplaced during the main folding and metamorphic event (F_1, S_1) recognised in the adjacent Corella Formation, and is probably anatectic.

Williams Granite

Map symbols. Pgi, Pgi_a, Pgi_g.

Nomenclature. Defined by Carter & others (1961); named after Williams River, in Mount Angelay Sheet area; described previously by Joplin & Walker (1961) and Carter & Opik (1963).

Distribution. Crops out extensively in Selwyn region between longitudes 140°53' and 140°27' and N of latitude 21°51'; extends N into adjoining Mount Angelay (Donchak, & others, 1979) and Malbon (Noon, 1978, 1979) Sheet areas. Three main outcrop areas in Selwyn region: in E, from S of Squirrel Hills homestead to N edge of map area (Pgi); in N central part, SE of Selwyn; and in S central part, mainly E of Mort Creek (Pgi$_a$). Also forms small stock at GR 510000 mapped as Pgi$_a$, and a poorly exposed 'roof zone' near GR 550960 also mapped as Pgi$_a$, both surrounded by Kuridala Formation. Some additional isolated outcrops (Pgi) occur 10 to 15 km S of Squirrel Hills homestead on E side of Bustard Creek, partly covered by Cainozoic alluvium. Some parts shown as Williams Granite by Carter & Opik (1963) are now mapped as Cowie, Marramungee, and Blackeye Granites and unnamed granite.

Reference areas. N of Pegmont prospect, at GR 662855 for Pgi; at GR 522908 for Pgi$_a$; at GR 843112 for Pgi$_g$.

Airphoto characteristics. Variety of landforms in outcrop areas; steep-sided plateaus, mesas, and buttes capped by weathered granite or flat-lying Mesozoic sediments; knobbly tors with spheroidal boulders; low hilly to undulating terrain formed on friable weathered granite; and plains with scattered, barely exposed, spheroidal boulders. Tones on airphotos range from white to pale on bleached and pale weathering granite, to medium on fresh granite and some weathered cappings, and to dark where strongly ironstained and lateritised.

Rock types. Pgi, porphyritic granite, minor even-grained granite; Pgi$_a$, mainly non-porphyritic granite; Pgi$_g$, greisen and chloritised granite; also minor granodiorite, monzonite, and aplite, and rare pegmatite; Pgi$_a$? in central part of area, near GR 550960, consists of highly weathered and altered coarse-grained igneous-looking rock consisting mainly of quartz and actinolite (sample 78530929 in Table 9). The granitic rocks are shades of pink and, less commonly, grey and yellow. They characteristically appear homogeneous and generally are not foliated. Local shearing and quartz veining (e.g., in SE, at GR 815891) is probably associated with faulting. In places phenocrysts show some 'flow' alignment. Xenoliths are generally rare. Exposed granite is variably weathered and friable, and only rarely fresh, even inside spheroidal boulders. Hematite-filled inclined joints/faults are present in places (well displayed at GR 725895, 4 km SW of Squirrel Hills homestead). Petrographic data is summarised in Table 9.

Porphyritic granite: abundant microcline (mainly pink) and sodic plagioclase (mainly white to greyish) megacrysts/phenocrysts from 1 cm to over 2 cm across set in mainly medium-grained groundmass; samples examined in thin section contain biotite and/or hornblende ± clinopyroxene, and several contain 1-5% sphene; feldspar megacrysts are subhedral to anhedral, poikilitic, and commonly composite and partly intergrown; quartz, absent in one sample (78531233), is variably strained (recrystallised to granular mosaic in a few samples), and locally occurs in graphic intergrowths with microcline and myrmekitic intergrowths with plagioclase; microcline and plagioclase occur in about equal amounts in most samples; microcline is commonly perthitic; plagioclase, mainly oligoclase, commonly shows weak normal zoning and some alteration to sericite/muscovite; biotite is brown, reddish brown, or greenish brown, and shows alteration mainly to chlorite; amphibole ranges from dark blue-green to pale green; clinopyroxene is very pale green or colourless and shows uralitic alteration.

Non-porphyritic granite: medium to coarse-grained; mainly even-grained, but locally contains some slightly megacrystic feldspar; samples examined in thin section are generally similar in petrography to porphyritic granite but are richer in biotite (up to 15%), and none contain clinopyroxene.

Pgi$_g$: greisen and chloritised granite; forms small patches in Pgi in NE (near GR 840110).

Aplite; sparse veins and patches present at most granite exposures.

Pegmatite: rare, except in some granite contact areas; consists mainly of quartz and feldspar; in south, near Pegmont prospect, abundant veins of tourmaline-bearing muscovite granite and pegmatite, probably related to Williams Granite, cut Kuridala Formation.

Structure and metamorphis. The granite is not foliated, nor has it been recrystallised, and metamorphic effects appear to be largely restricted to straining of quartz and alteration of biotite to chlorite and plagioclase to sericite/muscovite.

Relations. Intrudes Soldiers Cap Group, Corella Formation, and Cowie Granite in E, and Kuridala Formation and metadolerite in W and S; intruded by E-trending dolerite dykes; overlain by flat-lying Mesozoic sediments.

Intrusive contacts: well exposed at numerous localities; cross-cutting to subconcordant; commonly irregular in detail, but only at a few localities (e.g., near Pegmont Prospect and 10 km to NNW) do granitic veins penetrate far into adjacent country rock; no apparent chilling at margins; bedding and foliation in country rocks are not distorted by granite at cross-cutting contacts, and thermal metamorphic effects are apparent at only a few localities (e.g., within 100 m of granite near GR 502911, GR 525886, and GR 528168, and around small stock at GR 510 000), mainly in Kuridala Formation.

Age. Probably Middle Proterozoic; younger than all Proterozoic sedimentary rocks in area.

Mineralisation. None known in area.

Remarks. The Williams Granite forms several intrusive bodies. Features such as general lack of foliation, mainly cross-cutting intrusive contacts, little associated thermal metamorphism, and undisturbed bedding in adjacent country rocks indicate post-tectonic emplacement by stoping at epizonal or mesozonal depths. Emplacement clearly post-dates the main folding and metamorphic events affecting adjacent Proterozoic rocks. The shapes of the eastern and north-western granite masses appear to be partly controlled by pre-existing structures, as overall they are concordant to subconcordant with regional trends. However, the southwestern granite mass trends E, strongly oblique to the NNE-trending Kuridala Formation, and its shape cannot be related to any obvious structural feature.

Gin Creek Granite

Map symbol. Pgg.

Nomenclature. Named after Gin Creek, a tributary of Mort Creek, and Gin Creek bore (GR 378988), in W of Selwyn region. Gin Creek and its tributaries drain most of main outcrop area of unit. Named Gin Creek Granite and briefly described, but not defined, by White (1957); also mentioned by name in Brooks (1960). Included within Williams Granite by Carter & others (1961) and Carter & Opik (1963).

Table 9. Williams Granite: petrographic data

Sample no. (prefix 7853)	Location (GR)	Quartz	K-feldspar	Plagioclase	Muscovite	Biotite	Amphibole	Clinopyroxene	Sphene	Apatite	Zircon	Tourmaline	Opaques	Epidote	Calcite	Chlorite	Sericite	Other minerals; remarks	
Porphyritic granite (mainly Pgl)																			
0587	678877	X	X	X			x	x	x	†			†	†					10
0599	608899	X	X	X	†	x			†	†	†		†	†	†	†			10
1232	845943	X	X	X		x	x	x	x	†			x			†			15
1233	843945		X	X			†	X	x	†								Monzonite	15
1234	844938	X	X	X		x	x		x		†		†	†			†		10
1293	859983	X	X	X			x	†	x	†	†		x	†				Metamict mineral, †	8
1313	807945	X	X	X			x		†	†	†		x	†				Microgranite	8
1315	773918	X	X	X			x	x	x	†	†			†					10
1371	662855	X	X	X		x	x		x	†	†		x			†		fluorite, †	10
1714	760770	X	X	X	†	x				†	†		x	†	†	†	†	fluorite, †	10
1772	816881	X	X	X		(x)	x		x	†	†		x	†	†	†	†	Sheared/foliated	7
Non-porphyritic granite (mainly Pgl_a)																			
0263	489131	X	X	X	†	x				†	†		x			†		Allanite, †; fluorite, †	8
0291	473095	X	X	X	†	x	x		x	†	†		x	†		†	†	Allanite, †; fluorite, †	5
0361	491043	X	X	X		x	x		x	x	†	†	x					Allanite, †; fluorite, †	15
0447	625003	X	X	X		x			†	†	†		†			†	†	Fluorite, x	5
0593	619906	X	X	X		x	x		†	†			†	†			†		7
0598	607900	X	X	X		X	x			†	†								10
0626	630898	X	X	X		X	x		x				†			†		Allanite, †	10
0699	584918	X	X	X	†	X			x	†	†		x		†	†	†		15
0837B	506003	X	X	X		X			x	†	†		x			†		Fluorite, †	15
0903	522908	X	X	X		X	x		x	†	†		x	†		†	†		20
1669	741044	X	x	X		(x)	x			†			x	†	†			Granodiorite	10
Altered granite, (Pgl_a and Pgl_g)																			
0904	528913	X		X	X					†								Greisen	0
0902	554958	X		(X)			X			†		†	x					Fluorite? †	15
1031	843112	x				x					†		x			X		Chloritic greisen	93

X, major constituent (>10% of rock) ( ), pseudomorphed
x, minor constituent (1-10% of rock)
†, trace constituent (<1% of rock) or alteration product

Distribution. Restricted to W part of region, W of Williams Granite. Two main outcrop areas, that to the E being much the larger, separated by outcrops, mapped as Staveley Formation ($\mathcal{E}ks_g$) and unnamed metamorphics ($\mathcal{E}lm$), in which there are many granitic veins. Also small outcrops at GR 322035 and GR 336080. Not as extensive as shown (as Williams Granite) on Duchess 4-mile map (Carter & Opik, 1963).

