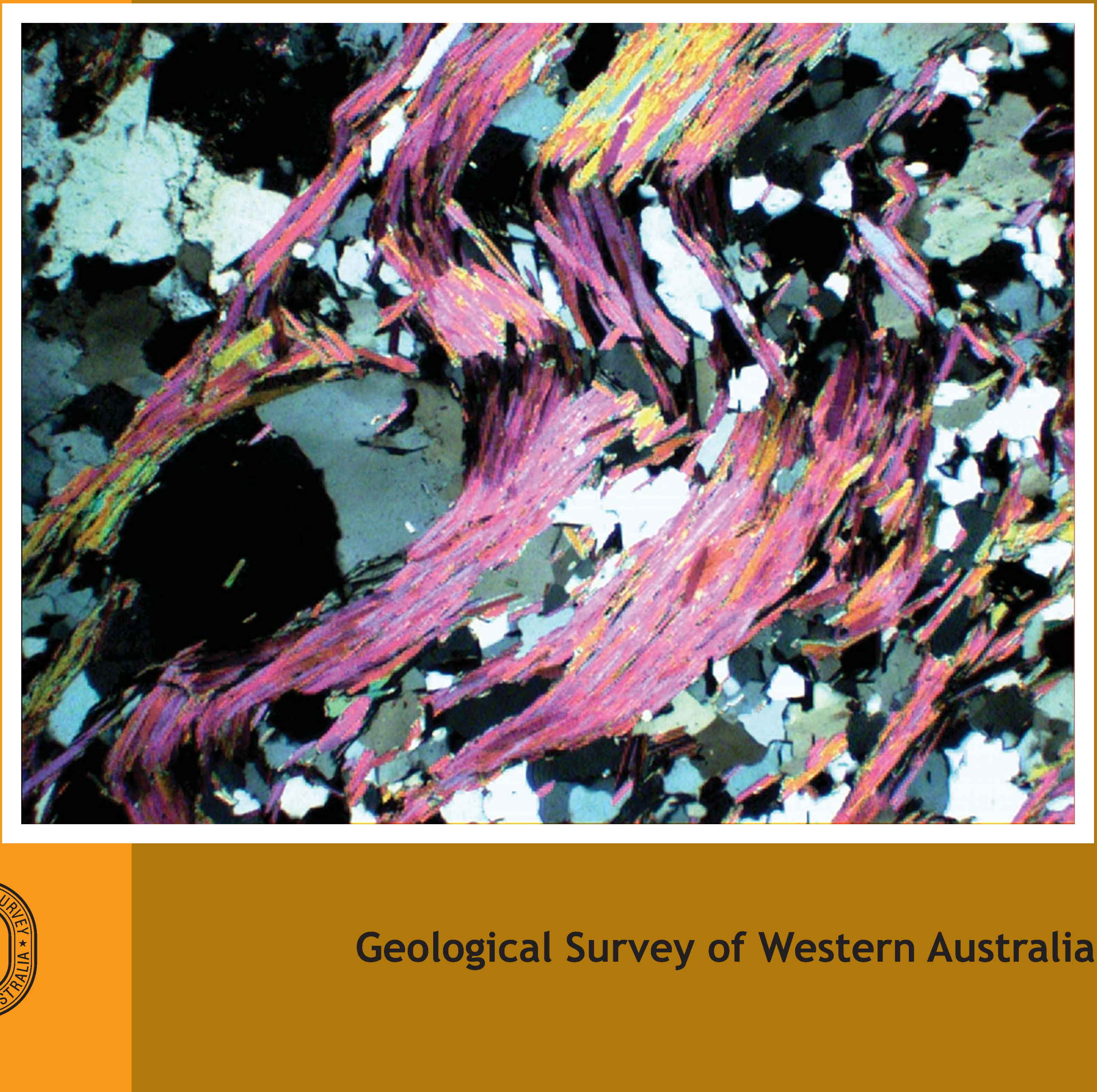
EXPLANATORY NOTES

Department of
Industry and Resources

GEOLOGY OF THE EVERETT CREEK 1:100 000 SHEET

by A. Riganti

1:100 000 GEOLOGICAL SERIES



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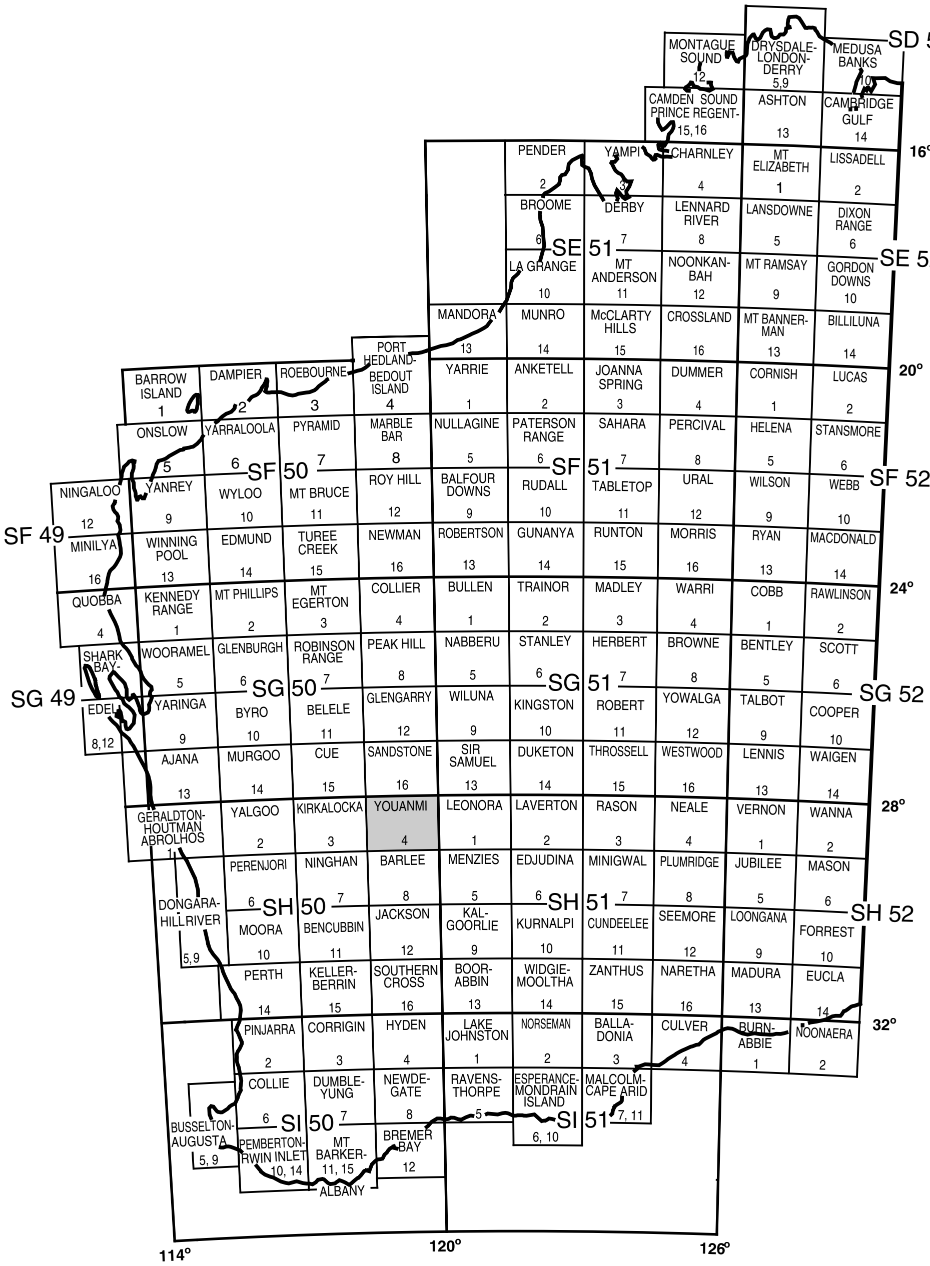
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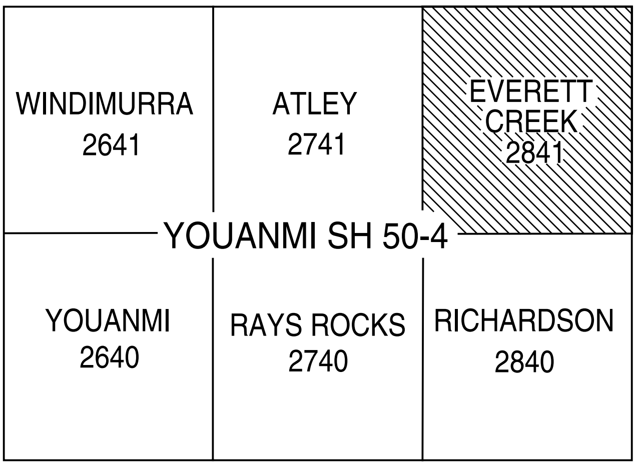
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GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

GEOLOGY OF THE EVERETT CREEK 1:100 000 SHEET

by
A. Riganti

Perth 2003

MINISTER FOR STATE DEVELOPMENT
Hon. Clive Brown MLA

DIRECTOR GENERAL, DEPARTMENT OF INDUSTRY AND RESOURCES
Jim Limerick

DIRECTOR, GEOLOGICAL SURVEY OF WESTERN AUSTRALIA
Tim Griffin

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Copies available from:
Information Centre
Department of Industry and Resources
100 Plain Street
EAST PERTH, WESTERN AUSTRALIA 6004
Telephone: (08) 9222 3459 Facsimile: (08) 9222 3444
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Cover photograph:
Photomicrograph of muscovite-bearing quartzite from the Maynard Hills greenstone belt, showing folding and kinking of muscovite laths around a polygonized quartz clast in a matrix of granoblastic quartz; GSWA 164921, crossed polars, field of view is 5 mm

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Geology of the Everett Creek 1:100 000 sheet

by

A. Riganti

Abstract

The Everett Creek 1:100 000 sheet lies within the Southern Cross Granite–Greenstone Terrane in the central part of the Archaean Yilgarn Craton. Granitoid rocks are the main bedrock type, with greenstones confined to two narrow, north-northwesterly trending tracts in the western half of the map sheet — the North Cook Well greenstone belt to the west and the Maynard Hills greenstone belt to the east. These belts comprise metamorphosed mafic and ultramafic rocks (mainly basalt and gabbro with minor pyroxenite and tremolite schist) complexly interlayered with metasedimentary rocks (dominantly quartzite, para-amphibolite, and banded iron-formation). Detrital zircons from a quartzite unit in the Maynard Hills greenstone belt yielded a maximum depositional age of c. 3131 Ma for this sequence. Granitoid rocks on Everett Creek range in age between c. 2691 and c. 2665 Ma, and vary in composition from monzogranite to local syenogranite.

The major structural feature on Everett Creek is the regional-scale, north-northwesterly trending Edale Shear Zone that encompasses the North Cook Well and Maynard Hills greenstone belts, and an intervening zone of gneiss and strongly deformed monzogranite. Kinematic indicators give a sinistral shear sense. The Edale Shear Zone formed during a D_3 east–west compressional event. This followed an early north–south compression (D_1) that produced an originally east-trending foliation, and east–west compression (D_2) during which north-trending folds overprinted D_1 structures. Granitoid intrusion was largely during D_2. Post-D_3 deformation includes north-northeasterly and east to east-northeasterly trending faults and fractures, some of which are intruded by mafic to ultramafic dykes of probable Proterozoic age.

Greenstones within the Edale Shear Zone have been metamorphosed to at least middle-amphibolite facies. Amphibolite and gabbro have annealed assemblages of hornblende, clinopyroxene, calcic plagioclase, and biotite, with para-amphibolite containing intercalations rich in cummingtonite or diopside, and garnet. Andalusite is common in recrystallized feldspathic sandstone and muscovite-bearing quartzite, whereas grunerite is typical of magnetite-bearing quartzite units. Pinite after cordierite is present in muscovite–quartz–plagioclase schist. Most of these metamorphic minerals grew synkinematically, with peak metamorphic conditions probably reached during D_3. Hornblende, biotite, muscovite, and epidote continued to form after the period of most intense deformation.

Gold has been reported from a few localities on Everett Creek, but no economic concentrations have been identified. The area has also been explored for uranium in calcrete and channel-fill sediments along palaeodrainage lines.

KEYWORDS: Archaean, granite, gneiss, greenstone, Southern Cross, Everett Creek, Edale Shear Zone.

Introduction

The Everett Creek* 1:100 000 geological map sheet (SH 50-4, 2841) occupies the northeastern part of the Youanmi 1:250 000 map sheet, and is bound by latitudes 28°00'S to 28°30'S, and longitudes 119°30'E to 120°00'E (Fig. 1). The sheet is named after the prominent creek that traverses its central-western part†.

Access to the region is provided by the formed Menzies–Sandstone and the sealed Agnew–Sandstone roads (Fig. 2). The former crosses the central-western part of Everett Creek, linking the towns of Menzies (about 200 km from the southern boundary of the sheet) and Sandstone (about 30 km to the northwest). The Agnew–Sandstone Road joins Sandstone with the towns of Agnew and Leinster, about 55 and 75 km to the east of Everett Creek. This road crosscuts only the northeastern corner of Everett Creek, but the old Agnew–Sandstone Road traverses the northern part of the map sheet (Fig. 2). In the centre of the sheet, the Daly Road runs from the Menzies–Sandstone Road to the abandoned Daly Outcamp‡. In the north, the Blackhill Road links Sandstone with the old Agnew–Sandstone Road via the abandoned Blackhill Homestead. Most of Everett Creek can be reached along

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

† According to the database of geographical names held by the Department of Land Administration (DOLA), the name 'C. Everett' is of unknown origin, and appeared for the first time on a plan of the area in 1903.

‡ MGA coordinates of localities mentioned in the text are listed in Appendix 1.

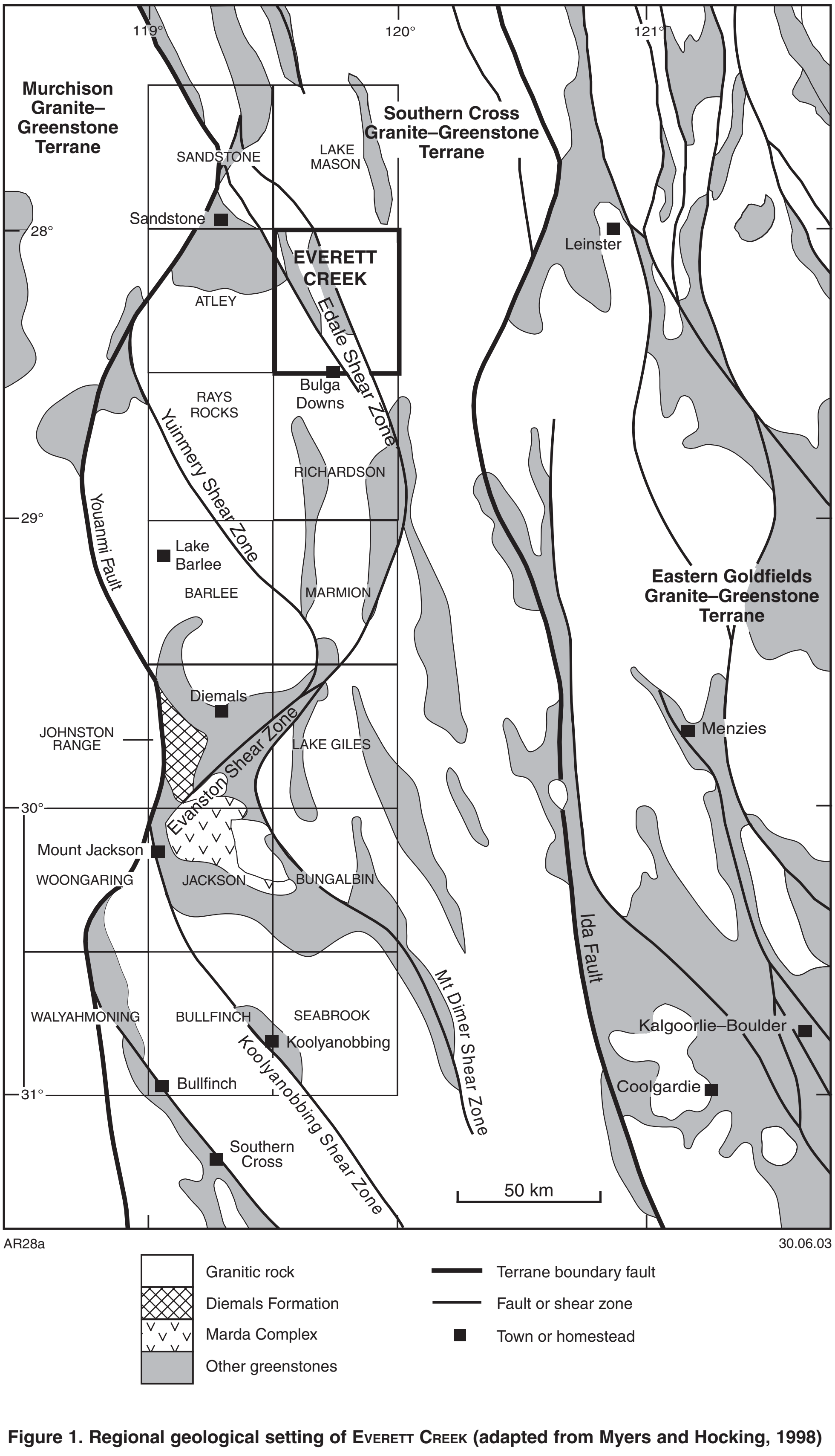

Figure 1. Regional geological setting of EVERETT CREEK (adapted from Myers and Hocking, 1998)

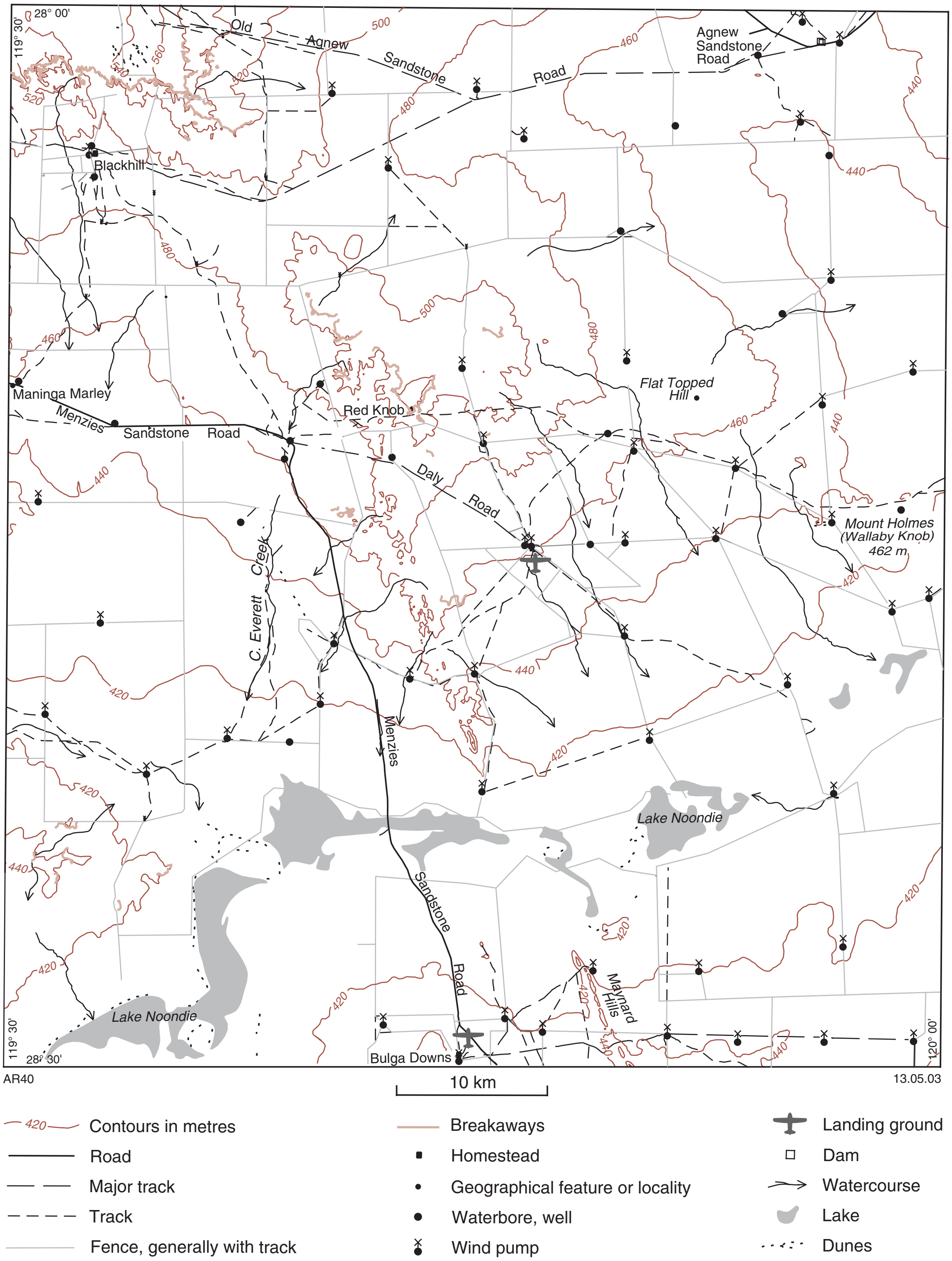

Figure 2. Principal localities, roads, and physiographic features on Everett Creek

old station tracks, many of which run alongside fences in various states of disrepair. Because much of the area is no longer grazed, some of the tracks are not used and can be difficult to trace.

EVERETT CREEK was visited in 1869 by John Forrest, who named Mount Holmes in the extreme east of the map sheet (Feeken et al., 1970). The area was settled in the early 1900s, when the Blackhill Homestead was established to breed and rest horses used by travellers through the area (Senior, 1995). EVERETT CREEK is now covered by four leasehold pastoral stations (Bulga Downs, Dandaraga, Black Hill, and Kaluwiri) and some vacant Crown land, with the only permanent settlement being the Bulga Downs Homestead at the southern edge of the sheet (Fig. 2). Sheep grazing for wool production is the main commercial activity in the area. There has been limited mineral exploration.

Climate, physiography, and vegetation

The EVERETT CREEK region has an arid climate, characterized by hot, dry summers with temperatures regularly exceeding 40°C, and mild winters with some frosty nights. Rainfall is sporadic in both seasons. Light winter rain is due to the passage of cold fronts from the southwest. In summer, thunderstorms or rain-bearing depressions associated with tropical cyclones result in major, short-lived precipitation events that may produce substantial runoff. Rainfall data are not available for EVERETT CREEK, but the nearby town of Sandstone has an average annual rainfall of 245.8 mm*, with an annual evaporation of almost 15 times the annual rainfall (Biological Surveys Committee, 1992; Payne et al., 1998).

The physiography of EVERETT CREEK is largely controlled by the underlying rock types, with only gentle topographic variations. The dominant granitoid rocks are overlain by extensive sandplains and alluvial deposits. The sandplains are dissected along breakaways in which granite bedrock highs are typically capped by ferricrete or silcrete. Discrete monoliths or flat pavements of granitoid commonly punctuate the areas below and away from these erosional surfaces. North-northwesterly trending, narrow tracts of greenstones that include metasedimentary and meta-igneous rocks with intercalated granitoids form low hills and ridges across the western half of EVERETT CREEK (e.g. Maynard Hills in the south). Drainage is controlled by the broadly easterly trending Lake Noondie (Fig. 2), and varies from channelized flow on the higher ground adjacent to hills, breakaways, and granitoid outcrops to sheet flooding on alluvial plains. There are no permanent streams on EVERETT CREEK, although water can persist in claypans and waterholes for long periods after heavy rains. Calcareous plains are developed locally, particularly around the edges of Lake Noondie. The lake has an average elevation of about 420 m above sea level, and is part of the southeasterly draining Raeside Palaeoriver system (van de Graaff et al., 1977; Hocking and Cockbain, 1990).

