EXPLANATORY NOTES

GOVERNMENT OF WESTERN AUSTRALIA

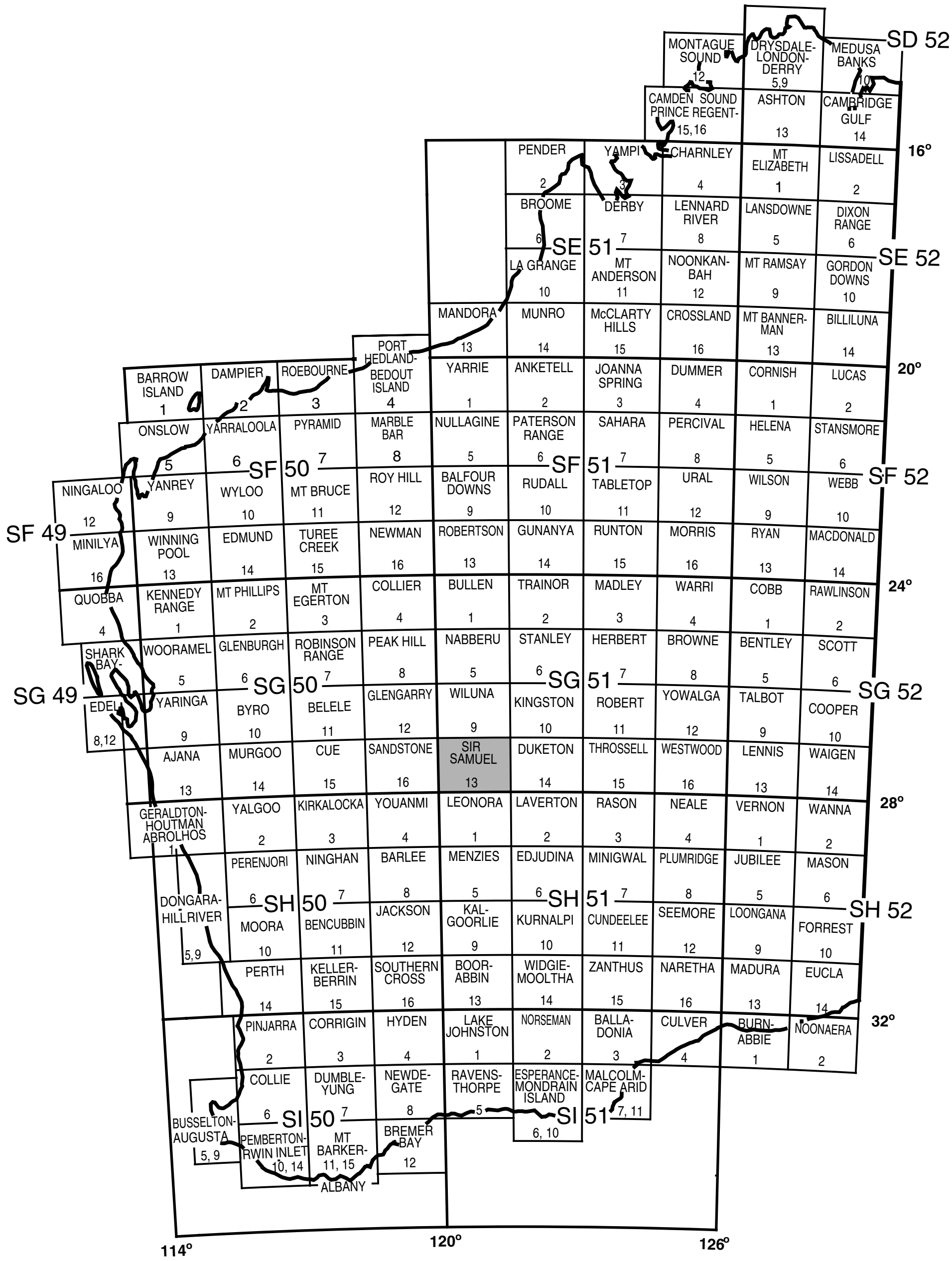
GEOLOGY OF THE SIR SAMUEL 1:100 000 SHEET

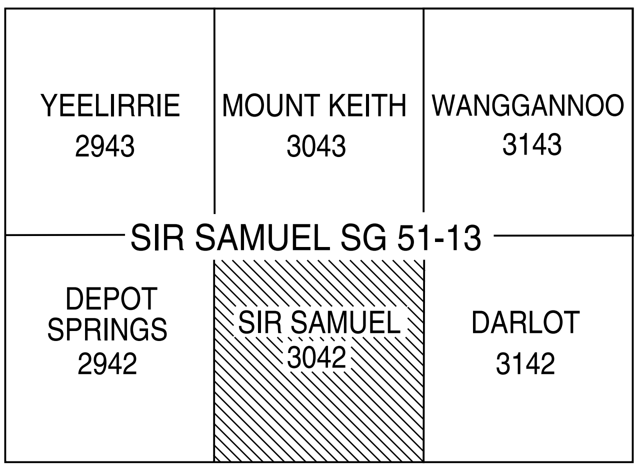
by S. F. Liu, T. J. Griffin, S. Wyche, J. M. Westaway, and K. M. Ferguson

1:100 000 GEOLOGICAL SERIES

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

DEPARTMENT OF MINERALS AND ENERGY





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Cover photograph:

Flattened pillow structures in metabasalt near the north shore of Lake Miranda.

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Abstract

The Archaean granite–greenstone terrain on the SIR SAMUEL 1:100 000 map sheet can be broadly divided into two north-trending strips of greenstones and two areas of granitoid rock. The Mount Keith – Perseverance, Agnew, and Yakabindie greenstone belts are situated within the western part of the sheet area, and are bounded to the west by a small, poorly exposed area of foliated granitoid rock. Monzogranite underlies the central part of the SIR SAMUEL map area, and part of the Yandal greenstone belt is exposed in the east.

The Yakabindie greenstone belt comprises the Kathleen Valley Gabbro and the overlying massive, tholeiitic Mount Goode Basalt. The Agnew greenstone belt comprises an upper sequence, in the Mount White Syncline, of metabasalt, metagabbro, and metasedimentary rocks, and a lower sequence, in the Agnew and Leinster Anticlines, of metamorphosed ultramafic, mafic, felsic volcanic, and sedimentary rocks. Metamorphosed ultramafic rocks in the Mount Keith – Perseverance greenstone belt host a number of major nickel deposits. The Jones Creek Conglomerate represents a late clastic sequence, and is restricted to a narrow, fault-bounded zone along the western margin of the Mount Keith – Perseverance and Agnew greenstone belts.

Four deformation events are recognized. The poorly understood D_1 event is evident in local flattening of pillow structures in basalts, and local east-plunging folds. Major compression during D_2 and D_3 produced the north-northwest linear structures and greenstone belt trends. The D_4 event is characterized by normal faults, fractures, and subhorizontal crenulations. Regional metamorphism was initiated during D_2 and peaked late in D_2, or post-D_2. There may have been a metamorphic event prior to D_2. Granitoid intrusion took place throughout the deformation and metamorphic history.

KEYWORDS: granitoid, greenstone, ultramafic rocks, komatiite, nickel, gold, Kathleen Valley Gabbro, Perseverance Fault, Waroonga Shear, Agnew Anticline, Leinster

Introduction

The SIR SAMUEL* 1:100 000 map sheet (SG 51-13, 3042), bounded by latitudes 27°30'S and 28°00'S and longitudes 120°30'E to 121°00'E, is located in the south-central part of the SIR SAMUEL 1:250 000 sheet. The first edition of the SIR SAMUEL (1:250 000) geological map (Bunting and Williams, 1977) was prepared and published during the intensive nickel exploration in the 1970s, but before the intensive gold exploration in the 1980s. Gold and nickel exploration and mining has resulted in a large amount of geological data, much of which is contained in statutory reports held at the library of the Geological Survey of Western Australia (GSWA).

Field mapping on SIR SAMUEL, along with the adjacent sheets of DARLOT (Westaway and Wyche, 1998) to the east, and MOUNT KEITH (Jagodzinski et al., 1997) to the north, was carried out in 1994 as part of the National Geoscience Mapping Accord (NGMA) with the Australian Geological Survey Organisation (AGSO). WILDARA (Oversby et al., 1996) is the adjacent map sheet to the south, and DEPOT SPRINGS (Wyche and Griffin, 1998) lies to the west.

The current field mapping was carried out using 1:50 000 black and white aerial photographs taken in May 1989, 1:25 000 colour aerial photographs taken in March 1994, and Landsat Thematic Mapper images. The aerial photographs and Landsat images are available from the Western Australian Department of Land Administration (DOLA). Images produced from aeromagnetic survey data on a 400 m line spacing (Geological Survey of Western Australia, 1996), together with images of airborne radiometric survey data and regional ground gravity data, and information from mining and exploration company statutory reports (WAMEX), were used extensively during this study. Topographic and cultural data are modified from digital data supplied by DOLA.

* Capitalized names refer to standard 1:100 000 map sheets, unless specified otherwise.

Previous investigations

The first systematic description of the geology on Sir Samuel was presented in the Explanatory Notes and accompanying map for the first edition of Sir Samuel (1:250 000) by Bunting and Williams (1979). Durney (1972) presented the results of a detailed study of the conglomerates in the Jones Creek area along the northern boundary of Sir Samuel. He recognized a major unconformity within the Archaean greenstones at Jones Creek. In a study of the Mount Keith – Lawlers area, Naldrett and Turner (1977) interpreted the presence of two greenstone sequences — a western lower greenstone sequence and an eastern upper greenstone sequence. Naldrett and Turner's lower greenstones are dominated by mafic rocks (greater than 90%) with a minor felsic component, and the upper greenstones consist of approximately one-third mafic and two-thirds felsic rocks. These two sequences are separated by an unconformity and associated conglomerate. Marston and Travis (1976) concluded that the structural complexity makes regional stratigraphic relationships difficult to justify, particularly Durney's (1972) suggestion that the Jones Creek Conglomerate separates two major mafic-dominated greenstone sequences. Eisenlohr (1989, 1992) carried out a detailed mapping and structural study of the Kathleen Valley Mining Centre – Lawlers (Agnew) area with emphasis on the northern part. He recognized contrasting deformation styles between eastern and western greenstone sequences in the Mount Keith – Perseverance, Agnew, and Yakabindie greenstone belts.

Physiography and access

Sir Samuel has subdued topography ranging from flat to undulating. The hills, at 500 m to 540 m Australian Height Datum (AHD), rise above the plains, which are at 460 to 500 m AHD. The hills correspond to areas of greenstone exposure that form belts trending approximately north on each side of the map sheet area. These belts are separated by a broad sandplain containing low breakaways above outcrops of granitoid rock. The western greenstone belt is cut by the east-trending Lake Miranda playa system. The area north of Lake Miranda has the highest relief and the best exposures of rock.

Beard (1990) included Sir Samuel in the eastern part of the Murchison Region, or Austin Botanical District of the Eremaean Province. On Sir Samuel, hilly areas typically have a dense cover of trees and shrubs (*Acacia* and *Cassia* species). Both narrow and broad ephemeral drainage courses are characterized by larger trees (*Acacia* and *Eucalyptus* species). Salt-tolerant plants including bluebush (*Maireana* species) and saltbush (*Atriplex* species) grow around the playa lake systems. Sandplains over granitoid rock are covered by grasses, including spinifex (*Triodia basedowii*) and wind grass (*Aristida contorta*), and scattered trees.

Sir Samuel is a semi-arid area with an annual rainfall of about 200 mm. The most significant rainfall events are typically associated with tropical weather patterns prevalent in the first half of the year. Temperatures regularly exceed 40ºC in the summer months from November to March, and there are occasional frosts in the winter months of June to August.

Leinster, the only town on Sir Samuel, is the place of residence for the workforce at the Perseverance (Agnew) nickel mine, 11 km to the north (Figs 1, 2). Pastoral leases in the Sir Samuel area are used mainly for sheep production, and include Yakabindie in the northwest, Leinster Downs in the southwest, Yandal in the northeast, and Weebo in the southeast. The Leinster Downs and Yakabindie homesteads are on Sir Samuel.

Sir Samuel is about 700 km northeast of Perth and about 350 km north of Kalgoorlie. The Wiluna–Leinster road, which bypasses Leinster, is sealed from Mount Keith to Kalgoorlie. The road from the Perseverance mine, via Leinster, is sealed to the Wiluna–Leinster road. Leinster is also linked to Perth by a gravel road through Agnew and Sandstone to the Great Northern Highway. A gravel road links the Perseverance mine to the Mount McClure and Bronzewing mining operations to the northeast. Access to the poorly exposed greenstones in the southeast corner of the map area is attained via station tracks from Weebo Homestead to the southeast. The low relief and numerous station and exploration tracks enable good access to most parts of Sir Samuel.

Precambrian geology

Regional geological setting

Sir Samuel is situated in the northern part of the Eastern Goldfields Province in the Archaean Yilgarn Craton, Western Australia. The Archaean geology in the map area can be divided into four parts: north-trending areas of greenstones on either side; a large area of granitoid rocks in the central part, which separates the two areas of greenstones; and foliated granitoid rocks on the extreme western margin (Fig. 3). The greenstones in the west include part of the Agnew greenstone belt, the Mount Keith – Perseverance greenstone belt (Griffin, 1990), and the Yakabindie greenstone belt (see **Stratigraphy and correlations** below). The greenstones in the east include the western edge of the Yandal greenstone belt (Griffin, 1990), of which the major part lies on Darlot (Westaway and Wyche, 1998).