Type areas. 3 selected, as 3 main granite types of unit are not well represented in any one area: central part of western outcrop, at GR 360060, where tourmaline-muscovite granite is well exposed; E part of eastern outcrop, at GR 440040, which is representative of non-foliated biotite granite; and W side of eastern outcrop, at GR 410030, where foliated biotite granite containing raft-like inclusions, mainly of schist, predominates.

Airphoto characteristics. Forms low hills and undulating terrain, and mesas and buttes capped by weathered granite and/or Mesozoic sediments; tors and spheroidal boulders are present locally in east, but most exposures consist mainly of blocky and rubbly rock; mainly pale tones.

Rock types. Foliated biotite granite, non-foliated biotite granite, and tourmaline-muscovite granite (Table 10); minor pegmatite and aplite veins; sheared in places; locally includes large raft-like blocks of country rocks, mainly mica schist but also some quartz-hematite rock.

Foliated biotite granite: predominates on W side of eastern outcrop area; pink to grey; mainly medium to coarse-grained; weakly foliated to gneissic and migmatitic; feldspar phenocrysts commonly present; in north of eastern outcrop is mostly fine-grained, recrystallised, and weakly porphyritic - sample examined in thin section (78534132) contains deformed phenocrysts of partly altered microcline and zoned plagioclase, granulated quartz, biotite (less than 5%) largely altered to chlorite, and minor muscovite and Fe-Ti oxides.

Non-foliated biotite granite: predominates on east side of eastern outcrop area; pink or pale grey; medium to coarse-grained and locally porphyritic; xenoliths rare; petrographically similar to Williams Granite (mainly $\mathcal{E}gi_a$).

Tourmaline-muscovite granite: forms most of western outcrop area and locally dominant in eastern outcrop area, where it commonly occurs as veins cutting other granite types; white to pale pink; medium to coarse-grained and locally pegmatitic; generally even-grained though some feldspar is weakly porphyritic in places; not foliated.

Westernmost outcrop, at GR 322035, consists of pinkish medium to fine-grained biotite granite, greisen, and tourmaline and quartz veins. In N, at GR 336080, medium to fine-grained leucocratic biotite granite is exposed in a creek bed. At both localities the granite is even-grained and not foliated.

Structure and metamorphism. Foliation, where present, generally parallel to that of adjacent country rocks. Only foliated granite appears to be metamorphosed.

Relations. Intrudes unnamed metamorphics (Zlm), Answer Slate, Kuridala and Staveley Formations, and metadolerite; overlain by flat-lying Mesozoic sediments in S. Intrusive contacts are sharp, though locally intricate, and those of foliated granite are commonly lit-par-lit. Veins and apophyses of granite and associated pegmatite and aplite are common in adjacent country rocks for 1 km or more from mapped granite contacts, and are especially abundant between the two main granite outcrop areas and in unnamed metamorphics. Hornfels zone about 100 m wide locally present adjacent to granite in E (e.g., near GR 445040).

Correlations. One of main granite types, non-foliated biotite granite, appears identical to much of Williams Granite (Zgi_a), and may be related to this granite. Another main type, tourmaline-muscovite granite, may be related to tourmaline-muscovite granite forming veins cutting Kuridala Formation in southern central part of region, near Pegmont prospect and to SSW, S of Sandy Creek. Foliated biotite granite is possibly much older than the other two types, and may be similar in age to the unnamed metamorphics.

Age. Middle and/or Early Proterozoic.

Table 10. Gin Creek Granite: petrographic data

Sample no. (prefix 7853)	Location (GR)	Quartz	K-feldspar	Plagioclase	Muscovite	Biotite	Amphibole	Clinopyroxene	Sphene	Apatite	Zircon	Tourmaline	Opaques	Epidote	Calcite	Chlorite	Sericite	Remarks; rock type	
0782A	441995	X	X	X	X					†		×					†	Vein cutting Pkr; tourmaline-muscovite granite	8
4132	419082	X	X	X	†	×							×			†		Porphyritic; foliated biotite granite	5
4178	364054	X	X	X	×					†		×					†	Tourmaline-muscovite granite	5
4431A	408168	X	X	X	×	†			†	†		†	†			†		Porphyritic muscovite granite; vein cutting Pks	5
4742	423123	X	X	X		×											†	Lit-par-lit veins of biotite granite with schist	5

X, major constituent (>10% of rock)
x, minor constituent (1-10% of rock)
†, trace constituent (<1% of rock) or alteration product

Mineralisation. None known in granite itself, but some in Staveley Formation veined by granite at Belgium copper mine (GR 431120) and nearby Utah uranium prospect (Brooks, 1960).

Remarks. Gin Creek Granite consists of three main, spatially associated, granite types, and probably represents several separate intrusions. Foliated to gneissic and migmatitic granite is probably syntectonic, and is considered to represent the oldest intrusion(s); some recrystallised granite in N may be late tectonic, as in places it cuts across the regional foliation; non-foliated biotite granite, like Williams Granite, cuts across foliation and bedding in adjacent country rocks, and is clearly post-tectonic. Tourmaline-muscovite granite cuts across other granite types, and is the youngest phase of Gin Creek Granite exposed.

Dolerite

Map symbol. Unlabelled dyke symbol.

Distribution. Forms dykes trending east to east-northeast in NE and N central parts of area. One dyke in NE mapped from E side of Soldiers Gap Group outcrop westwards, with several offsets to the S, to near western margin of main Williams Granite outcrop. Two dykes mapped to W: 15 km SE of Selwyn, at GR 625074, and 3 km SSE of Mount Dore mine, at GR 482018; both cut Kuridala Formation and metadolerite; another small dyke, not shown on map, is located at GR 472014.

Thickness. 10 m to about 50 m.

Airphoto characteristics. Forms mainly shallow linear depressions, but occurs as a low ridge in places where it crosses Williams Granite; has a mainly smooth medium tone on aerial photographs.

Rock type. Non-metamorphosed, although generally somewhat altered, dolerite; medium grey, much paler than metadolerite; medium to fine-grained (finer-grained at margins); primary igneous texture preserved; massive; generally exposed as small corestones lying on surface, but occurs as spheroidal boulders where ridge-forming; 2 samples examined in thin section (Table 7) consist of

subophitic clinopyroxene (showing marginal alteration to uralitic amphibole) and orthopyroxene (pseudomorphed by chlorite in one sample), plagioclase laths (cores determined optically at about An_{90} in one sample, saussuritised in other), pseudomorphs after olivine? (one sample), interstitial micrographic quartz and untwinned K-feldspar, and minor Fe-Ti oxides, apatite, and biotite.

Structure and metamorphism. Forms steeply dipping to vertical dykes which are strongly oblique to regional bedding and foliation trends. Alteration probably deuteric.

Relations. The dykes cut Soldiers Gap Group, Marramungee Granite, Corella Formation, Williams Granite, Kuridala Formation, and metadolerite. They are overlain by Mesozoic sediments.

Age. Probably Late Proterozoic.

correlation. May be correlated with Lakeview Dolerite, which forms dykes to NW and has been dated (Rb-Sr) at 1140 ± 10 m.y. (Page, quoted in Wilson & Derrick, 1976). Similar dykes crop out in Mount Angelay Sheet area to north.

Remarks. The dolerite dykes are the youngest Precambrian rocks in area. They postdate the main tectonic and metamorphic events and the emplacement of Williams Granite.

BRIEF NOTES ON PHANEROZOIC UNITS

Cambrian

Cambrian sedimentary rocks of the Burke River Outlier/Structural Belt succession crop out in the west. The units present are as mapped and described by de Keyser (1968), modified after Carter & Opik (1963), and are part of a mainly concordant to locally interfingering shallow-marine sequence. They form low, gently sloping cuestas and plateau areas, and have mainly medium tones on aerial photographs. Beds are gently dipping to flat-lying, and the rocks have not been regionally metamorphosed. The succession is separated by a major unconformity from underlying Precambrian rocks and by a low-angle unconformity from overlying Mesozoic sediments. It does not appear to contain any mineralisation in the Selwyn area.

Mount Birnie Beds

Map symbol Clb; up to 200 m thick; consists of ferruginous sandstone, conglomerate, red and green shale, mudstone, and dolomite (tillite recorded only to W); may be Early to early Middle Cambrian in Selwyn area; oldest unit of succession, and unconformable on Precambrian rocks; overlain conformably or disconformably by unit Cmt.

Thorntonia Limestone?

Map symbol Cmt; mapped as 'quartzite' overlying and possibly part of Thorntonia Limestone by de Keyser (1968); directly overlies Mount Birnie Beds in Selwyn area; generally less than 10 m thick; consists of black and grey convoluted chert, chert nodules, and silicified beds; probably Middle Cambrian; overlain by Roaring Siltstone.

Roaring Siltstone

Map symbol Cmr; up to 75 m thick; consists of bedded siltstone, fine-grained sandstone, and subordinate chert/siliceous shale; Middle Cambrian.

Pomegranate Limestone

Map symbol Cup; may be up to 30 m thick; consists of limestone, some marl and breccia, and minor chert; Late Cambrian.

