EXPLANATORY NOTES

GOVERNMENT OF WESTERN AUSTRALIA

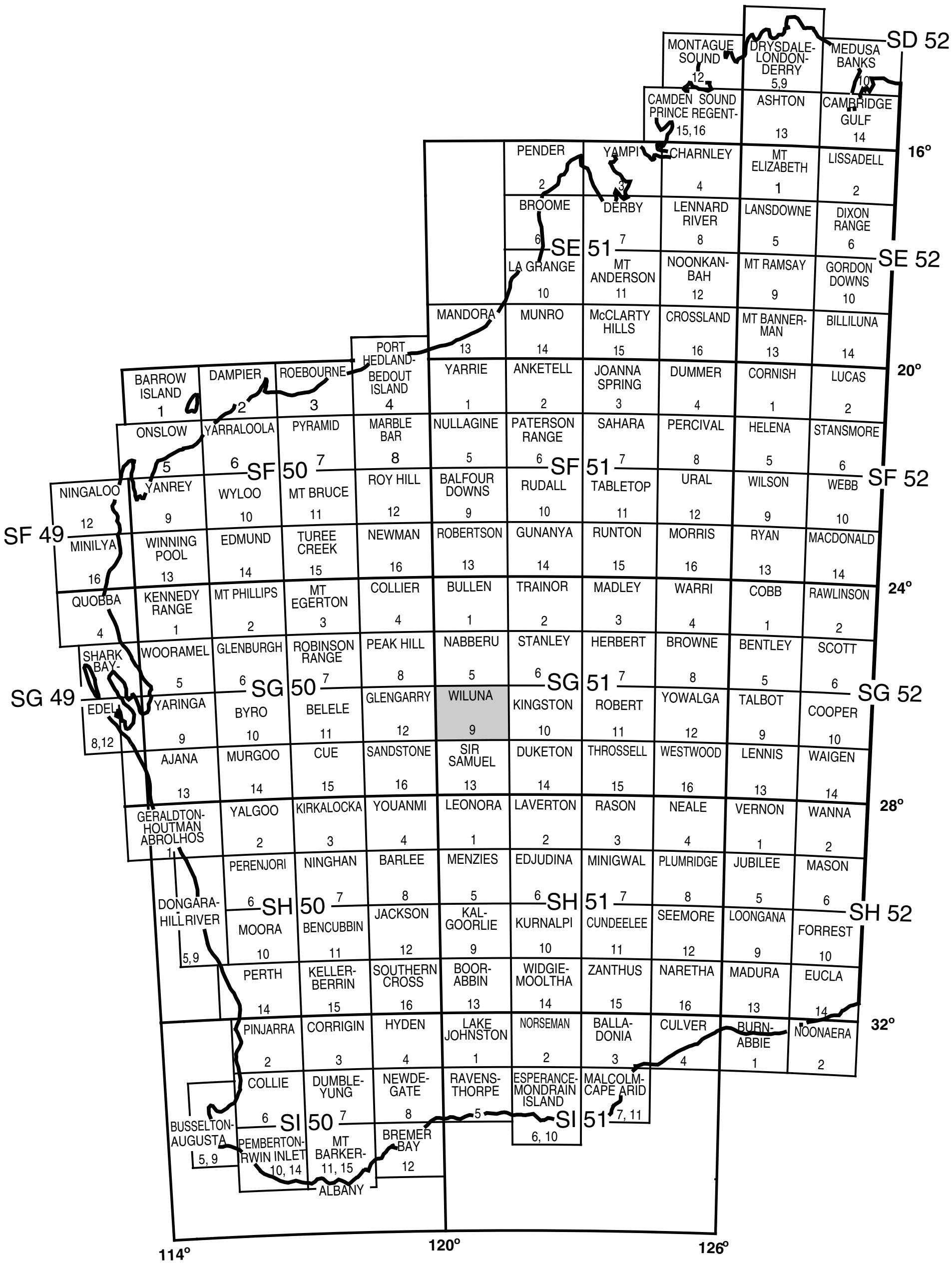
GEOLOGY OF THE WILUNA 1:100 000 SHEET

by R. L. Langford, S. Wyche, and S. F. Liu

1:100 000 GEOLOGICAL SERIES

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

DEPARTMENT OF MINERALS AND ENERGY



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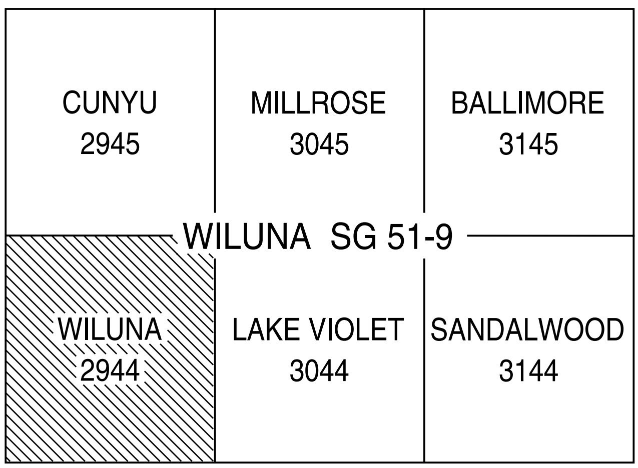

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Cover photograph:
Exhumed corestones of fresh to slightly weathered megacrystic medium-grained granitoid rock, with duricrust-capped hills over amphibolite in the background, 8 km southwest of Little Diorite Well (AMG 025335)

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Abstract

The WILUNA 1:100 000 sheet includes granite–greenstone terrain of the northern part of the Eastern Goldfields Province of the Archaean Yilgarn Craton, and the southeastern margin of the Proterozoic Yerrida Basin. At their widest point, the greenstones are about 35 km across, and can be divided into the Wiluna and Matilda domains, separated by the Erawalla Fault. The greenstones comprise a poorly exposed, deformed, and metamorphosed sequence of ultramafic, mafic, and felsic volcanic rocks with associated volcaniclastic sedimentary rocks and thin units of banded iron-formation and chert. Extensive areas of granitoid rocks are poorly exposed, and mainly monzogranite to granodiorite in composition. The greenstone sequences have undergone a complex history of deformation, with peak metamorphism, typically of very low to low grade, approximately coincident with granitoid intrusion during a major regional folding event.