Archaean rock types

Metamorphosed ultramafic rocks (*Au, Auc, Auk, Aup, Aur, Aut, Aux*)

Ultramafic rocks are a significant component of the greenstone sequences on Sir Samuel, particularly in the western part of the sheet area (Figs 3, 4). The rocks outcrop east of Mount Goode in the Meredith Well – McDonough Lookout area, in a narrow zone from Mount Keith to the Perseverance mine, in the Mount Roberts – Brilliant mine area, east of the Vivien mine, north of Eleven Mile Well, and in the poorly exposed greenstone

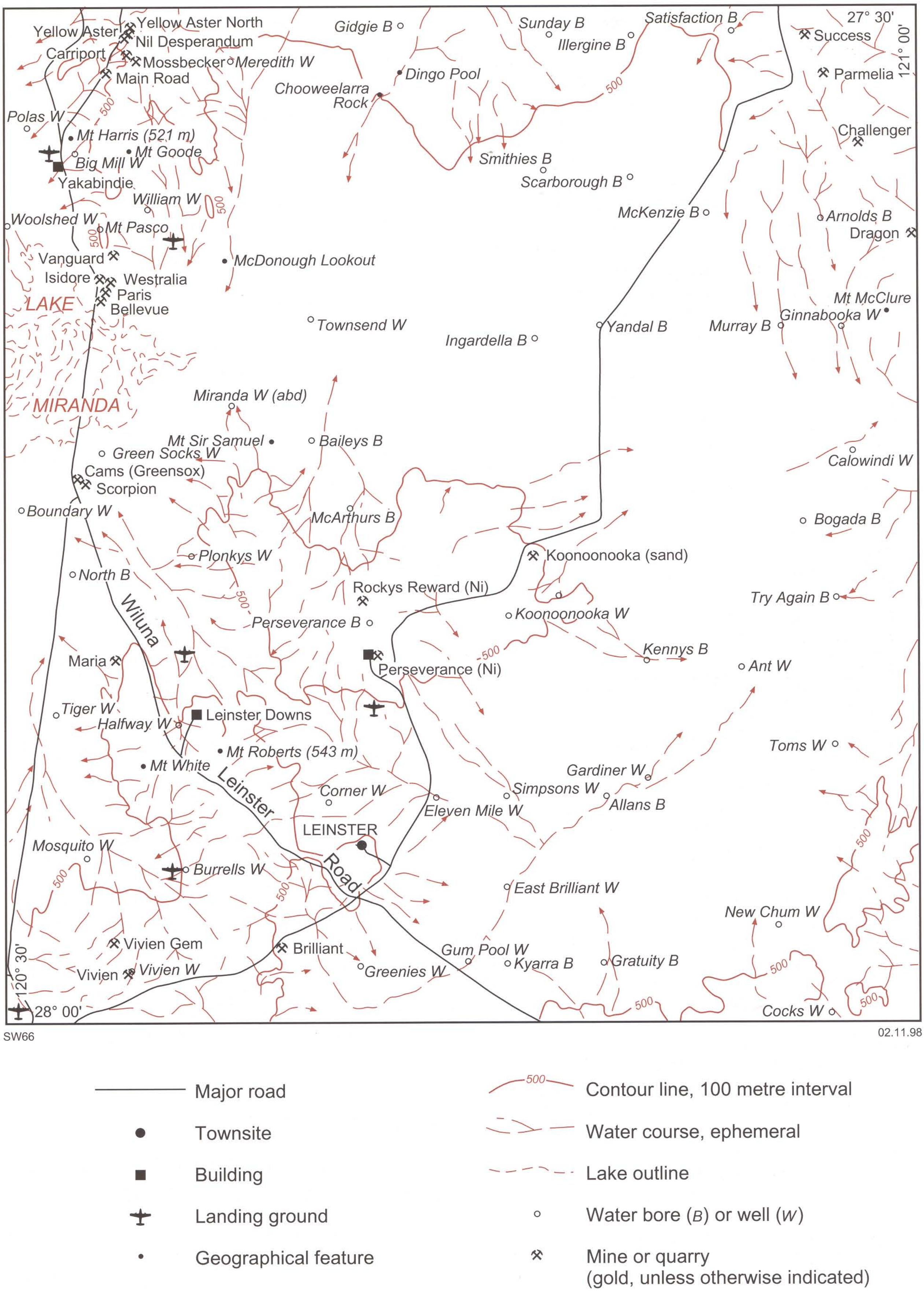

Figure 1. Main cultural and physiographic features on Sir Samuel

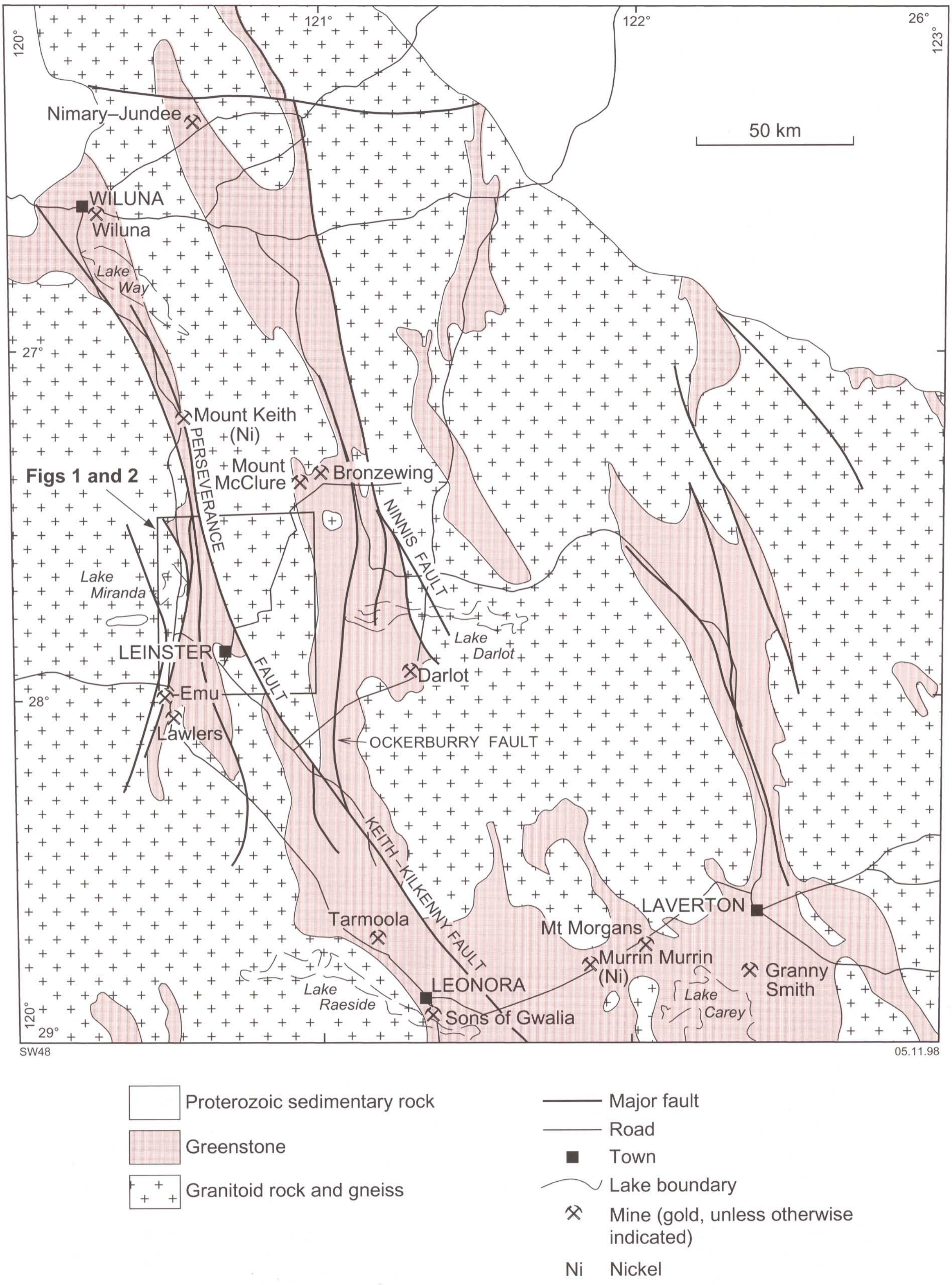

Figure 2. Regional setting of SIR SAMUEL

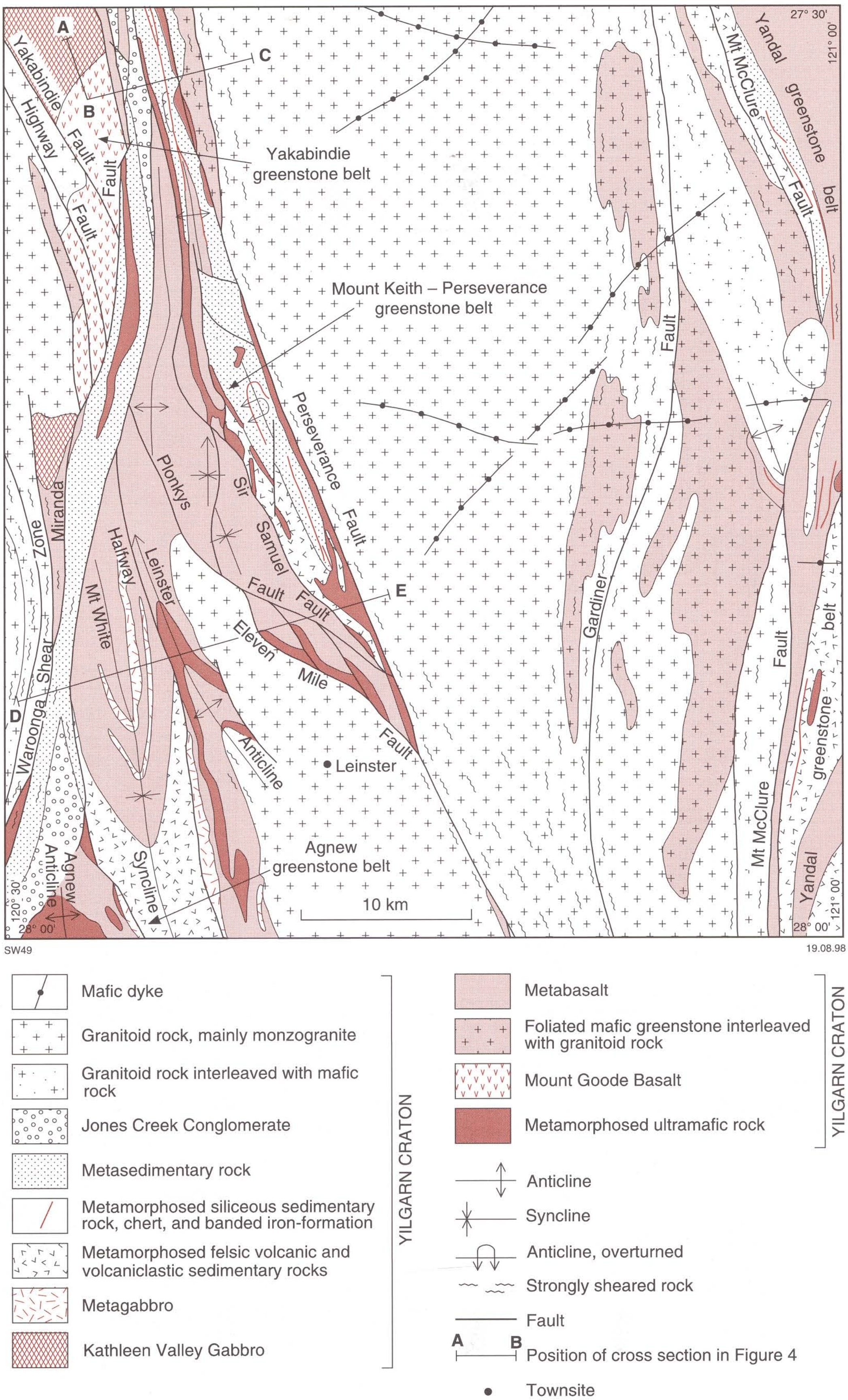

Figure 3. Simplified interpretative geology of SIR SAMUEL with positions of cross sections (Fig. 4) indicated

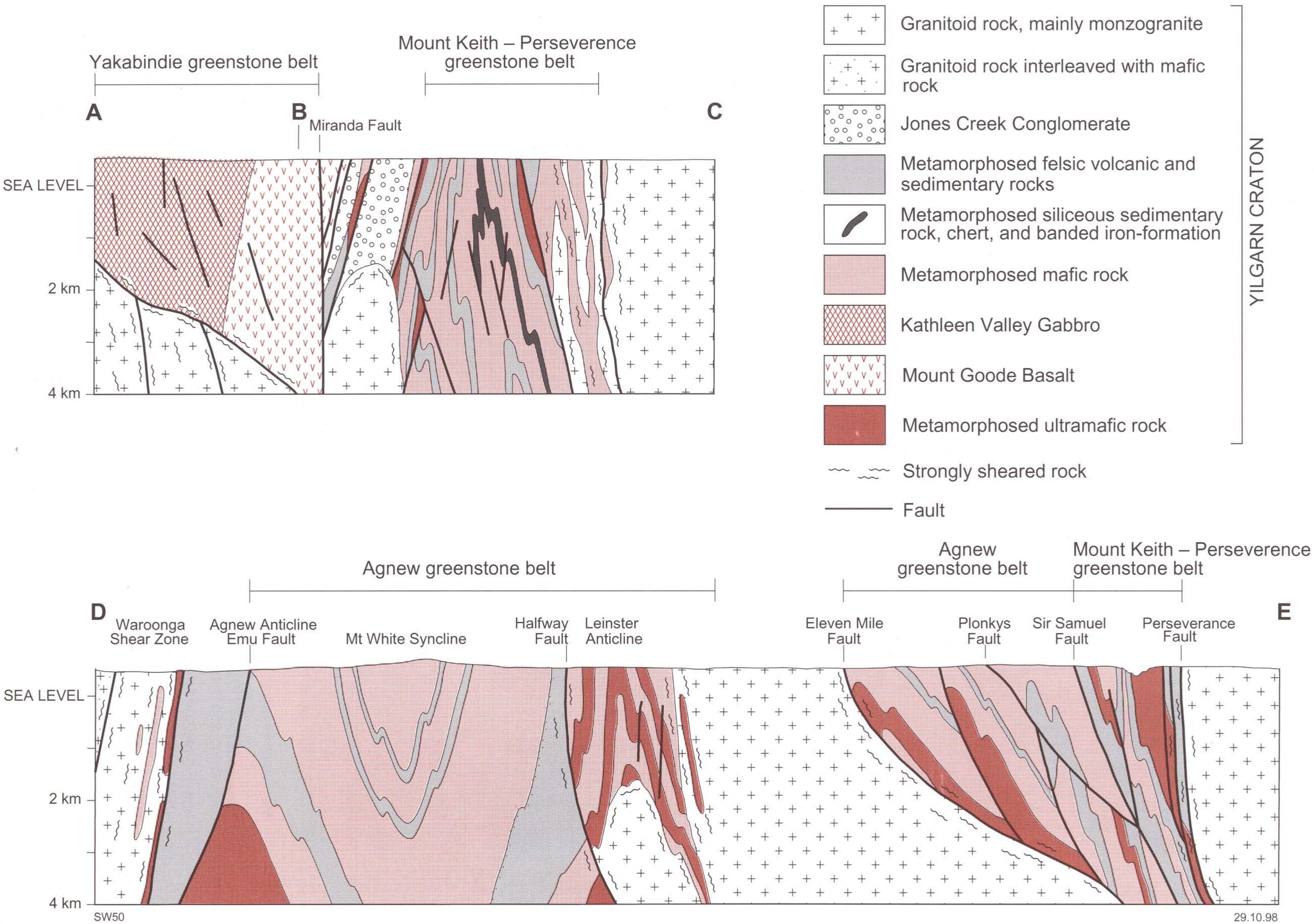

Figure 4. Cross sections of Sir Samuel. See Figure 3 for the location of the section lines

sequences in the southeast. They correspond to prominent highs on magnetic images (Fig. 5). In many areas where concealed ultramafic rocks have been interpreted from the magnetic data, their presence has been confirmed by shallow drilling by exploration companies. Exposed ultramafic rocks are commonly serpentinized, silicified, and may or may not be schistose.

Undivided metamorphosed ultramafic rock (*Au*) is locally covered by light-brown silica caprock (*Czu*), which, in places, preserves primary igneous textures such as spinifex and cumulate textures. Serpentinized peridotite with a relict olivine-cumulate texture (*Aup*) is interpreted to be part of thick komatiite lava flows (Hill et al., 1990). Metakomatiite (*Auk*) is characterized by the presence of relict platy olivine-spinifex textures. Metapyroxenite (*Aux*) outcropping northeast of McDonough Lookout is fine- to medium-grained, and comprises a mixture of tremolite and actinolite, with minor talc and chlorite.