O'Hara Shale

Map symbol Cuh; up to 85 m thick; consists of siltstone and minor chert and sandstone; no exposed contacts with other Cambrian or older units; Late Cambrian; generally capped by lateritic gravel (mapped as Tl).

Chatsworth Limestone

Map symbol Cuc; may be over 50 m thick; consists of limestone and some breccia and marl; Late Cambrian.

Mesozoic

The Mesozoic in the area is represented by flat-lying sediments. These are correlated with those of the Eromanga Basin to the E, following Senior, Mond, & Harrison (1978). Four formations are represented, the most extensive being Gilbert River Formation; the other three belong to Rolling Downs Group. They are not known to be mineralised in the Selwyn region, although one unit, Toolebuc Formation, contains potentially economic oil shale deposits in areas to E.

Gilbert River Formation

Map symbol: JKg.

Nomenclature: defined by Laing & Power (1959); mapped as Gilbert River Formation in eastern part of region by Senior & others (1978); mapped as undifferentiated Mesozoic by Carter & Opik (1963).

Distribution: extensive exposures in N, E central, S central and SW parts of region.

Type area: in Georgetown 1:250 000 Sheet area.

Thickness: maximum probably about 100 m (east of Selwyn).

Airphoto characteristics: forms cappings on plateaus, mesas, and buttes; mainly pale to medium tones on cappings and white on scarp faces.

Rock types: fine to coarse, quartzose to sublabile sandstone, grit, and pebbly sandstone; conglomerate, (mainly at or near base), containing mostly locally derived subangular pebbles and cobbles; claystone, mainly in upper part. Sediments bleached to ironstained; thick to thin-bedded; cross-bedding common.

Relations: overlies weathered Precambrian and Cambrian rocks; overlain in places by thin veneer of lateritic gravel; erosional unconformity at base, wi local relief of about 100 m to E of Selwyn; uncertain if underlying rocks, we weathered before or only after being covered by Mesozoic sediments.

Age: Upper Jurassic? to Lower Cretaceous.

Correlations: probably stratigraphically equivalent to part of Wallumbilla Formation to S.

Remarks: represents non-marine and shallow-marine sediments.

Wallumbilla Formation

Map symbol: Klu.
Nomenclature: defined by Vine & others (1967); previously mapped as Wilgunya Formation (Casey, 1959; Carter & Opik, 1963).
Distribution: crops out in S and SW.
Type area: in Roma 1:250 000 Sheet area.
Thickness: maximum probably about 100 m.
Airphoto characteristics: forms low plateaus and mesas with pale to medium tones.
Rock types: interbedded bluish grey to bleached or ironstained mudstone and siltstone; minor poorly sorted sandstone and conglomerate bands; some highly ferruginous bands in south, at GR 615765; medium to thin-bedded.
Relations: unconformable on Precambrian units (Soldiers Cap Group and Kuridala Formation) and on Cambrian Chatsworth Limestone.
Age: Lower Cretaceous (Aptian/Albian).
Correlations: part of formation is probably equivalent to part of Gilbert Riv Formation to N.
Remarks: represents shallow-marine sediments.

Toolebuc Formation

Map symbol: Klo
Nomenclature: termed Toolebuc Formation by Senior & others (1978); defined as Toolebuc Member of Wilgunya Formation by Casey (1959) and as Toolebuc Limestone by Vine & others (1967); previously mapped in area as Toolebuc Memb (Carter & Opik, 1963).
Distribution: crops out near eastern margin of area.
Type area: in Boulia 1:250 000 Sheet area.
Thickness: up to 25 m.
Airphoto characteristics: forms pale toned cuestas/terraces a few metres high.
Rock types: mainly flaggy and concretionary limestone and calcareous sandstone; white, pale grey, pale pink and buff; richly fossiliferous.
Relations: may be unconformable on Precambrian rocks and/or conformable on concealed Wallumbilla Formation to W; overlain conformably by Allaru Mudstone to E.
Age: Lower Cretaceous (Albian).
Remarks: represents shallow-marine sediments.

Allaru Mudstone

Map symbol: Kla.
Nomenclature: defined by Vine & others (1967); previously mapped in area as part of Wilgunya Formation (Carter & Opik, 1963).
Distribution: restricted to SE corner of area.
Type area: in Richmond 1:250 000 Sheet area.
Airphoto characteristics: forms dark-toned mesas.
Rock types: mainly bluish grey mudstone with thin interbeds of calcareous siltstone.
Relations: conformable on Toolebuc Formation.
Age: Lower Cretaceous (Albian).
Remarks: represents shallow-marine sediments.

Cainozoic

Weathered cappings on bedrock

Map symbol. Stipple.

Distribution. Widespread; most extensive on granite; includes some areas mapped as lateritic Mesozoic rocks by Carter & Opik (1963).
Thickness. Probably up to 10 m.
Airphoto characteristics. Preserved on plateaus, mesas, and buttes; mainly pale to medium tones.
Rock types. Bleached to ironstained kaolinised bedrock, strongly weathered, but with pre-weathering textures and structures partly preserved; includes small patches of laterite in which original bedrock features are no longer recognisable.
Relations. Developed on Precambrian rocks; locally overlain by Mesozoic Gilbert River Formation.
Age. Forms part of erosion surface formed before Gilbert River Formation was deposited, but weathering is at least partly Cainozoic and is probably mainly Tertiary.
Remarks. Part of deep-weathering profile which also affects Gilbert River Formation; no convincing evidence found to indicate that some of weathering may be older than Gilbert River Formation.

Laterite

Map symbol. Tl.

Distribution. Mainly in far W; small remnants elsewhere, but generally not differentiated from weathered cappings on bedrock.

Thickness. Probably about 3 m.

Airphoto characteristics. Occurs as dark-toned veneer mainly on low plateaus and gentle dip slopes.

Rock types. Mainly pisolitic gravel in far W; some small patches of massive, layered, and pisolitic ironstone to E.

Relations. Lateritic gravel forms thin veneer on Cambrian O'Hara Shale in W; small patches of laterite to E are developed mainly on granite.

Age. Probably Tertiary (Twidale, 1964).

Limestone and minor chalcedony

Map symbol. Ts.

Distribution. Along general drainage depressions in SE and SW; that in SW was mapped as Noranside Limestone by Carter & Opik (1963).

Thickness. Possibly up to 15 m.

Airphoto characteristics. Forms low rises, with pale to medium speckled tones, in general depressions.

Age. Probably Tertiary.

Remarks. May result from evaporation of groundwater (cf. calcrete in The Granites-Tanami region; Blake, Hodgson & Muhling, 1979).

Relations. Surrounded (and underlain?) by unconsolidated Cainozoic detrital sediments (Cz).

Unconsolidated sediments

Map symbol. Cz.

Distribution. Widespread; most extensive in southern parts; mapped as Cza by Carter & Opik (1963).

Thickness. Over 15 m in places (Carter & Opik, 1963).

Airphoto characteristics. Forms flat to gently undulating plains, gently sloping alluvial fans, and river floodplains; smooth pale to medium tones.

Rock types. Unconsolidated alluvial, colluvial, and residual sand, silt, and gravel.

Age. Tertiary and Quaternary.

Remarks. Also occurs as a thin patchy cover on many areas mapped as bedrock.

STRUCTURE AND METAMORPHISM

Folding

Bedding and cleavage in the Precambrian formations generally trend between NNE and NNW and have steep to vertical dips. Folds are mostly isoclinal or nearly so, and range in size from major structures several kilometres across to minor folds only a few millimetres wide.

The major folds mapped are indicated on aerial photographs by bedding trend-lines showing fold closures. Because of a scarcity of clear facing evidence, anticlines can be clearly distinguished from synclines in only a few cases. Major folds are most apparent where there are outcrops of interlayered rocks of contrasting compositions, such as interbedded mica schist and meta-arenite in Kuridala Formation and interlayered metasediments and metadolerite sills in Answer Slate and Staveley Formation. No major folds have been mapped within outcrops of Soldiers Cap Group, Corella Formation, and Argylla Formation, as no fold closures have been located. However, minor folds are widespread in the Soldiers Cap Group and Corella Formation, and some of these may mirror major folds. Minor folds are also common within the Kuridala Formation and Answer Slate. Mesofolds, with limbs tens of metres long, have been identified locally within the Corella Formation.

Two main phases of folding can be recognised: an earlier phase, F_1, usually the most prominent, which was accompanied by the widespread development of an axial-plane cleavage/schistosity, S_1, and a generally less intense later phase, F_2.

A relatively detailed study of folding in a small area, about 5 km across, centred at GR 548998, within Kuridala Formation, has been made by Donchak. The exposures in this small area consist of interbedded meta-arenite, metasiltstone, and fine-grained mica schist. Cross-bedding in meta-arenite and metasiltstone indicates facings. In the W a relatively open F_1 anticline plunges 25° NNE, and an axial-plane S_1 cleavage dips steeply E; there is no

evidence of F_2 or S_2 structures. In the central part of the area, along the hinge zone of another NNE-trending F_1 anticline, local F_2 refolding is evident where horizontal to gently dipping S_1 surfaces in mica schist are crossed by N-trending subvertical S_2 crenulations. To the E, where the rocks exposed are mainly meta-arenites, and cleavages are less easy to identify, bedding (S_o) and schistosity (S_1) dip at moderate angles to the E, S_1 generally dipping more steeply than S_o; local reversals in dip of S_1 indicate the probable presence of some F_2 folding. Most of the mica schist in this area contains stubby porphyroblasts up to 3 cm long of andalusite; these overprint bedding but appear to be pre or syntectonic with respect to S_1, and are crenulated by F_2 folds.