Proterozoic sedimentary rocks of the Yerrida Basin unconformably overlie the Archaean rocks in the northwest where they dominantly comprise flat-lying to gently dipping clastic and carbonate sedimentary rocks, although carbonate minerals are now completely replaced by silica. The Finlayson and Bubble Well Members of the Juderina Formation are exposed as horizontal to gently dipping sequences in escarpments in the northwestern and western parts of the area, forming the prominent hills of the Finlayson Range. There are also outliers of presumed Proterozoic sedimentary rocks that have not been assigned to a particular stratigraphic unit.

Gold mines have been active in the Wiluna area since the early part of the twentieth century. Despite extensive exploration, there are no producing base metal sulfide deposits, although nickel prospects at Honeymoon Well are potentially economic.

KEYWORDS: Archaean, Proterozoic, Cainozoic, Eastern Goldfields, Wiluna, greenstone, granite, regolith, mining, gold, nickel, uranium, stratigraphy.

Introduction

The WILUNA* 1:100 000 geological sheet (SG 51-9, 2944), bounded by longitudes 120°00'E and 120°30'E, and latitudes 26°30'S and 27°00'S, occupies the southwestern corner of the WILUNA 1:250 000 sheet in the north Eastern Goldfields (Fig. 1). The town of Wiluna lies within the sheet area, and there are several pastoral stations and aboriginal communities in the district. The major gold production has come from the openpit gold mines of the Wiluna mining centre, immediately south-southeast of the Wiluna township, and the Coles mining centre, about 18 km south of the town.