Grey-green, schistose ultramafic rocks comprising tremolite, chlorite, and carbonate (*Aur*) outcrop east of metasedimentary rocks about 1 km north of the Rockys Reward openpit. These rocks are typically weathered on the surface, but fresher material is exposed in exploration trenches and drill cuttings. Talc schist (*Aut*) is exposed about 4 km northwest of the Perseverance openpit (AMG* 697258), where it is associated with silica caprock. The dominant schistosity at this locality (S_2) overprints an S_1 foliation. The S_2 schistosity has been overprinted by an open-spaced (about 0.8 cm) crenulation cleavage (S_3). A linear belt of talc–carbonate rock (*Auc*), 1.4 km long and ranging from 100 to 200 m wide, is located about 1 km south-southeast of the abandoned Miranda Well.

The rocks are yellow-brown and contain small red-brown spots (less than 3 mm in size) of hydrated iron oxides. Less-silicified exposures have a pronounced foliation.

Metamorphosed fine-grained mafic rocks (*Ab, Aba, Abf, Abm, Abp, Abv*)

Basaltic rocks that have been metamorphosed under greenschist to lower amphibolite facies conditions are a major component of the greenstones on SIR SAMUEL. These are mapped as undivided mafic rock (*Ab*) where deeply weathered and fine grained, and where they cannot be assigned to a specific category described below.

Metabasalt (*Abv*) is well exposed south of Mount Sir Samuel, west of the Perseverance mine, in the Mount White area, and in the Yandal greenstone belt. In these areas, it is associated and probably interbedded with metasedimentary rocks and gabbros. Some gabbroic rocks may be parts of thick flows. Most of the metabasalt designated as *Abv* is fine-grained, massive, and probably has a tholeiitic rather than high-Mg composition (Naldrett and Turner, 1977).

Metabasalt with plagioclase phenocrysts, commonly referred to as 'cat-rock', is a distinctive local variant (*Abp*). Three kilometres west of the Brilliant mine (AMG 650041), weathered metabasalt with plagioclase phenocrysts up to 10 mm in diameter is exposed adjacent to some shallow pits. The most distinctive outcrop of metamorphosed porphyritic basalt forms part of the Mount Goode Basalt (*Abmgp*).

Metamorphosed high-Mg basalt (*Abm*) is characterized by Mg-rich metamorphic minerals such as tremolite, and secondary carbonate, variolitic textures, and pyroxene-spinifex textures. The variolitic texture consists of pale spheres ranging from 2 to 10 mm in diameter. In places, weathering has highlighted the texture by either preferentially eroding the spheres to create small depressions, or by eroding around resistant spheres to form lumps on the rock surface. The pyroxene-spinifex texture is a relict texture in which 5–15 mm-long needles of primary pyroxene have been replaced by tremolite. A prominent unit of high-Mg basalt outcrops as part of the greenstone sequence south of Mount Roberts, where it is bounded by ultramafic rocks to the east and tholeiitic basalt to the west. Some high-Mg basalt has a relatively high magnetic susceptibility; for example, the outcrop 1 km south-southeast of the Yellow Aster mine (AMG 604532). The eastern margin of this unit is sheared and composed of tremolite schist. Variolitic high-Mg metabasalt, exposed 4 km west-southwest of McArthurs Bore (AMG 681278), has a sheared eastern margin that consists of tremolite schist.

Strongly foliated, fine-grained mafic rock (*Abf*) occurs in areas of shearing, such as at contacts with granitoid bodies and fault zones. The high degree of recrystallization obscures evidence of the protolith for these rocks.

Amphibolite (*Aba*) outcrops close to, or in contact with, granitoid rocks. The rock commonly has a well-developed foliation and, locally, a clear mineral lineation. The foliation is defined by compositional layering of metamorphic plagioclase and hornblende on a scale of 0.2–0.5 mm.

Mount Goode Basalt (Abmg, Abmgp)

The extensive suite of massive and porphyritic tholeiitic metabasalt that lies west of the Miranda Fault has been named Mount Goode Basalt (Figs 3, 4). Typical Mount Goode Basalt (*Abmg*) is a massive, fine-grained metabasalt with tholeiitic affinities. The upper part (*Abmgp*) contains areas of fine-grained metabasalt with plagioclase phenocrysts composing less than 15%, but locally up to 30%, of the rock. Pillow-lava structures are preserved locally. Exposures of the porphyritic metabasalt are typically patchy. One spectacular outcrop at the south-eastern end of an island in Lake Miranda, 3 km south of the Bellevue gold mine (AMG 594376, Fig. 6), contains plagioclase megacrysts up to 20 cm across. Flattened pillow structures are well preserved in the southernmost outcrop on the island (Fig. 7).

* Localities are specified by the Australian Map Grid (AMG) standard six-figure reference system whereby the first group of three figures (eastings) and the second group (northings) together uniquely define position, on this sheet, to within 100 m.

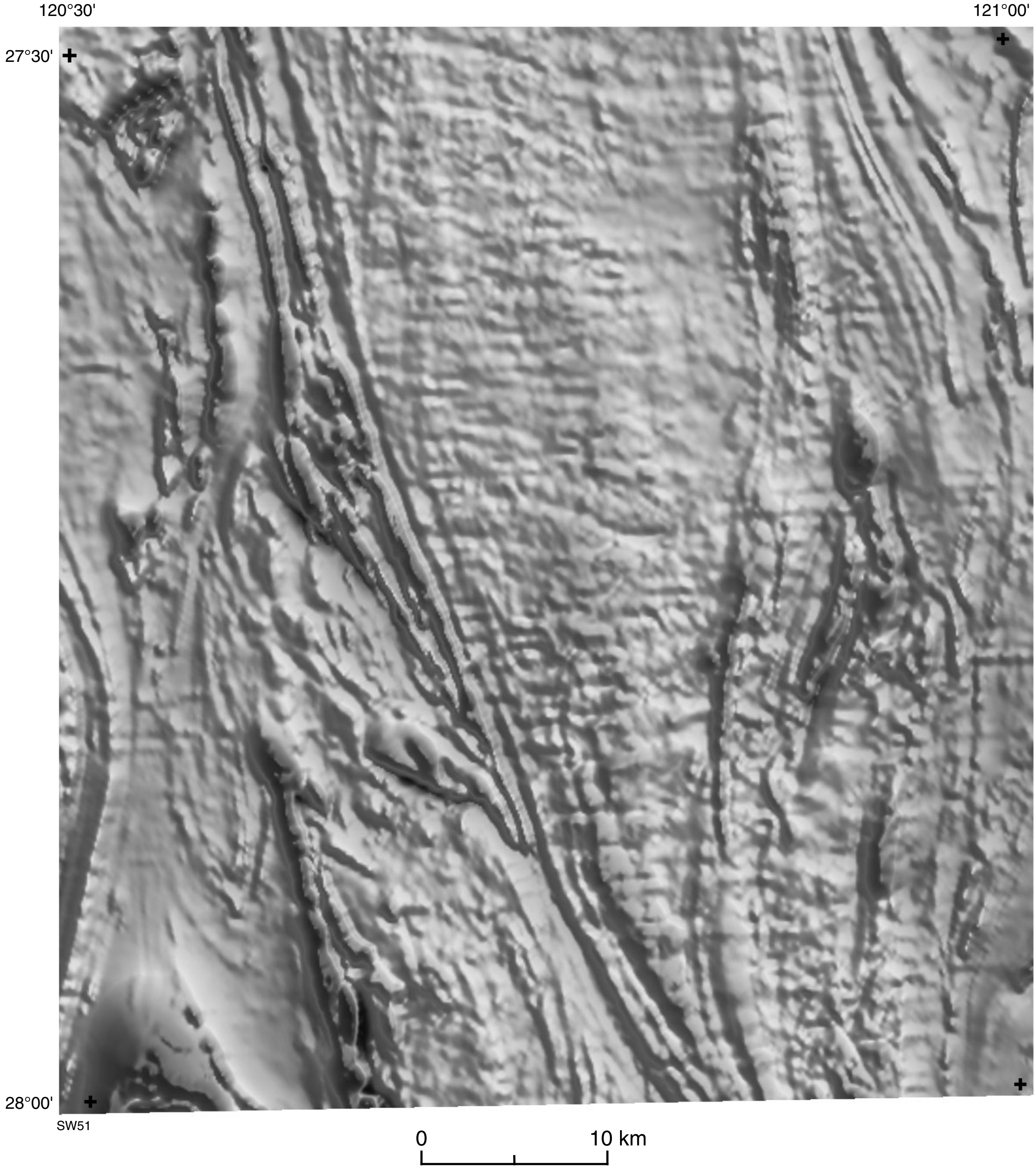

Figure 5. Grey-scale magnetic image of SIR SAMUEL; based on 400 m-line spaced data (Geological Survey of Western Australia, 1996)

Intercalated greenstone and granitoid rocks (Abg)

Intercalated layers of moderately to steeply dipping, foliated greenstone and granitoid rocks, (*Abg*) form layered units up to 1.5 km wide in the northeastern part of SIR SAMUEL. This unit is locally well exposed, and forms north-northwesterly trending, low, narrow ridges that have a distinctive striped pattern on aerial photographs, and on satellite and magnetic images. Individual lenses of greenstone or granitoid rock vary in width from less than 1 m to about 30 m. The greenstones are dominated by metamorphosed mafic rocks, including local amphibolite with subordinate layers of deformed, coarsely feldspar-phyric basalt, and rare ultramafic rocks. These rocks are deformed to varying degrees, with some primary textures such as spinifex texture in ultramafic rocks locally preserved. Some of the rocks contain a gneissic banding,

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Figure 6. Metabasalt with abundant plagioclase phenocrysts near the north shore of Lake Miranda (AMG 595376). Hammer is 26 cm long

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Figure 7. Flattened pillow structures in metabasalt near the north shore of Lake Miranda (AMG 593375). Hammer is 26 cm long

and thin mylonitic bands are present in felsic rocks that may be derived from either granitoid rock or felsic volcanic and/or volcaniclastic rocks in the greenstone sequence. All rock types assigned to this unit, and especially the granitoid rocks, contain a pronounced subhorizontal mineral lineation trending about 340°. In granitoid rocks, it is defined by recrystallized quartz and aggregates of recrystallized biotite that are 1–2 mm wide and up to 4 cm long. West of Mount McClure, this lineation has a shallow plunge to the southeast. Areas west of the Yandal greenstone belt have been interpreted as intercalated greenstone and granitoid rock (Fig. 3) on the basis of limited exposure in the south and interpretation of magnetic images (Fig. 5).

Metamorphosed mafic intrusive rocks (*Ao, Aod, Aog, Aogq*)

Undivided metamorphosed mafic intrusive rocks (*Ao*) outcrop in the Agnew and Yandal greenstone belts. These metagabbros are either deeply weathered or moderately deformed, and the interpretation of an intrusive origin is based primarily on a medium to coarse grain size. Metamorphic amphibole has pseudomorphed original pyroxene.

Fine-grained mafic intrusive rocks with an ophitic to subophitic texture have been mapped as metadolerite (*Aod*). The best exposure is in the southern part of the sheet, in the hills 3 km west of Brilliant mine, where mafic rocks with both ophitic and granular textures are interlayered with metabasalt. A small dyke of metadolerite intrudes the Kathleen Valley Gabbro in the north, about 600 m north of the Main Road openpit. Although pyroxene is completely replaced by metamorphic amphibole, the rock retains a relict intergranular texture. The strongly recrystallized nature of the rock suggests the dyke is late Archaean in age, rather than Proterozoic.

Metagabbro (*Aog*) is a medium- to coarse-grained mafic rock within the greenstone sequences, and is well exposed in the Kathleen Valley Gabbro, where it is present as part of an extensive, layered mafic sequence (see below). Metamorphosed quartz-bearing gabbro (*Aogq*) has been mapped in the Yandal greenstone belt south of Mount McClure.

Kathleen Valley Gabbro (Aokv, Aokva, Aokvg, Aokvq, Aokvx)

The Kathleen Valley Gabbro (*Aokv*) forms low hills in the northwest corner of SIR SAMUEL (Fig. 3), and extends onto the adjacent MOUNT KEITH sheet. These intrusive rocks comprise a weakly deformed, layered sequence (Durney, 1972; Bunting and Williams, 1979). Primary igneous layering in most outcrops of Kathleen Valley Gabbro strikes to the northeast and dips steeply to the northwest. However, the strike of the igneous layering changes from northeast on the eastern side of the exposure, to north-northeast near the Yakabindie Fault on the western side. The compositional layering indicates that this unit youngs to the southeast, indicating that the Kathleen Valley Gabbro is overturned. The gabbro is stratigraphically overlain by the Mount Goode Basalt. Faults normal to the layering have produced small offsets.

The stratigraphically lowest unit of the Kathleen Valley Gabbro on SIR SAMUEL is metamorphosed anorthositic gabbro and anorthosite (*Aokva*) that is commonly coarse grained and contains only a small component of fine- to medium-grained metagabbro. Plagioclase content in the anorthositic gabbro and anorthosite ranges from about 50% to more than 90%. Most of the rocks assigned to this unit contain more than two-thirds plagioclase, which is present as both phenocryst and groundmass phases. The phenocrysts are commonly milky and, although widely dispersed, typically constitute only a few percent of the total rock. They range in size from 5 mm to 10 cm, but are commonly less than 2 cm. Plagioclase crystals in the groundmass are mainly euhedral, and range from less than 0.5 to 6 mm in diameter. The euhedral crystal shape is best seen on weathered surfaces.

Some of the plagioclase-rich metagabbro has a poikilitic texture with euhedral plagioclase crystals within large (up to 15 cm) pyroxene oikocrysts that have been pseudomorphed by amphibole during metamorphism (for example, on the northern edge of the map area at AMG 580557). The amphibole oikocrysts are locally present as crystal aggregates with the same crystallographic orientation.

South of the anorthositic metagabbro, a unit of medium-grained metagabbro (*Aokv*) forms a northeast-trending hilly unit about 1.5 km wide. Three layers within the medium-grained metagabbro can be recognized on aerial photographs, as the central layer is slightly darker due to its higher amphibole content. The northernmost layer is only exposed in the west, whereas the central and southern layers are exposed throughout.

Near the northeastern margin of the anorthositic metagabbro, the central layer contains 60–70% metamorphic amphibole that has replaced primary igneous pyroxene. The amphiboles (commonly 2–5 mm across) preserve original euhedral pyroxene crystal outlines, and stand out in relief on weathered surfaces. This layer shows primary igneous layering, with individual bands mainly 15–30 cm thick, but locally up to 1 m thick. The northern and southern layers contain equal amounts of plagioclase and pyroxene (now amphibole). Unlike those in the central layer, most of the pyroxene pseudomorphs are not euhedral. However, some of the plagioclase grains are idiomorphic.

Metamorphosed pyroxenitic gabbro (*Aokvx*) outcrops as a 100 m-wide layer south of the medium-grained metagabbro, and has a distinctive smooth texture on aerial photographs. The rocks are very dark and fine to medium grained, with most grains being 0.5–2 mm in size. The rocks contain more than 80% amphibole (derived from pyroxene), 10% plagioclase, and less than 3% quartz. The amphibole is blue-green and is probably actinolite or actinolitic hornblende.