The results of Donchak's study, together with the presence of a major isoclinal syncline overturned to the W and closed to the S in Staveley Formation (Pks_x) SW of Selwyn, suggest that most major folds in the western half of the Selwyn region may plunge N. One exception is an open F_2 synform/syncline, 23 km SE of Selwyn, which plunges gently south. On the basis of N-plunging folds prevailing, the overall structure of the western and central parts of the Selwyn area may be generalised as follows: the Staveley Formation occupies the central part of a major synclinorium, with unit Pks_x and Agate Downs Siltstone (Pkg) being preserved in the keels of subsidiary synclines; the Argylla Formation, Marraba Volcanics, Mitakoodi Quartzite, and Answer Slate crop out on the locally complexly folded western limb zone of this synclinorium; the Kuridala Formation to the east represents the corresponding anticlinorium; the unnamed metamorphics (Plm) remain an enigma.

The structural picture in the E is less clear, partly because of the uncertain age of the Corella Formation relative to that of the Soldiers Cap Group, and partly because of complications due to faulting. One possibility is that the Corella Formation occupies the central part of another synclinorium, the E and W sides of which are formed of Soldiers Cap Group; if this is correct, the Soldiers Cap Group would underlie the Corella Formation.

Faulting

Many faults are present in the Selwyn region, but only those with significant and/or mappable displacements are shown on the 1:100 000 scale geological map. Strike faults more or less concordant with bedding and with apparently only minor displacements are very common. They are represented by

narrow shears, especially along contacts between different rock types, and are probably related to the main folding event (F_1). Most of the faults mapped, however, post-date this event. Some faults were probably activated during emplacement of granite, especially Williams Granite. The youngest recognised is a N-trending fault in the NW which displaces Cambrian rocks of the Burke River Outlier but not, apparently, overlying Mesozoic rocks.

Regional metamorphism

Metamorphic assemblages in rocks of the Soldiers Cap Group and Corella Formation in the E indicate amphibolite grade regional metamorphism. Partial melting in these rocks, especially those of the Soldiers Cap Group, is evident from abundant veins and pods of leucogranite and pegmatite, and the local development of migmatite. Typical mineral assemblages are quartz + sodic plagioclase + microcline + biotite + muscovite ± garnet ± andalusite ± sillimanite in gneiss and schist; green hornblende + oligoclase/andesine ± clinopyroxene ± garnet in amphibolite; and amphibole + clinopyroxene + albite ± garnet in calc-silicate rocks. In general, the grade of metamorphism appears to increase slightly eastwards.

To the W the regional metamorphism appears to have been 'drier' and/or lower grade overall, and only at a few localities is there any evidence of partial melting. In the Kuridala Formation, considered to be the westward lateral equivalent of the Soldiers Cap Group, typical schists consist of quartz + biotite + muscovite ± alkali feldspar + porphyroblasts of andalusite, garnet, and less commonly staurolite, and interbedded calc-silicate rocks contain diopsidic clinopyroxene, indicating amphibolite grade metamorphism. The Staveley Formation in the NW appears to be somewhat less metamorphosed; well-preserved sedimentary structures and mineral assemblages of chlorite + biotite + sericite/muscovite + quartz + feldspar and of quartz + sodic plagioclase + actinolitic amphibole in unit Pks, quartz + sericite in unit Pks_x, and epidote + actinolite + albite in unit Pks_{xb} indicate probable lower or middle greenschist grade; however, porphyrobalsts of andalusite and staurolite in unit Pks_g indicate some local amphibolite grade metamorphism.

W of the Staveley Formation the regional metamorphism appears to increase from upper greenschist or lower amphibolite grade in the Answer Slate and Mitakoodi Quartzite to amphibolite grade in Marraba Volcanics and Argylla Formation. Unnamed metamorphic rocks (Plm) S of the Staveley Formation and E of the Answer Slate are also metamorphosed to amphibolite grade; the metamorphism of these rocks, however, appears to be more akin to that of the Soldiers Cap Group than to that of other units in the W. This difference in metamorphism between the unnamed metamorphic rocks and adjacent rock units is one reason why the unnamed metamorphic rocks may represent rocks form deeper in the crust carried to their present position during emplacement of Gin Creek Granite.

The main regional metamorphism is considered to be related to the same tectonic event as F_1 and S_1. The emplacement of the Cowie, Marramungee, and Blackeye Granites and unnamed granite, in the E, and possibly the foliated phases of Gin Creek Granite in the W, amy also have taken place during this event. Retrogressive metamorphism represented by the alteration of biotite to chlorite, clinopyroxene to actinolite, and feldspar and andalusite to sericite may be related to the F_2 folding event and/or emplacement of Williams Granite and non-foliated Gin Creek Granite.

Thermal metamorphism

Thermal metamorphic events are apparent locally within 100 metres or so of Williams and Gin Creek Granites where these granites intrude Kuridala Formation: some hornblende hornfels facies rocks containing andalusite, cordierite, and fibrolitic sillimanite are present at a few localities (see section on Kuridala Formation). The marked increase in metamorphic grade of the Staveley Formation towards Gin Creek Granite may be related to this granite.

ECONOMIC GEOLOGY

General

In the past the Selwyn region has produced significant amounts of copper, cobalt, and gold, some silica flux, and a minor amount of tungsten. Most production has come from the mines, Mount Elliott (24 920 tonnes Cu, 1 854 199 g Au), which closed in 1920, Answer (1032 tonnes Cu and 11 072 g Au to 1920), which also closed in 1920 but reopened as a Cu-leaching operation in 1974, and Mount Cobalt (778 tonnes Co), which closed in 1934. In addition to

these and other small mines, the region contains several copper, lead, zinc, tungsten, and uranium prospects and a barytes deposit.

Most of the copper mineralisation occurs in shear zones within carbonaceous slate, phyllite, and metasiltstone, mainly in Kuridala Formation (at Mount Elliott, Flora, Marilyn, Mariposa, Mount Dore, and Stuart mines), but also in Answer Slate (at Answer and Christmas Gift mines and Guess prospect). Some is also present in shears within interbedded mica schist and meta-greywacke of the Kuridala Formation (at ?Lady Ella, Mount Carol, Mount Cobalt, and New Hope mines) and in veins in metasediments of the Staveley Formation (at Belgium mine). Much of this mineralisation appears to be stratabound. Secondary copper minerals are commonly visible in metamorphosed basaltic lavas of the Soldiers Cap Group and Marraba Volcanics, but no copper has been mined from these units in the Selwyn region.

Cobalt has been produced only from Mount Cobalt mine. The ore here occurs in a shear zone along or close to the contact between metasediments of the Kuridala Formation and a metadolerite intrusion to the west.

Gold occurs in variable amounts in the copper ore-bodies. The ores richest in gold were those at Mount Elliott mine.

Tungsten mineralisation, in the form of scheelite, is present in the, Mount Cobalt lode. Total production is less than 250 kilograms of scheelite.

Silica flux has been obtained from Mount Carol mine. No production figures are available.

Copper-lead-zinc prospects occur within the Kuridala Formation and Soldiers Cap Group. At the best known prospect, Pegmont, stratiform lead, zinc, and subordinate copper mineralisation is contained in banded iron formation within Kuridala Formation. Almost identical mineralisation is present in similar banded iron formation within the Soldiers Cap Group at Cowie, Black Rock, and Marramungee prospects, and also at prospects farther north, in the Mount Angelay Sheet area (Donchak & others, 1979). The banded iron formation at all these localities could be at essentially the same stratigraphic level. It is a chemical sediment, and may be an exhalative deposit related to contemporaneous volcanism some distance away, possibly represented by some of the metamorphosed acid and basic volcanic rocks within the Kuridala and Corella Formations and the Soldiers Gap Group.

Two uranium prospects are located in the region, one at the Mariposa mine, in Kuridala Formation, and the other, the Utah prospect, located SE of the Belgium mine in the Staveley Formation. Neither appears to have any economic potential.

Barytes occurs in Answer Slate at GR 320196. According to White (1957), it is of good quality, and forms a lens-shaped body about 6 m thick surrounded by a zone of siliceous limonite. The deposit is about 138 m long, and occurs in chert and silicified slate near an intrusion of metadolerite.

Most, if not all, the mineralisation in the region has probably resulted from the concentration during tectonism of metals previously dispersed within the Precambrian succession, especially in pyritic and carbonaceous shale and banded iron formation: the metals migrated into structural traps (shears, veins, tension gashes) during folding, faulting, regional metamorphism, and igneous intrusion. Some lodes are situated close to bodies of granite and metadolerite, but none appear to be genetically related to such intrusions. However, some of the intrusions could have provided a source of heat to help mobilise the mineralising solutions.

At present several mineral exploration companies are active in the region. They are concentrating their search on Pegmont-type Pb-Zn-Cu deposits in both the Kuridala Formation and Soldiers Cap Group, and on stratabound Cu-Au deposits in the Answer Slate and Kuridala and Staveley Formations.