The geological mapping was carried out as part of the National Geoscience Mapping Accord (NGMA) between April and December 1995, using 1:25 000-scale colour aerial photographs, supplemented by Landsat TM5 (Thematic Mapper) imagery, and both magnetic and radiometric geophysical surveys that were acquired through the NGMA, and are available from the Geological Survey of Western Australia (GSWA) and the Australian Geological Survey Organisation (AGSO). Additional information was obtained from open-file exploration company reports held in the Department of Minerals and Energy's (DME's) Western Australian mineral exploration (WAMEX) system.

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

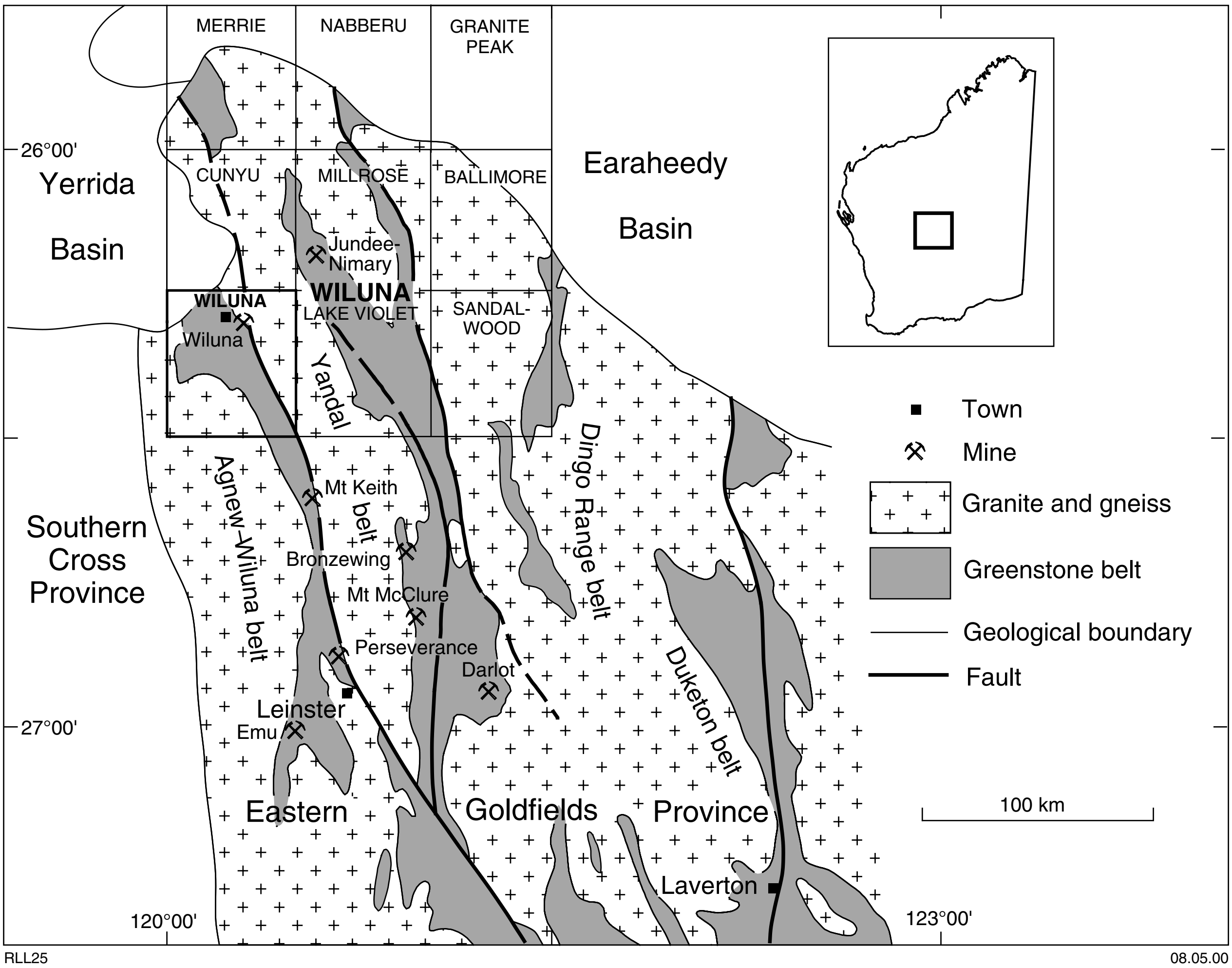

Figure 1. Regional setting of WILUNA

Access

A major sealed road extends south from Wiluna to Kalgoorlie. Major unsealed roads extend west to Meekatharra, northeast to Granite Peak, and east to the Gunbarrel Highway at Carnegie on the STANLEY 1:250 000 sheet. There are also unsealed roads to Sandstone, Yeelirrie, Cunyu, and Jundee (Fig. 2). An airstrip south of Wiluna serves the town and minesite. WILUNA is also traversed from southeast to northwest by the Peak Hill – Leonora Stock Route, and is the starting point for the Canning Stock Route.