Immediately south of, and stratigraphically overlying, the metamorphosed pyroxenitic gabbro, there is a unit of metamorphosed quartz gabbro and tonalite (*Aokvg*). This unit is best exposed in a 500 m-wide zone about 1 km north of the Main Road openpit. Farther to the south, there is a 200 m-wide zone of metamorphosed quartz-bearing gabbro and quartz gabbro (*Aokvq*) and a 100 m-wide zone of coarse-grained metagabbro (*Aokv*). The metatonalite contains 40–50% plagioclase, 30–40% quartz, and 15–20% dark blue-green amphibole. Quartz is present as megacrysts (about 10 mm in size) and in the groundmass of the metamorphosed quartz gabbro, but is only present in the groundmass of the quartz-bearing metagabbro. Amphibole in these rocks is blue-green to dark blue-green. These units mark the exposed stratigraphic top of the Kathleen Valley Gabbro.

Metamorphosed felsic volcanic and volcaniclastic rocks (*Af, Afp, Afpq, Afs, Aft, Afv*)

Significant outcrops of felsic rocks are present in all major greenstone sequences on SIR SAMUEL. Many outcrops are foliated and deeply weathered, making determination of the protolith difficult. These outcrops commonly contain relict small, euhedral or embayed quartz phenocrysts. Felsic volcanic and subvolcanic rocks, and volcaniclastic sedimentary rocks, have been identified from very small, isolated exposures in the areas mapped as undivided felsic rock (*Af*). Where the foliation and recrystallization in these poorly exposed felsic rocks is intense, the outcrop has been labelled *Afs*. The schistosity is defined by white micas and oriented feldspar and quartz. Quartzofeldspathic schist of uncertain protolith is described with the low-grade metamorphic rocks.

A narrow, north-trending strip of felsic lithic tuff (*Aft*) up to 100 m wide and 2.5 km long outcrops 300 m east of the Yellow Aster mine. This unit is not bedded and is relatively fresh. The best exposure (Fig. 8) is in the south, between two basalt hills, where blotchy, pale grey, boulder outcrops have a fragmental texture. The clasts are dominated by crystal-rich felsic volcanic rocks, some of which have fragmental textures. Clasts of fine-grained mafic schist and metasedimentary rocks are a minor component. The matrix consists mainly of fine-grained quartz and feldspar. Boundaries between clasts and matrix are locally diffuse. The mostly angular to subangular clasts are poorly sorted (Fig. 9) and range in size from a few millimetres to 10 cm across, but are locally up to 40 cm across. Some thin, sharp siltstone clasts have a dark zone just inside the margin and a pale zone in the surrounding matrix (Fig. 10). The pale zone consists of quartz and feldspar, whereas the dark zone is biotite rich; similar zones are present in and around the rare mafic clasts. The zones may be reaction rims.

The felsic tuff at Kathleen Valley has a characteristic blotchy appearance with pale grey to white patches 1–10 cm across in a darker grey host (Fig. 8). The pale patches consist of feldspar, quartz, and amphibole with a grain size of 1–2 mm. The amphibole (probably hornblende) forms long prisms and makes up 5–10% of

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Figure 8. Felsic tuff south-southeast of the Yellow Aster mine (AMG 601534). Pencil is 14 cm long

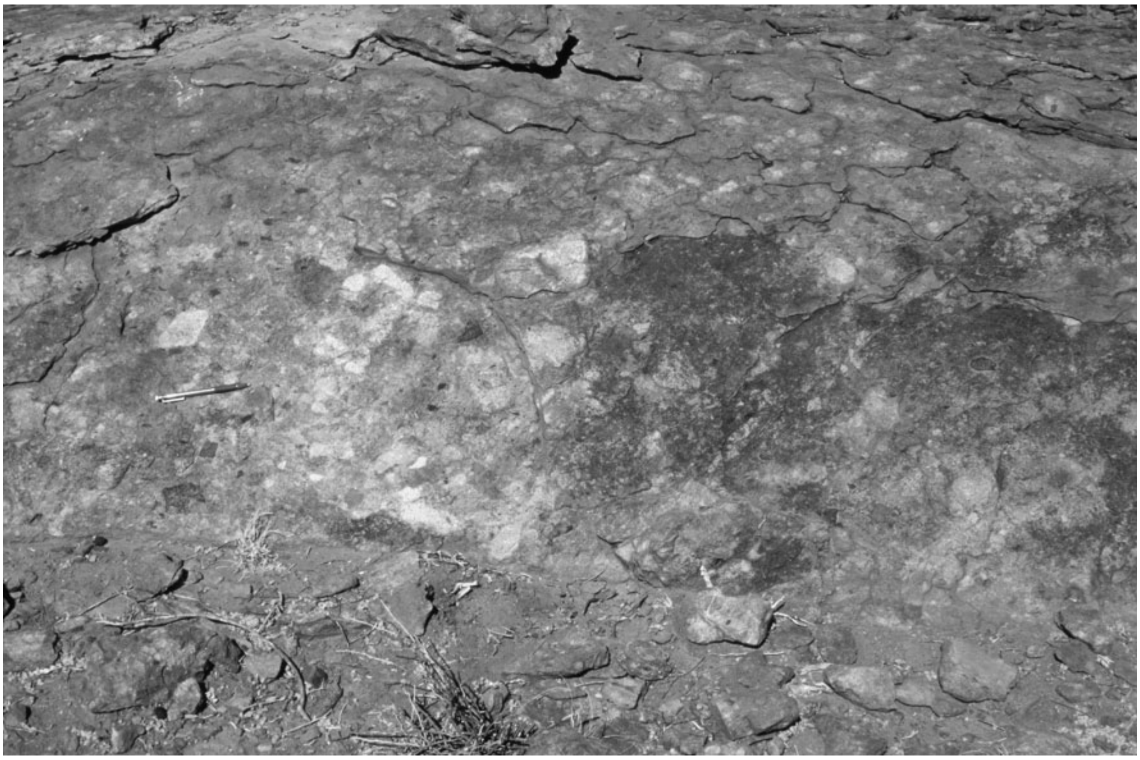

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Figure 9. Felsic lapilli tuff south-southeast of the Yellow Aster mine (AMG 602533). Pencil is 14 cm long

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Figure 10. Reaction rim around a metasiltstone clast in felsic tuff south-southeast of the Yellow Aster mine (AMG 602533). Pencil is 14 cm long

the volume of the tuff. The grey material surrounding the pale patches contains biotite and has a finer grain size. The margins of pale patches vary from sharp to gradational. This blotchy heterogeneity may reflect small water-content variations in the original magma. In other outcrops in this area, the pale patches are more vein-like and are associated with thin quartz veins in some cases. Finer grained, more even-textured felsic rocks in this unit have gradational layering on a scale of 10 cm that is best seen on weathered surfaces.

Exposures of metamorphosed felsic volcanic and volcaniclastic rocks (*Afv*) are commonly weathered. The lack of regular compositional layering in thick sequences of fine-grained rocks with prominent, commonly euhedral quartz and feldspar, indicates a proximal felsic volcanic origin. Crystal content ranges from 5–30% of the total rock. These rocks contain subordinate, thin (10–50 cm) layers of tuff in outcrops 5 km north of McDonough Lookout.

There are small outcrops of metamorphosed, fine-grained plagioclase-phyric felsic rock (*Afp*) 3 km north of Mount Sir Samuel, and fine-grained quartz-phyric felsic rock (*Afpq*) 4 km west of the Perseverance nickel mine.

Metasedimentary rocks (*As, Ash, Ashc, Ashd, Ashg, Ass, Ac, Aci*)

Metasedimentary rocks are a widespread, poorly exposed component of the greenstone sequences throughout SIR SAMUEL. Undivided metasedimentary rocks (*As*) are poorly exposed and deeply weathered. Many have a well-developed foliation and some outcrops are silicified. The protolith for most of these rocks is assumed to be sandstone, siltstone, and mudstone, but may include felsic volcanic rocks, particularly in finely interbedded sequences. The metasedimentary rocks in the western greenstone sequences are mostly present as narrow units within the felsic, mafic, and ultramafic rocks, although relationships are not always clear in the field, either due to poor exposure or structural complexity.

In the Mount White area, weathered, fine-grained metasedimentary rocks are interbedded with metabasalt and metagabbro. The rocks are not well exposed, but differential weathering results in clear trend patterns on aerial photographs. Thin-bedded metasedimentary rocks in mafic rocks define macroscopic fold structures.

Metamorphosed shale, siltstone, and fine-grained sandstone (*Ash*) are mainly present as thin beds within metamorphosed mafic, ultramafic, and felsic volcanic rocks. Fine-grained metasedimentary rocks can provide evidence of multiple deformation, such as those 3.6 km east of William Well (AMG 647450) where pelitic rocks contain an early cleavage that has been crenulated. The fine-grained metasedimentary rocks may include subordinate quartz–mica schist, and locally contain andalusite and cordierite porphyroblasts. Phyllite with abundant andalusite porphyroblasts (*Ashd)* outcrops as a north-northwest trending unit about 3.5 km northeast of Mount Goode. The best exposures are in a small creek (AMG 628503), where the rocks are grey and scattered andalusite porphyroblasts (1–3 mm) constitute 15–20% of the rock. Metamorphosed black graphitic shale *(Ashg)* outcrops as a north-trending, narrow (20 m) strip 1.5 km west of Meredith Well. One drillhole in the Yandal greenstone belt, 4 km northeast of Toms Well, contained chips of strongly carbonated, fine-grained metasedimentary rock *(Ashc)*.

Thin units of metamorphosed sandstone with subordinate conglomerate and siltstone (*Ass*) outcrop in the McDonough Lookout area.

Metamorphosed siliceous metasedimentary rocks (*Ac*) are prominent in the Mount Keith – Perseverance and Yandal greenstone belts where they are exposed in discontinuous ridges parallel to regional trends. The rocks are fine to very fine grained and quartz rich, with most quartz recrystallized during metamorphism. They are typically grey- and white-banded, locally pyritic, and are locally very ferruginous on outcrop surfaces. These rocks are generally called cherts, but a chemical sedimentary origin is not always clear. Banded iron-formation (*Aci*), which weathers to prominent, narrow ironstone ridges, outcrops between the Rockys Reward and the Perseverance openpits. The metamorphosed chert and banded iron-formation units are rarely more than a few metres thick, and are commonly associated with shales and quartz–mica schist. Because the chert and banded iron-formation form prominent ridges, they can be good marker horizons that preserve complex fold structures.

Low- to medium-grade metamorphic rocks (*Al, Ala, Alb, Ald, Alhb, All, Alqb, Alql, Alqm*)

Where the protolith of low- to medium-grade metamorphic rocks cannot be recognized due to the high degree of deformation and recrystallization, the prefix *Al* is used with a suffix indicating the characteristic mineralogy. Many of these rocks are identified from small rock chips obtained from shallow exploration drilling through the regolith.

Layered plagioclase–hornblende–diopside–quartz rock (*Ala*) is exposed in a thin, north-trending recessive unit east of Mount McClure (AMG 024403). This strongly deformed rock is markedly more leucocratic than the deformed mafic rocks to the east and west. A pronounced layering, which is typically streaky or discontinuous, is defined by both compositional and grain size variations. This rock has been extensively recrystallized, and is mainly fine to very fine grained with thin (up to 5 mm wide), coarser grained layers containing various combinations of plagioclase, quartz, amphibole, and clinopyroxene. Plagioclase is the principal component of the very fine grained phase; because it is commonly untwinned, it is difficult to estimate an absolute ratio of feldspar to quartz. Plagioclase grains with multiple twinning are up to 4 mm across in some of the coarser grained layers. The clinopyroxene, probably diopside, is colourless, has a high birefringence, and is typically fine-grained, but is coarser and locally poikiloblastic in the more-mafic layers. The fine to very fine grained amphibole displays dark green to pale brown pleochroism. The amphibole is concentrated in layers as fine prismatic and acicular crystals oriented parallel or subparallel to the main layering. Fine to very fine grained epidote, titanite, and apatite are significant accessory minerals.

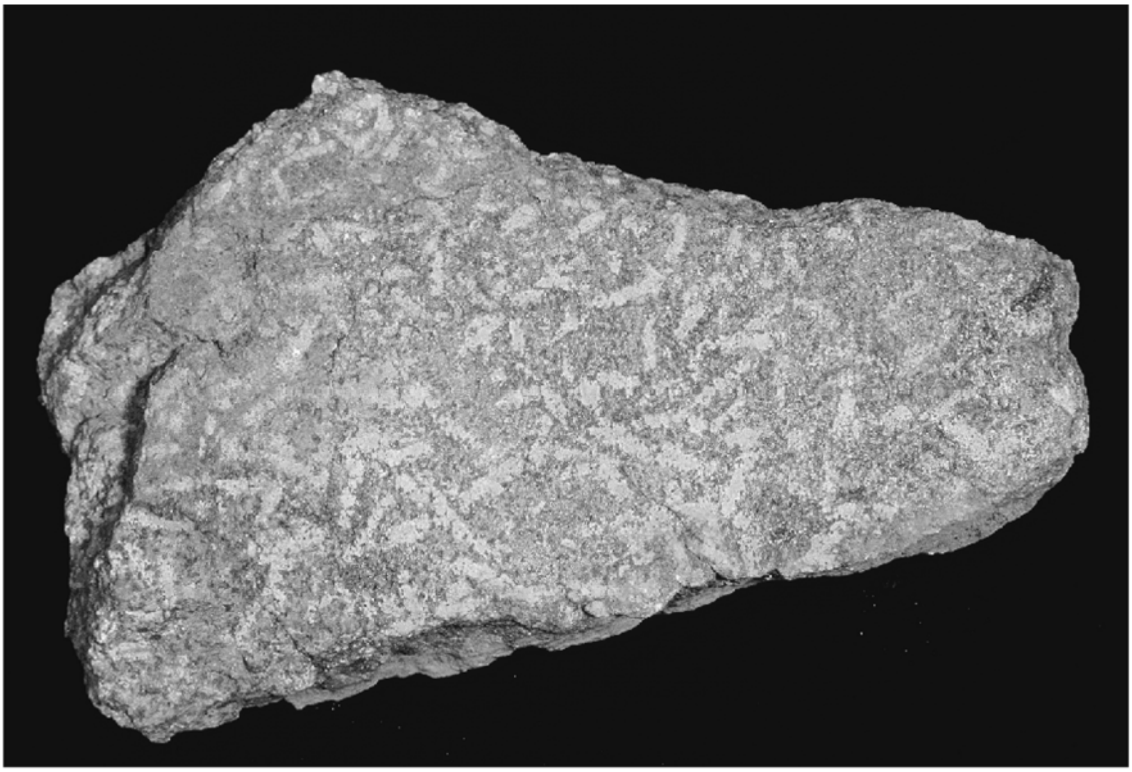
Low- to medium-grade metamorphic rocks identified in drillholes in the southwest of SIR SAMUEL are closely associated with metamorphosed conglomeratic and arkosic sedimentary rocks, felsic volcanic rocks, or granitoid rocks adjacent to major fault zones. Both sheared granitoid and arkosic sedimentary rocks could be precursors to quartz–biotite schist (*Alqb*), quartz–chlorite schist (*Alql*), or quartz–muscovite schist (*Alqm*). Similarly, mafic conglomerate, basalt, or gabbro may be the parent rocks of chlorite schist (*All*) and biotite schist (*Alb*). Chlorite schist is found adjacent to faults around the Agnew Anticline. Hornblende–biotite schist (*Alhb*) has been identified in drillholes adjacent to the Perseverance Fault.