Quartz-hematite rocks

Massive, banded, and locally brecciated quartz-hematite rocks are common in the northwest, where they occur as predominantly concordant bodies within outcrops of unnamed metamorphic rocks, Mitakoodi Quartzite, Answer Slate, Staveley Formation, Agate Downs Siltstone, and Kuridala Formation, and in screens of country rock within intrusions of metadolerite and Gin Creek Granite. They are mainly medium to coarse-grained, commonly somewhat porous, and consist essentially of quartz and specular hematite; some magnetite is also commonly present. The hematite appears to be replacing original detrital grains. The quartz-hematite bodies are thickest, and generally most iron-rich, in hinge zones of folds, e.g., at GR 445990, in Kuridala Formation, and at GR 355157, in Staveley Formation. Many show thin to laminar banding which represents original bedding: it is always parallel, and of similar thickness, to bedding in adjacent rocks. The regional metamorphism of the associated rocks ranges from amphibolite to greenschist grade, but is generally much lower than that, for example, at the Pegmont prospect well to the east.

The quartz-hematite rocks are relatively resistant to erosion, and form prominent dark walls and rib-like exposures, commonly on ridge crests. Some can be traced for several kilometres along strike. The proportion of hematite within any one band varies considerably from place to place. Drilling has shown that at depth the hematite passes down into magnetite (White, 1957). Geochemically, at least some of the quartz-hematite bodies are known to be anomalousy rich in copper and gold.

Quartz-hematite rock also occurs as veins cutting Williams Granite (e.g., at GR 723896 and GR 478070).

The quartz-hematite rocks within the sedimentary sequences are probably epigenetic rather than primary iron-rich sediments. This is because they occur at various stratigraphic levels and in several rock units, and are developed preferentially in fold hinges. They differ from banded iron formation of the Pegmont type, a chemical sediment, in being mainly coarse-grained, porous, detrital rocks. Their continuity at depth indicates they are not just surface weathering phenomena. For these reasons they are considered to be epigenetic and post-tectonic.

White (1957) suggested that the quartz-hematite bodies are skarns related to granite intrusion, and were formed by replacement of calcareous sedimentary rocks. Although in many cases there is no evidence that the original rock was calcareous, and there are no associated typical skarn minerals, it certainly seems likely that the quartz-hematite rocks were formed during late-stage hydrothermal activity associated with the emplacement of Williams Granite and Gin Creek Granite: iron-rich solutions passed through porous zones, such as beds of loosely cemented detrital sediments, dissolving minerals such as mica, feldspar, and calcite, and depositing iron and silica.

Notes on main mines and prospects

Anitra prospect; Cu, Pb, Zn; GR 568700.

Surface workings: pits.
Country rocks: interbedded mica schist and metagreywacke, Kuridala Formation (P_{kr}^{g}); appear to be tightly folded about N-trending axes.
Lode: not known
Ore and gangue: not known.

Answer mine; Cu, Au; GR 340035

References: White (1957), Carter & others (1961), Brooks (1977, 1979b).

Surface workings: shafts, pits.

Country rocks: black and grey carbonaceous slate and minor phyllite of Answer Slate (Pka), dipping about 70°ENE.

Lode: ore shoots along shear zone parallel to bedding; some jaspery ironstone gossan on surface; worked along length of 220 m and to depth of 61 m.

Ore and gangue: almost all ore mined came from zone of oxidation and secondary enrichment, above 30.5 m level - mainly chalcocite; bornite, chalcopyrite and pyrite present at depth; quartz gangue. Highly pyritic sulphide lode was exposed at 61 m level.

Production: 10 922 tonnes ore, yielding 1032 tonnes Cu (grade about 10%) and 11 072 g Au, recorded to 1920, when mine closed. Reopened in 1974, when a 5-vat leaching plant was set up adjacent to old workings, using highly acid water pumped from main shaft; water in mine is replenished by influx of groundwater.

Belgium mine; Cu; GR 432120.

References: White (1957), Brooks (1960), Carter & others (1961).

Surface workings: collapsed shaft, pits.

Country rocks: calcareous and micaceous metasiltstone and phyllite of Staveley Formation (P_g^{ks}), cut by granite veins.

Lode: veins trending north.

Ore and gangue: chalcopyrite and malachite in quartz-hematite (and pyrite?) rock.

Production: 354 tonnes ore, 88.7 tonnes Cu (grade 25%) recorded.

Black Rock prospect; Pb, Zn, Cu; GR 909075.

Surface workings: recently bulldozed costeans across N-trending lode, prospect pits.

Country rocks: migmatitic banded gneiss and pegmatite, quartzite, garnet quartzite, and amphibolite of Soldiers Cap Group (Po); some tight minor folds; general dip of bedding/foliation steep to E.

Lode: banded iron formation; stratiform; discovered early 1970s.

Ore and gangue: some Cu-stained ironstone gossan on surface; primary mineralogy probably similar to that at Pegmont prospect.

Christmas Gift mine; Cu; GR 292068.

Surface workings: collapsed shaft, pits.
Country rocks: slate and phyllite of Answer Slate, metadolerite.
Lode: not known.
Ore and gangue: malachite and vein quartz on dump.
Production: not known, minor.

Cowie prospect; Pb, Zn; GR 863890 (S end).

Surface workings: series of recently bulldozed costeans across lode.
Country rocks: migmatitic gneiss, muscovite pegmatite, mica schist, and quartzite of Soldiers Cap Group.
Lode: banded iron formation a metre or so thick, locally highly contorted; stratifrom; general trend NNW; extends along strike for at least 2.5 km; exposed at N and S ends as hillocks of black Mn-stained cherty ironstone gossan; discovered early 1970s.
Ore and gangue: reported to be similar to that at Pegmont prospect.

Flora mine; Cu; GR 470095

Surface workings: shafts and pits; recently bulldozed costeans.
Country rocks: Kuridala Formation - mainly medium-bedded to laminated carbonaceous metasiltstone, some with matchstick andalusite porphyroblasts, and interbedded fine-grained meta-arenite (Pkr_s); also some pits in calcsilicate rock (Pkr_c). Williams Granite (Pgi_a) crops out less than 100 m to E.
Lode: shear zone or zones apparently concordant with bedding; dips about 65°E.
Ore and gangue: malachite and vein quartz on dumps.
Production: not known but minor; mine long abandoned, but actively prospected during 1970s.

Guess prospect; Cu; GR 369938

Surface workings: costeans and pit.
Country rocks: slate, phyllite and fine-grained schist of Answer Slate (Pka) dipping steeply ESE.
Lode: stratabound quartz-hematite body.
Ore and gangue: malachite, quartz, hematite.
Production: none, or very minor.

Lady Ella? mine; Cu; GR 475133.

Surface workings: two vertical shafts, pits.
Country rocks: grey, crenulated, medium to fine-grained mica schist containing relict andalusite porphyrobalsts, Kuridala Formation (Ekr); schistosity vertical, trends NNE.
Lode: shear zone concordant with foliation.
Ore and gangue: malachite and azurite on dumps.
Production: unknown, minor.

Marilyn mine; Cu; GR 482043

Surface workings: vertical shaft, recently bulldozed costean.
Country rocks: subvertical, N-trending, carbonaceous metasiltstone of Kuridala Formation (Ekr_s) surrounded by Williams Granite (Egi_a).
Lode: shear zone apparently concordant with bedding.
Ore and gangue: malachite, chrysocolla, and quartz on dump.
Production: not known, minor.

Mariposa mine and prospect; Cu, U; GR 463012

References: White (1957); Brooks (1960).
Surface workings: shaft and pits on S side of creek, prospect pit on N side.
Country rocks: thin band of partly bleached carbonaceous slate, phyllite, and fine-grained mica schist in sequence of mainly quartzitic meta-arenite, Kuridala Formation (Ekr_q); beds dip steeply E.
Lode: shear zones dipping 85°E, about concordant with bedding of country rocks.
Ore and gangue: malachite and chrysocolla on dump S of creek; torbernite, saleeite(?), and Cu carbonates reported in pit N of creek.
Production: little if any Cu; no U.

Marramungee prospect; Pb, Zn, Cu; GR 908133 (S end)

Surface workings: several recently bulldozed costeans across strike of lode.
Country rocks: mica schist, gneiss, pegmatite, quartzite, garnet quartzite, and amphibolite, Soldiers Cap Group (Zo); general dip steep to E, strike north-south. Marramungee Granite (Zgr) crops out within 100 m to W.
Lode: banded iron formation, stratiform; shows some tight minro folds; mineralisation extends for at least 1 km along strike; discovered early 1970s.
Ore and gangue: probably similar to that at Pegmont prospect.

Mount Carol mine; Cu and silica flux; GR 608033

Surface workings: open cuts.
Country rocks: interbedded mica schist and metagreywacke of Kuridala Formation (Zkr_g), dipping 5-15°SE; some beds rich in andalusite and garnet porphyroblasts.
Lode: not observed.
Ore and gangue: chrysocolla, malachite, azurite, and vein quartz on dumps.
Production: not known.

Mount Cobalt mine; Co, minor Cu; GR 474960.

References: Reid (1921), Rayner (1938, 1953), Honman (1941), Brooks (1960, 1979a), Carter & others (1961), Croxford (1974).
Surface workings: stopes, shafts, adits, pits; remains of mill.
Country rocks: medium bedded to laminated fine-grained mica schist, metagreywacke, and meta-arenite of Kuridala Formation (Zkr_g) to E, meta-dolerite 'sill' (dl) to W; beds dip steeply E.
Lode: along shear zone, at least 1.5 km in length, generally following contact between metasediments and metadolerite 'sill'. Lode is up to 9 m wide, and has been worked over length of 220 m and to a depth of 34 m.
Ore and gangue: in Co ore - hypogene cobaltite, supergene erythrite, and black oxide; minor galena, pyrite, chalcopyrite, sphalerite, traces of Au, Ag, and scheelite; gangue minerals include quartz, calcite, magnetite, siderite, and biotite. In Cu ore - chalcopyrite, pyrite, and supergene chalcocite, covellite, cuprite, malachite, azurite, and chrysocolla. Torbernite has been recorded near S end of workings.