* Meteorological records have been kept in Sandstone since 1904, and are available from the Bureau of Meteorology, Australia.

EVERETT CREEK is entirely within the Austin Botanical District (or Murchison Region) of the Eremaean Botanical Province (Beard, 1990). The vegetation in the region is largely mulga, a tall shrubland of *Acacia* species (*A. aneura* dominant), with a lower layer of local *Eremophila* and *Cassia* shrubs, and herbaceous annuals (e.g. wanderrie grasses) in season. The mulga shrubland is typical of the alluvial plains, with denser thickets along drainage lines. Sandplains have a characteristic vegetation of sparse *Acacia* and local *Eucalyptus* spp. developed over a widespread layer of spinifex grass (*Triodia* spp.) and less common ericoid shrubs. Granitoid exposures and adjacent areas mantled by quartzofeldspathic superficial deposits are characterized by an open shrubland of *Acacia* spp. (e.g. *A. quadrimarginea* and *A. aneura*) and *Eremophila* spp. (e.g. *E. exifolia*), with rich herbaceous communities of perennial and ephemeral grasses. Hills of intercalated greenstones and granitoid rocks support a variety of vegetation communities reflecting changes in bedrock lithology, with common *Acacia* and *Eremophila* shrubs, and various types of grasses. Adjacent to Lake Noondie, a succulent steppe of samphire (leafless shrubs with jointed succulent stems) and other salt-tolerant species is developed on saline, sandy clay soils. The vegetation of calcareous plains varies from an open woodland of *Casuarina* spp. (e.g. *C. cristata*) to an open scrub of wattle (e.g. *Acacia acuminata,* subsp. *burkittii*) with a limited understorey of *Chenopodiaceae* shrubs (e.g. bluebush and saltbush) and lime-loving ephemerals in season. Detailed descriptions of the ecosystems on EVERETT CREEK are given by Beard (1976, 1990), Payne et al. (1998), and the Biological Surveys Committee (1992).

Previous and current investigations

The earliest published geological account of the region is by Talbot (1912), who described the main geological subdivisions in the area north of Lake Noondie and in the Maynard Hills. Other early reports from the region focused on the gold workings around Sandstone and at Maninga Marley, west of EVERETT CREEK (Gibson, 1908; Clarke, 1914). An airborne magnetic and radiometric survey of the YOUANMI 1:250 000 sheet was carried out by the Bureau of Mineral Resources (now Geoscience Australia) in 1968 (Gerdes et al., 1970), and the area was included in the regional metamorphic study of Binns et al. (1976) and in a study of landforms, regoliths, and soils by Churchward (1977). The first systematic regional mapping of EVERETT CREEK was completed by the Bureau of Mineral Resources and the Geological Survey of Western Australia (GSWA) as part of the YOUANMI 1:250 000 sheet mapping project (Stewart et al., 1983). Ahmat (1986) used the extensive GSWA thin-section collection to refine the regional distribution of metamorphic grades. Sensitive high-resolution ion microprobe (SHRIMP) geochronological data for the area are presented by Nelson (2002).

EVERETT CREEK was mapped between May and October 2000 using 1:24 600-scale colour aerial photography flown for the Western Australian Department of Land Administration (DOLA) in 1998. Map compilation was assisted by Landsat TM5 (Thematic Mapper) images, as well as 200-m and 400-m line-spaced aeromagnetic data collected respectively by Kevron Geophysics Pty Ltd in 1995 and Tesla Airborne Geoscience (now part of the Fugro Group of Companies) in 1998. These aeromagnetic data are available for purchase from Geoscience Australia. Information was also derived from mining and exploration company statutory reports accessed through the Western Australian mineral exploration (WAMEX) open-file database, available at the Department of Industry and Resources (DoIR) in Perth, the GSWA Kalgoorlie Regional Office, and the DoIR website (www.doir.wa.gov.au).

Precambrian geology

Regional geological setting

EVERETT CREEK lies in the northern part of the Southern Cross Granite–Greenstone Terrane (Fig. 1), one of the major tectono-stratigraphic components of the Yilgarn Craton (Tyler and Hocking, 2001), which roughly corresponds to the Southern Cross Superterrane of Myers (1997) and the Southern Cross Province of Gee et al. (1981). About 50 km east of EVERETT CREEK, the regional-scale Ida Fault is inferred to represent the boundary between the Southern Cross and Eastern Goldfields Granite–Greenstone Terranes (Myers, 1995, 1997). The distinction between the two terranes is based on lithological variations, relative volumes of different rock types, and different ages and structural styles of the greenstone sequences. West of EVERETT CREEK, the Youanmi Fault (Myers, 1995, 1997; Myers and Hocking, 1998) separates the Southern Cross Granite–Greenstone Terrane from the Murchison Granite–Greenstone Terrane (Tyler and Hocking, 2001). However, the Southern Cross and Murchison terranes may share a broadly similar geological history (e.g. Watkins and Hickman, 1990; Wyche et al., in prep.).

Granitoid rocks are the main bedrock type over most of EVERETT CREEK (Fig. 3). Their continuity of exposure is interrupted by two north-northwesterly trending, narrow corridors of greenstones comprising complex intercalations of strongly foliated metasedimentary and meta-igneous rocks (Fig. 3). The North Cook Well greenstone belt is exposed in the west, and the Maynard Hills greenstone belt in the east (Fig. 3; Stewart et al., 1983; Griffin, 1990), and both belts extend farther southeast onto RICHARDSON. Very small sections of the Sandstone and Booylgoo Range greenstone belts are exposed respectively along the western edge and in the northeastern corner of EVERETT CREEK. The North Cook Well and the Maynard Hills belts are separated by a zone of strongly deformed granitoid rocks and gneiss (Fig. 3), which Stewart et al. (1983) called the White Cloud Gneiss Zone. Strongly deformed granitoid rocks grade into undeformed equivalents on the flanks of the Maynard Hills and North Cook Well greenstone belts.

The greenstones on EVERETT CREEK comprise mafic and ultramafic rocks (mainly basalt and gabbro with minor pyroxenite and tremolite schist) complexly interlayered with sedimentary rocks (dominantly quartzite, mafic sedimentary rocks, and banded iron-formation), which have undergone medium- to high-grade, largely dynamic metamorphism (Stewart et al., 1983; Binns et al., 1976). Based on similarities in the lithological sequence and metamorphic grade, Stewart et al. (1983) postulated that the North Cook Well and Maynard Hills successions had been part of a single greenstone belt dismembered by deep erosion. A maximum depositional age of c. 3131 Ma for the greenstones was obtained from SHRIMP dating of detrital zircons from a quartzite unit in the Maynard Hills belt (Nelson, 2002). This is consistent with an estimated depositional age of 3.0 Ga for the greenstones in the central part of the Southern Cross Granite–Greenstone Terrane (Chen and Wyche, 2001, and references therein).

Available SHRIMP U–Pb zircon geochronology indicates that granitoid rocks in the region range in age from c. 2730 to 2640 Ma (Wang et al., 1998; Nelson, 2002), consistent with the age of similar rocks in the central part of the Southern Cross Granite–Greenstone Terrane (e.g. Bloem et al., 1997; Dalstra et al., 1998; Wang et al., 1998; Nelson, 1999, 2000, 2001; Qiu et al., 1999).

In terms of structure, EVERETT CREEK is dominated by the north-northwesterly trending (~340°) Edale Shear Zone that encompasses the North Cook Well and Maynard Hills greenstone belts, and the intervening zone of strongly deformed granitoid rocks (Fig. 3). The shear zone is readily apparent on aeromagnetic images (Fig. 4), but its regional extent has been interpreted variously. Stewart et al. (1983) considered the north-northwesterly Edale Fault (at the western edge of the Edale Shear Zone as interpreted in these notes) and the north-northeasterly Youanmi Fault exposed farther to the west (cf. Fig. 1) to represent a conjugate pair of wrench faults. According to these authors, the Edale Fault extends farther south onto RICHARDSON, where it has a northerly trend, and a strike-slip, dextral displacement of about 8 km can be estimated. Tingey (1985) suggested that the Edale Fault terminates on SANDSTONE just northwest of EVERETT CREEK, but he also noted its alignment with the Barrambie belt exposed farther to the northwest. Eisenlohr et al. (1993) argued that the Edale Fault is not a single continuous structure, but is part of a wide zone of deformation — the Edale tectonic zone — defined by a number of converging discrete structures with various orientations and movement senses. These authors described the Edale tectonic zone as a craton-scale lineament that is likely to extend for more than 400 km from north of Meekatharra to about 80 km west of Menzies, possibly crosscutting the Youanmi Fault. On EVERETT CREEK the main component of the Edale tectonic zone of Eisenlohr et al. (1993) is the sinistral Coomb Bore shear zone, which roughly coincides with the Edale Fault of Stewart et al. (1983) and is characterized by a significant decrease in strain and displacement from the northwest to the southeast (Eisenlohr et al., 1993).

Chen et al. (2001) considered the sinistral Edale Shear Zone to be part of the Edale–Evanston arcuate structure — one of the tectonic elements that dominate the structural architecture of the Southern Cross Granite–Greenstone Terrane. These arcuate structures typically

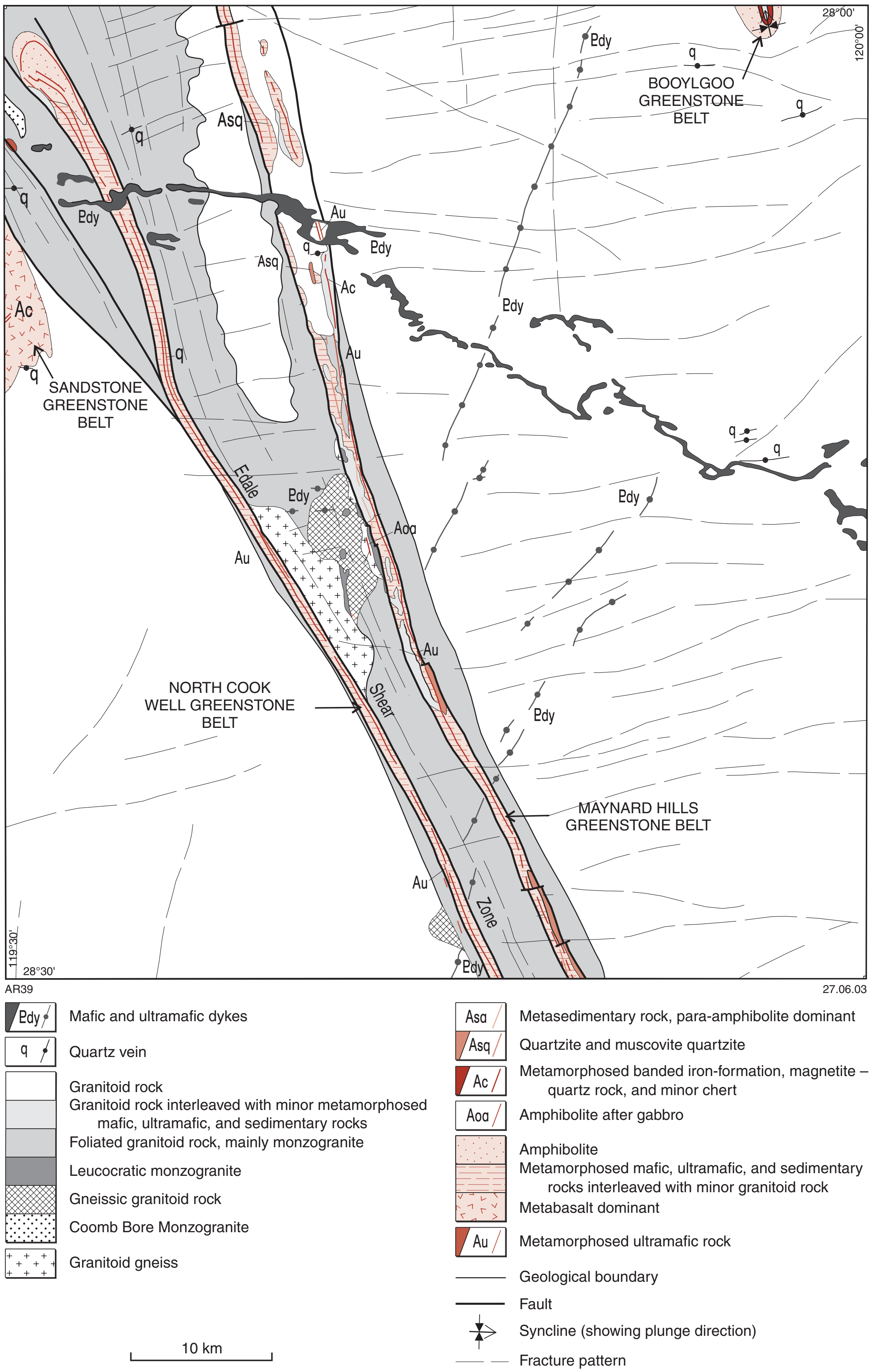

Figure 3. Simplified geological map of Everett Creek

consist of northwesterly sinistral and northeasterly dextral shear zones that are linked by a north-trending contractional zone in the apex regions. They are interpreted to have formed in response to rheological inhomogeneities between greenstones and granitoid bodies during a D_3 east–west compressional event that reoriented earlier structures (Chen et al., 2001). This D_3 event followed an early north–south compression (D_1) that produced low-angle thrusts, tight to isoclinal folds, and an originally east-trending foliation in the greenstones. The onset of east–west compression is interpreted to have occurred during D_2, and to have resulted in north-trending upright folds with an axial-planar foliation that overprinted D_1 structures. Granitoid intrusion was mainly syn-D_2. Following the formation of shear zones within the arcuate structures during D_3, brittle deformation produced north-northeasterly and east-northeasterly trending faults and fractures, some of which have been intruded by mafic to ultramafic dykes and sills of probable Proterozoic age (Figs 3 and 4). The evolution of EVERETT CREEK is summarized in Table 1.

Archaean rock types

All Archaean rocks described in these notes have undergone low- to high-grade metamorphism, and many have been strongly deformed. However, primary textures are preserved at many localities and protoliths can be inferred in most instances. Thus, the prefix 'meta' is omitted in the following descriptions where appropriate.

Greenstone rock types described in this section are exposed within the Edale Shear Zone. Because of the intense deformation, interleaving of different rock types at outcrop scale is typical, generally with considerable lateral variation. Although each polygon on the map sheet was assigned a code according to the dominant rock type for that area, details of the intercalated rock types are also provided in the following descriptions.

Metamorphosed ultramafic rocks (*Au, Auk, Aur, Aus, Aux*)

Ultramafic rocks comprise only a small proportion of the greenstones on EVERETT CREEK (Fig. 3). Undivided ultramafic rocks (*Au*) form small and rubbly exposures at Cook Well and 3 km farther north-northeast, where they consist of very weathered, slightly talcose schists, with local evidence of silicification. It is unclear whether these exposures (and the intervening patch of silica caprock) are part of a continuous area of ultramafic rocks (cf. Stewart et al., 1983) or represent isolated occurrences within deformed granitoid rocks.

Metakomatiite (*Auk*) is only found in a small outcrop on the eastern flank of a banded iron-formation (BIF) ridge 4 km northeast of Red Well (MGA 754670E 6879890N). It is a fine-grained, dark-green rock, with local relict platy spinifex textures. Serpentinized olivine plates are separated by an altered groundmass of tremolite and chlorite.

Tremolite–chlorite(–talc) schist (*Aur*) forms small intercalations in both the North Cook Well and Maynard Hills greenstone belts. In the former, tremolite schist is common on the flanks of BIF units (e.g. 2.7 km northwest of Elspon Well, MGA 760560E 6868580N) or intercalated within amphibolite (e.g. 4 km northwest of Blackhill Homestead, MGA 747440E 6895830N). In the Maynard Hills greenstone belt, tremolite schist preserves evidence of a complex metamorphic and deformation history. A locally developed blastoporphyritic texture shows metamorphic tremolite and clinochlore mimicking grains in which parallel exsolutions of Fe-oxides suggest derivation from ?phenocrystic pyroxene (e.g. 2.7 km southeast of Middle Well, MGA 768590E 6863000N). Tremolite schist 2 km south-southeast of Volprecht Well (MGA 763780E 6879360N) is characterized by black tourmaline crystals, up to 5 cm long, distributed along foliation planes. Tourmaline growth is most likely related

Table 1. Geological evolution of EVERETT CREEK

Age	*Deformation event*	*Geology*
< c. 3131 Ma		Deposition of the lower greenstone succession; burial or seafloor metamorphism
	D_1	North–south compression: layer-parallel foliation and thrusting; tight to isoclinal folding
	D_2	Initiation of east–west compressional regime
		Upright to inclined folding
c. 2.70 Ga – c. 2.68 Ga		Granitoid intrusion (external granitoids)
c. 2665 Ma	D_3	Development of the northwesterly trending Edale Shear Zone; reorientation of D_2 structures
		Peak metamorphism along the shear zone
	Post-D_3	North–northeasterly and east to east–northeasterly trending brittle faults Intrusion of easterly to northeasterly trending mafic to ultramafic dykes and sills, and quartz veins along crosscutting fractures

SOURCE: modified from Riganti and Chen (2002) to fluid circulation during injection of pegmatite veins that parallel the foliation at this locality. Multiple stages of deformation are indicated by crenulation (e.g. MGA 766370E 6870470N, MGA 763780E 6879360N) and folding of the foliation (e.g. MGA 768590E 6863000N).

Serpentinite (*Aus*) is confined to two localities on EVERETT CREEK. About 3 km north of Cook Well, serpentinite is the dominant rock type in a zone of weathered ultramafic rocks extending north-northwesterly for about 1 km. Patches of calcrete and silica caprock are widespread, but foliated cumulate textures within serpentinite are preserved at the northern end of this segment (e.g. MGA 769880E 6850620N). Intercalations of chlorite–talc, chlorite, and tremolite schist are common, whereas chlorite-bearing quartzite is subordinate. Four kilometres west of Blackhill Homestead (MGA 745940E 6892460N), intensely deformed serpentinite is intercalated with amphibolite, siltstone, and granite. Alteration to calcrete is common around a network of quartz veins up to a few centimetres in thickness. This area coincides with one of the strongest magnetic lineaments identified on EVERETT CREEK (Fig. 4) and the Edale Fault of Stewart et al. (1983).

Metamorphosed pyroxenite (*Aux*) with minor metagabbro forms distinct, dark hills and ridges over a distance of about 4 km, northeast of Quartz Blow Well. The pyroxenite is dark brown and medium to coarse grained, with a preserved cumulate texture overgrown by cummingtonite with local relict clinopyroxene and subordinate orthopyroxene (e.g. MGA 764750E 6877930N). Sericite after small interstitial plagioclase grains is partly recrystallized to muscovite.

Metamorphosed fine- to medium-grained mafic rocks (*Ab, Abf, Aba, Abg, Abv*)

Metamorphosed, fine- to medium-grained mafic rocks are a significant component of the North Cook Well and Maynard Hills greenstone belts.

Undivided metamorphosed, chlorite-bearing mafic rocks (*Ab*) are typically deeply weathered, green to dark grey and fine grained, with no distinctive textures. They are most abundant on the flanks of BIF ridges about 7 km north of Middle Well, where they are associated with weathered chlorite–tremolite schist, fine-grained amphibolite, and magnetite-bearing quartzite units. This lithological association, together with the absence of primary quartz in these rocks, suggests derivation from mafic volcanic rocks or sedimentary rocks with a dominantly mafic component. Similar metamorphosed mafic rocks with a strong foliation (*Abf*) and granitic intercalations outcrop about 4 km north-northeast of Middle Well, along strike from the unit described above.

Fine- to medium-grained, black to dark-grey amphibolite (*Aba*) is the dominant mafic rock type in the northern part of the North Cook Well greenstone belt (e.g. 4 km north-northwest of Blackhill Homestead) and forms several units scattered along the western side of the Maynard Hills greenstone belt. Strong recrystallization and well-developed foliation have largely obliterated original textures, but stretched quartz amygdales, up to 7 mm long, are locally preserved (e.g. about 3.5 km north-northeast of Middle Well, MGA 766790E 6868460N). The amphibolite typically consists of a strongly annealed assemblage of hornblende and calcic plagioclase (Fig. 5), with subordinate quartz and accessory opaque minerals, titanite, and local muscovite (after sericitized plagioclase) or biotite. Foliation is defined by the preferred orientation of hornblende and by local millimetre-scale plagioclase- and amphibole-rich bands. Clinopyroxene is locally abundant and can form porphyroblasts that probably represent recrystallized augite phenocrysts (e.g. MGA 765510E 6872450N). Coarse, randomly oriented amphibole needles (e.g. MGA 764100E 6878340N) could represent deformed and recrystallized spinifex textures. Poikiloblastic hornblende and epidote grains overgrow the foliation locally (e.g. MGA 766690E 6867870N; see **Metamorphism**). The mineral assemblage, together with relict amygdaloidal and possible spinifex textures, strongly suggest a basaltic protolith for the amphibolite, with some intercalations of komatiitic basalt. The amphibolite units have abundant intercalations, up to a few metres thick, of BIF and magnetite-bearing quartzite, para-amphibolite, tremolite and chlorite schist, and metamorphosed gabbro. Intervals of foliated granite and pegmatite within the amphibolite have resulted from intense shearing during formation of the Edale Shear Zone.

Intense deformation along the Edale Shear Zone has produced units of strongly foliated amphibolite interleaved with subordinate, strongly deformed granite and pegmatite (*Abg*) in both the Maynard Hills and North Cook Well greenstone belts. The amphibolite in these units is associated with subordinate chlorite and tremolite–chlorite schist, and locally abundant metasedimentary rocks, mainly para-amphibolite and magnetite-bearing quartzite, ferruginous chert, and BIF. Metasedimentary intercalations are particularly abundant south of Lake Noondie, where they range from a few metres to a few tens of metres in thickness, and extend laterally for a few hundred metres. Bedding is parallel to the north-northwesterly trending, steep to vertical foliation, but tight and isoclinal to open mesoscale folding is locally prominent (see **Structural geology**). Greenstones and granitoid rocks are interleaved at a scale of a few metres to a few hundreds of metres. Along the ridge that constitutes the Maynard Hills greenstone belt, these repeated intercalations produce a step-like physiography, with resistant risers of pegmatite-rich granite alternating with terraces of greenstone.