Numerous fence lines, station tracks, exploration tracks, and cut lines provide good access to the greenstone areas, although most of the fences have fallen into a state of disrepair. A disused railway embankment extends west from Wiluna, with good parallel vehicle tracks. Access to the areas underlain by granitoid rocks is difficult due to the scarcity and poor state of the tracks, particularly east of Lake Way. The Proterozoic escarpments in the northwest and west are traversed by few tracks, mainly because of the steep and rocky nature of the ground.

Climate, physiography, and vegetation

The climate is semi-arid to arid, with a mean annual rainfall of 246 mm* recorded at Wiluna, most of which falls between January and June. Potential evaporation far exceeds the annual rainfall. The summers are hot and dry with a mean daily temperature range of 22 to 38°C at Wiluna, and the winters are cool and mild with occasional frosts and a mean daily temperature range of 5 to 19°C.

WILUNA is typically flat to undulating, but is dominated by prominent hills of the Finlayson Range in the northwest and the Lake Way basin in the east. The altitude ranges from more than 600 m AHD (Australian Height Datum) in the Finlayson Range to about 490 m at the southeastern end of Lake Way (Fig. 2). A range of hills west of Lake Way includes Mount Lawrence Wells (610 m) and Mount Wilkinson.

The landforms on WILUNA have largely formed by the erosion and dissection of a deeply weathered land surface.

* Climate data from Commonwealth Bureau of Meteorology website, 1999.