At a locality about 2.5 km north of Mount Goode (AMG 599503), pelitic schist (*Ald*) is associated with quartzofeldspathic schist. Here, the pelitic schist contains altered andalusite and cordierite porphyroblasts. Pale blue andalusite porphyroblasts are commonly a few millimetres wide, up to 2 cm long, and randomly oriented (Fig. 11). Former cordierite porphyroblasts appear as brown, round patches of alteration products 1–2 cm in diameter.

Jones Creek Conglomerate (*Asjc, Asjcb*)

Metamorphosed conglomerates are abundant in the Kathleen Valley area and the southwestern part of SIR SAMUEL (Figs 3, 4). They were called the Jones Creek Conglomerate by Durney (1972), who studied them in the area around the Yellow Aster mine and northwards towards Jones Creek on the adjoining MOUNT KEITH sheet.

Marston and Travis (1976) interpreted the conglomerate sequences to be part of a unit of metasedimentary rocks that is mostly contained within a fault-bounded zone that extends from west of the Agnew Anticline to the Mount Keith nickel mine. They described a variety of rock types in the Jones Creek area on MOUNT KEITH. The major rock types include granitoid metaconglomerate with granitoid clasts in an arkosic matrix; metaconglomerate with granitoid, felsic, and mafic clasts in a mafic matrix; mafic metaconglomerate; meta-arkose; and mafic and ultramafic metasedimentary schists. The meta-arkose is bedded, and low-angle cross-stratification indicates eastward younging. Near Jones Creek, the conglomerate has been deformed by D_2 and D_3, and has undergone lower amphibolite facies metamorphism. There is no indication of a different metamorphic history from that of the surrounding greenstones (Marston and Travis, 1976). SHRIMP (Sensitive High-Resolution Ion Microprobe) U–Pb geochronology on zircons, interpreted as detrital, in Jones Creek Conglomerate from MOUNT KEITH (AMG 590619) are considered by Nelson (1997a) to indicate



SW36 28.07.98

Figure 11. Randomly oriented andalusite porphyroblasts in quartzofeldspathic schist (from 2.5 km north of Mount Goode). Sample length is 23 cm

deposition after 2632 ± 13 Ma. This age is significantly younger than the crystallization age for the foliated monzogranite that unconformably underlies the Jones Creek Conglomerate on MOUNT KEITH (AMG 586619) based on a U–Pb zircon age of 2685 ± 7 Ma (Nelson, 1997a). It is also younger than undeformed late granitoids dated at around 2640 Ma (Nelson, 1997b) from elsewhere in the granite–greenstones from the Eastern Goldfields.

Felsic conglomerate (*Asjc*) on SIR SAMUEL is best exposed in the northern part of the map area. Here, the conglomerate contains clasts of predominantly medium- to coarse-grained, massive granitoid rock, with subordinate felsic porphyry and mafic rock. Clasts range in size from a few centimetres up to 40 cm, but most are smaller than 20 cm. They are rounded to semi-rounded and closely packed. The conglomerates have been partially recrystallized, and boundaries between clasts and matrix are typically sharp, but locally gradational. A few fractures less than one centimetre wide in massive outcrop are the only evidence of deformation within the conglomerate, but contacts with the adjacent rock units are strongly sheared.

Clasts in the Jones Creek Conglomerate in drillcore from 2 km south of the Yellow Aster mine are mostly porphyritic felsic rock with only minor granitoid, mafic, and sedimentary rock clasts. Some of this conglomerate contains gold-bearing quartz veins.

Mafic conglomerate (*Asjcb*) outcrops 1 km east of the Yellow Aster mine, and exposures extend to the south for about 5 km. This unit has a mafic matrix, and locally contains clasts of both granitoid and mafic rocks. The aerial photograph pattern for these rocks is similar to that of areas of metabasalt. The mafic conglomerate does not outcrop as well as the felsic conglomerate, but forms low, rubble-covered hills where granitoid clasts (mostly pebbles and boulders) stand out due to differential weathering, or are present as rounded to semi-rounded float. Unlike the felsic conglomerate, which is commonly only weakly deformed, outcrops of mafic conglomerate typically have a strongly deformed matrix with a well-developed cleavage or schistosity that is consistent with the regional north-northwest structural trend.

The Scotty Creek sequence of Platt et al. (1978), in the southwest, west of the Vivien mine, is considered to be part of the Jones Creek Conglomerate. In this area, the sequence is mainly made up of felsic conglomerate with granitoid clasts and arkosic sandstone. A small outcrop of strongly foliated mafic conglomerate (AMG 579041) contains metabasalt boulders up to 10 cm in diameter scattered through mafic schist. The foliation wraps around some clasts, but penetrates others.

Granitoid rocks (*Ag, Agb, Agdq, Agf, Agm, Agn*)

Granitoid rocks occupy more than half of SIR SAMUEL, but are rarely exposed. Outcrops are most commonly present as deeply weathered patches in areas of sand at the base of low breakaways and isolated, relatively fresh pavements and small tors. The large masses of granitoid rock that separate the greenstone belts are typically undeformed in the centre, and are dominated by biotite monzogranite (*Agm*). The cores of these bodies have an even texture on magnetic images that contrasts with the strongly banded or heterogeneous margins (Fig. 5). Granitoid rock (*Ag*) is used as an undivided category for areas of poor exposure that could contain a variety of granitoid rocks, including foliated and unfoliated varieties, and may include areas of granitoid rock containing a significant amount of intercalated and xenolithic greenstone. The intercalated material includes long, mappable strips of foliated, low-grade metamorphosed greenstones along the margins of large areas of granitoid rock and patchy outcrop and inclusions, up to 5 m across, of folded, gneissic-banded amphibolite within areas of massive granitoid rock. Strongly foliated granitoid rock (*Agf*) on the eastern side of the sheet area is typically weathered, but may be mainly monzogranite.

There are two large areas dominated by monzogranite. One of these areas is bounded by the Agnew greenstone belt to the west and north, and the Mount Keith – Perseverance greenstone belt and Perseverance Fault to the east (Fig. 3). The sheared, faulted western contact can be seen in outcrop about 500 m west of the Wiluna–Leinster road (AMG 671113). Elsewhere, the contact is interpreted as being sheared, faulted, and probably folded. There are large pavements and tors west of the road junction south of Leinster (AMG 730073) where the monzogranite varies from porphyritic to fine-grained and massive. Similar varieties have been mapped on WILDARA to the south (Oversby et al., 1996). A later porphyritic phase is associated with diffuse pegmatite. Potassium feldspar and plagioclase phenocrysts (3–10 mm in size) are set in a groundmass of quartz, potassium feldspar, plagioclase, and brown biotite, with accessory titanite, magnetite, and apatite. The plagioclase is ragged, zoned, multiply twinned, and has very cloudy cores. Chlorite is a minor to abundant alteration product of biotite. The monzogranite is cut by aplite and quartz veins.

The largest area of monzogranite, in the central part of the map area, is bounded to the west by the Perseverance Fault and the Mount Keith – Perseverance greenstone belt, and to the east by the Gardiner Fault and a zone of intercalated granitoid rock and greenstone along the western side of the Yandal greenstone belt (Fig. 3). On magnetic images, this granitoid body has a distorted lens shape, suggesting a sinistral shear sense. Most outcrops are low and deeply weathered, although there are large pavements and tors in the north of SIR SAMUEL. At Chooweelarra Rock, the biotite monzogranite has several inclusions (up to 1 m wide) of folded, layered gneissic amphibolite. There are outcrops of foliated monzogranite with more-abundant amphibolitic inclusions (*Agb*) near the southern boundary of the map area, 2 km east of the Perseverance Fault. At a locality 2.5 km south-southwest of Koonoonooka Quarry (AMG 814240), tors of fresh, unfoliated porphyritic biotite monzogranite contain potassium feldspar phenocrysts up to 30 mm (typically 10 mm) across. The phenocrysts are perthitic, and contain abundant coarse-grained inclusions of quartz and biotite. The groundmass contains plagioclase, quartz, pale brown biotite that is variously altered to chlorite, and accessory sphene and magnetite. Although the monzogranite contains no large mafic inclusions, there are some biotite-rich schlieren and rare, small (less than 20 mm in size), discoid, biotite-rich inclusions. Minor pegmatite and coarse-grained leucogranite veins, less than 5 cm across, have intruded the main monzogranite body.

Granitoid rocks on the margins of the large masses, adjacent to the greenstones, are characterized by well-developed, moderately to steeply dipping tectonic foliations and, in some cases, by intercalations of foliated greenstones. The zones of high strain and intercalation vary in width from a few hundred metres (for example, east of the Perseverance Fault at Rockys Reward) to 6 km (for example, west of the Challenger openpit). Magnetic data indicate that the marginal zone west of the Yandal greenstone belt may be up to 13 km wide. The zone is very poorly exposed in the south and the interpreted geology is based almost entirely on magnetic data. Deformed granitoid rock containing lenses of mafic rock (*Agb*) is best exposed in the northeastern part of the sheet, where it is associated with foliated greenstones containing thin lenses and layers of granitoid rocks (*Abg*). These rocks have a distinctive northwest-trending pattern on aerial photographs and magnetic images in the area between Ginnabooka Well and Satisfaction Bore. The granitoid rocks are dominated by medium-grained, foliated to strongly foliated and lineated biotite monzogranite. The greenstone lenses are dominated by strongly foliated mafic rocks that have been metamorphosed in the greenschist and lower amphibolite facies. They outcrop as layers up to 30 m wide within the deformed granitoid rocks. Individual bands of granitoid rock contain local gneissic layering, and can be traced for several hundred metres. Contacts with adjacent rock units are sheared. The foliation in the granitoid bands has a consistent strike of 340° and dips moderately to steeply to the northeast, and locally to the southwest. A subhorizontal stretching lineation is defined by fine biotite aggregates and recrystallized quartz. Abundant pegmatite veins are typically parallel or subparallel to the foliation.

A SHRIMP U–Pb zircon age of 2738 ± 6 Ma was obtained on a sample of foliated monzogranite from west of the Parmelia openpit (AMG 955522; Nelson, 1997a). Although this age is older than any other published age for a granitoid rock in the Eastern Goldfields, the presence of significantly older xenocrystic zircons in sequences throughout the Eastern Goldfields suggests it is likely that the greenstones were deposited onto older sialic basement (Swager et al., 1995).

Granitoid rock on the western edge of SIR SAMUEL is not exposed, but has been interpreted from patchy outcrop to the west, rock chips from mineral exploration drilling, and magnetic data. These data indicate that this area is dominated by very strongly deformed granitoid rocks with subordinate intercalated foliated mafic rocks.

Small elongate lenses and pods of partially recrystallized quartz diorite and tonalite (*Agdq*) outcrop adjacent to fault-bounded strips of metamorphosed felsic volcanic rocks and metabasalt 500 m west of the Yellow Aster mine. Exposures vary from fresh material on rounded, bouldery hills and slopes to deeply weathered material in gullies. These rocks are typically equigranular and fine-grained, with a poorly defined compositional layering in some exposures. The mineralogy comprises polygonized quartz, twinned plagioclase, large poikilitic hornblende grains, biotite with minor chlorite, large poikilitic clinopyroxene grains, and equant garnet crystals.

Gneissic granitoid rock (*Agn*) is poorly exposed, strongly foliated granitoid rock with thin layers that include pegmatite, aplite, monzogranite, leucogranite, quartz veins, and coarsely recrystallized layered mafic rocks. These rocks outcrop in the south, adjacent to the Perseverance Fault.

Veins and dykes (*d, g, p, po, q*)

Small dolerite dykes (*d*) are of uncertain affinity and may be Proterozoic or Archaean in age.

Veins and dykes of granitoid rock (*g*) are abundant near granite–greenstone contacts. Although typically deeply weathered, most dykes probably consist of biotite monzogranite.

Pegmatite veins (*p*) are common in areas of granitoid rock, where they are present as both diffuse phases in the granitoid rock and late, cross-cutting veins. The pegmatite veins locally cross-cut greenstones.

A prominent northwest-trending felsic porphyry dyke (*po*) outcrops on the northeastern side of a hill on the northern shore of Lake Miranda, east of the Wiluna–Leinster road. The dyke is 3 m wide, contains both quartz (2–5 mm in size) and plagioclase phenocrysts (up to 2 cm in size), and is strongly foliated along its margins. Smaller felsic porphyry dykes at the east end of the northwest-trending island near the north shore of Lake Miranda are 10–20 cm thick, and have been boudinaged and folded (Fig. 12). Felsic porphyry dykes have also been recorded in drillcore in the Bellevue gold mine area.

Quartz veins (*q*) intrude both granitoid and greenstone rocks. They occur as short, discontinuous outcrops ranging from a few centimetres to several metres wide. Large quartz veins are commonly surrounded by an apron of quartz-vein rubble (*Czcq*). Many of the larger veins are associated with sheared contacts between granitoid rocks and greenstones. Gold mineralization is commonly associated with quartz veins, which were a major target for early prospectors.

Stratigraphy and correlations

Determination of a complete stratigraphic succession for the greenstones on SIR SAMUEL is hampered by the limited outcrop, complex deformation, and lack of stratigraphic markers and younging indicators. However, some partial stratigraphic sequences are recognized.

Greenstones on SIR SAMUEL have been subdivided into separate greenstone belts based on their distribution, differences in the dominant rock types, and structural

Figure 12. Folded felsic porphyry in metabasalt near the north shore of Lake Miranda (AMG 594378). Width of bag is 39 cm

complexity (Griffin, 1990). These belts included the Mount Keith – Perseverance, Agnew, and Yandal greenstone belts. The greenstone belts are named primarily for ease of discussion and boundaries are not well defined. These notes follow the earlier usage (Griffin, 1990), except that the greenstone sequence that lies west of the Miranda Fault has been assigned to the Yakabindie greenstone belt (Fig. 3). All of these greenstone belts form part of the Agnew–Wiluna greenstone belt of Hill et al. (1990).

In the Kalgoorlie Terrane, south of SIR SAMUEL, a simple stratigraphy has been described consisting of a lower basalt overlain by a komatiite, followed by an upper basalt, and then a unit of felsic volcanic and sedimentary rocks, all unconformably overlain by a clastic sedimentary unit (Swager et al., 1995). Hallberg (1985) presented a synthesis of the geology in the Leonora–Laverton area immediately to the south and southeast of SIR SAMUEL. Although he did not produce a regional stratigraphy, Hallberg (1985) divided rocks in the Leonora–Laverton area into a lower sequence (Association 1) with abundant ultramafic rocks and rare felsic volcanic rocks, and an upper sequence (Association 2) with only rare ultramafic rocks and abundant felsic volcanic rocks. The Yakabindie, Mount Keith – Perseverance, and Agnew greenstone belts, and the western part of the Yandal greenstone belt, may correspond to Hallberg's lower sequence; the eastern part of the Yandal greenstone belt on DARLOT may correspond to his upper sequence (Westaway and Wyche, 1998).