Metabasalt (*Abv*) on the western edge of EVERETT CREEK forms part of the Sandstone greenstone belt, which outcrops extensively on the adjacent ATLEY sheet (Chen, in prep.a). Metabasalt is typically a dark- to medium-grey, fine-grained, massive to moderately foliated rock, consisting of actinolite, plagioclase, and opaque oxide minerals, with local incipient silicification. Rounded to elongate amygdales up to 2 cm wide (but generally only 3–4 mm across) contain calcite or chlorite and clinozoisite, and the rock is locally variolitic. Exposures are generally rubbly, but rounded shapes up to 20 cm across suggest the presence of pillow structures. Pillows have been identified 1 km to the west on ATLEY, where younging of the succession to the north-northeast is indicated (MGA 744410E 6881310N;

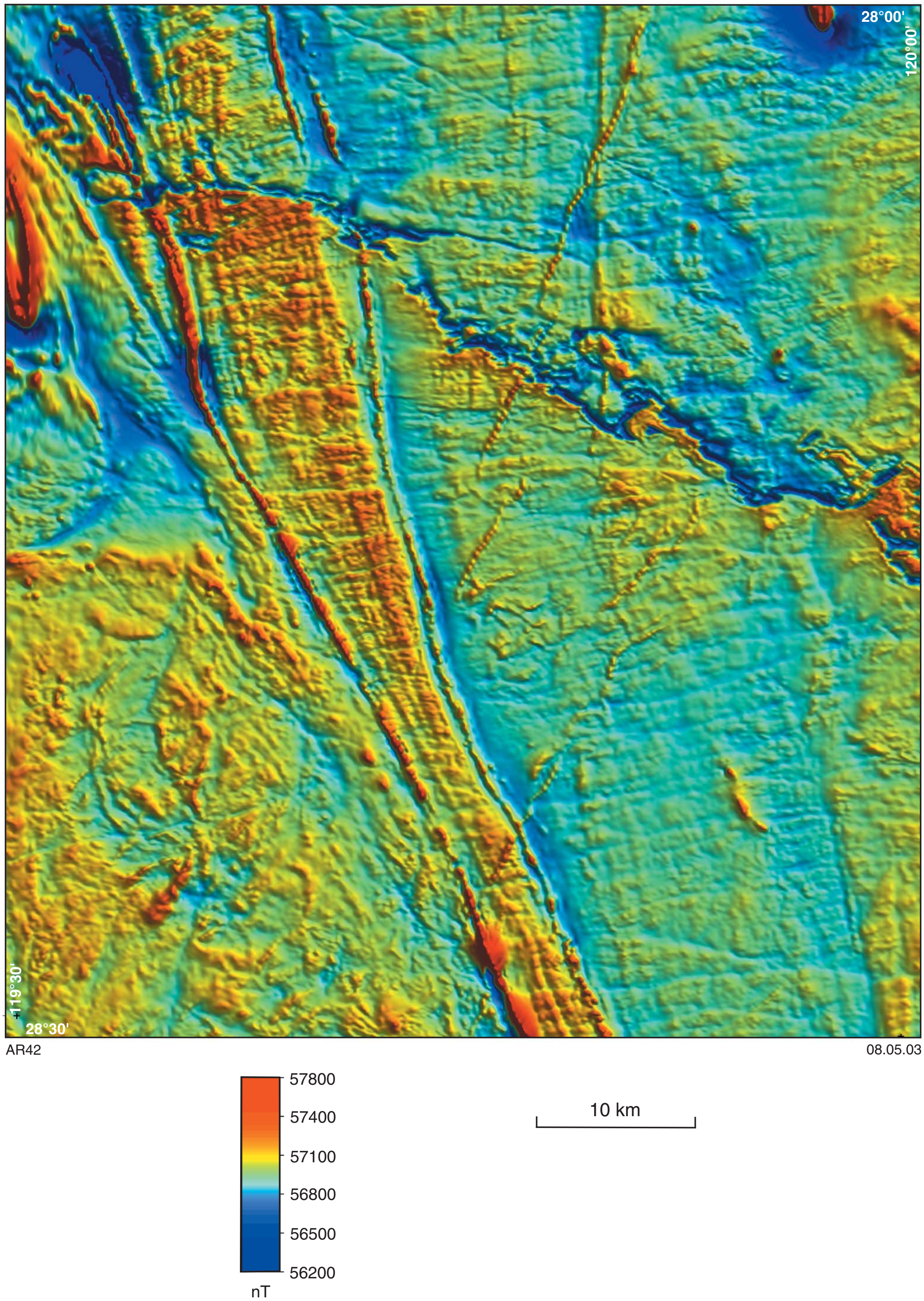

Figure 4. Aeromagnetic map of total magnetic intensity for Everett Creek (based on 200 m and 400 m line-spaced data)

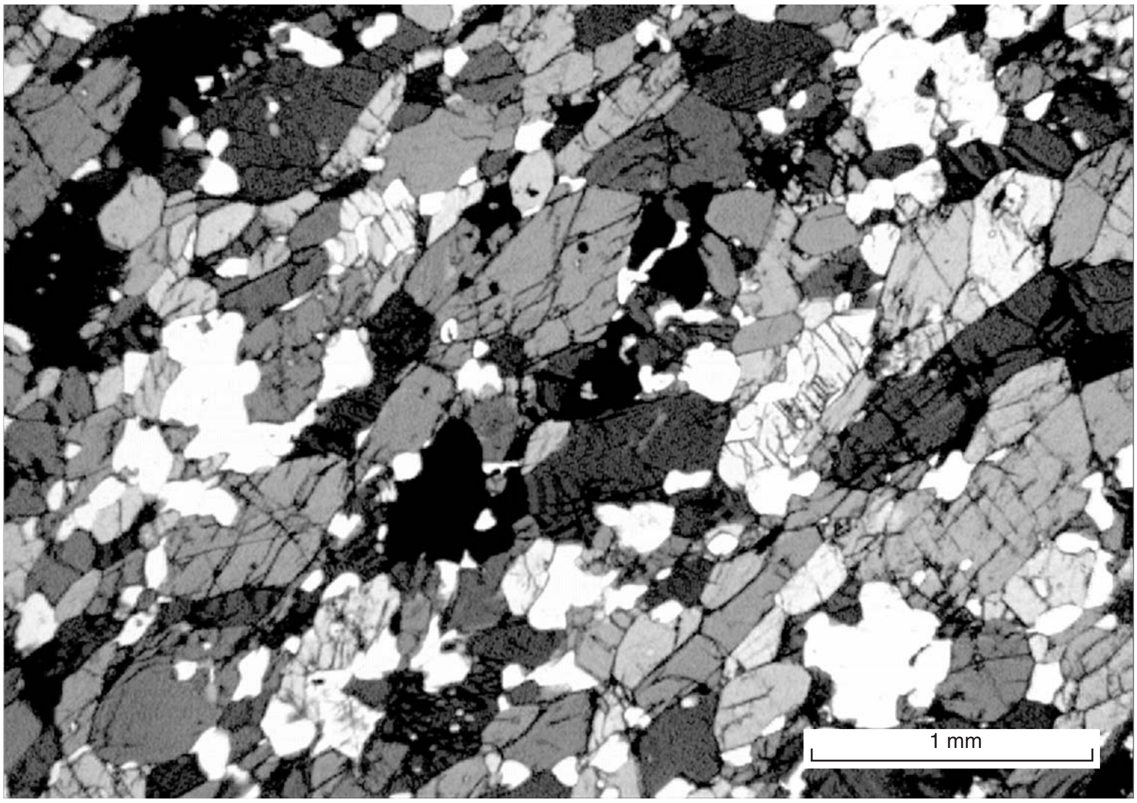

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Figure 5. Granoblastic polygonal assemblage of hornblende, plagioclase, and minor quartz in amphibolite from the Maynard Hills greenstone belt; GSWA 164923, plane-polarized light, field of view is 4 mm

Chen, in prep.a). Chemical analysis of a sample from this area indicates a tholeiitic composition (GSWA 165412, MGA 745860E 6880860N; Chen, in prep.b).

Metamorphosed medium- to coarse-grained mafic rocks (*Aoa, Aogf*)

Coarse-grained amphibolite (*Aoa*) consisting of clinopyroxene–plagioclase–hornblende is interpreted as medium-grade metamorphosed gabbro. These foliated units are found in the Maynard Hills greenstone belt and in a few small, bouldery mounds within granitoid gneiss about 4.5 km north of Middle Well. The intensity of foliation and recrystallization varies, resulting commonly in inequigranular assemblages. The rocks have had a complex evolution. Metamorphic clinopyroxene (most likely diopside) and calcic plagioclase commonly form granoblastic assemblages, whereas hornblende forms larger (up to 7 mm), commonly poikiloblastic grains locally overgrowing the clinopyroxene (e.g. MGA 765850E 6869560N). There are small, isolated remnants of relict augite (with ?pigeonite exsolution lamellae) within large amphibole grains in some of the coarsest occurrences (e.g. MGA 767630E 6864970N), whereas relict plagioclase is locally preserved as large porphyroclastic, sericitized aggregates with some mortaring at the edges (e.g. MGA 767210E 6867850N). Kinked, fractured, and altered amphibole grains that are commonly frayed at the edges and show evidence of incipient recrystallization are also interpreted to be a relict phase, and could be related to either deuteric alteration of the gabbro or an earlier metamorphic event. Granoblastic quartz and local granophyric intergrowths are subordinate intergranular phases. Epidote and zoisite, opaque oxides, titanite, and local apatite and biotite are accessory minerals. Compositional variations are indicated by plagioclase-dominated portions (e.g. MGA 767950E 6864380N and MGA 767300E 6867840N), with Mg-rich intervals containing cummingtonite instead of hornblende (e.g. MGA 767630E 6864970N). The amphibolite in the small mounds about 4.5 km north of Middle Well is coarse grained and surrounded by granitoid gneiss. The amphibolite mounds are broadly aligned north-northwesterly, parallel to the structural grain of the Edale Shear Zone, and may represent metamorphosed and boudinaged relicts of early mafic dykes (cf. Stewart et al., 1983).

Strongly foliated metagabbro with minor pyroxenite (*Aogf*) is a medium- to coarse-grained rock, dark brown on weathered surfaces, characterized by an inequigranular assemblage of polygonized cummingtonite surrounding larger plagioclase grains, with accessory opaque oxides and titanite. Magnesium-rich chlorite is locally abundant. Amphibole and plagioclase define a strong foliation that represents the main distinguishing feature from the amphibolitic assemblages described above. Pyroxenitic intervals within the gabbro may have relict clinoyroxene and orthopyroxene overgrown by cummingtonite and diopside, with subordinate sericitized plagioclase partly recrystallized to muscovite (e.g. MGA 764770E 6877390N). Similar units of foliated gabbro are also common as small intercalations within basaltic amphibolite. Locally, large amphiboles preserve cores with relict exsolution lamellae of opaque minerals (?rutile and hematite) along cleavage planes (MGA 768250E 6864160N).

Metamorphosed sedimentary rocks (*As, Asa, Asq, Asqm, Asqi, Aci, Acis*)

Metamorphosed sedimentary rocks on Everett Creek comprise a significant proportion of the succession in both the Maynard Hills and North Cook Well greenstone belts. Here, BIF and quartzite form prominent ridges, whereas para-amphibolite has a more subdued topographic expression. Banded iron-formations are also represented in the Booylgoo Range and Sandstone greenstone belts.

Undivided metasedimentary rocks (*As*) are typically deeply weathered. They are exposed on the flanks of a north-northwesterly trending quartz-vein ridge, immediately west of Quartz Blow Well. Small outcrops of ferruginized micaceous schist are scattered among the quartz-vein debris, and are associated with subordinate finely banded ferruginous chert and quartzite. This association suggests a sedimentary protolith (most probably a siltstone) for the schist.

Dominant para-amphibolite and subordinate quartzite, with minor mafic and felsic (granitic to pegmatitic) intercalations (*Asa*) are well exposed in the Maynard Hills greenstone belt, particularly north of Middle Well. Para-amphibolite is dark green to dark grey, generally fine grained and very thinly to thinly bedded, with a prominent layer-parallel, north-northwesterly, steeply dipping to vertical foliation. More-massive units are not so readily distinguished from basaltic amphibolites (cf. *Aba* above), but the contact between the two types appears to be gradational, with sedimentary beds becoming progressively indistinguishable over a distance of a few tens of metres (e.g. northwest of Quartz Blow Well). The para-amphibolite contains quartz-rich metamorphosed sedimentary intercalations, comprising mainly quartzite, magnetite quartzite, and fine-grained feldspathic metasandstone. These intervals are also thinly bedded, range from a few tens of centimetres to about a metre in total thickness, and are in sharp contact with the para-amphibolite (Fig. 6). Poorly preserved cross-bedding in a steeply dipping, greenish quartzite intercalation 6.5 km north of Middle Well (MGA 766000E 6871240N) suggests younging of the sequence to the west-southwest. In thin section, para-amphibolite is distinguished by a granoblastic to grano-nematoblastic assemblages of hornblende, calcic plagioclase, clinopyroxene, and accessory opaque oxides (magnetite and ilmenite) and apatite, with millimetre-scale banding defined by changes in the proportions of these minerals. Some beds are rich in cummingtonite, whereas calc-silicate horizons are dominated by diopside, calcic plagioclase, and epidote. Quartz is generally subordinate, but locally increases in abundance to define hornblende–plagioclase gneiss layers. Biotite and titanite are common, with biotite–quartz–plagioclase schist in places. Almandine

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Figure 6. Para-amphibolite (bottom), with intercalations of thinly bedded quartzite

crystals up to 1 cm across are locally abundant in the most aluminous beds, whereas grunerite is typical of magnetite-bearing quartzite intercalations. Andalusite is common in recrystallized feldspathic sandstone and in some muscovite quartzite layers, whereas pinite after cordierite is present in muscovite–quartz–plagioclase schist, and in some hornblende–plagioclase gneiss. Most of the metamorphic minerals grew synkinematically and define a strong, layer-parallel foliation. A second foliation at a low angle to the first is visible in the finer grained and most micaceous units. Peak metamorphic conditions were probably reached during D_3, but hornblende, biotite, muscovite, and epidote continued to form after the period of most intense deformation (see **Structural geology** and **Metamorphism**).

Medium- to coarse-grained quartzite with common micaceous and ferruginous intercalations (*Asq*) is the dominant metasedimentary rock type in the southern part of the Maynard Hills greenstone belt on EVERETT CREEK (i.e. in the Maynard Hills and north of Lake Noondie). Quartzite is massive to well bedded, and forms distinctive ridges with subordinate, recessive intercalations of muscovite-bearing quartzite, muscovite–quartz schist, and fine-grained magnetite-bearing quartzite. Other primary sedimentary structures were largely destroyed by recrystallization and deformation, with strong flattening and bedding-parallel cleavage. Folding is ubiquitous in the quartzite. In the massive and more coarsely bedded types, folding is indicated by a prominent bedding–cleavage intersection lineation (Fig. 7a). In thinly bedded quartzite, it varies from small-scale, tight to isoclinal folds (Fig. 7b) to mesoscale, open to tight synforms and antiforms (Fig. 7c,d). Folding prevents precise assessment of the overall thickness of the quartzite unit, but it is likely to be at least a few hundred metres. A quartzite unit in the Illaara greenstone belt, about 130 km to the south-southeast on MOUNT MASON, has an estimated thickness of 900 m and could be a regional correlative of the quartzite in the Maynard Hills (Wyche et al., in prep.). The only way-up indicator observed in the Maynard Hills greenstone belt is some poorly preserved cross-bedding west of Minga Bore (MGA 775260E 6849240N) that indicates younging of the succession to the west-southwest.

Quartzite is generally white to pale pinkish-grey, with locally abundant fuchsite imparting a green colour in places. Ferruginous staining, mainly along fractures, is due to weathering of accessory magnetite, and is locally pronounced. White quartz veins crosscut the quartzite at a number of localities, and up to several tens of centimetres thick (e.g. MGA 769940E 6859930N). Varying degrees of recrystallization and deformation have resulted in a range of microstructures. Cataclastic textures are locally preserved, with the outline of quartz clasts suggesting variable poor sorting for some of the quartzite beds (Fig. 8a). Quartz in the more strongly recrystallized parts of the unit has pronounced undulose extinction and sutured contacts, with a clear foliation defined by mica (generally muscovite or fuchsite, and accessory biotite; Fig. 8b). More pure quartzites tend to have more distinct granoblastic textures. Most of the quartzite unit appears to have been derived from compositionally mature quartz sandstone, whereas the associated micaceous intercalations formed from sandstone with a higher clay or feldspathic matrix component. No clear environmental indicators are preserved in the quartzite, but possible irregular ripple marks observed on loose boulders 2.5 km west-southwest of Kohler Bore (MGA 776820E 6844990N) and cross-bedding (see above) suggest that the unit was deposited in shallow water, most likely in a fluvial or shallow-marine environment. Quartzite samples collected for SHRIMP geochronology have yielded several populations of detrital zircons, with the youngest of these constraining the maximum age of deposition for the unit at 3131 ± 3 Ma (GSWA 169074, MGA 777080E 6845000N; Nelson, 2002).

Muscovite quartzite and muscovite–quartz schist (*Asqm*) are common as small intercalations (from a few centimetres up to several metres in thickness) within the quartzite described above, and form thicker units that are well developed on the eastern flank of the quartzite ridges. The rocks vary from silver-green to silver orange-brown in the most weathered exposures. They are commonly fine to medium grained and strongly deformed, with a prominent layer-parallel foliation and distinct S–C fabrics that consistently indicate a sinistral shear sense (Fig. 9). In thin section, muscovite commonly kinks around polygonized quartz clasts (see front cover). The muscovite-bearing quartzite unit contains subordinate intercalations of ferruginous quartzite and small lenses (up to 2 m long and 50 cm wide; e.g. MGA 770100E 6859850N) of fine-grained foliated mafic metasedimentary rocks (hornblende–plagioclase–quartz assemblages dominate).

Magnetite(–grunerite)-bearing quartzite (*Asqi*) forms small intercalations within the quartzite units (*Asq*), and is common as resistant units within mafic rocks exposed on the western flank of the quartzite ridges in the southern part of the Maynard Hills greenstone belt. North of Blue Hills Well, quartzite becomes progressively less significant along the belt, concomitant with an increase in the abundance of magnetite-bearing quartzite and, farther north, BIF (see **Stratigraphy**). Magnetite-bearing quartzite units range in thickness from a few metres to a few tens of metres, with possible repetition due to folding (particularly in the southern exposures). Magnetite-bearing quartzite is dark grey to brown (where ferruginized), fine grained, and strongly recrystallized. It is thinly bedded (layers range from <1 cm to 10 cm), typically with recessive layers that contain less quartz. Contacts between beds are sharp but sinuous, due to deformation and boudinaging of layers along strike. Millimetre-scale banding, interpreted as recrystallized laminations, is generally well developed and defined by varying proportions of granoblastic quartz and magnetite. More-aluminous layers contain a significant proportion of grunerite and accessory biotite that define a strong layer-parallel foliation. Deformation and recrystallization have obliterated sedimentary structures other than bedding and laminations, but randomly oriented fissures on loose bedding surfaces at a few localities could represent desiccation or syneresis cracks (Fig. 10).

Metamorphosed BIF with minor banded chert (*Aci*) is common in all greenstone belts on EVERETT CREEK. In the North Cook Well greenstone belt, BIF forms a discontinuously exposed but prominent unit that can be traced on aeromagnetic images along the length of the belt (Fig. 4). In the southern part, exposures typically comprise

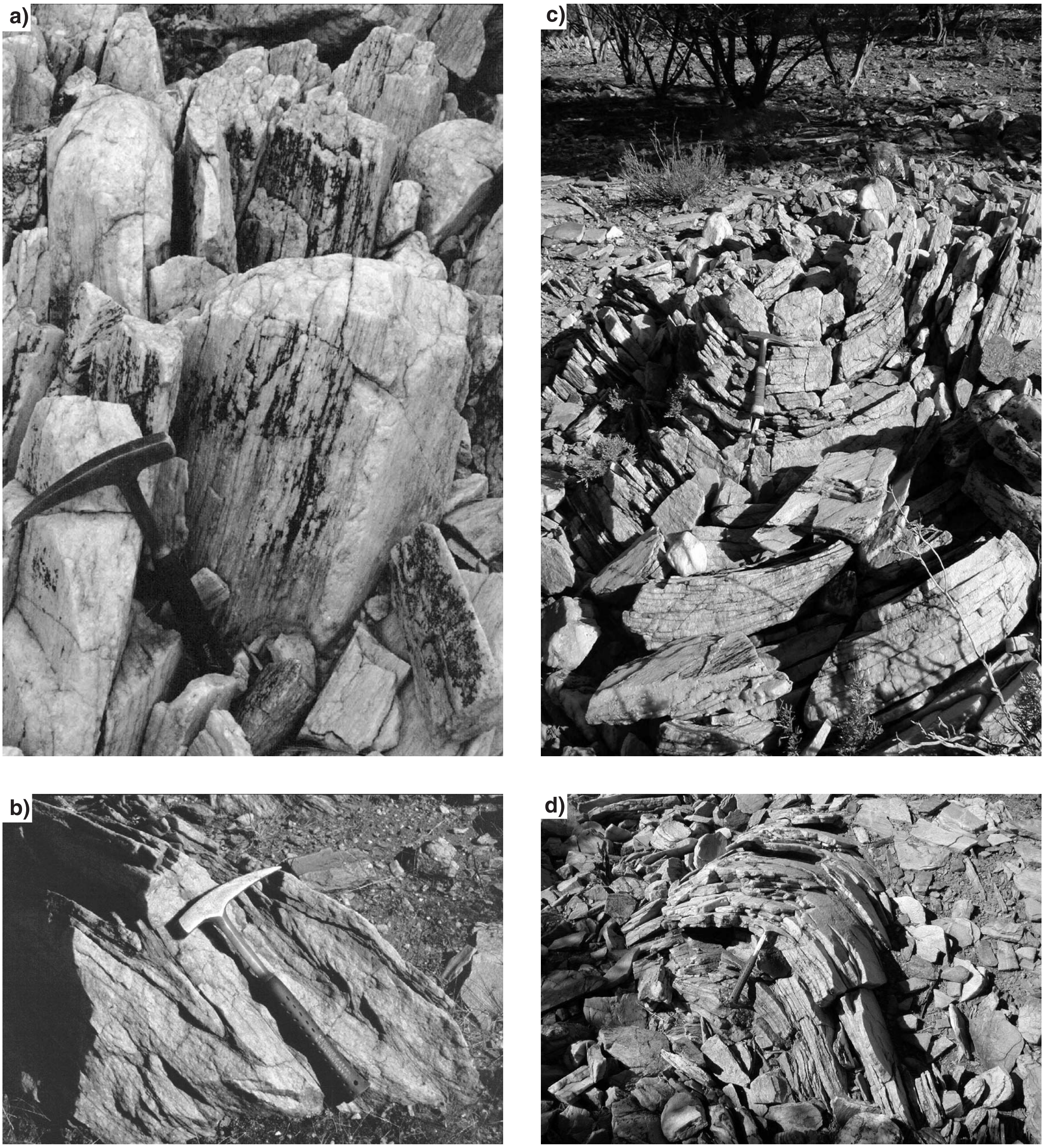

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Figure 7. Structural characteristics of quartzite: a) coarsely bedded quartzite with a prominent, south-southeasterly, steeply plunging bedding–cleavage intersection lineation (MGA 777570E 6844230N); b) small-scale tight folds in medium-bedded quartzite (MGA 776840E 6845520N); c) and d) mesoscale, gently to moderately south-plunging, open to tight cylindrical synform and antiform in thinly bedded quartzite (around MGA 776250E 6846520N)

several BIF units a few metres in thickness, commonly with intercalations of mafic and ultramafic schists and fine-grained amphibolites. In the north, BIF units become progressively thicker and form more prominent ridges, commonly flanked by basaltic amphibolite. A similar but thinner magnetic unit in the Maynard Hills greenstone belt (Fig. 4) corresponds to disrupted, intermittent exposures of BIF in the northern section of the belt, whereas magnetite-bearing quartzite dominates over BIF in the central and southern parts. A thick BIF unit forms prominent hills at the southernmost extension of the Booylgoo Range greenstone belt, in the northeastern corner of the map sheet, and numerous BIF units are intercalated with metabasalt in the Sandstone greenstone belt at the western edge of EVERETT CREEK. Banded iron-formation is laminated to thinly bedded, typically with magnetite-