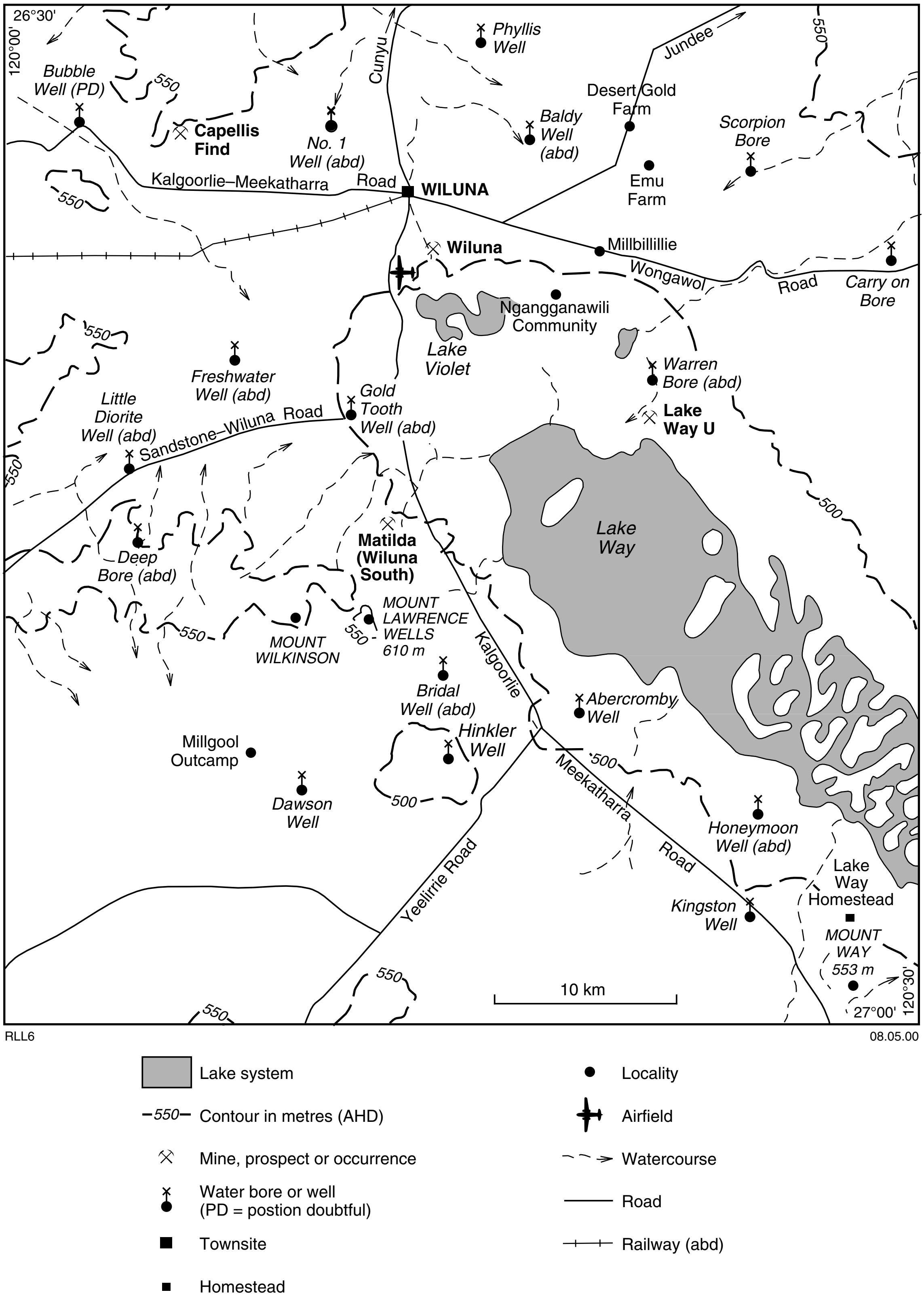

Figure 2. Principal localities, roads, and topography on Wiluna

Areas underlain by greenstone are characterized by subdued strike ridges and low rounded hills of lateritic duricrust and ironstone debris with well-developed breakaways, whereas areas underlain by granitoid rocks are characterized by extensive sand sheets and scattered exposures of weathered rock. The Lake Way basin forms part of a major southeasterly trending drainage system. Areas underlain by Proterozoic sedimentary rock form relatively high, flat or gently sloping hills with prominent escarpments.

Lake Way is fed by drainage channels from the northeast (Uramurdah Creek), north, and northwest, and forms a basin that is up to 10 km wide and more than 30 km long. There are extensive outwash fans and sandplains east and southwest of Lake Way. A line of low hills underlain by greenstones extends northwest from Mount Way (553 m) along the western margin of the lake.

WILUNA lies in the Murchison Region of the Eremaean Province (Beard, 1990). The Murchison Region (Austin Botanical District) is dominated by low mulga woodland (*Acacia aneura*) on plains, reduced to mulga scrub on hills, and by spinifex (*Triodia basedowii*) and *Eucalyptus* spp. on sandplains. The saline margins of lakes support a variety of relatively salt tolerant species, such as the conspicuous gypsum plant (*Lawrencia helmsii*) and samphires (*Halosarcia* spp.).