Production: from its discovery in 1919 to its closure in 1934, recorded production was 766 tonnes metallic cobalt, comprising 2200 tonnes of concentrates containing 20% Co obtained from milling operations (mill operated 1922-1929), and about 1800 tonnes hand-picked ore averaging about 15% Co. Estimated total production is 778 tonnes Co (Brooks, 1979a).

Mount Dore mine; Cu; GR 472043

References: White (1957), Brooks (1960).
Surface workings: shafts, pits.
Country rocks: carbonaceous metasiltstone and phyllite of Kuridala Formation (Pkr_s); subvertical, N-trending.
Lode: shear zone subparallel with bedding.
Ore and gangue: malachite and azurite on cleavage/bedding planes and in cross fractures; sparsely disseminated flakes of torbernite also recorded.
Production: 16 tonnes ore yielding 5.9 tonnes Cu recorded by Nye & Rayner (1940).

Mount Elliott mine; Cu, Au; GR 485178

References: Nye & Rayner (1940), Sullivan (1953), White (1957), Carter & others (1961).
Surface workings: shafts, pits, remains of smelter.
Country rocks: graphitic slate of Kuridala Formation (Pkr_s), some of which contains 'matchstick' andalusite porphyroblasts, and sill of metadolerite (not shown on 1:100 000 scale map), with dyke-like offshoots, to E; some folding, but generally steep dip to ENE.
Lode: shear zone trending NNW and dipping steeply ENE, subparallel to bedding; main orebody pitches steeply NNW; four en echelon orebodies worked.
Ore and gangue: malachite, cuprite, and subordinate tenorite, azurite, chrysocolla, and native Cu in oxidised zone (to depth of 75 m), and chalcopyrite with magnetite, pyrite, and pyrrhotite in primary zone; calcite, diopside, scapolite, gypsum, apatite, sphene, and prehnite as gangue.
Production: 269 308 tonnes of ore yielding 24 920 tonnes of Cu (9.3%) and 1 854 199 g Au; mine closed in 1920 due to fall in price of Cu and exhaustion of high-grade oxidised ore.

Mount Ulo prospect; Pb, Zn, Cu; GR 624977

Surface workings: pits.
Country rocks: schist, phyllite, chert, and carbonaceous metasiltstone of Kuridala Formation (Pkr, Pkr_h, Pkr_s).
Lode: carbonaceous metasiltstone?
Ore and gangue: ?
Production: nil; prospected in 1970s, several drillholes.

New Hope mine; Cu, W?; GR 476969

Surface workings: shaft, pits.
Country rocks: interbedded mica schist, metagreywacke, and feldspathic meta-arenite of Kuridala Formation (Pkr_g), dipping steeply E; metadolerite sill (dl) just to W; some of mica schist contains porphyroblasts of staurolite and garnet.
Lode: shear zone concordant with bedding, some cherty ironstone exposed; N end of Mount Cobalt shear.
Ore and gangue: malachite on dump; may be mine from which 5.75 tonnes of scheelite ore with limonitic jasper and calcite gangue was obtained (Carter & others, 1961).
Production: not known, minor.

Pegmont prospect; Pb, Zn; GR 667835 (main gossan)

References: Lőcsei (1977), Stanton & Vaughan (1979).
Surface workings: bulldozed costeans, pits; work started 1971.
Country rocks: interbedded mica schist, metagreywacke, meta-arkose, and quartzite, some garnetiferous beds, Kuridala Formation (Pkr_g); muscovite and tourmaline-bearing pegmatite; minor amphibolite. Bedding complexly folded; overall dip appears to be gentle to E; most folds plunge gently NE.
Lode: Banded iron formation, stratiform, 4-6 m thick; extends for over 2 km along strike; general NE trend; main gossan forms prominent ridge.
Ore and gangue: primary minerals present are galena, sphalerite, pyrite, pyrrhotite (minor), chalcopyrite (traces), magnetite, gahnite, fayalitic olivine, garnet, apatite, graphite, green hornblende, grunerite, quartz, and clinopyroxene. Gossans consist of goethite, clay, and secondary lead minerals, and are stained by Mn.

Stuart mine; Cu; GR 453917

Reference: No Hope mine of White (1957).
Surface workings: collapsed shaft, pits, recently bulldozed costeans.
Country rocks: Kuridala Formation - thin-bedded grey phyllite, slate, and carbonaceous metasiltstone (Pkr_s) just to W of metamorphosed acid volcanics (Pkr_a); beds dip steeply E.
Lode: along shear zone concordant with bedding in carbonaceous metasiltstone.
Ore and gangue: malachite, azurite, chyrsocolla, chalcocite.
Production: not known, minor; being worked by one man on part-time basis in August, 1979 - hand picked ore averaged about 13% Cu.

Utah prospect; U; situated about 0.8 km SE of Belgium mine (GR 432120)

References: White (1957), Brooks (1960).
Surface workings: pits? - not located during 1978 survey.
Country rocks: calc-silicate rocks of Stavely Formation (Pks_g).
Ore and gangue: davidite and calc-silicate minerals.

White Cliffs prospect; Cu; GR 819028

Surface workings: bulldozed costeans and pits excavated in early 1970s.
Country rocks: mica schist and amphibolite (probably metabasalt) of Soldiers Cap Group dipping about 85°E.
Lode: shear zone?
Ore and gangue: malachite and ferruginous 'opal' on dumps.

SUMMARY OF GEOLOGICAL HISTORY

The sequence of events outlined below should be regarded as highly speculative because of uncertainities regarding stratigraphic relations and correlations.

In the west the earliest events recorded were probably acid and basic volcanism and accompanying shallow-water clastic sedimentation, represented by the Argylla Formation and Marraba Volcanics. The close association of volcanic rocks and water-laid sediments indicates that the volcanism could have been subaqueous. Shallow-water sedimentation continued during deposition of most of the overlying Mitakoodi Quartzite, and was accompanied by some local basic volcanism. Towards the end of Mitakoodi Quartzite time generally finer-grained and more argillaceous sediments were deposited, perhaps because of deepening water and increasing distance from the source of detritus. Relatively deep-water conditions and mainly argillaceous sedimentation became dominant during the deposition of the succeeding Answer Slate. The more calcareous, though still largely argillaceous, nature of the conformably overlying Staveley Formation may indicate a return to shallower-water conditions which may have persisted through the deposition of Agate Downs Siltstone: the source of terrigeneous detritus may have been either a distant landmass or a nearby landmass of low relief. However, not all of the Staveley Formation may have been deposited during this period, as part, unit Pks$_x$, may belong to a much younger sequence.

At about the same time as the Answer Slate was being deposited in the west, immature and coarse-grained feldspathic and greywacke-type sediments, those of the Soldiers Cap Group, were being laid down in the east. Some at least of these may be proximal turbidites from a source possibly to the east. The turbidite sediments became increasingly finer-grained westwards, forming first the greywacke-siltstone-shale sequence which constitutes the bulk of the Kuridala Formation, and then mainly siltstone and shale, distal turbidites, represented by the western part of the Kuridala Formation, the Answer Slate, and probably part of the the Staveley Formation. Periods of slow and quiet sedimentation between turbidity current activity, either in localised areas or throughout most of the region, led to deposition of carbonaceous and pyritic shale and siltstone where water circulation was restricted, mainly in relatively deep water, to carbonate deposition in shallow water, and to precipitation of exhalative chemical sediments to form banded iron formation. Probably towards

the end of Soldiers Cap time the calcareous sediments of the Corella Formation began to be deposited over a wide area in the east, perhaps in a lagoonal shelf environment that persisted for a considerable time. The presence of acid and basic volcanic rocks within the Soldiers Cap Group and Corella and Kuridala Formations indicates that sedimentation in the eastern and central parts of the region, as in the west, was accompanied locally by some volcanic activity.

The first period of tectonism recorded in the region took place some time after the deposition of the Corella Formation. During this period the Tewinga, Malbon, Soldiers Gap, and most of all of the Mary Kathleen Group rocks were isoclinally folded about N-trending axes and regionally metamorphosed to mainly amphibolite grade. Some of the many metadolerite bodies in the rregion may have been intruded at about this time. The development and emplacement of anatectic granites - Cowie, Blackeye, and Marramungee Granites, and unnamed granite in the northeast - probably took place during this tectonism. Uplift associated with the tectonism caused the region to become a landmass subjected to subaerial erosion. A subsequent marine transgression may be represented by the shallow-water sediments of unit Pks$_x$ of the Staveley Formation. Basic igneous activity associated with this sedimentation is represented by amygdaloidal metabasalt of unit Pks$_{xb}$, and perhaps by many of the metadolerite bodies which intrude the adjacent Kuridala Formation, units Pks and Pks$_g$ of the Staveley Formation, and other Precambrian units.

The second major period of tectonism resulted in tight to isoclinal folding about axes essentially parallel to those of the earlier folds. This tectonism saw the final development in the west of the synclinorium in which the present outcrops of Agate Downs Siltstone and unit Pks$_x$ of the Staveley Formation represent subsidiary synclines. The folding was accompanied by regional metamorphism to mainly greenschist grade, and this resulted in some retrogression of rocks previously metamorphosed to amphibolite grade.