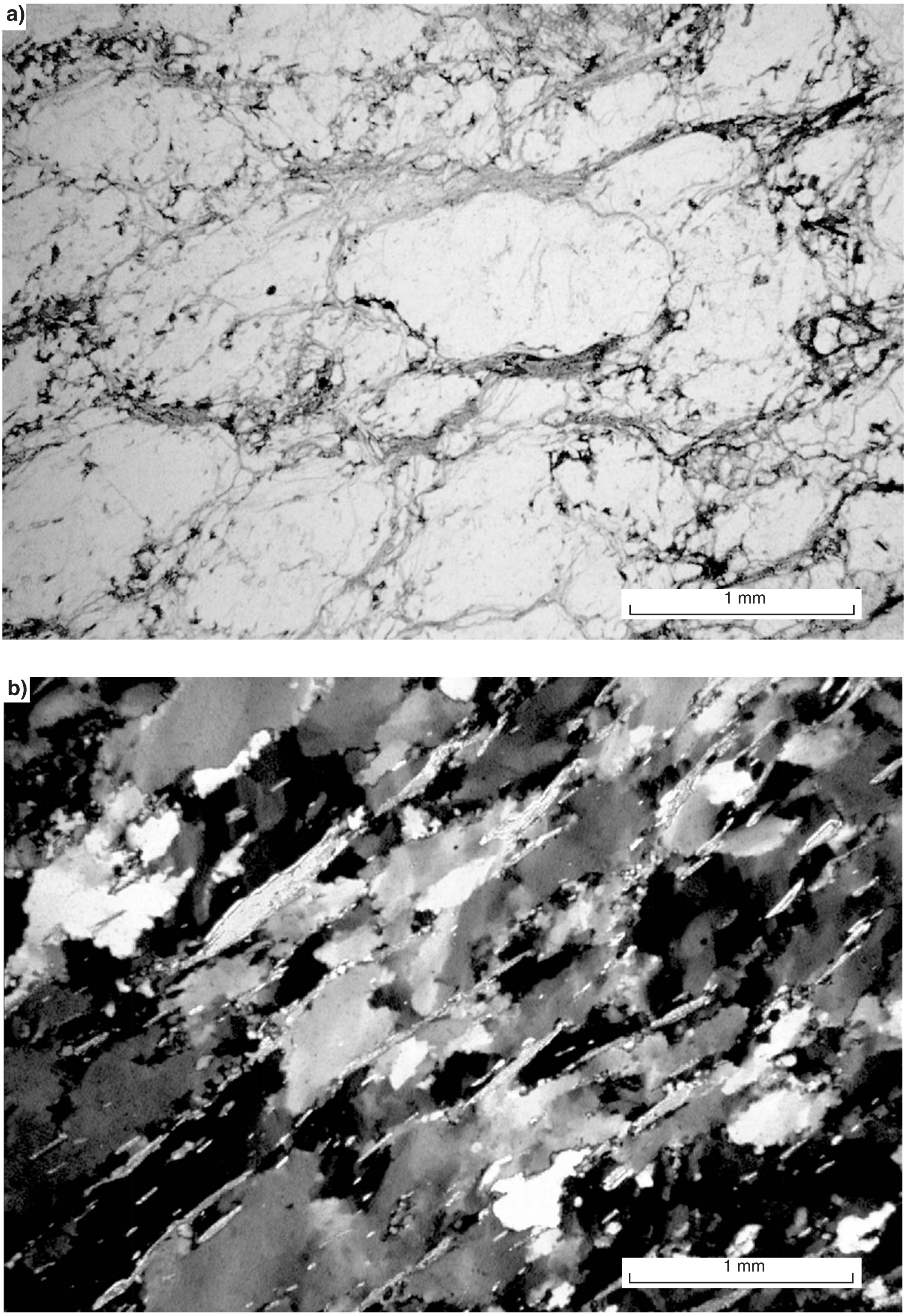

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Figure 8. Textural characteristics of quartzite: a) cataclastic texture, with variably sized quartz clasts mortarized at the edges; GSWA 164901, plane-polarized light, field of view is 4 mm; b) recrystallized quartzite, with quartz grains characterized by undulose extinction and sutured contacts, and with muscovite defining a strong foliation, GSWA 164897, crossed polars, field of view is 4 mm

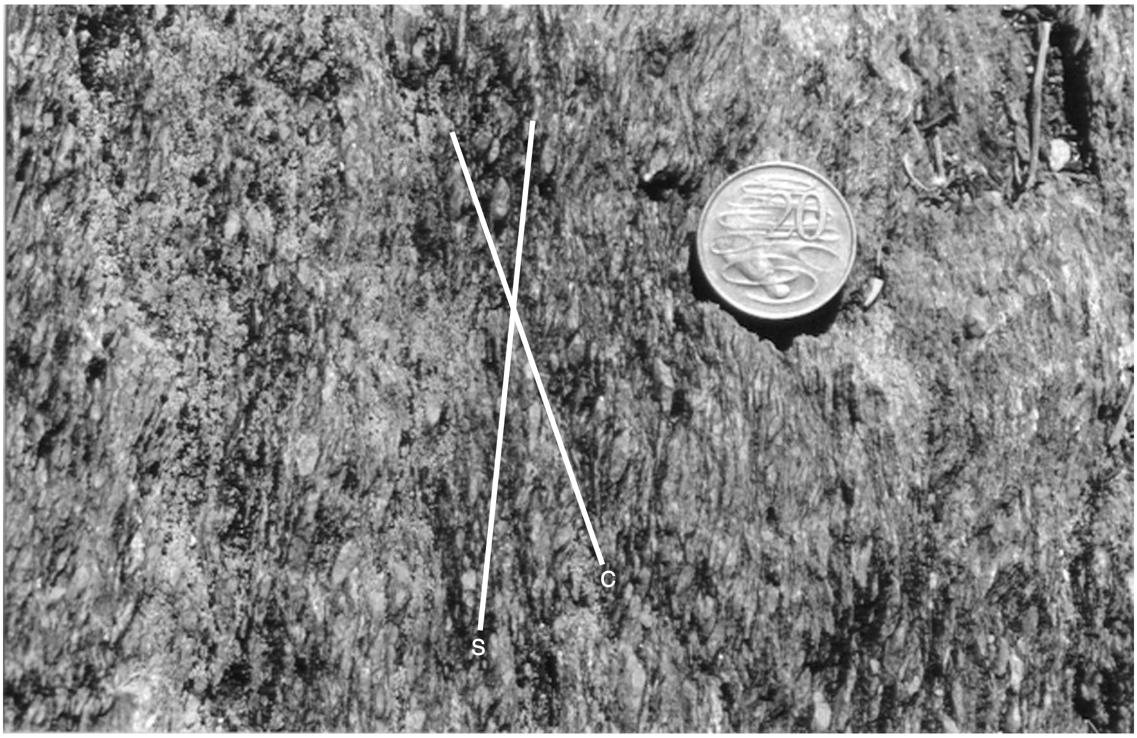

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Figure 9. S–C fabric in muscovite-bearing quartzite, indicating sinistral shear sense. North-northwesterly trending S-planes dip steeply (72°) to the west-southwest, C-planes trend northwest (MGA 768940E 6862330N)

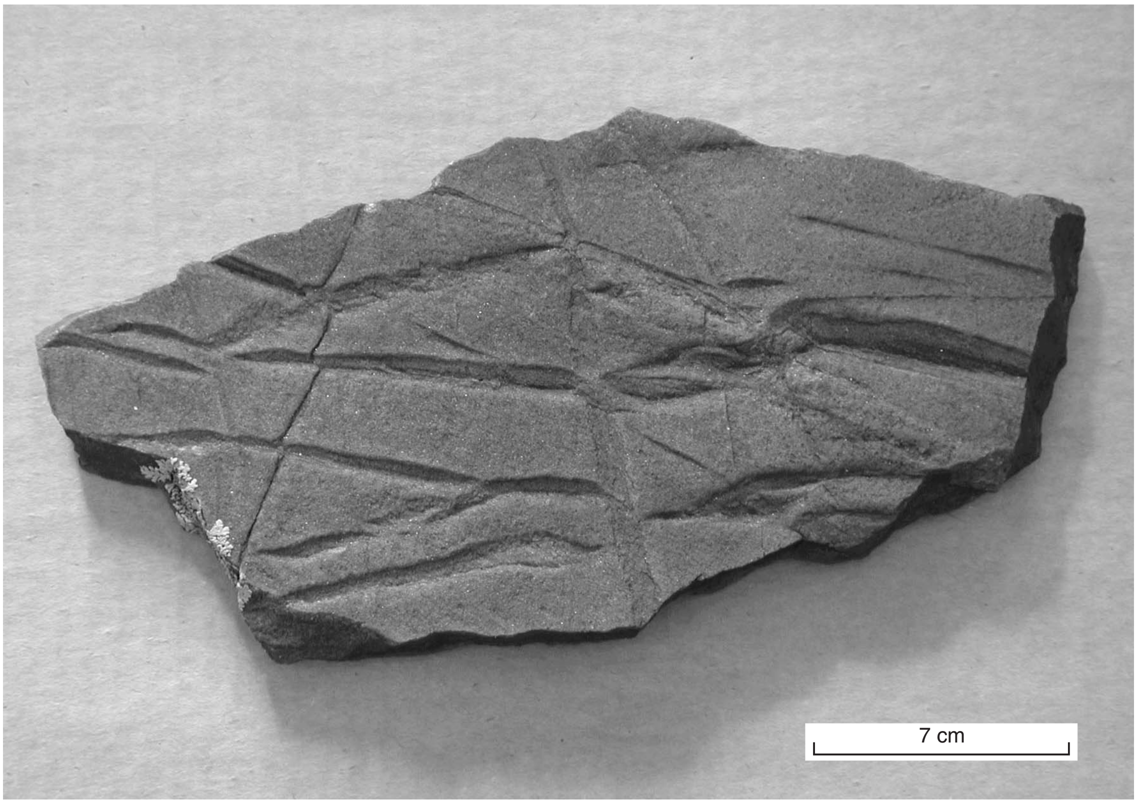

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Figure 10. Probable desiccation or syneresis cracks on a bedding surface in a magnetite-bearing quartzite from the Maynard Hills greenstone belt (around MGA 768400E 6863700N). Sample is 27 cm long

bearing black layers interbedded with brown, finely crystalline chert, white quartzite, and red jasper. Magnetite is variably altered to hematite.

Banded iron-formation is deformed at all scales, with easily traced units allowing evaluation of deformation styles within the different belts. A southerly plunging, large-scale synform in the northernmost part of the North Cook Well greenstone belt is poorly exposed, but clearly outlined on aeromagnetic images (Fig. 4). The Booylgoo Range BIF exposures define a moderate north-northwesterly plunging syncline (based on younging directions from pillow basalts on LAKE MASON; Wyche, in prep.). Mesoscale folds are present in all belts (e.g. north-northwesterly plunging synform at MGA 745520E 6882380N, east-southeasterly plunging antiform at MGA 747610E 6896110N, south-plunging synform at MGA 763900E 6884850). The typically vertical to steeply dipping beds are commonly tightly to isoclinally folded, with more chaotic folds at a number of localities (e.g. MGA 750780E 6892850N, MGA 748740E 6895470N, MGA 771340E 6846990N), together with some brecciation and common jointing. Kinking of beds and S-shaped folds with planes parallel to bedding suggest a sinistral sense of movement in both the Maynard Hills and North Cook Well greenstone belts (e.g. MGA 759960E 6869680N, MGA 754410E 6881210N). Layer-parallel quartz bands and quartz-rich or cherty beds within the BIF in these two belts are commonly boudinaged, with imbrication also indicating sinistral shear (Fig. 11).

Banded magnetite–hornblende–quartz rock with minor mafic schist and amphibolite (*Acis*) is associated with BIF in the North Cook Well and Maynard Hills greenstone belts. It commonly forms small intercalations within and on the flanks of BIF units, with the most conspicuous exposure immediately west of Cook Well. This rock type is typically laminated at a millimetre scale, with strongly recrystallized bands alternately rich in granoblastic magnetite, quartz, and hornblende. It is most likely derived from an Fe-rich cherty metasediment that had a considerable input of detrital mafic material. A prominent layer-parallel foliation is commonly overprinted at a low angle by a second ductile deformation.

Granitic rocks (*Ag, Agf, Agb, Agi, Agm, Agmf, Agml, Agmp, Agn, Agcm, Ang*)

Granitic rocks occupy or underlie much of EVERETT CREEK (Fig. 3). Exposed granitic rocks are commonly monzogranitic, with only subordinate granodiorite and rare syenogranite varieties. Strong deformation is typical of granitic rocks within the Edale Shear Zone, where granitic gneiss is developed, with the intensity of deformation decreasing rapidly away from the zone (Fig. 3).

Undivided granitoid rocks (*Ag*) are poorly exposed, deeply weathered, and have a relict granular texture. They are typically at the base of breakaways or form low-lying aprons surrounding fresher granitoid exposures. Strongly

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Figure 11. Boudinaged, layer-parallel quartz band in BIF of the North Cook Well greenstone belt, with imbrication of the boudins suggesting sinistral shearing (MGA 765710E 6859590N). Pocket knife is 11 cm long

foliated granitoid rocks (*Agf*) in which deep weathering prevents identification of the original composition are distinguished by a prominent fabric, and characteristically confined to the Edale Shear Zone.

Strongly foliated granite with abundant coarse-grained pegmatite and tectonically interleaved with amphibolite and quartz–mica(–plagioclase) schist (*Agb*) outcrops extensively in the Maynard Hills greenstone belt (Fig. 3). Resistant granite and pegmatite dominate this unit, and alternate on a metre scale (locally less) with a variety of recessive metamorphosed volcanic and sedimentary rock types. The granite is typically coarse to medium grained, with coarser, muscovite-rich pegmatites that increase in abundance from the west to the topographically highest section of the ridge that forms the Maynard Hills greenstone belt. Both rock types have a pronounced north-northwesterly trending foliation, with poorly defined folding and local crenulation (e.g. MGA 769790E 6859860N). Alternating rock types include basaltic amphibolite, metagabbro, para-amphibolite, quartz–biotite–plagioclase schist, and muscovite-bearing quartzite, all with the same foliation as the granite. Rare, east-trending pegmatite and aplite veins crosscut the north-northwesterly foliation (e.g. MGA 768120E 6863970N).

Mixed granitoid rocks of mainly monzogranitic composition (*Agi*) form isolated, distinctive hills about 3 km east of No. 6 Well, amid low-lying monzogranite exposures (*Agm*). In some outcrops (e.g. MGA 780320E 6877010N, MGA 779830E 6877460N), the dominant phase is an orange-brown, fine- to medium-grained, undeformed, biotite-bearing granitoid, which contains fragments of coarse-grained, megacrystic, foliated monzogranite (Fig. 12). The fragments are subrounded to angular, range from a few centimetres to boulder-size, and generally have sharp contacts with the finer grained host. The most intensely foliated megacrystic fragments have asymmetric feldspar crysts (Fig. 12a), and some are compositionally banded (Fig. 12b). Other exposures are more homogeneous, with finer and coarser grained granitic portions irregularly juxtaposed, and with thin compositional banding on some weathered surfaces (e.g. MGA 780240E 6876750N, MGA 780330E 6878090N). Feldspar grains of the finer granitoid phase are pervasively altered to clay and sericite, whereas biotite is extensively replaced by chlorite. Titanite and apatite are abundant accessory phases, and carbonate is locally common along fractures and grain boundaries. Stewart et al. (1983) considered the finer grained phase of these rocks to represent muscovite–biotite microgranodiorite veins up to 20 m thick. The localized and unusual nature of these exposures, and their proximity to the magnetic trace of the main mafic sill crosscutting EVERETT CREEK, suggest that the fine-grained granitoid at these localities represents a felsic differentiate from this late mafic intrusion (*Edy*). A similar interpretation is tentatively proposed for a small granophyre outcrop near the same sill on ATLEY (Chen, in prep.b).

Monzogranite (*Agm*) is the most common granite type on EVERETT CREEK. It is typically massive, medium to coarse grained, and leucocratic to mesocratic, with locally abundant pegmatite, aplite, and quartz veins. The monzogranite is commonly equigranular, but locally has a seriate texture, with a gradational increase in the length of feldspar megacrysts up to 3 cm. Some of the porphyritic exposures are large enough to be mapped separately (e.g. MGA 748420E 6856220N; see *Agmp* below). The monzogranite becomes progressively more deformed over a distance of a few hundred metres adjacent to the Edale Shear Zone (see *Agmf* below). Minor tonalitic and granodioritic patches and bands are developed locally (e.g. MGA 787490E 6849700N, MGA 746530E 6861540N), and can form enclaves up to several metres across (e.g. tonalite lenses at MGA 788430E 6874520N and MGA 785490E 6883210N). The monzogranite is granular to almost granoblastic in places, and contains variable amounts of biotite, minor muscovite, and accessory opaque minerals, zircon, titanite, and apatite, with minor secondary carbonate. Sericite and clay alteration of feldspars is locally pronounced, and biotite is typically partly replaced by chlorite. At a few localities the monzogranite contains enclaves of metasedimentary rocks (mainly BIF, e.g. MGA 745800E 6861353N), indicating an intrusive relationship with the greenstones. A monzogranite sample collected by Geoscience Australia near the Bulga Downs Homestead on RICHARDSON yielded a SHRIMP U–Pb age of 2684 ± 8 Ma (Cassidy et al., 2002), consistent with the main phase of granite intrusion in the central part of the Southern Cross Granite–Greenstone Terrane (Chen and Wyche, 2001, and references therein).

Strongly foliated monzogranite (*Agmf*) on EVERETT CREEK is coarse to medium grained and locally porphyritic, and is spatially related to the Edale Shear Zone (Fig. 3). The intensity of deformation characteristically increases towards the shear zone, with massive, undeformed monzogranite grading into a strongly deformed equivalent over a short distance, typically a few hundred metres to one kilometre. These relationships are best developed on the eastern side of the Edale Shear Zone (e.g. around MGA 770500E 6863200N), where the transition is characterized by the appearance of a weak, north-northwesterly trending fabric that rapidly develops into a steeply dipping to vertical foliation defined by strings of quartz and feldspar, and alignment of mica (biotite and muscovite). Over the same interval, the granite is characterized by the appearance of sparse to locally common, metre-scale amphibolite slivers (e.g. MGA 769550E 6863680N), as well as the reorientation and flattening of pegmatite and quartz veins parallel to the foliation. Muscovite-rich, coarse-grained pegmatite veins increase in abundance towards the greenstones, possibly due to shearing of the pegmatite-rich periphery of a granite that intruded the greenstones. Near the faulted contact with the Maynard Hills greenstone belt (Fig. 3), the granite is mylonitized, and the milling of feldspar is so intense that portions of the granite can resemble the muscovite-bearing quartzite. These most intensely deformed portions are characterized by S–C fabrics that consistently indicate sinistral shear, with shallow-dipping mineral lineations on foliation planes. Sinistral S–C fabrics and asymmetric plagioclase porphyroclasts are also typical of strongly foliated, meso- to melanocratic granite exposures adjacent to the North Cook Well greenstone belt, about 4 km north-northwest of Cook Well. At this locality, there are rapid changes in the style of deformation, with some of the granite characterized by an augen mylonitic texture (Fig. 13a), whereas nearby exposures have a grano-

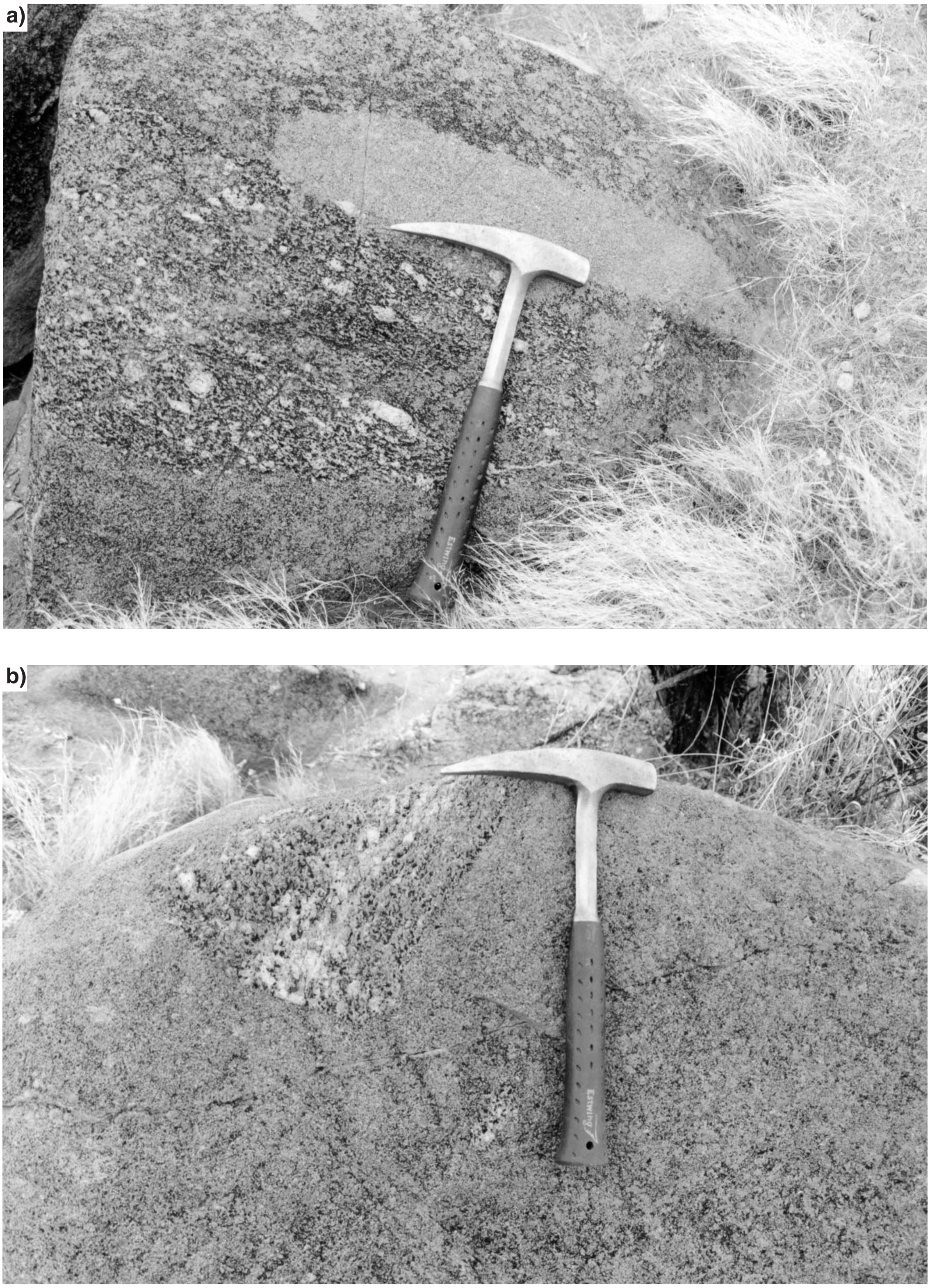

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Figure 12. Textural relationships of mixed granitoid rocks northeast of No. 6 Well (MGA $_{7}$80320E, $_{68}$77010N): a) strongly foliated, coarse-grained monzogranite block with asymmetric feldspar porphyroclasts within a fine- to medium-grained granitic host; b) subrounded, coarse-grained monzogranite fragment showing compositional banding in a finer grained granitic host

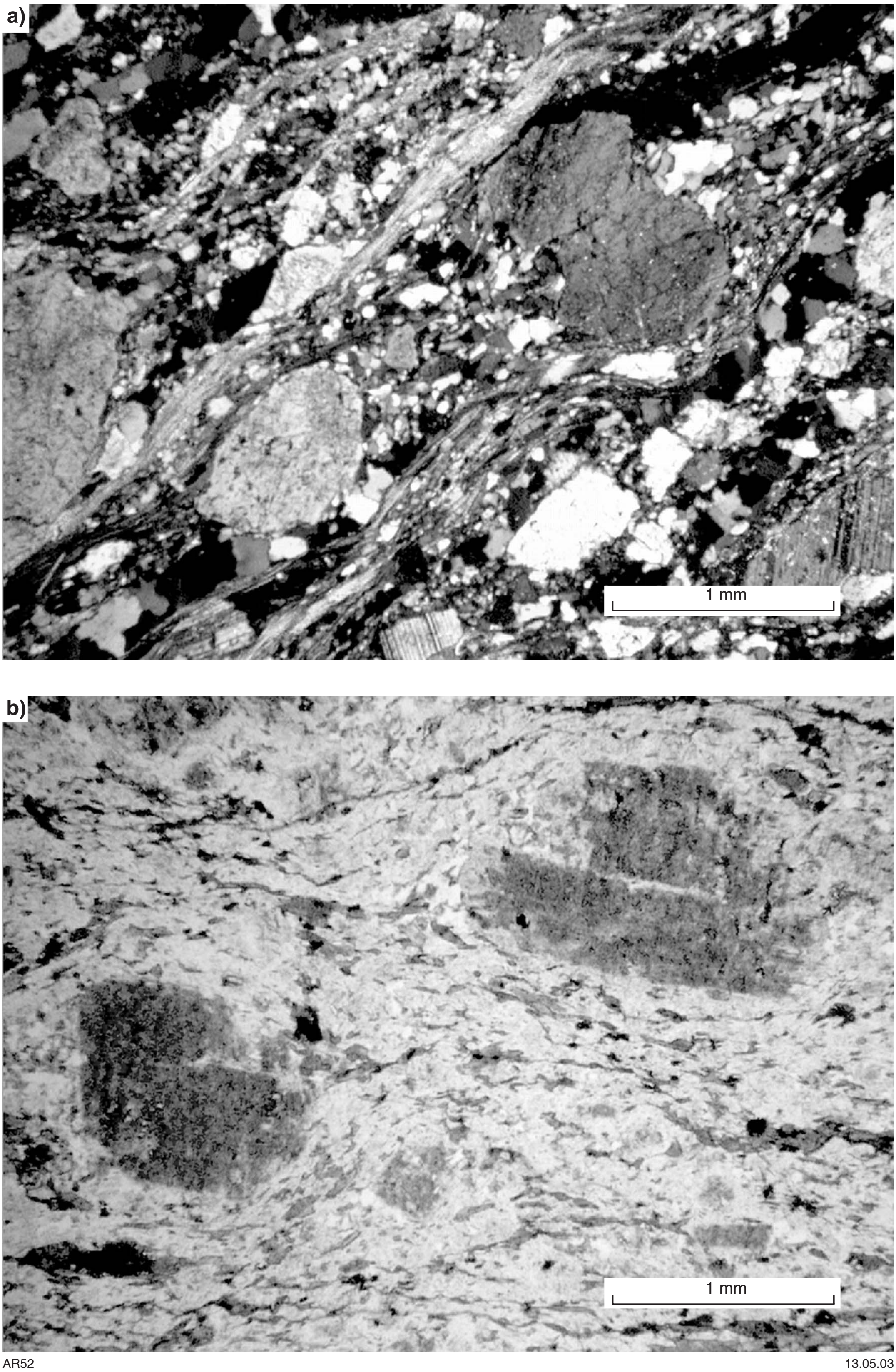

Figure 13. Textural characteristics of strongly foliated monzogranite in the Edale Shear Zone: a) augen mylonitic texture, with feldspar porphyroclasts in a fine-grained, microfolded matrix of quartz, feldspar, muscovite, and minor biotite, GSWA 164907, crossed polars, field of view is 4 mm; b) grano-nematoblastic texture, with metamorphic hornblende and a granoblastic quartzofeldspathic groundmass surrounding symmetric plagioclase porphyroclasts; GSWA 164904, plane-polarized light, field of view is 4 mm

nematoblastic fabric with metamorphic hornblende and a recrystallized quartzofeldspathic groundmass surrounding plagioclase porphyroclasts (Fig. 13b). This area also contains ultramafic schist and amphibolite enclaves within the deformed granite. In the central part of the Edale Shear Zone, between the Maynard Hills and North Cook Well greenstone belts, strongly foliated granite grades into gneissic granitoid and gneiss (cf. *Agn* and *Ang*). In the northwestern corner of the map sheet, strongly foliated granite contains tonalite lenses, parallel to the foliation, and up to 2.5 m wide (e.g. MGA 753720E 6894820N), with local transitions to zones with poorly developed gneissic banding due to irregular distribution of biotite (e.g. MGA 754260E 6894650N, MGA 749710E 6896520N).