Hill et al. (1995) concluded that the ultramafic rocks in this region are volcanic rocks that can be correlated for more than one hundred kilometres of strike length. They were probably erupted during the same event that was responsible for the large volumes of komatiite in the southern part of the Eastern Goldfields, including the Kalgoorlie Terrane of Swager et al. (1995).

Durney (1972) interpreted the Jones Creek Conglomerate as representing a major unconformity in the Archaean Yilgarn Craton. He suggested that the greenstones to the east, the Mount Keith – Perseverance and Agnew greenstone belts, are younger than the Jones Creek Conglomerate. However, Marston and Travis (1976) noted that, although the western contact between the Jones Creek Conglomerate and the underlying granitoid and greenstone rocks is a deformed unconformity, the eastern contact between the conglomerate and the greenstones is so strongly deformed that its original nature cannot be determined. Moreover, Marston and Travis (1976) and Marston (1978) suggested that the Jones Creek Conglomerate represents the youngest Archaean formation in the greenstone sequences, rather than an unconformity between two greenstone sequences. The very immature nature of these sedimentary rocks indicates that they were locally derived. The greenstones east of the Jones Creek Conglomerate are structurally complex, but typically young to the west (Naldrett and Turner, 1977). The Yakabindie sequence, west of the conglomerate, youngs to the southeast. Marston and Travis (1976) presented a model in which the conglomerate represents alluvial fan deposits in a linear, partly fault-bounded basin with a granitoid–mafic source area to the west and a mafic–ultramafic source area to the east.

The Jones Creek Conglomerate is similar in character and setting to conglomerate formations in the southern part of the Eastern Goldfields, such as the Kurrawang Formation and Merougil Conglomerate in the Kalgoorlie Terrane (Swager et al., 1995).

Yakabindie greenstone belt

The weakly deformed Yakabindie greenstone belt sequence comprises the layered Kathleen Valley Gabbro overlain by massive, tholeiitic Mount Goode Basalt (Figs 3, 4). These rocks do not appear to have equivalent sequences in the adjacent greenstone belts, so their absolute stratigraphic position is unknown.

The Yakabindie sequence is bounded by the north-trending Miranda Fault to the east, and is intruded in the west by granitoid rocks. The sequence youngs towards the south, and has a steep to nearly vertical dip to the northwest, and is thus overturned. The upper part of the Mount Goode Basalt is characterized by patchy development of a plagioclase-phyric phase, and is overlain by metamorphosed sedimentary and felsic volcanic rocks. This apparently simple stratigraphic succession is disrupted along the Miranda Fault, particularly near the junction with northwest-trending faults such as the Yakabindie and Highway Faults, where blocks have been rotated and there has been intense shearing.

Agnew greenstone belt

In the Agnew greenstone belt, the sequence of metabasalt and thin metasedimentary units with subordinate metagabbro in the Mount White Syncline is structurally above the sequence of ultramafic rock, metabasalt, and metagabbro in the Agnew Anticline (Fig. 3). Although the two sequences are separated by a fault, the Mount White sequence is interpreted to be stratigraphically above the Agnew Anticline sequence. The greenstones in the Agnew Anticline are correlated with those in the Leinster Anticline because they contain similar rock types. Greenstones between the Sir Samuel and Plonkys Faults consist mainly of metabasalt with a small ultramafic component, and are similar to those in the Mount White Syncline.

Mount Keith – Perseverance greenstone belt

The Mount Keith – Perseverance greenstone belt (Fig. 3) is characterized by abundant metamorphosed ultramafic and siliceous metasedimentary rocks (chert). The sequence also includes basaltic, and felsic volcanic and volcaniclastic, rocks. This belt hosts several major nickel deposits between Leinster and Wiluna. The Mount Keith – Perseverance greenstone belt is separated from the Agnew greenstone belt to the west by the Sir Samuel Fault. The sequence in the Mount Keith – Perseverance greenstone belt cannot be readily correlated with that in the Agnew greenstone belt.

The Mount Keith – Perseverance greenstone belt on SIR SAMUEL is dominated by faulted slices of folded rocks. The north-northwest structural trend is reflected in both the distribution of the greenstones and the orientation of the foliation. Most of the rocks are strongly deformed and contain a well-defined foliation. Almost all of the contacts between different rock types are faulted or sheared. However, there are local exposures where primary textures and rock relationships are preserved.

The northern part of the Mount Keith – Perseverance greenstone belt on SIR SAMUEL is bounded to the west by the Emu Fault and to the east by the Perseverance Fault. Here, the belt contains prominent and well-exposed siliceous and fine-grained clastic metasedimentary rocks (chert, shale, phyllite, and schist), and minor banded iron-formation. Other rock types in this area include metamorphosed basalt, gabbro, and ultramafic and felsic volcanic rocks.

Grey phyllite outcrops 3 km north of McDonough Lookout (for example, on a track at AMG 647449) within a sequence of fine-grained metabasalt with subordinate metagabbro. A well-developed, north-trending, nearly vertical cleavage in the phyllite is overprinted by a spaced (about 1 mm) crenulation cleavage which trends north-northeast with a moderate dip to the southeast.

Yandal greenstone belt

There is no recognized stratigraphy for the Yandal greenstone belt (Westaway and Wyche, 1998). The sequence along the SIR SAMUEL – DARLOT sheet boundary youngs to the east, with mafic and, in the south, ultramafic rocks immediately east of the granite–greenstone contact. Metamorphosed sedimentary and felsic volcanic rocks outcrop to the east. The east-younging is indicated by differentiation trends in a gabbroic sill on DARLOT (Westaway and Wyche, 1998), by poorly preserved cross-beds (AMG 998080), graded bedding in tuffaceous rocks exposed in openpits, and by relationships between sedimentary and mafic rocks displayed in drillcore obtained by Australian Resources (Harris, J., 1994, pers. comm.) from the Mount McClure gold mine to the north.

There is a suggestion of a structural or stratigraphic discontinuity between the northern and southern parts of the sequence in the vicinity of Calowindi Well, but the discontinuous nature of the outcrop and vague magnetic patterns preclude any conclusive resolution of relationships in this area. In the south, the sequence includes metamorphosed clastic sedimentary rocks and felsic schist, possibly derived from felsic volcanic or volcaniclastic rocks, and is characterized on SIR SAMUEL by prominent ridges of thinly bedded to laminated chert and fine-grained silicified shale interspersed with mafic and ultramafic rocks. Mafic rocks are the main component of the sequence to the east on DARLOT (Westaway and Wyche, 1998). In the north, just east of the main granite–greenstone contact, the metasedimentary rocks appear to be a discrete package containing mainly chert, shale, and micaceous schist. The distinctive leucocratic, layered calc-silicate rock (*Ala*) within the mafic sequence just to the east of the chert ridges (for example, AMG 024403) may be a strongly deformed metasedimentary rock.

Structure and metamorphism

The structural and metamorphic history of the region is poorly understood due to the lack of reliable stratigraphic markers in the greenstones and lack of continuity between areas of reasonable outcrop. However, a complex structural history is indicated by local fold structures, outcrops with multiple generations of superimposed tectonic fabrics, and evidence of multiple intrusions by granitoid stocks, felsic dykes, and quartz veins. Deformation fabrics in granitoid rocks, including large-scale interleaving of the greenstones along the contacts, suggest that they have also undergone a complex structural history.

The Archaean structural and metamorphic history of SIR SAMUEL is summarized in Table 1. Little is known about the earliest deformation (D_1) and metamorphism due to the overprinting by later structural and metamorphic events. During D_2, east-northeasterly directed compression produced north-northwesterly trending structures, including the regional-scale folds in the greenstone belts. Macroscopic and microscopic evidence suggests there was some sinistral movement associated with this deformation. The large-scale, asymmetric deformation of the large monzogranite body in the centre of the sheet area probably began during D_2 and continued during D_3, and is consistent with a sinistral sense of movement. The east-northeasterly directed compression continued during D_3. Interpreted thrust structures west of the Sir Samuel Fault (Fig. 4) appear to have displaced D_2 structures and granitoid rocks, and may have formed during late D_2, or D_3. The limbs of the D_2 Leinster and Agnew Anticlines, as well as those of the D_2 Mount White Syncline, were sheared out by D_3 structures including the Waroonga Shear Zone and the Halfway and Emu Faults (Fig. 3). The strong fabrics in regional-scale ductile faults such as the Waroonga Shear Zone, Perseverance Fault, and Mount McClure Fault also developed during D_3. The last recognized deformation event, D_4, produced east-trending normal faults, fractures, and some local, subhorizontal crenulations.

Clear indications of the relationship between the various deformation events are only rarely preserved. At the southeastern end of the elongate island 3 km south of Bellevue gold mine (AMG 593375), the Mount Goode Basalt is moderately to strongly deformed with a well-developed, almost vertical, north-trending cleavage defined by the alignment of plagioclase and amphibole. Pillow structures in metabasalt were flattened during the earliest recognized deformation. The S_1 is steep to vertical and trends to the north-northeast (Fig. 7). The flattened pillows are overprinted by the strong regional deformation (D_2) that produced the prominent, steep, north-trending cleavage throughout SIR SAMUEL (Fig. 13). The asymmetric shape of pressure shadows around plagioclase phenocrysts indicates a sinistral shear sense during D_2. In the northeastern part of the same island, a felsic porphyry dyke has been folded during D_3, producing upright folds (Fig. 12) and a spaced crenulation cleavage axial planar to the folds. In the central lower part of the outcrop shown in Figure 12, the locally horizontal S_2 foliation has been

Table 1. Structural and metamorphic history of Archaean rocks on SIR SAMUEL

Deformation event	*Major features*	*Metamorphism*	*Comments*
D_4	East-trending normal faulting and fracturing; subhorizontal crenulations	Some faults and fractures filled with quartz veins, and metasomatic alteration involving growth of amphibole	Small granitoid bodies intruded post-D_3
D_3	Regional north-northwest structures and fabric enhanced; development of regional-scale faults and shear zones	Greenschist facies recrystallization mainly in fault zones, local retrogression	Crustal architecture further defined; continued deformation with compression similar to that during D_2
D_2	North-northwesterly trending greenstone belts, elongated granitoid bodies, regional-scale folds, and widespread regional upright foliation	Peak metamorphism during late- or post-D_2. Randomly oriented andalusite porphyroblasts; regional greenschist facies, local amphibolite facies	East-northeasterly directed compression produced the crustal architecture; granitoid intrusion pre- to syn-D_2; deposition of Jones Creek Conglomerate pre- to early syn-D_2
D_1	Flattening of pillows in the Mount Goode Basalt	?Low-grade regional metamorphism	Possible intrusion of granitoid sheets
	Small-scale, east-plunging folds in siliceous metasedimentary rocks east-northeast of Mount Sir Samuel		
Pre-D_1			Deposition of main greenstone succession; syngenetic nickel mineralization

crenulated by the D_3 upright folding (Fig. 14). The S_2 foliation is represented by subhorizontal, pale and dark layers formed by mineral segregation during D_2. The S_3 crenulation axes trend to the northeast and have a very similar orientation to the regional S_2 cleavage. A later deformation (D_4) produced east-trending fractures that are filled with narrow quartz veins with dark alteration zones containing amphibole.

The Perseverance Fault was probably active throughout the deformation history. The fault is rarely exposed, but is a prominent linear feature on magnetic images (Fig. 5). Strongly deformed amphibolite and granitoid rocks (AMG 634558) have a northerly to north-northwesterly trending foliation. A mineral lineation in the amphibolite plunges steeply to the south-southwest. Immediately to the north-northwest on MOUNT KEITH (AMG 633561), foliated amphibolites are refolded into open, upright F_3 folds that have nearly vertical axial planes, and fold axes plunging 12° to the south-southeast. The contact between the greenstones and the strongly foliated granitoid rock to the east is not exposed.

In the Yakabindie greenstone belt, two prominent faults, the Yakabindie Fault and the Highway Fault, cut the Mount Goode Basalt. The Yakabindie Fault, which also cuts the Kathleen Valley Gabbro, is a 100 m-wide zone of deformed metabasalt with a well-developed, steep, northwest-trending mineral lineation (for example, at AMG 589448). Elongate plagioclase phenocrysts are aligned and plunge 64º to the north. Smaller scale shear zones are also present in the Kathleen Valley Gabbro. The realignment of structural trends in the Kathleen Valley Gabbro and the Mount Goode Basalt suggests sinistral movement on the Yakabindie Fault. An overprinting relationship between the prominent S_2 cleavage and earlier amphibole porphyroblasts (Fig. 15) suggests sinistral movement on the Highway Fault.

The Agnew Anticline, called the Lawlers Anticline by some authors, has been described in detail by Platt et al. (1978). The western side of the anticline is bounded by the Waroonga Shear Zone (D_3). Close to the Waroonga Shear Zone, the Jones Creek Conglomerate is represented by a thick sequence of arkosic sandstone and conglomerates. The anticline is upright with a shallow north-plunging (30° or less) fold axis. Platt et al. (1978) attributed isoclinal folds on the west limb of the Agnew Anticline to their D_1. They argued that this regional, penetrative deformation event produced the bedding-parallel foliation that can be seen in the fold hinge zone on WILDARA (Oversby et al., 1996). A second foliation (a spaced cleavage, S_2) is axial planar to the open, upright Agnew Anticline. In the greenstones, this cleavage is defined by narrow (1 mm) zones of hornblende or chlorite that has grown across the early fabric (Platt et al., 1978).

The axial plane of the north-plunging Leinster Anticline (Figs 3, 4) trends north-northwest and passes close to the Leinster Downs Homestead. The foliation on the western limb dips steeply west to vertical, trends north-northwest, and has a consistent south-plunging mineral-

SW 42 28.07.98

Figure 13. Prominent cleavage and asymmetric pressure shadows around plagioclase phenocrysts in metabasalt near the north shore of Lake Miranda (AMG 593375)

SW 61 19.10.98

Figure 14. Upright crenulation and a horizontal, earlier foliation in metabasalt near the north shore of Lake Miranda (detailed view of the central bottom part of the outcrop in Figure 12). Pencil is 14 cm long

SW 52 24.06.98

Figure 15. Photomicrograph showing prominent foliation overprinting an earlier amphibole porphyroblast in metabasalt just north of Lake Miranda (AMG 589390). Width of field is 2.8 mm

elongation lineation. Greenstones on the eastern limb have been intruded by monzogranite. The foliation on the eastern limb trends to the west-northwest and dips steeply east to vertical. The change in orientation of the foliation across the fold suggests it has been folded by, and so pre-dates, the Leinster Anticline. Lineation in the fold closure plunges northward.

Some granitoid plutons may have intruded pre- to syn-D_2, but D_2 fabrics may be indistinguishable from those produced during D_3 in the granitoid rocks. Granitoids in the Leinster Anticline, in the central part of the sheet area, and in the zone of intercalated granitoid and greenstone rocks along the western side of the Yandal greenstone belt were deformed by D_2. The small, interpreted granitoid stock that cuts the Mount McClure Fault (Fig. 3) intruded after D_3.