Either at the end of the second period of tectonism, or some time later, the Williams and Gin Creek Granites were emplaced, mainly by stoping, at moderate crustal levels (mesozonal intrusions). In the west the Gin Creek Granite may have brought up with it, from deeper in the crust, large blocks of previously crystallised and metamorphosed granite and gneissic rocks (foliated Gin Creek Granite and unnamed metamorphics). In a few places thermal metamorphism associated with the emplacement of granite resulted in the development of hornfels.

Most or all of the economic mineral deposits in the region were probably formed either during the second period of tectonism or during the emplacement of the Williams and Gin Creek granites, or during both: metals present in trace amounts in the sequence were mobilised, concentrated, and deposited in favourable sites. Most faults mapped are also probably related to either the second period of tectonism or to granite emplacement.

The youngest igneous event to affect the area was the intrusion of east-trending dolerite dykes, perhaps about 1140 m.y. ago. Between this period of dyke intrusion and the end of the Precambrian the region was extensively eroded to form a low-lying landmass.

Early in the Cambrian a marine transgression reached the area, and sediments of the Cambrian Burke River Outlier succession were deposited, mainly in shallow water. Later in the Palaeozoic the region once more became part of a large land and remained so until the next recorded depositional period, which probably began in the Jurassic, when it consisted of a low-lying gently undulating plain. Non-marine Jurassic sediments were succeeded by shallow-marine Cretaceous sediments of the Eromanga Basin succession. Late in the Cretaceous or early in the Tertiary, the region was gently uplifted to form a landmass once again, and it became subjected to subaerial weathering, erosional, and depositional processes which have continued to the present day.

The Cambrian and Mesozoic sediments in the region, like those of the Cainozoic, are flat-lying and have not been metamorphosed, indicating that the region has been part of a relatively stable tectonic block throughout the Phanerozoic.

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AUSTRALIA 1:100 000 GEOLOGICAL SPECIAL

GEOLOGY OF THE SELWYN REGION

QUEENSLAND

SHEET 7054, PART SHEET 6954

Symbol	Description	Age
Cz	Sand, silt, gravel: alluvial, colluvial and residual	CAINOZOIC
Ts	Limestone; minor chalcedony	TERTIARY, CAINOZOIC
Tl	Laterite, lateritic rubble	TERTIARY, CAINOZOIC
	Leached bedrock: mesa cappings	TERTIARY, CAINOZOIC
Kla	Mudstone, calcareous siltstone	EARLY CRETACEOUS, MESOZOIC
Klo	Limestone, calcareous sandstone	EARLY CRETACEOUS, MESOZOIC
Klu	Mudstone, siltstone; minor sandstone, conglomerate (Wallumbilla Formation)	EARLY CRETACEOUS, MESOZOIC
JKg	Sandstone, grit, conglomerate, claystone (Gilbert River Formation)	LATE JURASSIC TO EARLY CRETACEOUS, MESOZOIC
€uc	Limestone; minor breccia, marl	CAMBRIAN, PALAEOZOIC
€uh	Siltstone; minor chert, sandstone (O'Hira Shale)	CAMBRIAN, PALAEOZOIC
€up	Limestone, marl, breccia; minor chert	CAMBRIAN, PALAEOZOIC
€mr	Siltstone, sandstone; minor chert, silicified shale	CAMBRIAN, PALAEOZOIC
€mt	Black and grey convoluted chert, chert nodules, silicified beds	CAMBRIAN, PALAEOZOIC
€lb	Ferruginous sandstone, conglomerate, shale, mudstone, dolomite	CAMBRIAN, PALAEOZOIC
Pgg	Foliated and non-foliated biotite granite, tourmaline-muscovite granite; minor pegmatite, aplite; schistose and gneissic inclusions common	PROTEROZOIC
Pgi_a	Biotite and hornblende-biotite granite; non-porphyritic; minor aplite	PROTEROZOIC
Pgi_g	Greisen, chloritised granite	PROTEROZOIC
Pgi	Porphyritic biotite and hornblende-biotite granite; minor non-porphyritic granite, pyroxene-bearing granite, aplite	PROTEROZOIC
Pg	Foliated leucocratic tonalite and pegmatite, biotite granite, hornblende-biotite tonalite	PROTEROZOIC
Pgc	Fine to pegmatitic leucocratic biotite granite, granodiorite and tonalite, locally migmatitic	PROTEROZOIC
Pge	Leucocratic granodiorite, commonly foliated; minor pegmatite	PROTEROZOIC
Pgr	Fine to pegmatitic leucocratic biotite granite, granodiorite, and tonalite; foliated to massive	PROTEROZOIC
dl	Metadolerite, amphibolite	PROTEROZOIC
Pkg	Phyllitic metasiltstone; minor calcareous sandstone, siltstone and breccia	PROTEROZOIC
Pkg_q	Fine quartzite, cherty metasiltstone	PROTEROZOIC
Pks_x	Calcareous, ferruginous and feldspathic arenites, siltstone, phyllite, marble, calcilutite, conglomerate; convolute bedding and cross-bedding common	PROTEROZOIC
Pks_{xb}	Amygdaloidal metabasalt	PROTEROZOIC
Pks	Calcareous and non-calcareous phyllite, slate, arenite and siltstone	PROTEROZOIC
Pks_c	Calcareous arenite and phyllite, calc-silicate rocks, marble; minor non-calcareous sedimentary rocks	PROTEROZOIC
Pks_g	Mica schist; abundant granite and pegmatite veins; minor calc-silicate rocks	PROTEROZOIC
Pka	Slate, phyllite, metasiltstone, mica schist; minor feldspathic quartzite, chert	PROTEROZOIC
Pkr	Schist, meta-arenite, slate, phyllite, calc-silicate rocks, metarhyolite	PROTEROZOIC
Pkr_p	Phyllite, slate, mica schist	PROTEROZOIC
Pkr_g	Interbedded schistose metagreywacke and mica schist commonly with porphyroblasts of andalusite ± garnet ± staurolite; minor quartzite, slate, calc-silicate rocks, hornfels	PROTEROZOIC
Pkr_c	Thin bedded calc-silicate rocks; minor phyllite, slate, mica schist	PROTEROZOIC
Pkr_s	Graphitic slate, phyllite and metasiltstone; minor schist, calcareous rocks	PROTEROZOIC
Pkr_{ch}	Thin bedded chert; minor schist, calc-silicate rocks	PROTEROZOIC
Pkr_q	Quartzite; minor schist, phyllite, slate	PROTEROZOIC
Pkr_f	Meta-arkose; minor schist, quartzite metagreywacke	PROTEROZOIC
Pkr_a	Metarhyolite, agglomerate, and bedded tuff	PROTEROZOIC
Pkc	Banded amphibolitic to siliceous calc-silicate granofels; minor breccia	PROTEROZOIC
Pkc_{br}	Calc-silicate breccia; minor banded calc-silicate granofels	PROTEROZOIC
Pkc_a	Metarhyolite	PROTEROZOIC
Po	Gneiss and schist commonly migmatitic; quartzite, pegmatite; minor amphibolite, banded iron formation	PROTEROZOIC
Po_c	Banded calc-silicate granofels, calc-silicate breccia	PROTEROZOIC
Po_d	Amphibolitic metabasalt and banded para-amphibolite, commonly garnetiferous; minor schist, gneiss, quartzite, calc-silicate rocks	PROTEROZOIC
Po_s	Mica schist	PROTEROZOIC
Pnm	Quartzite, feldspathic quartzite, phyllite, mica schist, chert, amphibolite	PROTEROZOIC
Pna	Metabasalt, amphibolite, meta-arenite, schist; minor chert	PROTEROZOIC
Pea	Felsic granofels and gneiss, commonly with feldspar megacrysts, representing metamorphosed acid porphyry, agglomerate and tuff; feldspathic quartzite; minor schist, metabasalt (Argylla Formation)	PROTEROZOIC
Plm	Quartz-feldspar-mica gneiss and schist, migmatitic gneiss, amphibolite; minor quartzite; abundant granite, aplite and pegmatite veins	PROTEROZOIC