Previous investigations

The earliest work dealing with the geology and mining of the area was by Gibson (1908), but the first regional reconnaissance mapping was not completed until 1958 by Sofoulis and Mabutt (1963). Elias and Bunting (1982) produced the first edition of the WILUNA 1:250 000 sheet with accompanying Explanatory Notes. Farrell (1999) compiled the second edition of the WILUNA 1:250 000 sheet.

Hagemann et al. (1992) described the lode gold deposits at Wiluna, and Morgan and El-Raghy (1990) described the Matilda (Wiluna South) gold deposits in the Coles mining centre. Although poorly exposed at the surface, the ultramafic rocks that host the nickel deposits at Honeymoon Well have been extensively investigated by both diamond and percussion drillholes. Gole and Hill (1990) reported on results of a study of the stratigraphy and volcanology of these rocks. Broader aspects of the komatiite volcanology in the region were described by Hill et al. (1995).

Following the surge in exploration for nickel and gold in the 1970s, a large number of company reports have been added to DME's open-file WAMEX system. The reports dealing in part with geology, geochemistry, and geophysics on WILUNA can be accessed through a computer-based Geographic Information System (GIS) developed as part of the north Eastern Goldfields mineralization mapping project (Ferguson, 1998).

Regional geological setting

WILUNA lies in the northern part of the Eastern Goldfields Province of the Archaean Yilgarn Craton (Gee et al., 1981; Griffin, 1990). The Eastern Goldfields Province is a typical Archaean granite–greenstone terrain (Condie, 1981), characterized by large areas of granitoid and gneiss with linear to arcuate, north-northwesterly trending greenstone belts containing abundant ultramafic and mafic volcanic rocks (Griffin, 1990).

As in many other granite–greenstone terrains, the greenstone belts in the Eastern Goldfields Province show a range of metamorphism from very low grade up to amphibolite facies, with the highest metamorphic grade found at granite–greenstone contacts (Binns et al., 1976). Farrell (1997) and Wyche et al. (1997) described four phases of Archaean deformation in reviews of the regional deformation history for the north Eastern Goldfields based on recent GSWA regional mapping. Upright folds and foliations dominate structures in the greenstone sequences, and the major faults and folds are typically parallel to the long axes of the belts. In common with other granite–greenstone terrains, late discordant plutons intruded both granitoids and greenstones.

The Wiluna and Coles Find greenstone belts of Griffin (1990, fig. 2-87, table 2-8) lie east and west respectively of the Erawalla Fault, and correspond to the Wiluna and Matilda domains (Fig. 3) of Hagemann et al. (1992). The latter terminology will be used in these Explanatory Notes to avoid confusion with the common use of the term 'greenstone belt' when referring to the Agnew–Wiluna greenstones (Hill et al., 1995; Wyche et al., 1997). Elias and Bunting (1982) and Hagemann et al. (1992) regarded what is called the Erawalla Fault as the northern extension of the Perseverance Fault. However, this is unlikely as the Perseverance Fault, where it has been mapped on SIR SAMUEL (Liu et al., 1998), marks the eastern boundary of the Agnew–Wiluna greenstones. The position of the Perseverance Fault on WILUNA is not well defined on magnetic images (Fig. 4), and the structure may break up into a set of fault splays in the southern part of the sheet area (Figs 3 and 4), or farther south on MOUNT KEITH (Jagodzinski et al., 1997; Stewart and Liu, 1999).

Most rocks in the Wiluna domain, particularly around Wiluna, are less deformed and at a lower metamorphic grade than those in the Matilda domain. Structures in the Wiluna domain are mainly faults (Fig. 3), although areas of tight folding have also been identified. Hagemann et al. (1995) interpreted the Wiluna and Matilda domains as segments from different crustal levels juxtaposed by the Erawalla Fault.

There are also extensive outcrops of Proterozoic sedimentary rocks of the Yerrida Basin in the northwest, and large outliers of other presumed Proterozoic sedimentary rocks, which unconformably overlie the Archaean granite–greenstones. The extensive regolith consists of residual and transported deposits ranging in presumed age from Early Cainozoic to Holocene.