Leucocratic monzogranite (*Agml*) forms elongate lobes within the Edale Shear Zone north and northwest of Middle Well. The exposures form ridges parallel to the north-northwesterly structural grain of the shear zone, and are characteristically at lithological contacts. The leucocratic monzogranite outcrops between gneiss and gneissic granite 2 km northwest of Middle Well, whereas north of Middle Well, it is exposed adjacent to the fault that juxtaposes gneiss with the Maynard Hill greenstones. Leucocratic monzogranite invariably forms distinct, bouldery outcrops that contrast sharply with the generally subdued relief of the adjacent gneiss, granite, and greenstone exposures (Fig. 14). A weak to moderate foliation in the leucocratic monzogranite has the same north-northwest orientation as in the adjoining units. Small veins and apophyses of leucocratic monzogranite locally crosscut banding in gneissic granite (e.g. MGA 763600E 6871550N), with both phases containing a coplanar, north-northwesterly trending foliation. Late, undeformed pegmatites crosscut the monzogranite (e.g. MGA 766100E 6869650N). The leucocratic monzogranite is whitish to cream, fine to medium grained, inequigranular granoblastic, and contains accessory magnetite, apatite, titanite, and altered ?allanite. Fresh microcline contains inclusions of plagioclase, whereas plagioclase is commonly clouded by sericite and may contain muscovite. Biotite is common but is extensively replaced by pennine, explaining the pale colour of the monzogranite in outcrop. In thin section, deformation is shown by distorted twinning of feldspars, elongation of biotite, and undulose extinction of most phases. Quartz and rare granophyric intergrowths form polygonized grains rather than occupying intergranular spaces, indicating that the granite was partly recrystallized. Quartz forms lenses and lamellae parallel to the foliation, but with c-axes generally oriented at a low angle to it. As noted for the adjacent gneiss (see *Ang* description below), this feature implies that metamorphic peak conditions were attained or persisted after the peak of deformation. The overall geometry and specific location of the leucocratic monzogranite exposures, together with the deformation features and relationships with adjacent units, suggest that the leucocratic monzogranite represents a relatively late, synkinematic intrusion that exploited structurally controlled lithological contacts within the Edale Shear Zone during the D_3 shearing event (cf. interpretation in cross section C–D on the map sheet; see **Structural geology**). Zircons recovered from a leucocratic monzogranite sample were unsuitable for SHRIMP geochronology.

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Figure 14. Northwesterly trending ridge of leucocratic monzogranite forming a bouldery hill in contact with amphibolite. Interleaved granite and amphibolite occupy the foreground, whereas the plain behind the ridge consists of low-lying granitoid gneiss (photo taken looking west at MGA 767110E 6868420N)

Fine- to coarse-grained, porphyritic monzogranite (*Agmp*) is distinguished by aligned, locally seriate, feldspar megacrysts up to 7 cm long. The most extensive exposures are in the central part of EVERETT CREEK, west of Red Knob, but equigranular monzogranite in the remaining part of the sheet locally grades into porphyritic portions that are large enough to be mapped separately (e.g. MGA 792000E 6893000N, MGA 748300E 6856400N). Tabular megacrysts of microcline (with common plagioclase, quartz, and biotite inclusions) and sericitized plagioclase are distributed in a fine- to medium-grained granular groundmass consisting of plagioclase, quartz, minor granophyric intergrowths, variably abundant biotite (commonly partly chloritized), and accessory apatite and opaque minerals. In most exposures, feldspar megacrysts are preferentially oriented, locally defining a prominent northerly trending, vertical to steep easterly dipping igneous foliation (e.g. MGA 770280E 6882070N). Similarly oriented biotite-rich strings locally enhance the igneous foliation (e.g. MGA 772750E 6873780N). A gradation in the size of the phenocrysts is observed in some outcrops (e.g. MGA 773050E 6887530N), and pegmatite and aplite veins are common. A porphyritic granite from southwest of Satan Well yielded a SHRIMP U–Pb zircon crystallization age of 2665 ± 8 Ma (GSWA 169071, MGA 768690E 6880050N; Nelson, 2002). The granite is undeformed to weakly foliated at this locality, and becomes progressively more strongly foliated towards the Edale Shear Zone to the west.

Gneissic granitoid rock (*Agn*) on EVERETT CREEK is a strongly to moderately foliated monzogranite, characterized by local areas with diffuse to well developed gneissic banding. This rock type is largely confined to the central part of the Edale Shear Zone, and typically grades into granitoid gneiss towards the contacts with the Maynard Hills and North Cook Well greenstone belts. The gneissic granite is medium to coarse grained, and equigranular to porphyritic, with local banding parallel to the north-northwesterly trending vertical foliation. Gneissic banding varies from irregular biotite-rich schlieren and lenses to more sharply defined granitic to granodioritic bands that range in thickness from a few to several tens of centimetres. Large pavements of gneissic granite in a small exposure to the west of the Edale Shear Zone (but probably still spatially related to it) contain irregular, medium- to coarse-grained, granitic to tonalitic banding with a broad north-northwesterly trend that is crosscut by northerly trending granitic bands with local pseudotachylite (MGA 769380E 6847300N).

The Coomb Bore Monzogranite (*Agcm*) is a small, foliated monzogranite intrusion that straddles ATLEY and EVERETT CREEK in the northwestern corner of the map sheet (Fig. 4). It forms an elongate, northwesterly trending pluton, about 1 by 3 km, that is entirely enclosed by strongly foliated monzogranite of the Edale Shear Zone. Whereas the surrounding deformed granite forms pavements and low-lying outcrops that are commonly deeply weathered, the Coomb Bore Monzogranite is less weathered and forms prominent bouldery hills within a flat area of colluvial and alluvial deposits. The bouldery outcrops have a distinct pattern on airphotos. Monzogranite is the dominant rock type in the Coomb Bore intrusion, but granodiorite and syenogranite phases are present, with an overall increase in the proportion of K-feldspar from southeast to northwest. The intrusion phases are typically medium grained, equigranular to porphyritic, and vary from dark pinkish-grey to pale red, with the changes related more to clay alteration and iron staining (limonite or hematite after magnetite) of K-feldspar and plagioclase than to increased K-feldspar abundance alone. All exposures are characterized by a weak to moderate foliation, mainly defined by biotite and strings of quartz, that trends northwesterly and is either vertical or dips steeply to the east-northeast. Rounded to euhedral feldspar augens up to 2 cm long consist of either orthoclase with quartz inclusions, or smaller but more abundant, extensively sericitized plagioclase grains that are commonly rimmed by K-feldspar. Microcline crystals with inclusions of plagioclase and quartz are subordinate. All phases exhibit some mortaring at the edges and can be locally polygonized. The augens are set in a granoblastic groundmass of recrystallized quartz and feldspar in anastomosing lenses parallel to the foliation. There is some recrystallization of biotite and titanite lenses. Biotite is altered to chlorite(–smectite), locally with some prehnite and fibrous pumpellyite. Opaque oxides, epidote, apatite, and subordinate zircon and allanite are accessory minerals. The textural and mineralogical characteristics of these rocks suggest that the Coomb Bore Monzogranite intrusion was metamorphosed under at least amphibolite facies conditions, with low-temperature alteration followed by oxidation during weathering. As observed in other strongly foliated granitoid rocks within the Edale Shear Zone (cf. *Ang* and *Agml* above), c-axes of quartz grains are mainly oriented at a low angle to the foliation. Centimetre-scale compositional layering is present in a few exposures (e.g. MGA 745650E 6894870N on ATLEY; Chen, in prep.b) and is defined by changes in the proportion and size of feldspar crystals. Poorly developed S–C fabrics in the more strongly foliated southeastern part of the intrusion suggest a sinistral sense of shear (e.g. MGA 745880E 6894810N). Two samples from a granodioritic phase of the Coomb Bore Monzogranite yielded SHRIMP U–Pb zircon crystallization ages of 2691 ± 3 Ma (GSWA 169070, MGA 746410E 6893600N; Nelson, 2002) and 2686 ± 5 Ma (GSWA 165365 on ATLEY, MGA 745650E 6894870N; Nelson, in prep.). These ages are consistent with the main stage of granite intrusion in the central part of the Southern Cross Granite–Greenstone Terrane (Chen and Wyche, 2001, and references therein). Chemical analyses of the Coomb Bore Monzogranite intrusion are provided by Chen (in prep.b).

Granitoid gneiss (*Ang*) is a component of the Edale Shear Zone in the central part of EVERETT CREEK between the North Cook Well and the Maynard Hills greenstone belts (Fig. 3). The gneiss lies adjacent to these belts in two elongate areas that are separated by gneissic granitoid rocks and strongly deformed monzogranite (Fig. 3). Stewart et al. (1983) assigned all these exposures to the 'White Cloud gneiss zone', a gneissic unit that was considered to extend for 105 km from north of Sandstone to Mount Alfred on RICHARDSON. Although gneiss outcrops sporadically between the two greenstone belts on RICHARDSON, most exposures in the northwestern part of EVERETT CREEK are of strongly deformed monzogranite

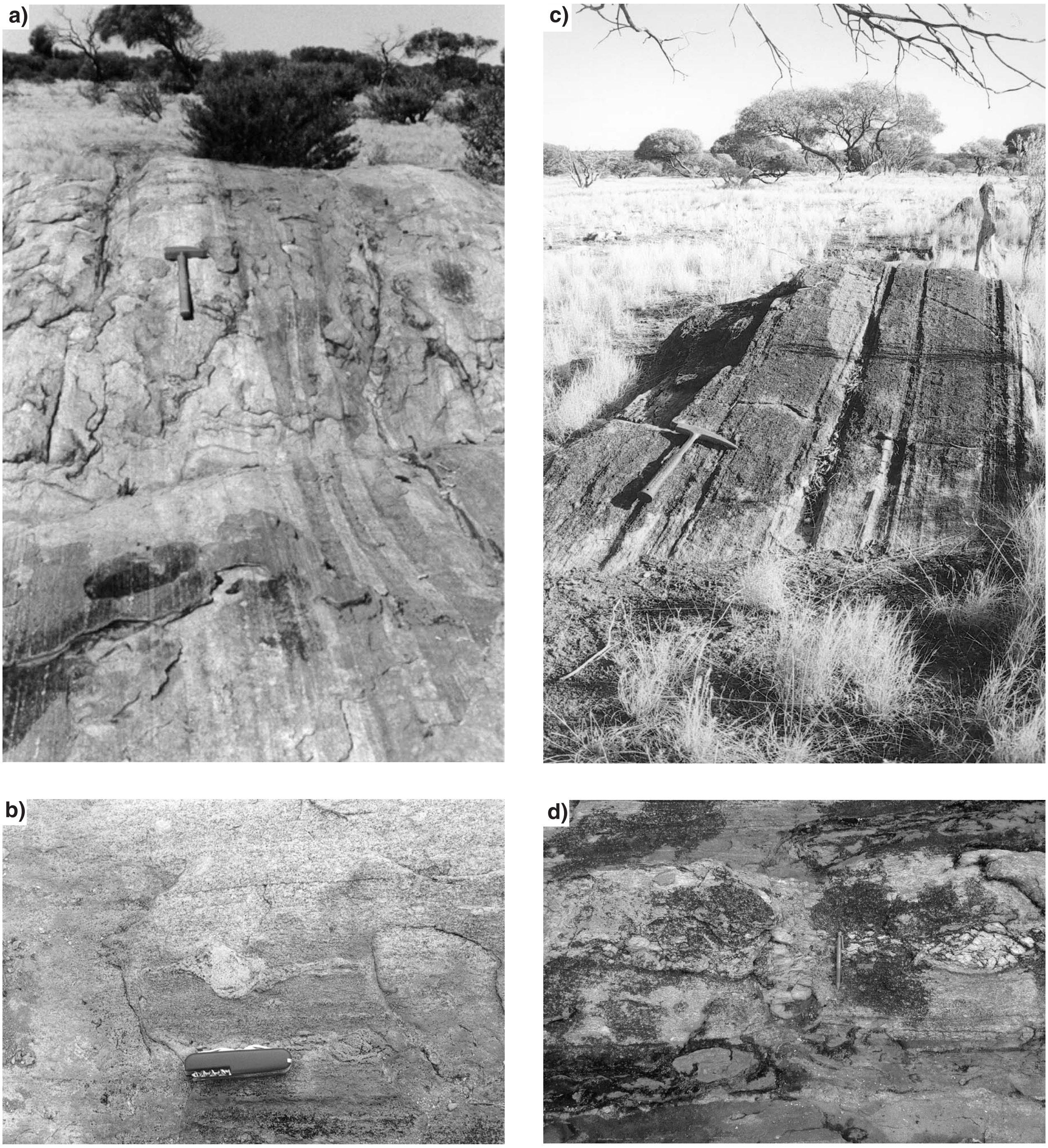

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Figure 15. Textural features of gneiss in the central part of the Edale Shear Zone: a) centimetre-scale gneissic banding, with sharply alternating leucocratic granitic and mesocratic granodioritic intervals (MGA 764330E 6866040N); b) asymmetric feldspar porphyroclast indicating sinistral shear (MGA 764260E 6865860N; pocket knife is 11 cm long); c) mylonitic gneiss with centimetre-scale bands adjacent to moderately foliated leucogranite (not visible in the photo) that has intruded along the gneiss–greenstone contact (MGA 766330E 6868230N); d) foliated and boudinaged pegmatite layer parallel to gneissic banding (here trending at 332°, subvertical), with quartz filling the tensional gash in the neck area (MGA 764040E 6865930N)

with only a minor gneissic component. Consequently, the term 'White Cloud gneiss zone' has not been retained here.

The gneiss is typically medium to coarse grained, and equigranular to porphyroclastic, with alternating leucocratic to mesocratic, sharp to diffuse bands that range from a few millimetres to 20 cm (Fig. 15a), but are locally up to several tens of centimetres in thickness. The bands are monzogranitic to granodioritic, with numerous pegmatitic and aplitic intervals, and rarer tonalite and syenogranite. Gneissic banding strikes between 320° and 360° (most commonly around 340° to 350°), and is vertical or dips steeply to the east-northeast. A strong coplanar to slightly oblique foliation is defined by strings of quartz grains, stretching of feldspar crystals, and alignment of biotite. A second, weaker foliation in many exposures trends between 310° and 325°, and movement along this plane sinistrally displaces the main foliation (e.g. around MGA 764300E 6865950N). In thin section, quartz c-axes are commonly slightly discordant to the main foliation, suggesting that metamorphic peak conditions were attained or persisted after the peak of deformation. Asymmetric feldspar porphyroclasts, from less than 1 cm and, rarely, up to 8 cm across are locally prominent and consistently indicate sinistral movement on the shear zone (Fig.15b). Asymmetric folds in thin quartz and aplitic bands are also consistent with a sinistral sense of shear (e.g. MGA 760840E 6870420N). Intrafolial folds of gneissic bands are observed locally (e.g. MGA 766330E 6868230N). The gneissic banding is crosscut by later pegmatite veins, or displaced in places by east-northeasterly trending fractures.

The gneiss is almost invariably in tectonic contact with the adjoining greenstones, except for an area between 3 and 7 km north of Middle Well, where the tectonic contact with the Maynard Hills greenstone belt is intruded by a weakly to moderately foliated leucocratic monzogranite (*Agml*). The gneiss changes in character with increasing distance from the greenstone–gneiss contact. Near the contact it appears mylonitic, with thin bands (commonly less than a few centimetres; Fig. 15c) and a blastomyloitic microtexture (cf. Stewart et al., 1983). In these areas, the gneiss can contain small (metre-scale or less) amphibolite lenses that are parallel to the gneissosity (e.g. about 7 km west and southwest of Daly Outcamp, MGA 766330E 6868230N), and, conversely, the adjacent amphibolite encloses tectonic slivers of gneiss. Away from the contact with the greenstones, banding thickens, and a dominant grano-lepidoblastic texture is characterized by biotite and strings of strained quartz that define a banding-parallel foliation. Asymmetric feldspar porphyroclasts (plagioclase and some microcline) indicate a sinistral shear sense, whereas symmetrical porphyroclasts are elongate parallel to the gneissosity and indicate strong flattening. At outcrop scale, strong shortening is also indicated by boudinaged pegmatite layers (Fig. 15d). Farther from the contact, the gneiss grades into strongly deformed monzogranite with only local, irregularly developed gneissic banding. Recrystallization of biotite in coarser lenses within the gneiss and the formation of decussate muscovite from sericitized plagioclase indicate amphibolite-facies metamorphism, with metamorphic peak conditions possibly extending after the peak of deformation.

Veins and dykes (*q, p*)

Quartz veins (*q*) on Everett Creek trend either north to north-northwesterly or east to east-northeasterly. The former typically lie within or immediately adjacent to the Edale Shear Zone, and are commonly strongly to moderately deformed with pronounced strike-parallel jointing. Vein quartz is commonly milky, locally with pale-green and brown portions containing networks of white quartz veinlets (e.g. MGA 764970E 6876700N). The veins can be more than 20 m thick, and were preferentially emplaced into metasedimentary rocks within the greenstone belts. They most likely exploited dilational structures within the shear zone during the relaxation stage that followed the main phase of shearing. Some gold exploration in the area has focused on these veins (Davies, 1996).

Undeformed quartz veins trend east to east-northeasterly, singularly or in clusters (e.g. around MGA 788500E 6873500N). Most veins are hosted by granitic rocks. Where they crosscut greenstones, sinistral offsets up to 100 m can be deduced from airphotos (e.g. MGA 765900E 6870700N), suggesting that veins have intruded late brittle faults (see **Structural geology**).

A pegmatite (*p*) with feldspars up to 60 cm across forms a small northerly trending ridge 2 km east-northeast of Volprecht Well (MGA 764050E 6880850N). Abundant pegmatites are associated with granitic rocks within the Edale Shear Zone, with the thickest (up to several metres wide) and coarsest veins typical of granite intercalations within the Maynard Hills greenstone belt (see **Granitic rocks**, *Agb* and *Agmf*). With only a few exceptions (e.g. MGA 763780E 6879360N, around MGA 766330E 6868230N), these muscovite-rich pegmatites are strongly foliated and elongated parallel to the structural grain of the shear zone. Smaller (centimetre-thick) pegmatite veins are commonly folded (e.g. MGA 749710E 6896530N, MGA 768010E 6867950N) or boudinaged (e.g. MGA 761920E 6880380N). In granite outside the Edale Shear Zone, pegmatite veins are randomly oriented or emplaced along joints (e.g. north-northwesterly trending veins around MGA 752300E 6853790N). Near Flat Topped Hill, an irregular pegmatitic zone contains abundant schorl (e.g. MGA 781540E 6879690N).