Foliated monzogranite, unconformably below the conglomerate and sandstone of the Jones Creek Conglomerate on MOUNT KEITH with a SHRIMP U–Pb zircon age of 2685 ± 7 Ma (Nelson, 1997a) is interpreted to be one of the early granitoid bodies. Clasts from this have been incorporated into the deformed and metamorphosed Jones Creek Conglomerate. The fabric in the conglomerate is probably due to D_2–D_3 deformation. SHRIMP U–Pb ages of zircons, interpreted as detrital, in arkose associated with the conglomerate are considered by Nelson (1997a) to indicate that these sediments were deposited after 2632 ± 13 Ma. Thus, the D_2–D_3 deformation continued beyond this time. However, elsewhere in the Eastern Goldfields D_2–D_3 is cut by undeformed granitoids dated at around 2640 Ma (Nelson, 1997b).

Metamorphic grade in the greenstones on SIR SAMUEL is in the greenschist facies, except locally at granite–greenstone contacts where metamorphic grade reached the lower amphibolite facies. A major metamorphic event probably began during D_2 and continued during D_3.

A metamorphic episode pre-dating the development of the prominent cleavage (S_2) in the deformed and metamorphosed basaltic rocks of the Mount Goode Basalt is indicated by amphibole porphyroblasts showing an earlier fabric that has been overprinted by the S_2 cleavage (Fig. 15). The round cordierite porphyroblasts and the randomly oriented andalusite porphyroblasts (Fig. 11) from north of Mount Goode suggest the highest temperature (peak metamorphism) was reached after the prominent cleavage development, some time either during or after D_2, but prior to D_3. Alteration of the porphyroblasts suggests retrograde metamorphism during D_3.

Mafic dykes (*Edy*)

Prominent east-trending magnetic lineaments (Fig. 3) have been interpreted as mafic dykes (*Edy*) by comparison with similar features elsewhere in the Eastern Goldfields. These dykes are commonly interpreted as being Proterozoic in age (Hallberg, 1987). However, a SHRIMP U–Pb zircon age of 2627 ± 6 Ma has been determined on a granophyric dyke (Nelson, 1998), interpreted as a felsic differentiate of a mafic dyke, on DEPOT SPRINGS to the west (Wyche and Griffin, 1998). This dyke coincides with a prominent magnetic lineament. Therefore, the geochronological data suggest an Archaean age for at least some of the mafic dykes. However, it is possible the zircon age reflects the age of the granitoid rock that the dyke has intruded.

Palaeozoic geology

Permian sedimentary rocks (*Psc*)

Two areas of sedimentary rocks interpreted as Permian in age (*Psc*) are shown on SIR SAMUEL. At a locality 4 km northwest of the Vivien mine (AMG 563047), silicified, poorly bedded coarse-grained sandstone and conglomerate are surrounded by extensive areas of cobble scree on a small rise. The clasts are subangular to well rounded, up to 20 cm across, and consist of vein quartz, with subordinate granitoid and metasedimentary rocks. In the second area, loose, rounded cobbles of mainly undeformed fine- and coarse-grained granitoid rocks, with subordinate clasts of vein quartz and metasedimentary rock, overlie the Archaean rocks northwest of Mount McClure. The cobbles range in size from 4 to 30 cm, but are typically 5 to 10 cm across. Some of the cobbles have flat surfaces that may be glacigenic facets. Bunting and Williams (1979) have correlated these isolated sedimentary rock and scree outcrops, along with more substantial, essentially flat-lying sequences elsewhere on SIR SAMUEL (1:250 000) with Early Permian fluvioglacial rocks of the Paterson Formation in the Officer Basin.

Cainozoic geology

SIR SAMUEL is dominated by a relatively stable, ancient landscape developed over deeply weathered rocks. Consolidated and unconsolidated Cainozoic regolith units are widespread. The type of Cainozoic unit, including its distribution and thickness, is closely related to the landforms and the source materials. For example, ferruginous units are common in areas of greenstone. The Cainozoic units on SIR SAMUEL can be broadly classified into four categories — residual, proximal depositional, distal depositional, and active alluvial.

Residual units are those developed on weathered rock and include lateritic duricrust (*Czl*), massive ironstone ridges and cappings (*Czli*), silica caprock developed over ultramafic rocks (*Czu*), silcrete (*Czz*), and residual sand and soil over granitoid rock (*Czg*). Duricrust units over mafic greenstones are commonly ferruginous and reddish-brown to black, while those on granitoid rock are commonly silica-rich and paler in colour.

Proximal depositional units include colluvial deposits on slopes and low hills. The colluvial deposits comprise gravel and sand as sheetwash and talus (*Czc*), degraded lateritic duricrust and massive ironstone rubble (*Czf*) in iron-rich source areas, and quartz-vein rubble and debris (*Czcq*) adjacent to quartz veins.

Distal depositional deposits contain significant clay and fine sand, and can form extensive sheetwash fans (*Cza*). Extensive sandplains (*Czs*) are dominated by unconsolidated, red, quartz-rich sand, and typically overlie granitoid rocks and associated duricrust. Dunes are stable and well vegetated with spinifex and a variety of small trees and shrubs.

There are deposits of saline and gypsiferous evaporites, clay, and sand (*Czp*) in Lake Miranda, and sand, silt, clay, and gypsum (*Czd*) form stabilized dunes in and around the lake. Calcrete (*Czk*) outcrops around Lake Miranda, in the alluvial valley east of the lake, and in the broad drainage valley south of Mount McClure. A large area of sandplain (*Czsv*) occupies an alluvial valley adjacent to, and east of, Lake Miranda. This material and the associated lake deposits define the channel of the Carey Palaeoriver (Hocking and Cockbain, 1990).

Alluvium (*Qa*) has been deposited in active fluvial channels and on floodplains. Small claypans (*Qac*) may be part of the active system, and hardpans of calcrete (*Qak*) have formed in the larger valleys.

Economic geology

Gold

Gold (with some silver) has been mined in the SIR SAMUEL sheet area since the 1890s from centres within the Agnew and Mount Keith – Perseverance greenstone belts and, more recently, from the Yandal greenstone belt. Table 2 summarizes production from the major centres.

Most early production came from the Kathleen Valley and Sir Samuel centres, and from the Vivien and Brilliant mines in the northern part of the Lawlers centre. At Kathleen Valley, the bulk of the production came from the Yellow Aster and Nil Desperandum mines, with some input from the Mossbecker mine. At Sir Samuel, the major producer was the Bellevue group, with some input from the Westralia, Vanguard, and Isidore mines. Only sporadic, small-scale production continued through the 1950s to the 1980s. In the 1970s, exploration and drill testing by Spargos Mining outlined the shallow Paris and Westralia orebodies in the vicinity of the old Bellevue mine and established major extensions at depth beneath the Bellevue workings. Mining of these deposits has continued since the late 1980s. At Kathleen Valley, the Main Road deposit was mined from 1990 to 1991. Mining difficulties and low recovery made the operation only marginally profitable.

Since 1992, Australian Resources Limited and Oresearch have been producing gold from a number of openpits in the Mount McClure area of the Yandal greenstone belt. The Mount McClure gold mine comprises seven openpits, including one that has been developed as an underground mine, and several prospects in a north-northwesterly trending zone on SIR SAMUEL, MOUNT KEITH, and DARLOT. The deposits on SIR SAMUEL include Success, Parmelia, Challenger, and Dragon. The Dragon openpit straddles the boundary between SIR SAMUEL and DARLOT. These deposits lie along north-northwesterly trending shear zones and associated splays. The main host rocks in Success, Parmelia, and Challenger are felsic to mafic tuffaceous metasedimentary rocks with minor lenses of sulfide-bearing graphitic metasedimentary rocks. Graded bedding in tuffaceous rocks has shown the sequence to be east-younging (Harris, J., 1994, pers. comm.). Mineralization in the Dragon deposit is hosted by an ultramafic schist that is overlain by a mixed sequence of metasedimentary rocks and metabasalt. Dolerite intrusions, intermediate to mafic dykes, and lamprophyric dykes are common in the Mount McClure deposits. These dykes postdate the mineralization, which is found in tabular orebodies that dip approximately 50° to the east. Mineralization is shear-controlled, but is commonly conformable with the surrounding rocks. Gold is associated with quartz veining and sulfides. Free gold has been observed in drillcore.

Most of the mineralization in the Kathleen Valley area is in gold-bearing quartz reefs and lenses hosted by metamorphosed felsic conglomerates of the Jones Creek Conglomerate. The main historical mines (Yellow Aster, Nil Desperandum, and Mossbecker) lie in a north-northwesterly trending zone adjacent to sheared metabasalt east of the Miranda Fault. Mineralized conglomerate from the Yellow Aster mine area contains a high proportion of felsic porphyry (rather than granitoid) clasts. The Main Road deposit, about 2 km southwest of the main group, west of the Miranda Fault, is hosted by metabasalt.

The Sir Samuel group of workings, centred on the Bellevue mine, also lies west of the Miranda Fault, about 13 km south of Kathleen Valley. The workings are associated with an east-younging, metamorphosed tholeiitic basalt sequence that has been mylonitized within a north-striking, west-dipping shear zone. The gold is contained within massive and disseminated sulfides in quartz breccia lodes and in the surrounding mylonitized basalt (Brotherton and Wilson, 1990).

A number of areas of gold mineralization have been discovered in greenstones along the Waroonga–Miranda fault system south of Bellevue. They include the Greensox group, including Cams and Scorpion, the Maria deposit at Mount White, and prospects at Leinster and in the vicinity of the Vivien mine. The Vivien and Vivien Gem mines operated in the first half of this century, and are quartz-vein deposits in foliated dolerite and quartz-bearing felsic porphyry, respectively. The nearby Brilliant mine is located on a granite–metabasalt contact.

Copper

Between 1909 and 1967, 424 t of copper was mined from the Kathleen Valley area (Bunting and Williams, 1979). The copper mineralization, commonly with gold and silver, is in pyrite–chalcopyrite–quartz veins within mafic hosts spatially related to north-northwesterly trending shear zones in Kathleen Valley Gabbro and Mount Goode Basalt (Bunting and Williams, 1979).

Table 2. Gold production on SIR SAMUEL to 31st December 1996

Mining centre	*Mine*	*Ore treated (t)*	*Gold production (kg)*	*Period*
Kathleen Valley	Yellow Aster	52 684	1 103.794	1900–1943
	Nil Desperandum	23 512	301.639	1899–1936
	Mossbecker	1 662	6.588	1939–1941
	Main Road	84 069	260.979	1990–1991
	Other	10 611	221.768	
	Total	**172 538**	**1 894.768**	**1897–1996**
Sir Samuel	Bellevue	252 329	4 032.310	1897–1912
	Bellevue	1 808 000	17 659.550	1986–1996
	Vanguard	15 286	158.520	1898–1937
	Other	175 100	1 357.867	
	Total	**2 250 715**	**23 208.247**	**1897–1996**
Vivien area	Vivien	225 092	2 415.178	1901–1941
	Vivien Gem	4 692	100.450	1905–1941
	Brilliant	9 274	177.406	1904–1907
	Total	**239 058**	**2 693.034**	**1901–1941**
Mount McClure	Combined Dragon, Parmelia, Success, Lotus [(a)]	3 846 000	12 112.392	1992–1996

NOTE: (a) Lotus is on MOUNT KEITH
SOURCE: Department of Minerals and Energy's mines and mineral deposits information (MINEDEX) database
Department of Minerals and Energy (1954)

Nickel

Ultramafic rocks along the Perseverance Fault host nickel-sulfide deposits within ultramafic adcumulates associated with komatiite flows. The Perseverance deposit, previously known as the Agnew deposit, was discovered in 1971 by Selco, following a seven year exploration program (Marston, 1984).

Underground production from the first of four ore shoots (1A) began in 1978 (Marston, 1984). The original Agnew mine closed in 1986, but was reopened by Western Mining Corporation (WMC) in 1989 as the Leinster Nickel Operation. Renewed opencut and underground mining has taken place within the main deposit (Perseverance), and also in the nearby Rockys Reward deposit. The mines produced 71 586 t of nickel in the first phase, up until September 1986. The Leinster Nickel Operation treated 7 823 000 t of ore to produce 127 954 t of nickel between 1989 and 1995 (WMC Annual Reports to Stock Exchange). A further 56 270 t of nickel was produced from 3 354 000 t of ore between June 1995 and April 1997 (Gonnella, 1997).

Nickel mineralization in the Perseverance (Agnew) deposit is hosted by the Perseverance lens (Marston, 1984). The lens, which lies immediately west of the Perseverance Fault, consists of coarse-grained olivine adcumulate, is about 2 km north–south by 700 m east–west, and extends to a depth of more than 1100 m. The main mineralized zone is at the western, basal contact of the lens, north of its thickest development, and consists of massive and net-textured ore with up to 50% olivine. It grades from around 2 to about 15% nickel. The mineralized zone and associated spinifex-textured flows extend northwards, and are conformable with the country rock. The Rockys Reward deposit lies about 2 km north, on strike with the main deposit, in what is probably a portion of the same flow unit (Hill et al., 1990).

Other nickel prospects on SIR SAMUEL in the Mount Keith – Perseverance greenstone belt ultramafic sequence include Melon, 6 km south of Perseverance, and Leinster Downs and Sir Samuel, 6 and 10 km north of Rockys Reward, respectively (Marston, 1984). The recently discovered Cosmos nickel deposit is about 4 km south of Mount Goode and 3 km northeast of the abandoned Sir Samuel townsite, in the vicinity of the Mount Goode nickel prospect of Marston (1984). Cosmos has a measured resource of 401 000 t at 8.2% nickel (Jubilee Gold Mines, 1998).

Tin

Two minor occurrences of tin were noted by Bunting and Williams (1979). A cassiterite-bearing lepidolite–albite pegmatite 3 km south-southwest of Kathleen Valley, and another small deposit 400 m southwest of the Sir Samuel townsite, were worked between 1945 and 1953 and produced 8 t of ore containing 0.2 t of tin (Bunting and Williams, 1979).