MARY KATHLEEN GROUP — SOLDIERS CAP GROUP — MALBON GROUP — TEWINGA GROUP

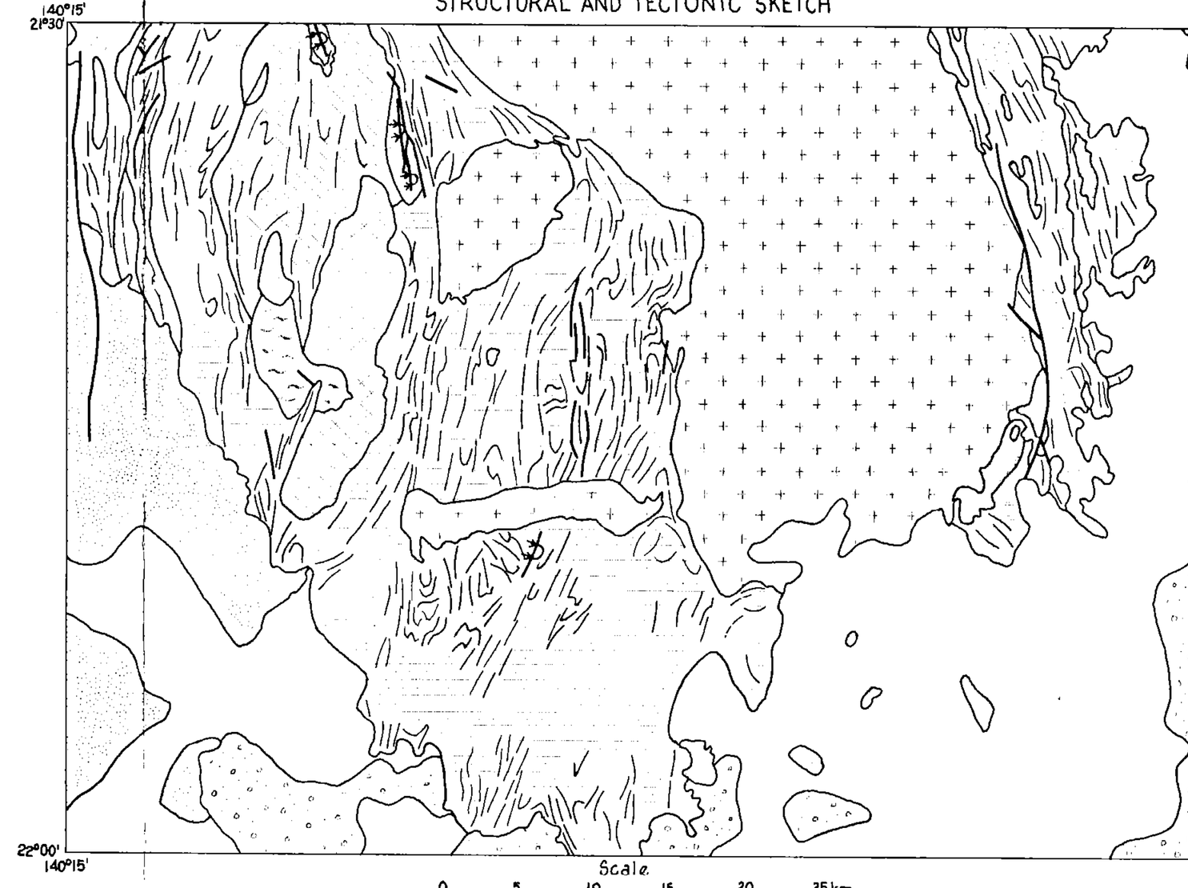
Facies change   * Name not yet approved

Geological boundary
Syncline, showing trend and plunge of axis
Overturned syncline
Fault, q indicates quartz filled
Where location of boundaries, folds and faults is approximate, line is broken; where inferred, queried; where concealed, boundaries and folds are dotted, faults are shown by short dashes
Plunge of fold axis
Plunge on trend line
Plunge of minor fold
Drag-fold with trend of plunge
Strike and dip of strata
Strike and dip of strata, facing not known
Vertical strata
Horizontal strata
Strike and dip of overturned strata
Strike and dip of strata, dip 5°-15° (airphoto interpretation)
Trend-line (airphoto interpretation)
Lineament (airphoto interpretation)
Joint pattern (airphoto interpretation)
Top of bed indicated by cross-bedding, arrow shows facing

Strike and dip of foliation
Vertical foliation
Strike and dip of foliation with trend and plunge of crenulation, first folding episode
Strike and dip of foliation, second folding episode
Strike and dip of cleavage
Strike and dip of cleavage with trend and plunge of crenulation
Vertical cleavage
Strike and dip of bedding and of cleavage
Quartzite marker bed
Quartz-hematite body
Dyke: dolerite, metadolerite, amphibolite
Dyke: a-acid, gr-granite, peg-pegmatite, q-quartz
Mine
Mine not being worked
Prospect
Costean
Minor mineral occurrence
Gold
Copper
Mica
Lead

Stratigraphic hole
Macrofossil locality with reference number
Windpump
Bore with windpump
Water tank
Earth tank or dam
Waterhole
Minor road
Vehicle track
Abandoned railway
Landing ground
Fence
Homestead
Building
Yard
Elevation in metres, approximate
Elevation in metres, accurate

STRUCTURAL AND TECTONIC SKETCH



Non-marine sediments	Cainozoic and Mesozoic
Marine sediments of Eromanga Basin succession	Mesozoic
Burke River Outlier succession	Cambrian
Williams Granite	Proterozoic
Gin Creek Granite	Proterozoic
Other granites	Proterozoic
Agate Downs Siltstone	Proterozoic
Unit Pks_x (Staveley Formation)	Proterozoic
Staveley Formation	Proterozoic
Kuridala Formation and Answer Slate	Proterozoic
Corella Formation	Proterozoic
Soldiers Cap Group	Proterozoic
Mitakoodi Quartzite	Proterozoic
Marraba Volcanics	Proterozoic
Argylla Formation	Proterozoic
Unnamed metamorphic rocks	Proterozoic

Scale 0 5 10 15 20 25 km

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

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GRID ZONE DESIGNATION: 100 000 METRE SQUARE IDENTIFICATION	TO GIVE A STANDARD REFERENCE ON THIS SHEET TO NEAREST 100 METRES
	SAMPLE POINT:
	1 Read letters identifying 100 000 metre square in which the point lies:
	2 Locate first VERTICAL grid line to LEFT of point and read LARGE figures labelling the line either in the top or bottom margin, or on the line itself:
	3 Estimate tenths from grid line to point:
IGNORE the SMALLER figures of any grid number; these are for finding the full co ordinates. Use ONLY the LARGER figures of the grid number; example:	4 Locate first HORIZONTAL grid line BELOW point and read LARGE figures labelling the line in either the left or right margin, or on the line itself:
	5 Estimate tenths from grid line to point:
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	If reporting beyond 18° in any direction, prefix Grid Zone Designation, as:

Brown numbered lines are 1000 metre intervals of the Australian Map Grid, Zone 54. Grid values are shown in full only at the southwest corner of the map

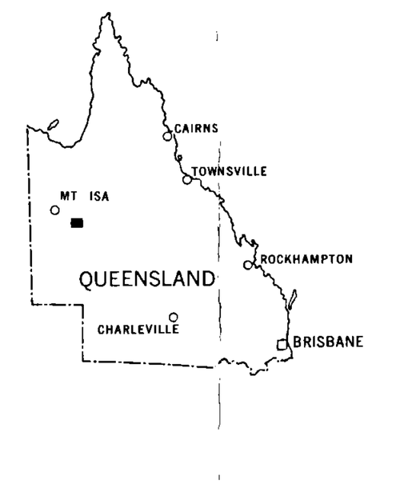
Transverse Mercator Projection

INDEX TO 1:100 000 MAPS

DUCHESS 6855	MALBON 6955	MOUNT ANGELAY 7056	McKINLAY 7155	EULOLO 7255	HAMILTON DOWNS 7355
DAJARRA 6854	MOUNT MERLIN 6954	SELWYN 7054	EL RITA 7154	KYNUNA 7254	DAGWORTH 7354
BUCKINGHAM DOWNS 6853	DIGBY PEAKS 6953	TOOLEBUC 7053	FINUCANE RANGE 7153	MIDDLETON 7253	JOHN HILLS 7353
BOULIA 6852	GOODWOOD 6952	LUCKNOW 7052	MACKUNDA 7152	HILLS RANGE 7252	TULMUR 7352

SCALE 1:100 000

MAP LOCALITY



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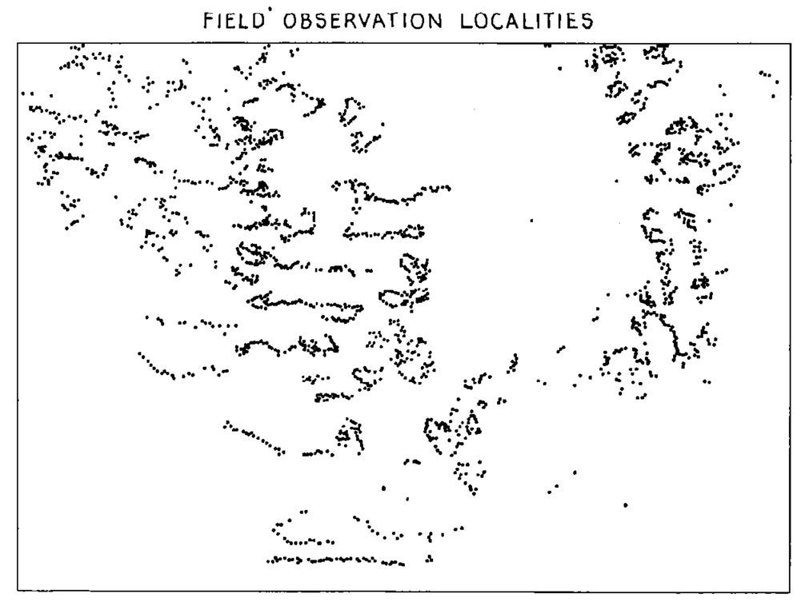

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Design and drafting by Cartography Section, BMR
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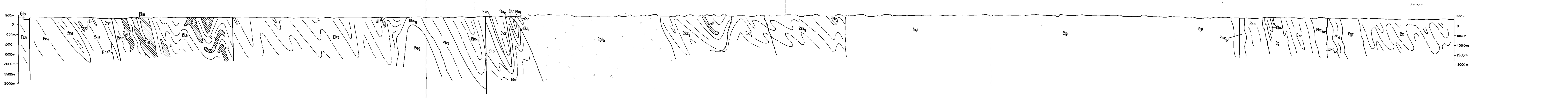
Schematic section

Cainozoic and Mesozoic sediments omitted



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NOVEMBER 1979

SUBJECT TO AMENDMENT

GEOLOGY OF THE SELWYN REGION
SHEET 7054, PART SHEET 6954