Mafic to ultramafic dykes and sills (*Ꝑdy*)

On Everett Creek, mafic to ultramafic dykes and sills of probable Proterozoic age (*Ꝑdy*) intrude both granitoid rocks and greenstones. They have limited surface expression, but are clearly distinguished as magnetic lineaments with various orientations that transect all other structural trends (Fig. 4). The most prominent lineament extends from Sandstone (just north-northwest of Everett Creek) to Mount Holmes in the extreme east of the map sheet. On the ground, this intrusion is represented by isolated gabbroic pods up to several hundred metres across that form distinct hills and bouldery outcrops. The sill geometry suggested by the aeromagnetic image (Fig. 4) is evident at Mount Holmes, where the intrusion is exposed as a flat sheet capped by granite. This sill comprises fine- to medium-grained, medium- to dark-grey, massive rock ranging from gabbro to norite that has a characteristic reddish-brown weathered surface. A possible granitic differentiate of the mafic sill is exposed northeast of No. 6 Well (around MGA 780300E 6877000N; see **Granitic rocks**, *Agi*). In thin section, the rocks are only slightly altered, and consist of varying proportions of subophitic to ophitic orthopyroxene (hypersthene), clinopyroxene, and labradorite, with abundant, partly resorbed magnetite (Fig. 16a). Olivine norite and gabbronorite contain large

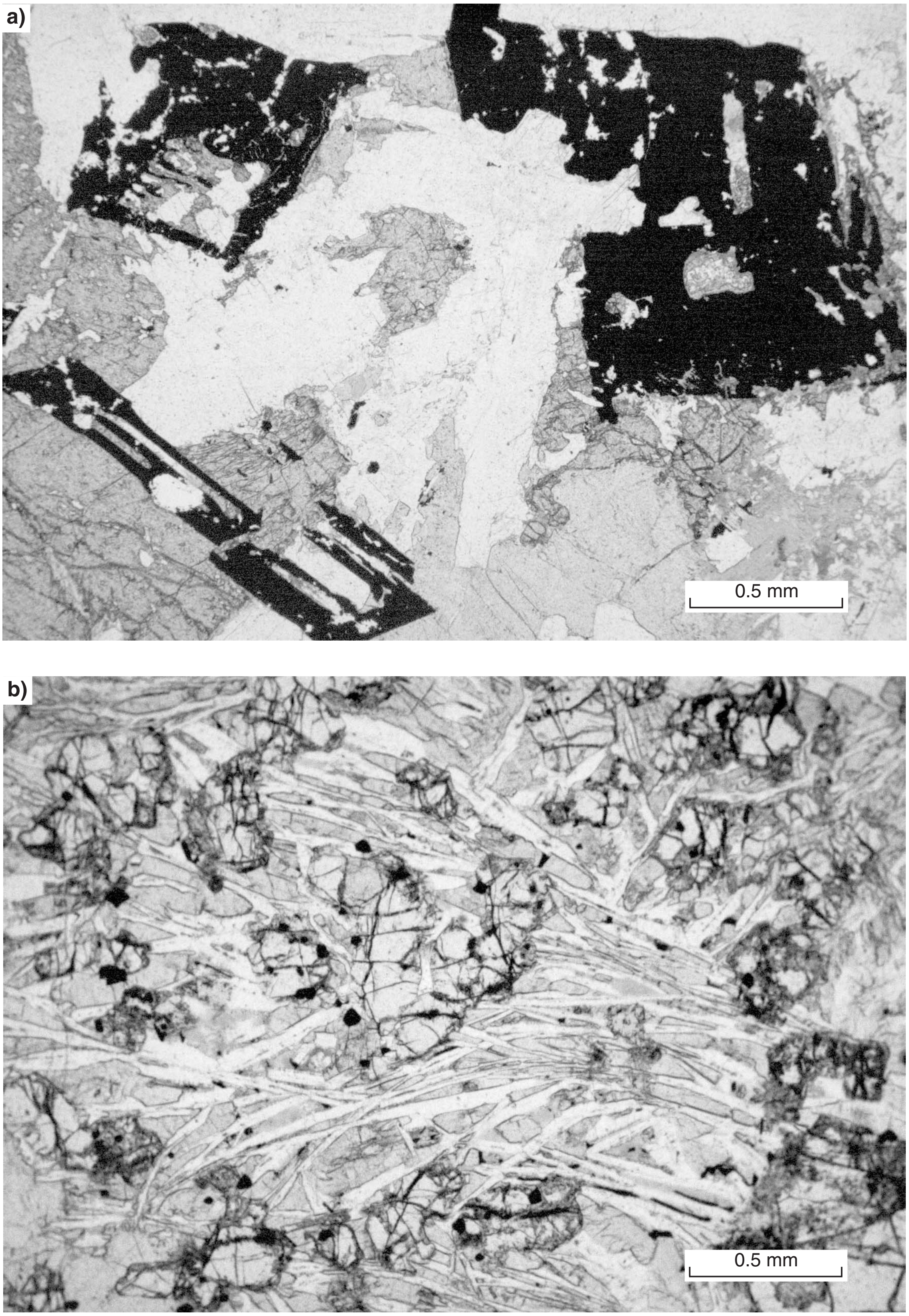

Figure 16. Textural characteristics of Proterozoic mafic dykes and sills: a) ophitic texture in a gabbronorite from a sill exposed near Mount Holmes, defined by labradorite laths within orthopyroxene oikocrysts, subordinate clinopyroxene (bottom left), and partially resorbed magnetite grains, GSWA 165402, plane-polarized light; b) quench texture in an olivine norite dyke, defined by random sprays of plagioclase laths (white) with interstitial olivine (highest relief) and orthopyroxene. Olivine grains are subidiomorphic and show incipient resorption; GSWA 164918, plane-polarized light

olivine grains that are partly altered to talc, magnetite, and serpentine. Granophyric intergrowths, free quartz, and accessory apatite distinguish the less mafic varieties. Partly chloritized green biotite is associated with clinopyroxene (which is also partly replaced by chlorite and actinolite) and magnetite. The granite in contact with the sill at Mount Holmes is a coarse-grained, almost granoblastic monzogranite, with extensively altered feldspar. Quartz has a pronounced undulose extinction, and contains trails of conspicuously aligned fluid inclusions.

Other exposed mafic to ultramafic dykes typically form linear, bouldery outcrops of fresh, medium- to dark-grey, fine-grained doleritic and gabbroic rocks. A quench texture is observed in a east-northeasterly trending dyke 4.5 km north of Elspon Well (Fig. 16b). The olivine norite at this locality is characterized by subidiomorphic to rounded, locally resorbed, olivine grains surrounded by orthopyroxene. Acicular plagioclase crystals up 4 mm long form randomly oriented sprays with interstitial pyroxene or plumose plagioclase.

Mafic to ultramafic dykes and sills intrude the c. 2686 Ma Coomb Bore Monzogranite (e.g. 3.5 km west-northwest of the Blackhill Homestead, MGA 746700E 6893510N) and cut across the Edale Shear Zone (Fig. 4), a structure interpreted to be broadly coeval with the c. 2665 Ma granite at Satan Well (see **Structural geology**). The mafic intrusions were most probably emplaced along tensional fractures during Proterozoic post-cratonization tectonic activity on the margins of the Yilgarn Craton (cf. Hallberg, 1987).

Stratigraphy

The stratigraphy of greenstones in the Southern Cross Granite–Greenstone Terrane is poorly constrained, but recent mapping recognized a c. 3 Ga lower succession unconformably overlain by a 2.73 Ga upper succession (Griffin, 1990; Chen and Wyche, 2001; Chen et al., in press). The lower greenstone succession is the major component of most greenstone belts in the region, and is dominated by mafic and minor ultramafic igneous rocks with abundant BIF units at some stratigraphic levels (Chen et al., in press). Quartz-rich metasedimentary rocks, including quartzite, quartz–mica schist, and metaconglomerate, represent the lowermost exposed unit in some belts. The upper greenstone succession consists of felsic volcanic and clastic sedimentary rocks that range in age from 2.8 to 2.7 Ga (Wang et al., 1998; Chen and Wyche, 2001). All greenstones were extensively intruded by monzogranite between 2.76 and 2.64 Ga, with the main phase of plutonic activity between 2.70 and 2.68 Ma (e.g. Wang et al., 1998; Nelson, 1999, 2000, 2001). Only the lower greenstone succession has been recognized on EVERETT CREEK, where the exposed greenstones are distinguished from other belts in the region by the predominance of metasedimentary over igneous rocks. No basement to the succession has been recognized in the Southern Cross Granite–Greenstone Terrane.

Despite the intense deformation of the Maynard Hills and North Cook Well greenstone belts along the Edale Shear Zone on EVERETT CREEK, some broad stratigraphic relationships can be recognized. In the better exposed Maynard Hills greenstone belt, lithological changes are observed both along strike and across the belt. Metasedimentary rocks form most of the belt, and the succession is either vertical or dips steeply to the west. Younging indicators are rare and poorly preserved due to shearing and recrystallization, but tentatively suggest that the sequence youngs towards the west (cf. *Abg* and *Asq*). This suggestion is supported by the presence of quartz-rich metasedimentary rocks (mainly quartzite) at what would then represent the lowermost preserved stratigraphic levels, in accordance with observations from other greenstone belts in the Southern Cross Terrane (e.g. Illaara belt, Wyche, 1999; Marda–Diemals belt, Riganti and Chen, 2002). The quartzite unit at the base of the Maynard Hills stratigraphy has been correlated with the lowermost metasedimentary unit in the Illaara greenstone belt, about 120 km to the southeast (Wyche et al., in prep.).

In the southern section of the greenstone belt near Maynard Hills, the lowest part of the stratigraphic succession consists of muscovite-bearing quartzite overlain by thick, massive to well-bedded quartzite with interlayered muscovite–quartz schist. Ferruginous and mafic components of the sedimentary rocks increase upwards through the succession, with progressively more abundant magnetite-rich quartzite and BIF intercalated with para-amphibolite and basalt. There is a gradual facies change along the strike of the greenstone belt north of Maynard Hills. The quartzite unit thins markedly, and is progressively replaced by finer grained magnetite-bearing quartzite and BIF, which are associated with weathered and poorly exposed, fine-grained metasedimentary rocks. Here the upper part of the succession comprises abundant para-amphibolite with subordinate pelitic schist and quartzite, intercalated with basaltic, ultramafic, and gabbroic units. In this area, granite slivers are tectonically interleaved with all rock types, particularly in the western part of the belt. Farther north, from Volprecht Well to Kayline Bore, the greenstone belt is increasingly intruded by massive to weakly foliated granite, with a resulting disruption of the stratigraphy. All other contacts between greenstones and adjacent granitic rocks along the belt are tectonized. Stewart et al. (1983) estimated a thickness of 1.5 km for the Maynard Hills succession on EVERETT CREEK, but the folding and intense shearing make such calculations problematical.

Deformation and recrystallization resulted in poor preservation of primary textural and sedimentological features in the metasedimentary rocks of the Maynard Hills greenstone belt; however, the massive to thinly bedded quartzite is probably derived from compositionally mature quartz sandstone, whereas muscovite quartzite and muscovite–quartz schist represent originally less mature quartz sandstone. A fluvial to shallow-marine environment is envisaged for deposition of the sediments. The presence of fuchsite in some quartzite indicates ultramafic rocks in the source area. The lateral change from quartzite to magnetite-bearing quartzite, BIF, and finer metasedimentary rocks to the north probably represents more distal facies and an overall deepening of the basin from south to north. The upwards stratigraphic change to ferruginous and mafic sediments could also reflect a more distal water environment, with para-amphibolite representing a change in the detritus source and increasing input from mafic rocks.

Detrital zircons from the quartzite unit indicate a maximum age of 3131 ± 3 Ma for deposition of the quartzite precursor and the greenstone belt (GSWA 169074; Nelson, 2002). Several older populations of detrital zircons were also recovered (i.e. 3318 ± 7, 3375 ± 4, 3470 ± 8, and 3681 ± 6 Ma; Nelson, 2002). One zircon was dated at 4351 ± 7 Ma (GSWA 169075; Nelson, 2002) and is similar in age to a zircon from the Jack Hills in the Narryer Terrane that has been recognized as the oldest terrestrial zircon yet identified (part of that zircon yielded an age of c. 4404 Ma; Wilde et al., 2001). There is no known local source for the zircons in the metasedimentary rocks on EVERETT CREEK, as igneous rocks older than 3.1 Ga have not been identified in the central part of the Yilgarn Craton. However, similarities in the zircon age profiles have been noted between the Maynard Hills and both gneiss and metasedimentary rocks from Mount Narryer and Jack Hills in the Narryer Terrane, more than 300 km to the northwest, as well as with quartzite in the Illaara greenstone belt, about 120 km to the southeast (Nelson, 2000, 2002; Wyche et al., in prep.). On the basis of these results, Wyche et al. (in prep.) infer the presence of an extensive pre-3.1 Ga continental crust in the central and western Yilgarn Craton that was rifted or extensively reworked prior to deposition of dominantly mafic, 3.0 – 2.7 Ga greenstones.

The North Cook Well greenstone belt is dominated by a thick BIF unit, with abundant basaltic amphibolite north of Blackhill Homestead. Ultramafic rocks (serpentinite, tremolite schist, metakomatiite) are associated with the BIF, both stratigraphically above or below it. A finely laminated quartzite is exposed west of the main BIF unit about 2.5 km northwest of Elspon Well (MGA 760560E 6868440N), and quartzite is intercalated with amphibolite near the lowermost BIF unit north-northwest of Blackhill Homestead. This unit could be interpreted as a thinner equivalent of the quartzite in the Maynard Hills (cf. Stewart et al., 1983), suggesting the two belts are remnants of an originally continuous greenstone sequence. However, the succession in the North Cook Well greenstone belt is poorly exposed and intensely disrupted, and there are differences in detail between the rock associations of the two belts. Therefore, a straightforward stratigraphic correlation is not possible.

Structural geology

Rocks on EVERETT CREEK have been subjected to three major deformation events, followed by at least one further deformation stage (Table 1). The most prominent structure in the area is the Edale Shear Zone (Figs 3 and 4), a north-northwesterly trending, regional-scale lineament assigned to a D_3 transpressional event that has largely overprinted and obliterated earlier structures. The structural evolution of the region is discussed by Stewart et al. (1983), Eisenlohr et al. (1993), and Chen et al. (2001).

Evidence for an early deformation event (D_1) is limited on EVERETT CREEK, and is confined to the greenstone successions. The earliest recognized structure is a foliation folded around northerly to north-northwesterly trending D_2 folds (see below). This S_1 foliation is best preserved in easily deformed rocks in contact with more resistant rock types. For example, a tremolite–chlorite schist unit adjacent to a bedded magnetite-bearing quartzite is tightly folded around a steeply south-southeasterly plunging synform 2 km southwest of 4 Corners Well (MGA 768590E 6863000N). An easterly trending foliation in amphibolite near quartzite units in the Maynard Hills area also appears to be folded around tight to open, northerly trending folds (e.g. MGA 776320E 6846210N, MGA 769470E 6860640N). Unravelling of these structures suggests that the D_1 event was directed north–south and was compressional in nature. These characteristics are consistent with a regional north–south D_1 compression event that produced tight to isoclinal folds and thrusts, as well as an easterly trending, layer-parallel foliation in the greenstone sequences of the central part of the Southern Cross Granite–Greenstone Terrane (Dalstra et al., 1999; Chen and Wyche, 2001).

The early deformation was followed by a prolonged period of east–west compression (Table 1), recognized as the main deformation event in the central Yilgarn Craton (Eisenlohr et al., 1993; Dalstra et al., 1999; Chen et al., 2001; Wyche et al., 2001). Broadly, an initial phase (D_2) formed northerly trending, open to tight folds and a north-trending regional foliation, accompanied by emplacement of voluminous granitoid intrusions. With ongoing east–west compression, impingement of large, rigid granitoid bodies into the greenstones resulted in reorientation of the earlier D_2 structures and development of regional-scale shear zones and arcuate structures (D_3; Chen et al., 2001).

On EVERETT CREEK, structures assigned to D_2 are largely overprinted and reoriented by D_3. North-trending S_2 foliation is locally preserved, particularly in the northern-central part of the map sheet where the Edale Shear Zone splays and strike-slip deformation is less intense. Folds assigned to D_2 range from small, tight to isoclinal folds in BIF and magnetite-bearing quartzite to mesoscale, symmetrical, open to tight synforms and antiforms that are well developed in the bedded quartzite of the Maynard Hills, particularly 4 km west and northwest of Kohler Bore (Fig. 7c,d). Fold-axial planes strike at an angle to the north-northwest orientation of the Edale Shear Zone. They generally trend south and south-southwest and are vertical or steeply dipping to the west. Fold axes plunge moderately (30°–45°) to the south and, less commonly, to the north. The overall geometry of these folds suggests that they were developed before the main D_3 strike-slip shearing event, and therefore they are assigned to D_2. Gneissic banding may have started to develop during D_2 and been enhanced and reoriented during later shearing. Evidence for a D_2 formation of gneissic banding has been noted elsewhere in the central Southern Cross Granite–Greenstone Terrane (Chen and Wyche, 2001).

With ongoing east–west compression, rheological inhomogeneities between greenstones and granite facilitated the development of regional-scale ductile shear zones and faults (D_3; Chen et al., 2001). These shear zones form arcuate structures that consist of northwesterly trending sinistral and northeasterly trending dextral shear zones, which are linked by north-trending contractional zones in the apex regions (Chen et al., 2001). The Edale Shear Zone on EVERETT CREEK is a regional-scale lineament (Figs 3 and 4) that represents the north-northwesterly trending arm of the Evanston–Edale arcuate structure (Chen et al., 2001). The Edale Shear Zone extends for more than 100 km from north of Sandstone (where it merges with the Youanmi Shear Zone) to Mount Richardson on RICHARDSON, where it is deflected into a contractional zone. The Edale Shear Zone is defined by a 6 to 10 km-wide zone of foliated to gneissic granitoid rocks and greenstones, with splays off the main structure in the northwestern part of EVERETT CREEK.

The Edale Shear Zone changes along strike. In the southern and central parts of the map sheet, the shear zone ranges from 6 to 10 km in width, and encompasses the corridors of greenstones represented by the Maynard Hills and North Cook Well belts, the intervening granitic rocks, and an outer zone of deformed monzogranite up to 2 km wide (Fig. 3). The intensity of deformation in this outer zone decreases rapidly away from the greenstone belts, with the transition from strongly foliated to undeformed monzogranite commonly over a distance of a few hundred metres to one kilometre. Within the shear zone, deformation intensity typically increases from the centre towards the greenstones, with a gradual transition from strongly foliated monzogranite to gneissic granite to gneiss at the contact with the greenstones. Textures in the gneiss vary from granoblastic to blastomylonitic near the contact. Within the Maynard Hills and North Cook Well greenstone belts, intense shearing has resulted in a complex interleaving of mafic igneous, sedimentary, and granitic rocks, down to metre and, locally, centimetre scale. The strong, layer-parallel foliation is vertical to subvertical across the shear zone, with steep east-northeasterly and west-southwesterly dips on the western and eastern flanks of the ridges that mark the Maynard Hills greenstone belt.

In the northwestern part of EVERETT CREEK, the main section of the Edale Shear Zone is 7 km wide and includes strongly deformed granitic rocks west of Blackhill Homestead and the northernmost extension of the North Cook Well greenstone belt (Fig. 3). Foliation and a locally developed coplanar gneissic banding trend northwesterly (300°–350°, typically 320°–330°), and are vertical or dip steeply to the northeast. The most intense deformation is at the edge of the map sheet (i.e. 3 km west of the homestead around MGA 746000E 6892500N) and farther to the northwest on ATLEY. Here, a strong lineament corresponds to the Edale Fault of Stewart et al. (1983), and the gneiss is mylonitized. In the central part of the map sheet, a northerly trending splay off the Edale Shear Zone encompasses the northern part of the Maynard Hills greenstone belt, and dissipates on LAKE MASON, just north of the boundary with EVERETT CREEK (Figs 3 and 4). The Maynard Hills greenstone belt bifurcates in this area, with isolated outcrops separated by weakly deformed to undeformed monzogranite.

Kinematic indicators are consistent with a sinistral strike-slip movement sense for the Edale Shear Zone, and include:

- asymmetric feldspar porphyroclasts in gneiss and foliated granite (Fig. 15b);
- S–C fabrics, most common in muscovite-bearing quartzite (Fig. 9), muscovite–quartz schist, biotite–quartz–plagioclase schist, augen mylonitic granite, and gneiss. S-planes are defined by the stronger foliation, and are typically vertical to steeply dipping and trend between 330° and 340°, whereas C-planes trend in a more northwesterly direction;
- imbricated boudins in layer-parallel quartz bands within BIF (Fig. 11);
- S-shaped, small-scale folds with north-northwesterly trending axial planes preserved in a number of rock types, including pegmatitic layers within granite and gneiss (Fig. 17), metagabbro (MGA 767210E 6867850N), BIF (MGA 765710E 6859590N), and magnetite-bearing quartzite (MGA 769870E 6859880N). Not all S-shaped folds are indicative of sinistral shearing, as some are parasitic folds to larger structures (MGA 754410E 6881210N).

Mineral and elongation lineations are mostly shallowly plunging to either the north and north-northwest or the south and south-southeast. However, lineations are mainly preserved on bedding surfaces, and possibly formed during D_2, particularly in areas of intense folding (e.g. quartzite west of Kohler Bore). Crenulation and gentle folding of the northerly trending S_2 foliation during D_3 is particularly evident in schistose rock types (e.g. chlorite schist at MGA 769930E 6850670N).

The timing of the D_2–D_3 east–west compression is not well constrained on EVERETT CREEK (Table 1), but regional interpretations recognize that D_2 was most probably active between c. 2.73 and 2.68 Ga, and D_3 between c. 2.68 and 2.65 Ga (Chen and Wyche, 2001; Chen et al., in press). The maximum age of the Edale Shear Zone is constrained by the SHRIMP U–Pb zircon ages of c. 2686 and 2691 Ma obtained for the sheared Coomb Bore Monzogranite intrusion (Nelson, 2002, in prep.). The undeformed to weakly deformed, c. 2665 Ma porphyritic monzogranite at Satan Well is progressively more strongly foliated near the Edale Shear Zone. The granite was probably emplaced during regional D_2–D_3 east–west compression.

Post-D_3 brittle deformation on EVERETT CREEK consists of mainly east-northeasterly and northeasterly joints, faults, and fractures that disrupt rocks already deformed by the Edale Shear Zone. Similarly oriented structures are also common outside the zone. Fractures and small-scale faults are either vertical or dip steeply to the north-northwest (e.g. MGA 764830E 6867140N) and commonly have apparent dextral offsets (Fig. 17). Larger scale faults are more clearly outlined on airphotos and at map scale by the displacement of lithological units. Faulting has resulted in the partial segmentation of the Maynard Hills greenstone belt, with a consistent sinistral offset (>300 m in places) between adjacent blocks. Many of these structures are infilled by undeformed pegmatites and quartz veins (e.g. around MGA 768190E 6863970N and MGA 788500E 6873500N respectively). Numerous east-northeasterly and northeasterly trending fractures are infilled by Proterozoic mafic and ultramafic dykes, and are visible as pronounced linear magnetic anomalies (Figs 3 and 4; Hallberg, 1987).

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Figure 17. Late (post-D_3) fracturing of granitoid gneiss: S-shaped fold in a north-northwesterly trending pegmatitic band (near top of hammer) indicating sinistral movement, with later apparent dextral displacement along an east-northeasterly trending fracture (MGA 768010E 6867950N)

Metamorphism

Early regional metamorphic studies that included Everett Creek recognized that the greenstones and granitic rocks along the Edale Shear Zone are characterized by a dynamic style of metamorphism that reached medium to high grades. Binns et al. (1976) documented a high-grade domain ('mid to high amphibolite facies') along the shear zone, and showed that metamorphism was generally synchronous with deformation, but in places outlasted the bulk deformation of the greenstone belts. Stewart et al. (1983) identified a zone of high-grade metamorphism in the northern part of the Maynard Hills greenstone belt, whereas Ahmat (1986) suggested that the Maynard Hills greenstone belt is mainly low to medium grade (greenschist to amphibolite facies), with only local areas of high-grade (upper amphibolite facies) metamorphism.

Mapping and petrography of rocks from the Edale Shear Zone have confirmed the conclusions of previous studies. The best metamorphic assemblages and textures are preserved in the amphibolites (whether of igneous or sedimentary derivation) and quartz-rich metasedimentary rocks of the Maynard Hills and North Cook Well greenstone belts along the Edale Shear Zone. These assemblages are consistent with a largely synkinematic (syn-D_3, see **Structural geology**) metamorphic event that reached at least middle-amphibolite facies conditions. Amphibolites typically consist of an annealed aggregate of hornblende, clinopyroxene (diopside), and calcic plagioclase (Fig. 18), with basaltic amphibolite and metagabbro characterized by cummingtonite in the most Mg-rich portions. In the para-amphibolite, hornblende, pyroxene, and plagioclase are strongly aligned to define a layer-parallel foliation. In these rocks, clinopyroxene is present both in the groundmass and as large boudinaged poikiloblasts wrapped by the foliation (Fig. 18), indicating that this phase began forming early during the deformation or metamorphic event. Calc-silicate horizons within the para-amphibolites are defined by clinopyroxene with calcic plagioclase, epidote, and minor hornblende. Grunerite is present in the most Fe-rich para-amphibolite, whereas an abundance of almandine garnet distinguishes the most aluminous layers. Garnet forms idiomorphic porphyroblasts that are gently enclosed by the foliation (Fig. 19a), with helicitic inclusions indicating a partial rotation of the garnet crystals during growth (Fig. 19b).

Quartz-rich metasedimentary rocks also have mineral assemblages indicative of middle-amphibolite facies metamorphism, and textures largely consistent with synkinematic growth. They are distinguished by a grano-lepidoblastic assemblage of quartz and muscovite, the latter defining a strong layer-parallel foliation (Fig. 20a). Locally abundant cordierite in the most pelitic layers is completely altered to pinite (Fig. 20a), whereas andalusite in grains elongated parallel to foliation is typical of feldspathic metasandstones (Fig. 20b). Grunerite is common in magnetite quartzite and BIF.