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SIR SAMUEL

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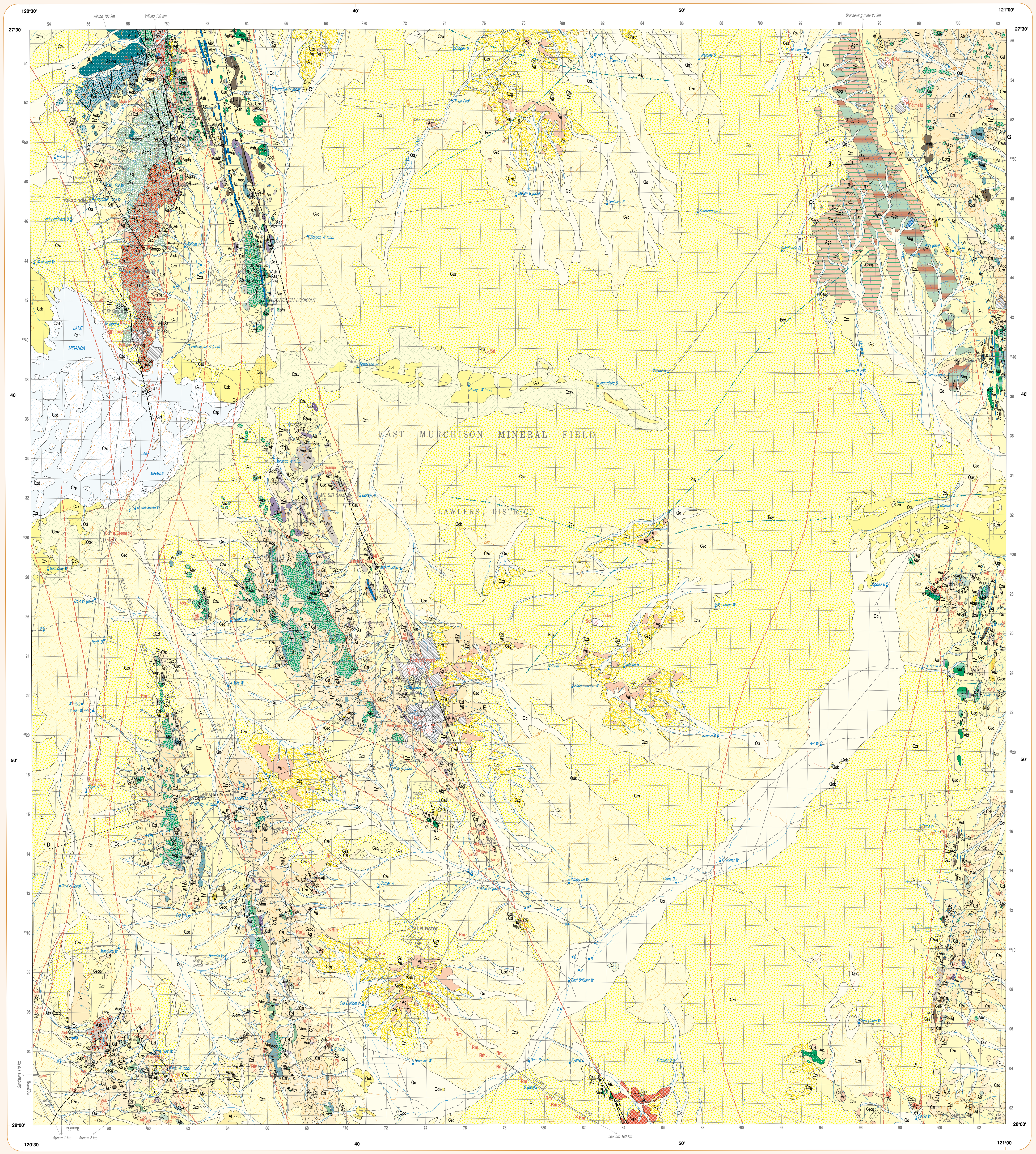

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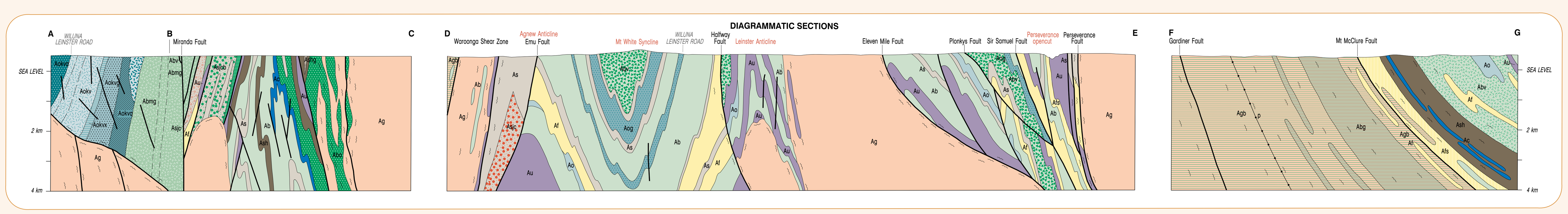


PHANEROZOIC — CAINOZOIC — QUATERNARY

Qa Alluvium—clay, silt, sand, and gravel in channels and floodplains
Qac Clay and silt in claypans
Qak Calcrete in active fluvial channels

Czd Dune deposits—sand, silt, clay, and gypsum as stabilized dunes adjacent to playa lakes
Czp Playa deposits—saline and gypsiferous evaporites, clay, and sand in playa lakes
Cza Sheetwash deposits—clay, silt, and sand as extensive fans; commonly ferruginous
Czs Sandplain deposits—unconsolidated sand and minor silt and clay; includes low vegetated dunes
Czsv Unconsolidated sand and minor silt and clay, restricted to old valley systems
Czc Colluvium—gravel, sand, and silt as sheetwash and scree; includes ironstone fragments
Czcq Quartz vein debris
Czf Ferruginous rubble and colluvium—ferruginous rock and ironstone rubble; degraded lateritic duricrust
Czg Sand over granitoid rock—quartzo-feldspathic sand; includes areas of low weathered outcrop

Czk Calcrete
Czl Lateritic deposits—lateritic duricrust, massive and rubbly; iron-rich over mafic rock
Czli Massive ironstone as ridge and capping
Czu Silica caprock over ultramafic rock
Czz Silcrete

PALAEOZOIC — PERMIAN

Psc Conglomerate and sandstone; poorly bedded; clasts dominated by vein quartz

PROTEROZOIC

Ꝑdy Mafic dyke, interpreted from aeromagnetic data

ARCHAEAN

Veins and dykes: d — dolerite, g — granitoid, p — granitoid pegmatite, po — felsic porphyry, q — quartz

Ag Granitoid rock, undivided; mainly monzogranite
Agb Foliated granitoid rock with minor lenses of mafic rock; gneissic banding locally developed
Agdq Quartz diorite
Agf Foliated granitoid rock
Agm Monzogranite
Agn Gneissic granitoid

Asjc **JONES CREEK CONGLOMERATE** : conglomerate and sandstone; granitoid clasts and matrix dominate; metamorphosed
Asjcb Conglomerate and sandstone; mafic matrix dominates; metamorphosed

Ala Banded amphibole-bearing metamorphic rock
Alb Biotite schist (subsurface only)
Ald Pelitic schist; quartz-plagioclase-muscovite(-andalusite-cordierite-biotite)
Alhb Hornblende-biotite schist (subsurface only)
All Chlorite schist
Alqb Quartz-biotite schist
Alql Quartz-chlorite schist (subsurface only)
Alqm Quartz-muscovite schist

As Metasedimentary rock, undivided; includes felsic volcanic and volcaniclastic rocks
Ash Shale, minor siltstone and sandstone, metamorphosed; slate, phyllite, and minor quartz-mica schist, locally contains andalusite porphyroblasts
Ashc Carbonated fine-grained metasedimentary rock (subsurface only)
Ashd Phyllite with abundant andalusite porphyroblasts
Ashg Graphitic metasiltstone
Ass Sandstone with subordinate conglomerate and siltstone; metamorphosed
Ac Siliceous sedimentary rock and chert, mainly grey and white banded; locally ferruginous and pyritic; metamorphosed
Aci Banded iron-formation

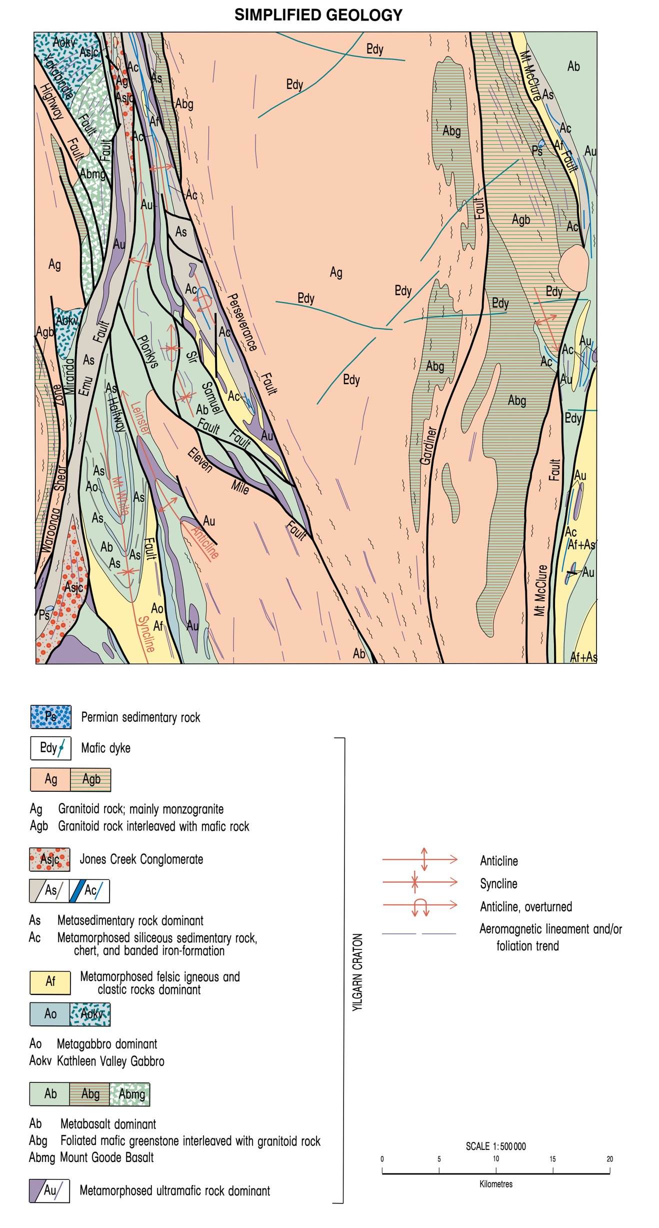
Af Metamorphosed felsic igneous and clastic rocks, undivided; generally deeply weathered
Afp Porphyritic felsic rock; metamorphosed
Afpq Quartz-phyric felsic rock; metamorphosed
Afs Felsic schist
Aft Felsic crystal tuff; metamorphosed
Afv Felsic volcanic and volcaniclastic rocks; metamorphosed

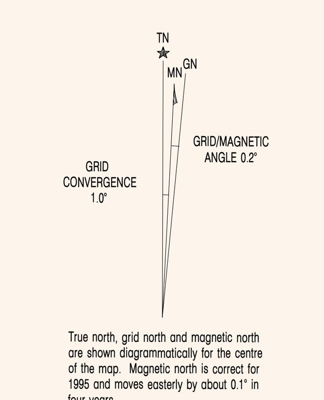
Ao Metamorphosed fine- to medium-grained mafic rock, undivided
Aod Dolerite; metamorphosed
Aog Gabbro; metamorphosed
Aogq Quartz-bearing gabbro and quartz gabbro; metamorphosed
Aokv **KATHLEEN VALLEY GABBRO** : gabbro, undivided; metamorphosed
Aokva Anorthositic gabbro and anorthosite; metamorphosed
Aokvx Pyroxene-rich gabbro; metamorphosed
Aokvg Quartz gabbro and tonalite; metamorphosed
Aokvq Quartz-bearing gabbro and quartz gabbro; metamorphosed

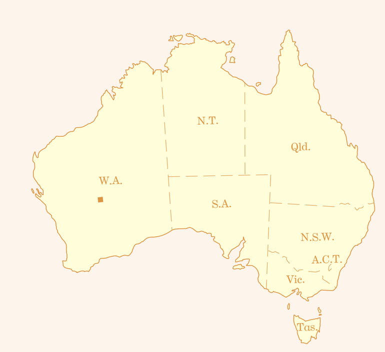
Ab Metamorphosed fine- to very fine-grained mafic rock, undivided; generally deeply weathered
Aba Amphibolite
Abf Foliated, metamorphosed mafic rock; mafic schist
Abg Mafic and subordinate felsic volcanic rocks intercalated with minor foliated granitoid rock; metamorphosed; gneissic banding locally developed
Abm High-Mg basalt; metamorphosed
Abp Basalt, plagioclase-phyric; metamorphosed
Abv Basalt; metamorphosed
Abmg **MOUNT GOODE BASALT** : tholeiitic basalt; metamorphosed
Abmgp Tholeiitic basalt, plagioclase-phyric; phenocrysts up to 20 cm long; metamorphosed

Au Metamorphosed ultramafic rock, undivided
Auc Talc-carbonate(-serpentine) rock; commonly schistose
Auk Komatiite; olivine spinifex texture; metamorphosed (subsurface only)
Aup Serpentinized peridotite; often silicified
Aur Tremolite-chlorite schist
Aut Talc-chlorite(-carbonate) schist
Aux Pyroxenite; metamorphosed

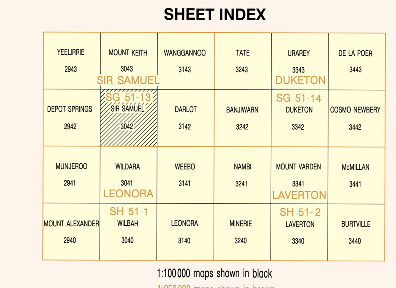
SIMPLIFIED GEOLOGY







SHEET INDEX



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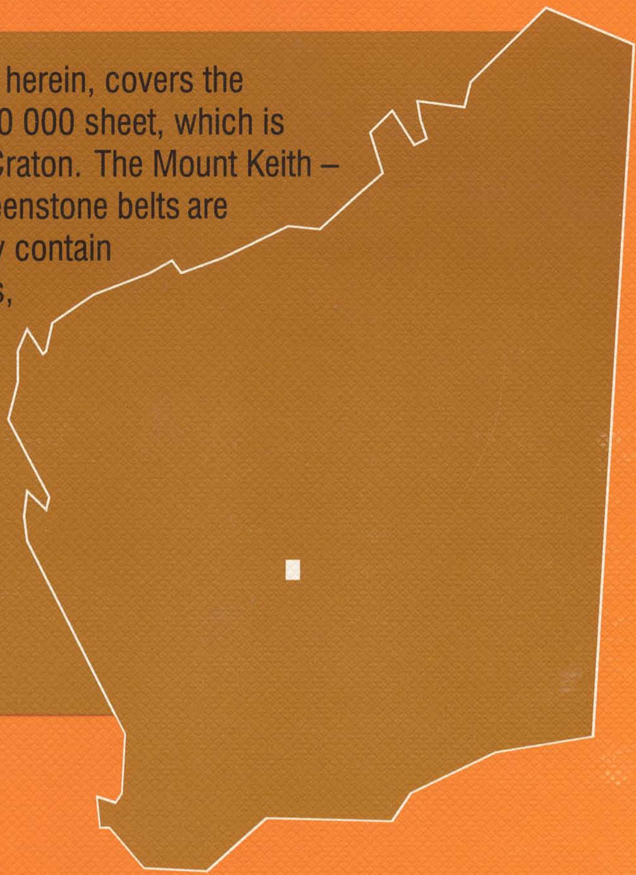
SIR SAMUEL

SHEET 3042 FIRST EDITION 1996

The Sir Samuel 1:100 000 map sheet, described herein, covers the southern central segment of the Sir Samuel 1:250 000 sheet, which is in the Eastern Goldfields Province of the Yilgarn Craton. The Mount Keith – Perseverance, Agnew, Yakabindie, and Yandal greenstone belts are bounded by faults and shear zones, and variously contain mafic and felsic volcanic and volcaniclastic rocks, ultramafic rocks, conglomerate, chert, and banded iron-formation. The greenstone belts have been intruded by granitoid rocks, predominantly monzogranite. Permian sedimentary rock and Cainozoic deposits partly overlie the granite–greenstone terrain. Structure and metamorphism are discussed. Significant amounts of gold and nickel have been mined in the area.



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LIU et al. **Geology of the Sir Samuel 1:100 000 sheet** **EXPLANATORY NOTES**