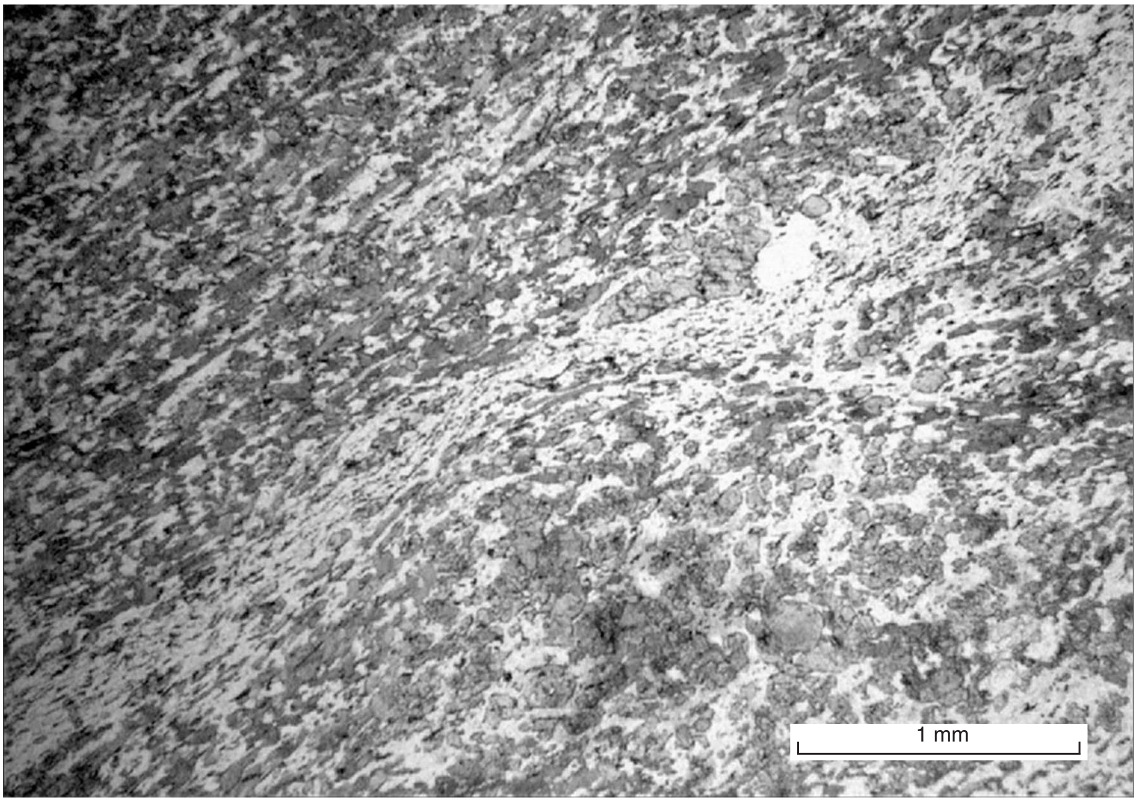

Figure 18. Para-amphibolite, defined by an annealed assemblage of plagioclase, hornblende, and clinopyroxene, with the amphibole defining a layer-parallel foliation. Clinopyroxene is also present as large poikiloblasts, boudinaged and wrapped by the foliation (centre-right); GSWA 164942, plane-polarized light, field of view is 4 mm

Although most metamorphic minerals grew synchronously with the most intense deformation, there was common late- to post-kinematic growth. Large, poikilitic grains of hornblende and epidote overgrow the foliation and are randomly oriented in the foliation planes (Fig. 21), and some random muscovite and biotite poikiloblasts are oriented at a high angle to the foliation.

Recrystallization under dynamic conditions has also affected the zone of strongly deformed granitoid rocks between the two greenstone belts. Here, mortaring of feldspar as a result of recrystallization in the pressure shadows of porphyroclasts, the distinct granoblastic habit of intergranular quartz, and the recrystallization of some biotite are also consistent with synkinematic, amphibolite-facies metamorphic conditions. The non-alignment of quartz c-axes with the foliation and the presence of decussate muscovite after sericitized plagioclase suggest that peak metamorphic conditions were attained or persisted after the peak of deformation, in agreement with similar observations made for the greenstones.

A later retrograde metamorphic phase is indicated by the local development of hornblende around pyroxene in amphibolite, the alteration of some pyroxene to actinolitic amphibole, the sericitization or saussuritization of plagioclase, and the widespread presence of chlorite after biotite.

Cainozoic geology

Mapping of the EVERETT CREEK extensive regolith cover combined field observations with interpretations of airphotos and Landsat TM5 images. Regolith deposits are classified following the Residual–Erosional–Depositional (RED) scheme of Anand et al. (1993), with modifications by Hocking et al. (2001). In addition to the erosional regime typical of bedrock exposures, the area comprises two main geomorphological elements: a low depositional surface of colluvial (C), alluvial (A), and playa lake deposits (L); and remnants of a higher undulating surface represented by tablelands of ferruginous and siliceous duricrust (R). Eolian and residual sandplains (S) are developed at various levels of the geomorphological profile. A review of the regolith geology of the Yilgarn Craton is given by Anand and Paine (2002). Detailed descriptions of the land systems (landform, soil, vegetation) in the Sandstone region are provided by Payne et al. (1998).

Residual or relict units (*Rd, Rf, Rz, Rzi, Rzu, Rg, Rgp$_g$, Rk*)

Residual (weathered in situ) or relict (transported) duricrust units generally form hills, breakaways, and broad plateaux.

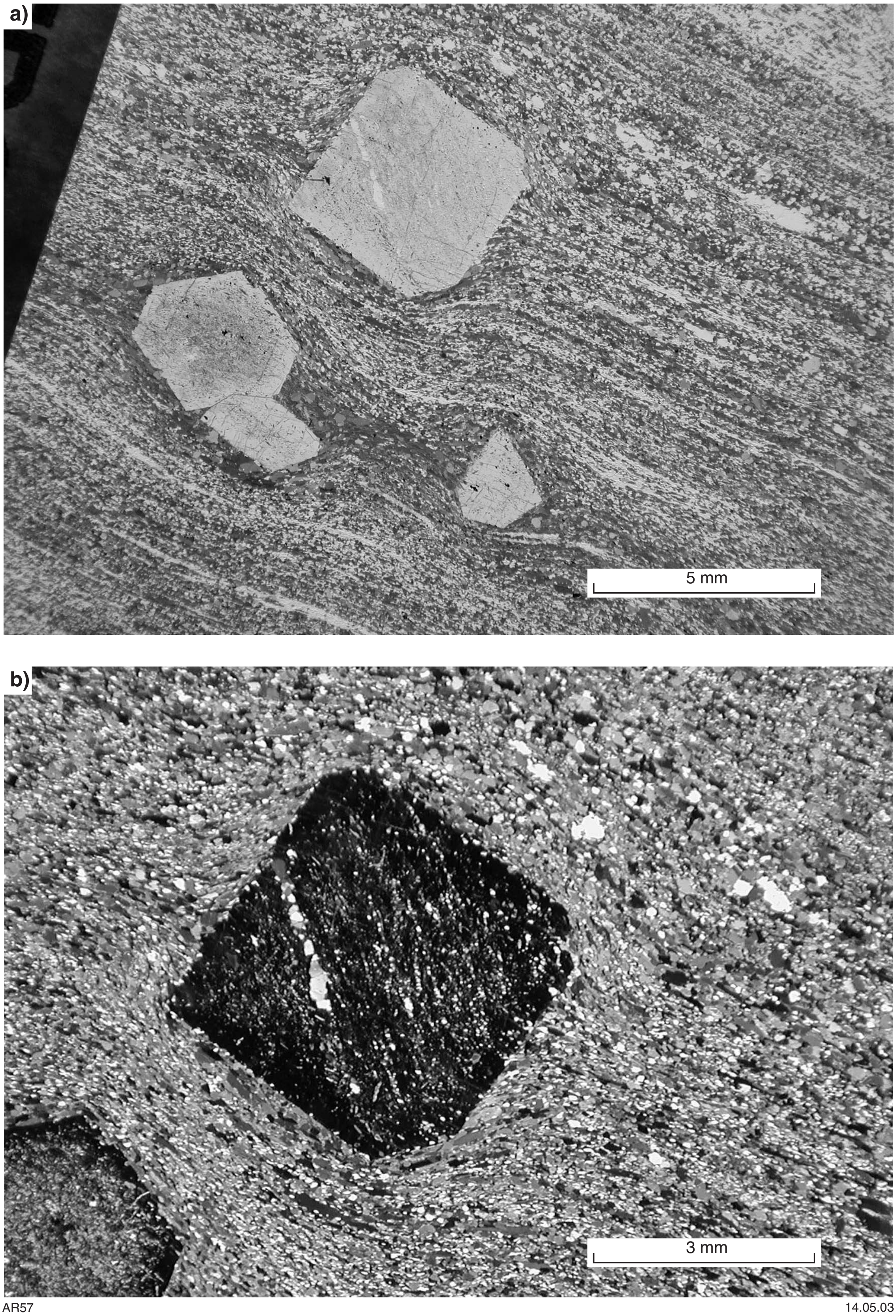

Figure 19. Garnet-bearing para-amphibolite: a) idiomorphic almandine porphyroblasts up to 4 mm across in a groundmass of granoblastic hornblende, plagioclase, and quartz are wrapped by the foliation; GSWA 164957, plane polarized light, field of view is 2 cm; b) detail of (a) illustrating the internal helicitic texture of the garnet, with almost sigmoidal quartz and amphibole inclusions; GSWA 164957, crossed polars, field of view is 12 mm

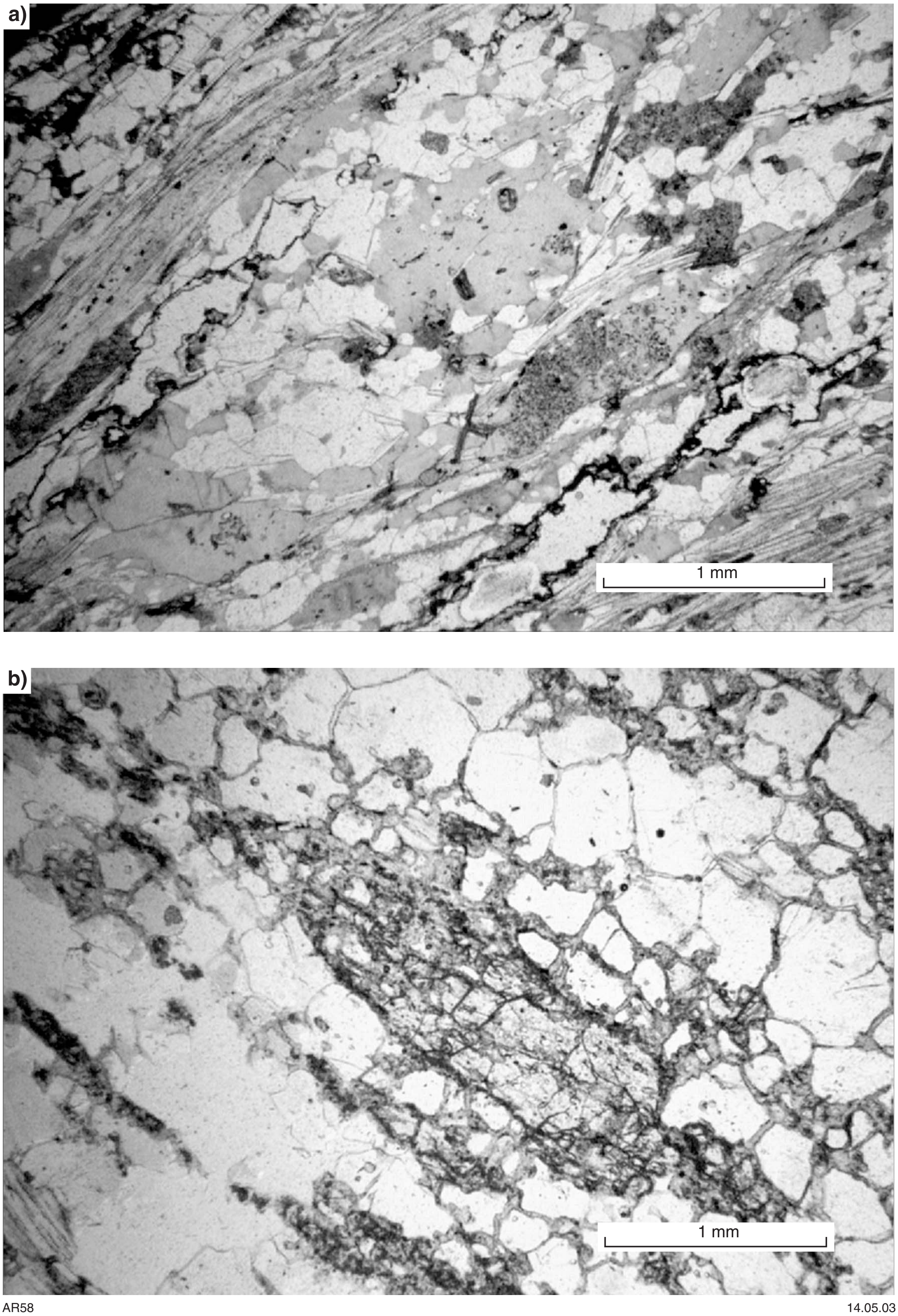

Figure 20. Metamorphic assemblages of quartz-rich metasedimentary rocks from the Maynard Hills greenstone belt: a) cordierite altered to pinite (irregular grey portions) in association with granoblastic quartz (white) and lepidoblastic muscovite defining a strong layer-parallel foliation; GSWA 164944, plane polarized light, field of view is 4 mm; b) andalusite elongate parallel to the foliation in a recrystallized feldspathic sandstone; GSWA 164983, plane polarized light, field of view is 4 mm

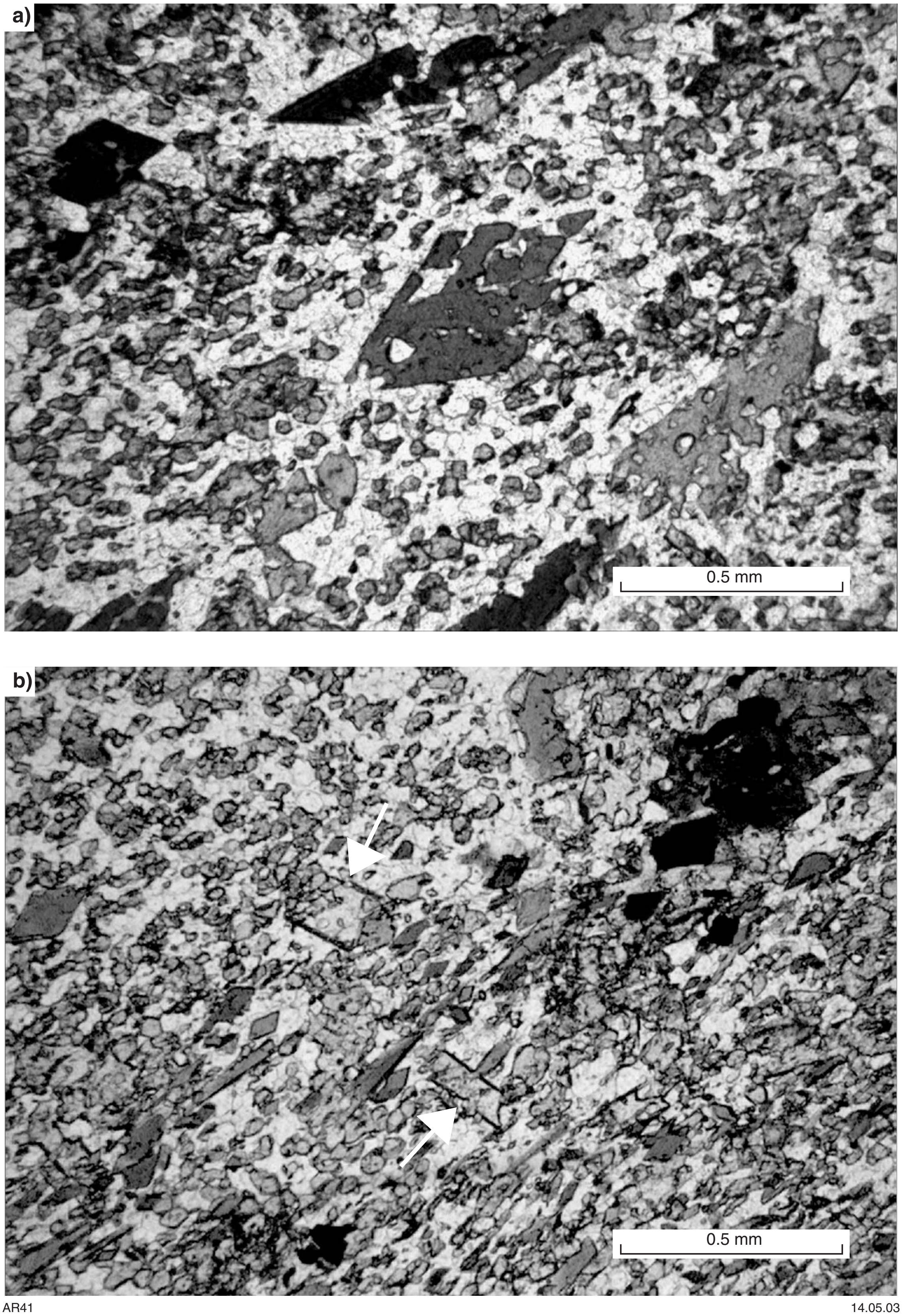

Figure 21. Late- to post-kinematic metamorphic minerals: a) para-amphibolite with large poikiloblastic hornblende grains randomly overgrowing the foliation (from top right to bottom left in the picture), GSWA 164953, plane-polarized light, field of view is 2 mm; b) large subidiomorphic hornblende and epidote (white arrow) grains overgrowing a recrystallized assemblage of hornblende, clinopyroxene and plagioclase; GSWA 164953, plane-polarized light, field of view is 2 mm

Undivided duricrust (*Rd*) comprises portions of dominantly siliceous or ferruginous duricrust, with gradational contacts over short distances. It is typically developed over granitic bedrock, and can be covered by a layer of largely residual yellow sand with minor pisolitic laterite, silt, and clay (*Sl*). Ferruginous or lateritic duricrust (*Rf*) comprises nodular, pisolitic, or massive ferricrete developed over both greenstones (particularly amphibolite and BIF in the northwestern corner of EVERETT CREEK) and granites, and typically shows as dark red-brown tones on airphotos and false-colour Landsat images. Siliceous duricrust (or silcrete, *Rz*) is typically developed on top of breakaways or as rubbly, low-lying, poorly vegetated areas underlain by granitic rocks. It is represented by massive chalcedony or, more commonly, angular, millimetre-sized quartz clasts set in cryptocrystalline, white to creamy and pink, vitreous siliceous cement. Silcrete with impregnations of iron oxides and hydroxides (*Rzi*) commonly marks the transition between siliceous and ferruginous duricrust. Dark-brown, limonitic silica caprock (*Rzu*) with relict cumulate texture is developed over a tectonic sliver of ultramafic rocks 500 m northwest of Cook Well.

Residual quartzofeldspathic sand over granitoid rock (*Rg*) contains scattered, deeply weathered granitic outcrops, and has locally abundant pebbles of vein quartz and silcrete. Adjacent to granite exposures, and in areas unequivocally underlain by a granitic bedrock, residual quartzofeldspathic sand (Rgp_g) is typically reddish-yellow and contains small granite outcrops, as well as sparse granite, ferruginous duricrust, silcrete, and quartz-vein debris. White sand from saprolitic granite dominates in the very gently sloping, open areas at the foot of breakaways, where weathered granite is locally exposed in small runoff channels. There is a complete gradation between residual granitic sand, sandy sheetwash, and fresh granite exposures.

Calcrete (*Rk*) on EVERETT CREEK falls into the group of groundwater calcrete in the classifications of Mann and Horwitz (1979), and Anand and Paine (2002). It is distributed along major drainage paths, particularly in the lower reaches of the main subcatchments on the northern margin of Lake Noondie. Here, calcrete-cemented valley-fill deposits form plains up to 4 km wide that are characterized by scattered platforms (1–4 m relief) with mantles of calcrete rubble and outcrop. The platforms are dissected and separated by creeks and swales, and are commonly partly obscured by alluvial wash. On airphotos, calcrete areas are distinguished by their white colour, with erosion by channeled drainage resulting in a blotchy pattern. Calcrete deposits are up to 8 m thick (Stewart et al., 1983), and vary from massive to nodular, commonly with development of fine laminae. The formation of groundwater calcrete is attributed to in situ replacement of valley-fill debris by magnesium and calcium carbonate precipitating at or below the watertable from percolating carbonate-saturated groundwater (Mann and Horwitz, 1979). Sofoulis (1963) suggested that calcrete formation at different elevations along the same drainage system (cf. the northeastern part of EVERETT CREEK) could be related to ‘ponding’ of water at buried physiographic barriers after a period of high rainfall. The high Ca-ion concentration in the waters could have resulted from slow movement over a Ca-rich igneous and metamorphic basement, with saturation attained through evapotranspiration. The presence of minor chalcedony in calcrete is ascribed to later silicification (Mann and Horwitz, 1979). Development of groundwater calcrete is attributed to arid climatic conditions (i.e. low irregular rainfall, high evaporation, little surface drainage or runoff, and a shallow watertable with sluggish groundwater movement that started to develop during the Pliocene; Hocking and Cockbain, 1990). Their well developed secondary porosity and high permeability mean that groundwater calcrete deposits form excellent aquifers (bore yields in excess of 1000 m^3/day; Payne et al., 1998), although commonly with brackish groundwater (between 2000 and 6000 mg/L total dissolved salt; Payne et al., 1998). Uranium is associated with calcrete deposits in the Sandstone – Mount Keith region northeast of EVERETT CREEK (see **Economic geology**).

Depositional units (*C, Cf, Cg, Clc_i, Cq, Cqm_q, W, Wg, A, A_c, A_d, A_f, A_p, L_l, L_d1, L_d2, L_m, S, Sl*)

Depositional regolith units are the most widely exposed surficial deposits on EVERETT CREEK. The depositional regime is primarily controlled by the Lake Noondie playa-lake system (*L*), with large areas of alluvium (*A*) and sheetwash (*W*) developed around the lake margins. The intervening parts are mainly occupied by sandplain (*S*), and colluvium (*C*) is proximal to outcrops.

Undivided colluvium (*C*) includes lithologically mixed and poorly sorted gravel, sand, and silt, which are deposited on steep to gently sloping ground adjacent to outcrops and below breakaways. Colluvium has been further subdivided where gravel is dominated by one rock type. Dominantly ferruginous colluvium (*Cf*) is derived from reworked ferruginous duricrust and iron-rich metasedimentary rocks, whereas detritus from granitoid rocks (*Cg*) includes granite or gneiss fragments with abundant quartzofeldspathic coarse sand and subordinate silcrete or vein-quartz pebbles. Coarse, angular talus of BIF and chert (Clc_i) dominates the flanks of prominent BIF ridges. Quartz debris is abundant adjacent to conspicuous quartz veins (*Cq*), whereas talus of quartzite (Cqm_q) flanks ridges in the Maynard Hills greenstone belt, particularly south of Lake Noondie.

Sheetwash deposits (*W*) of typically well-sorted clay, silt, and red sand are common in the lower reaches of drainage systems. Sheetwash derived from low-lying granitoid outcrops (*Wg*) contains a higher proportion of quartzofeldspathic sand.

Alluvial units are distinguished from areas of sheetflow mainly by interpretation of airphotos and Landsat images. Undivided alluvium (*A*) consists of mainly unconsolidated and poorly sorted, fine gravel to clay material on ill-defined drainage surfaces. Local cementation by carbonate produces calcrete deposits at various levels within the alluvial profile (see **Residual or relict units**, *Rk*). Stream-channels (A_c) have poorly sorted, coarse- to fine-grained sand with lenses of silt, gravel, and minor clay. These channels typically cut bedrock exposures, but seldom reach the broad drainage basins. However, they can extend for several kilometres into the floodplains where they are up to several metres wide and 2 m deep, have better developed overbanks, and can contain partially consolidated gravelly and sandy material. Alluvium derived from granitoid sources grades from coarse sandy grits on the upper pediments to sandy light clays downslope, whereas material from greenstones ranges from fine sandy clay loams to medium clays (Churchward, 1977). Areas with distinct channels grade downstream into zones of braided drainage without incised channels (A_d), consisting of broad alluvial flats, with unconsolidated clay, silt, and sand, that are slightly depressed relative to the surrounding floodplain. These swales form broad drainage zones, up to a few kilometres wide, that can be locally swampy. They are recognized on airphotos and Landsat images by their braided stream pattern and darker colour, and on the ground by dense scrub, clay-sealed soil surface, and heaps of light, flood-washed debris. The floodplains surrounding these swales (A_f) are level to gently inclined, locally with contour-aligned, arcuate drainage foci emphasized by *Acacia* groves. Clay and silt dominate, with local sandy tracts and banks. All drainage is ephemeral on EVERETT CREEK, but during the wet season and after heavy storms water can persist for long periods in claypans (A_p) along the major drainage lines and within the floodplain.

Lacustrine deposits on EVERETT CREEK comprise the northeastern part of Lake Noondie, which is a major lake system that is part of the southeasterly flowing Raeside palaeodrainage (van de Graaff et al., 1977; Hocking and Cockbain, 1990). Lake Noondie consists of narrow lakes and channels separated by numerous sandy ridges and samphire-vegetated flats. Lake surfaces (L_l) are unvegetated and covered by saline clays with a veneer of evaporitic halite and gypsum. Dune systems are developed within and on the fringe of the lakes. Barren to poorly vegetated, active dunes (L_d1) form hummocky plains within and at the edges of the lakes. Older, stabilized dunes (L_d2) include low kopi with gently undulating crests that are several kilometres long and about 200 m wide, with 1 to 8 m relief above the lake surface. They consist of encrusted gypsiferous sediments with red sand in shallow pockets, as well as linear, deep-red sand dunes up to 10 m high (Payne et al., 1998). The flat to gently undulating margins of the playa lake comprise a mixture of saline alluvial plains and small channels; small circular depressions, swamps, and claypans; sandy banks and lunettes; and scattered plains mantled by calcrete rubble (L_m).

Sandplain deposits on EVERETT CREEK form a variably thick cover, mainly over granitic rocks and other regolith deposits. Extensive (locally more than 10 km-wide), level to gently undulating sandplains (*S*) have well-sorted, deep-red sands, and clayey sands that probably represent a mixture of eolian and residual material from a largely quartzofeldspathic bedrock. Isolated dunes within these sandplains are commonly irregular, with gently inclined flanks and ill-defined crests up to 10 m in relief (Payne et al., 1998). At the margins, the sandplains grade into loamy alluvial plains with clayey sand and clay. Yellow sand with areas of pisolitic gravel, silt, and clay (*Sl*) is derived from ferruginous or siliceous duricrust. These residual, gently undulating sandplains are commonly less than 1 m thick, can have an overall relief to about 20 m, and have a local eolian component in the form of linear dunes (Payne et al., 1998).

Economic geology

Although there is no recorded mineral production on EVERETT CREEK, surface and near-surface exploration for gold, uranium, and diamonds was carried out using soil and stream sediment sampling; rotary air blast (RAB), reverse cycle (RC), and diamond drilling; and magnetic surveys. The information below is summarized from open-file WAMEX statutory reports.

Gold mineralization has been reported on EVERETT CREEK in a variety of settings: silicified quartz–muscovite schists in the Maynard Hills greenstone belt, dilational zones associated with the Edale Shear Zone, and in basalt-hosted quartz veins of the Maninga Marley mining centre.

In the Maynard Hills greenstone belt between Blue Hills Well (also referred to as Elvehill Well) and Volprecht Well, silicified quartz–muscovite schist crosscut by pyrite–chlorite–tourmaline–barite veins have anomalous base metal, arsenic, barium, tellurium, silver, and gold contents (Great Central Mines NL, 1985). The host rock consists of muscovite and quartz, with variable feldspar, garnet, biotite, cordierite, fuchsite, tourmaline, and iron sulfide, and is visually indistinguishable from the barren equivalent. Alteration is indicated by varying degrees of silicification. Low anomalous gold was determined from outcrop sampling on EVERETT CREEK, and the surrounding alluvium was panned to investigate the possibility of surface leaching of gold from the quartz–muscovite schist host, with the best results obtained northwest of 4 Corners Well (Pittorino, 1988). Concentrations of arsenic up to 80 ppm were reported from stream sediment samples from the Red Knob – Volprecht Well area, with samples from anomalous sites (oxidized mafic and pyritic sedimentary rocks, silicified tourmaline-bearing mafic rocks, and calcrete) containing up to 3020 ppm As but no associated anomalous gold values (Stevens, 1976). Similarly, a recrystallized ferruginous chert ridge between Middle Well and 4 Corners Well assayed up to 900 ppm As, but the maximum gold content was 0.10 g/t (Stevens, 1976). Low-order anomalies in gold, arsenic, boron, and barium have been recorded in the area south of Kohler Bore (Timms, 1995).

Gold is associated with dilational structures along the Edale Shear Zone. Faults and fractures in chlorite schist from the Coomb Bore area are filled by late auriferous quartz veins and reefs that trend between 040° and 070°, approximately orthogonal to the main structural grain of the north-northwesterly trending Edale Shear Zone (Wilkinson and Middleton, 1988). Intersections of these structures with the main shear or with the contacts between different rock types (e.g. gneiss–greenstone, metasedimentary–ultramafic) were considered to be the most favourable sites for gold mineralization. Davies (1996) identified dilational structures infilled by massive to lensoid quartz reefs and pegmatites within the Edale

Shear Zone in the area between Hell Gates and Hell Gates Well, but gold contents were low. In the Maynard Hills area (and farther south), the potential for structurally controlled gold mineralization was noted at dilational sites along shear directions (331°/70° and 314°/74°, and at the intersections of these structures), especially where rock types are favourable for precipitation of mineralized solutions (e.g. BIF, ultramafic rocks), and where there are significant competency contrasts between adjacent lithological units (Wilson and Downes, 1989). The development of these mineralized structures is generally ascribed to pressure release following the main period of shearing and metamorphism. In their study of large-scale shear zones and their relevance to gold mineralization, Eisenlohr et al. (1993) similarly concluded that mineralized structures post-date most of the movement or flattening on these shear zones. Eisenlohr et al. (1993) also pointed out that very few gold deposits of the Yilgarn Craton are located along crustal-scale lineaments such as the Edale Shear Zone, and that gold deposits in the southern part of the Southern Cross Granite–Greenstone Terrane are related more to areas of strong deformation around granitoids than to regional-scale lineaments.

About 1574 kg of gold at an average of 24 g/t were extracted from quartz veins in sheared basaltic rocks, dolerite, and BIF of the Sandstone greenstone belt in the Maninga Marley mining centre (at the boundary between ATLEY and EVERETT CREEK; Stewart et al., 1983).

The presence of a well-developed tributary system into Lake Noondie suggests the potential for alluvial gold. The possible presence of palaeoplacers near Radiator Well was investigated with no positive results (Smyth, 1987), but about 60 oz of alluvial gold have reportedly been collected in the area south of Coomb Bore across the boundary between EVERETT CREEK and ATLEY (Hughes, 1989). Stream sediment sampling has been commonly used for reconnaissance exploration on EVERETT CREEK, but Davies (1996) indicated that the method has limited applications in the vicinity of the Maynard Hills greenstone belt, as drainages here are commonly weakly incised and restricted in their catchment.

Calcrete and channel-fill sediments along Tertiary palaeodrainage lines were targeted in the late 1970s for the possible presence of uranium, following an airborne magnetic and radiometric survey conducted by the Bureau of Mineral Resources (Gerdes et al., 1970). Sediments on EVERETT CREEK were oxidized and generally gave low assay results (with no concentrations above 100 ppm U_3O_8 recorded in drillholes; Boots, 1979; Morgan, 1978), but calcrete up to 5 m thick near Yeelirrie Homestead (about 100 km to the north-northeast) is reported to host a significant amount of uranium (Churchward, 1977). Slightly anomalous radiometric values in granite (about 250 cps) were recorded in the 4 Corners Well area (Stewart et al., 1983).

Preliminary exploration for diamonds in the region revealed some prospective magnetic anomalies, particularly below Lake Noondie and Lake Mason. However, chrome spinel grains recovered from stream sediment and loam sampling were considered to be of non-kimberlitic affinity and derived from greenstones, and RC drilling of one anomaly failed to intersect any kimberlite intrusion (Fried, 1997).

Exploration for nickel and copper was conducted over mafic and ultramafic greenstones in the Maynard Hills belt west of Quartz Blow Well, but failed to produce anomalous results (International Nickel Australia Ltd, 1992).

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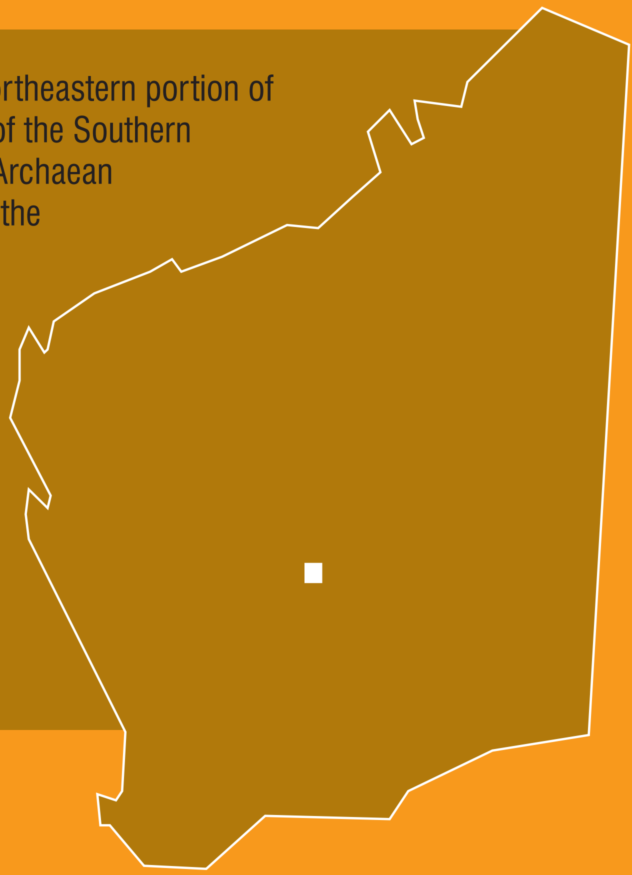
Appendix 1

Gazetteer of localities on EVERETT CREEK

Locality	*MGA coordinates*	
	Easting	*Northing*
Blackhill Homestead	750000	6892550
Blue Hills Well	770050	6858700
Bulga Downs Homestead	768550	6844700
Daly Outcamp	772500	6872800
Cook Well	771100	6846700
Coomb Bore (on ATLEY)	745400	6893300
Elspon Well	762300	6866650
Flat Topped Hill	781500	6879200
Hell Gates	767000	6878600
Hell Gates Well	762900	6885850
Kayline Bore	762550	6895400
Kohler Bore	779550	6845740
Maninga Marley	745600	6880350
Middle Well	766300	6864700
Mount Holmes	792250	6873100
Mount Richardson (on RICHARDSON)	792150	6811200
Mount Alfred (on RICHARDSON)	792150	6803990
No. 6 Well	776800	6877400
Quartz Blow Well	765450	6876350
Red Knob	766550	6878800
Red Well	750900	6878200
Sandstone (on SANDSTONE)	725150	6902000
Satan Well	769300	6881050
Volprecht Well	761750	6880200
4 Corners Well	769750	6864850

The EVERETT CREEK 1:100 000 sheet covers the northeastern portion of the YOUANMI 1:250 000 sheet in the western part of the Southern Cross Granite–Greenstone Terrane, in the central Archaean Yilgarn Craton. These Explanatory Notes describe the Precambrian rock types, and the structural and metamorphic geology of the granite–greenstone terrain that includes the North Cook Well and Maynard Hills greenstone belts, and the Edale Shear Zone. The constraints on the age of greenstone deposition and granitoid intrusion, and the relationships between deformation and metamorphism are discussed. These Notes also contain descriptions of the mineralization and extensive Cainozoic regolith cover.



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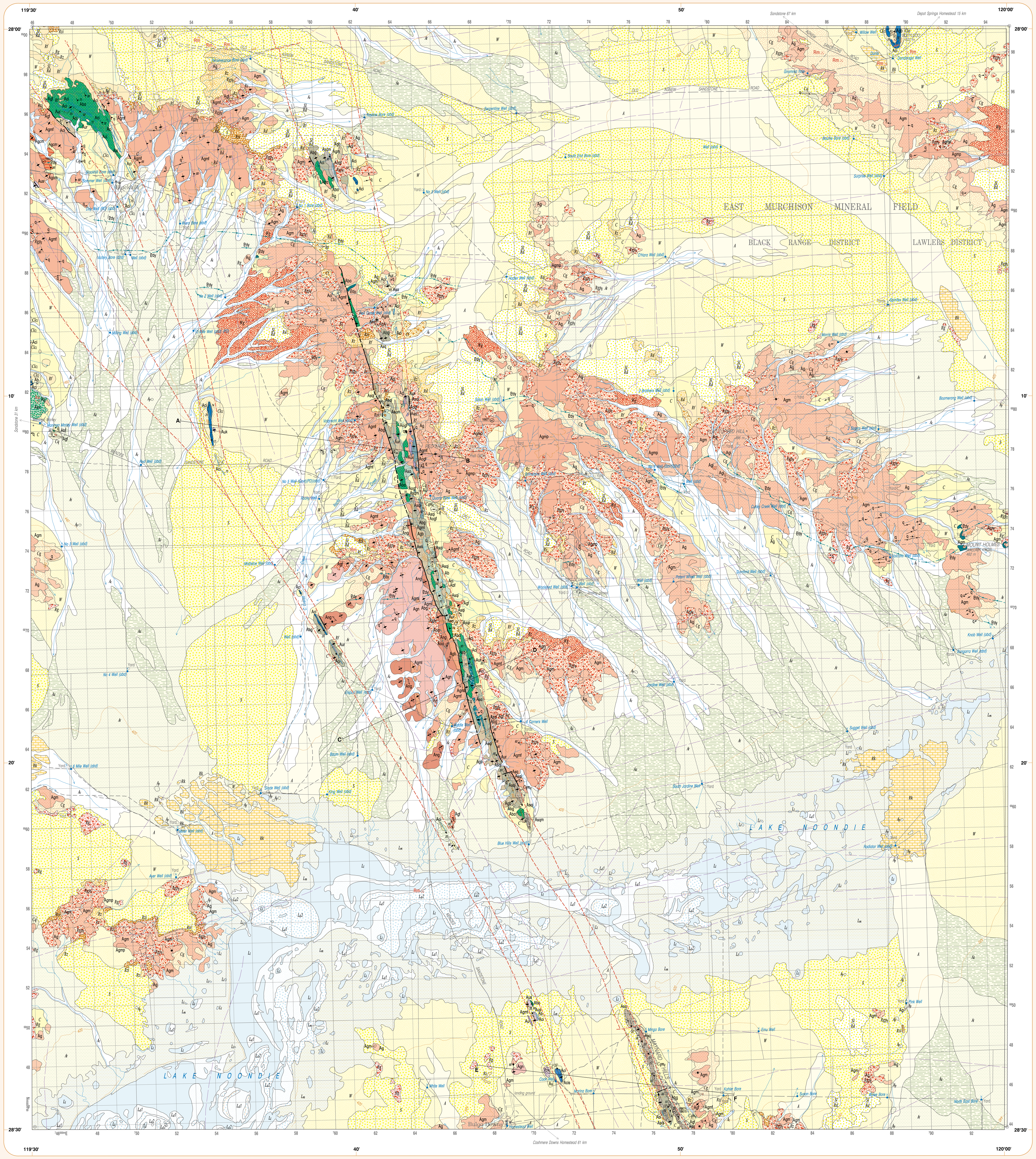
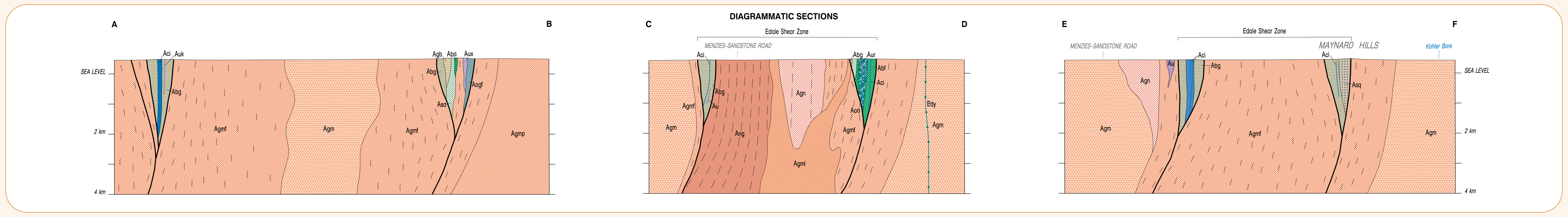
EVERETT CREEK

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA



DIAGRAMMATIC SECTIONS



CAINOZOIC

Colluvial units

- *C* Mixed gravel from different rock types as scree and proximal talus; includes sand and silt; locally ferruginous
- *Cf* Ferruginous gravel and reworked duricrust
- *Cg* Quartzofeldspathic gravel, sand, and silt, derived from granitoid rock and associated weathering products
- *Clci* Talus from banded iron-formation and chert; locally cemented
- *Cq* Quartz-vein debris
- *Cqmq* Talus from quartzite

Sheetwash units

- *W* Clay, silt, and sand; locally ferruginous
- *Wg* Clay, silt, and sand derived from granitoid rock

Alluvial units

- *A* Clay, silt, sand, and gravel in drainage systems
- *Ac* Clay, silt, sand, and gravel as stream-channel and adjacent overbank deposits
- *Ad* Clay, silt, and sand in braided swales within floodplain
- *Af* Clay, silt, and sand within floodplain
- *Ap* Clay and silt in claypans

Lacustrine units

- *Ll* Saline playa lake deposits
- *Ld1* Dune and lake deposits; active systems within and adjacent to playa lakes; non-vegetated or poorly vegetated
- *Lm* Mixed dune, evaporite, and alluvial deposits adjacent to playa lakes

Lacustrine unit

- *Ld2* Stabilized dunes within and adjacent to playa lakes; typically vegetated

Sandplain units

- *S* Residual and eolian sand
- *Sl* Yellow sand with minor pisolitic laterite, ferruginized silcrete, silt, and clay

Residual or relict units

- *Rd* Siliceous and ferruginous duricrust
- *Rf* Ferruginous duricrust; includes iron-cemented reworked products
- *Rg* Quartzofeldspathic sand over granitoid rock
- *Rgpg* Quartzofeldspathic sand and minor silcrete over granitic rock; sparse granite outcrop
- *Rk* Calcrete
- *Rz* Silcrete
- *Rzi* Silcrete with ferruginous cement
- *Rzu* Silica caprock over ultramafic rock

PROTEROZOIC

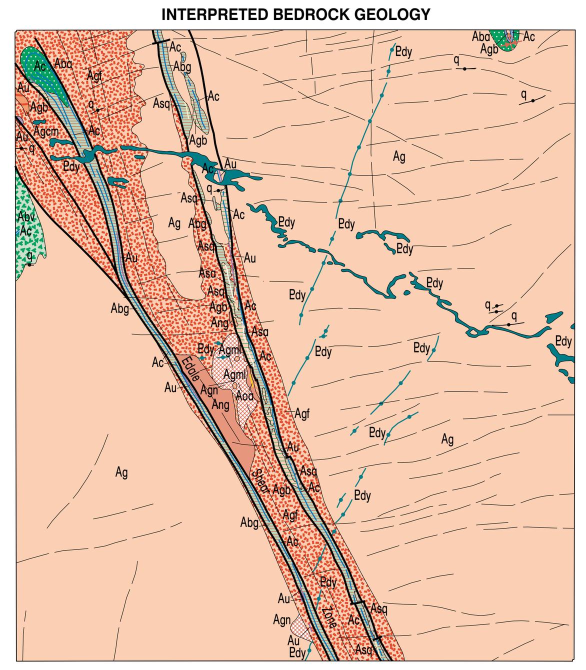
- Pdy Mafic to ultramafic dykes and sills; interpreted from aeromagnetic data where dashed
- q Quartz vein
- p Pegmatite dyke

ARCHAEAN

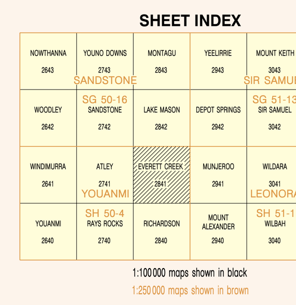
- Ag Granitoid rock, undivided; includes deeply weathered rock
- Agm Medium- to coarse-grained monzogranite; locally porphyritic
- Agmc COOMB BORE MONZOGRANITE: foliated monzogranite
- Ang Granitoid gneiss; banded quartz-feldspar-biotite orthogneiss
- Aa Metasedimentary rock, undivided; typically deeply weathered
- Ab Metamorphosed mafic rock, undivided; typically deeply weathered
- Au Metamorphosed ultramafic rock, undivided; typically deeply weathered

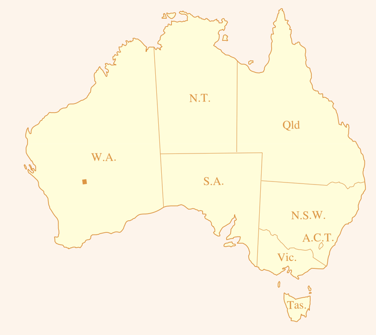
YILGARN CRATON

INTERPRETED BEDROCK GEOLOGY



SHEET INDEX





Geology by A. Riganti 2000

Edited by F. Eddison

Geochronology by:
D. R. Nelson, 2002, Record 2002/2, p.222–236.

Cartography by D. Ladbrook, T. Pizzi, and K. Greenberg

Topography from the Department of Land Administration Sheet SH 50-04, 2841, with modifications from geological field survey

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Web www.mpr.wa.gov.au Email geological_survey@mpr.wa.gov.au

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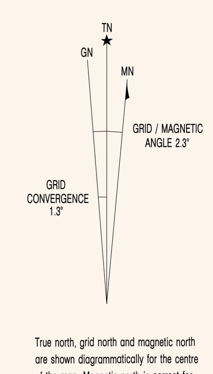
RIGANTI, A., 2002, Everett Creek, W.A. Sheet 2841: Western Australia Geological Survey, 1:100 000 Geological Series



Department of Mineral and Petroleum Resources

Geological Survey of Western Australia

CLIVE BROWN, M.L.A.
MINISTER FOR STATE DEVELOPMENT

JIM LIMERICK
DIRECTOR GENERAL

TIM GRIFFIN
DIRECTOR

SCALE 1:100 000

1000 Metres 0 1 2 3 4 5 6 7 8 9 10 Kilometres

UNIVERSAL TRANSVERSE MERCATOR PROJECTION
HORIZONTAL DATUM: GEOCENTRIC DATUM OF AUSTRALIA 1994
VERTICAL DATUM: AUSTRALIAN HEIGHT DATUM

Grid lines indicate 1000 metre interval of the Map Grid Australia Zone 50

The Map Grid Australia (MGA) is based on the Geocentric Datum of Australia 1994 (GDA94)
GDA94 positions are compatible within one metre of the datum WGS84 positions

Reference points to align maps based on the previous datum, AGD84, have been placed near the map corners

EVERETT CREEK

SHEET 2841 FIRST EDITION 2002

Version 1 – June 2002