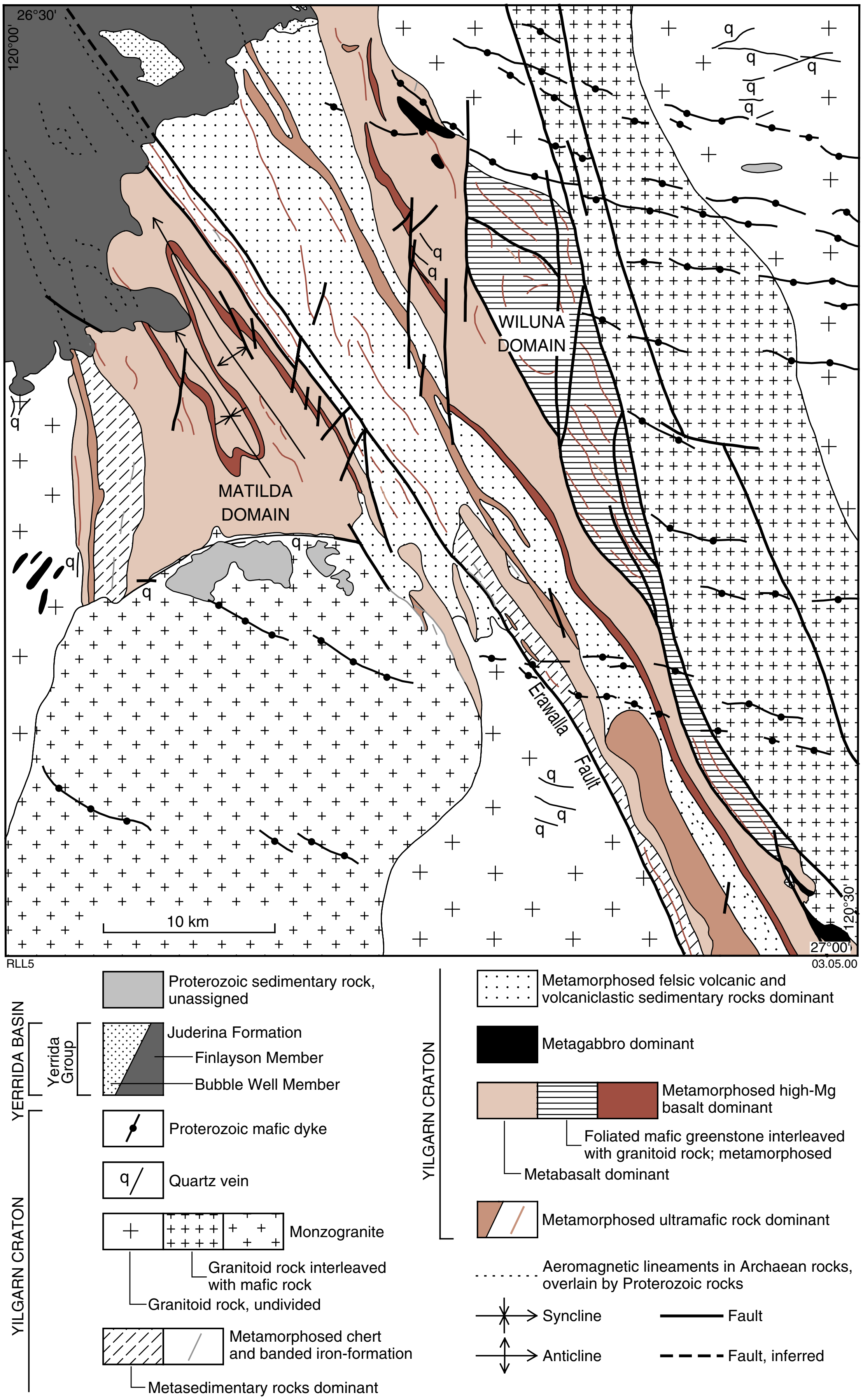

Figure 3. Simplified geological map of WILUNA

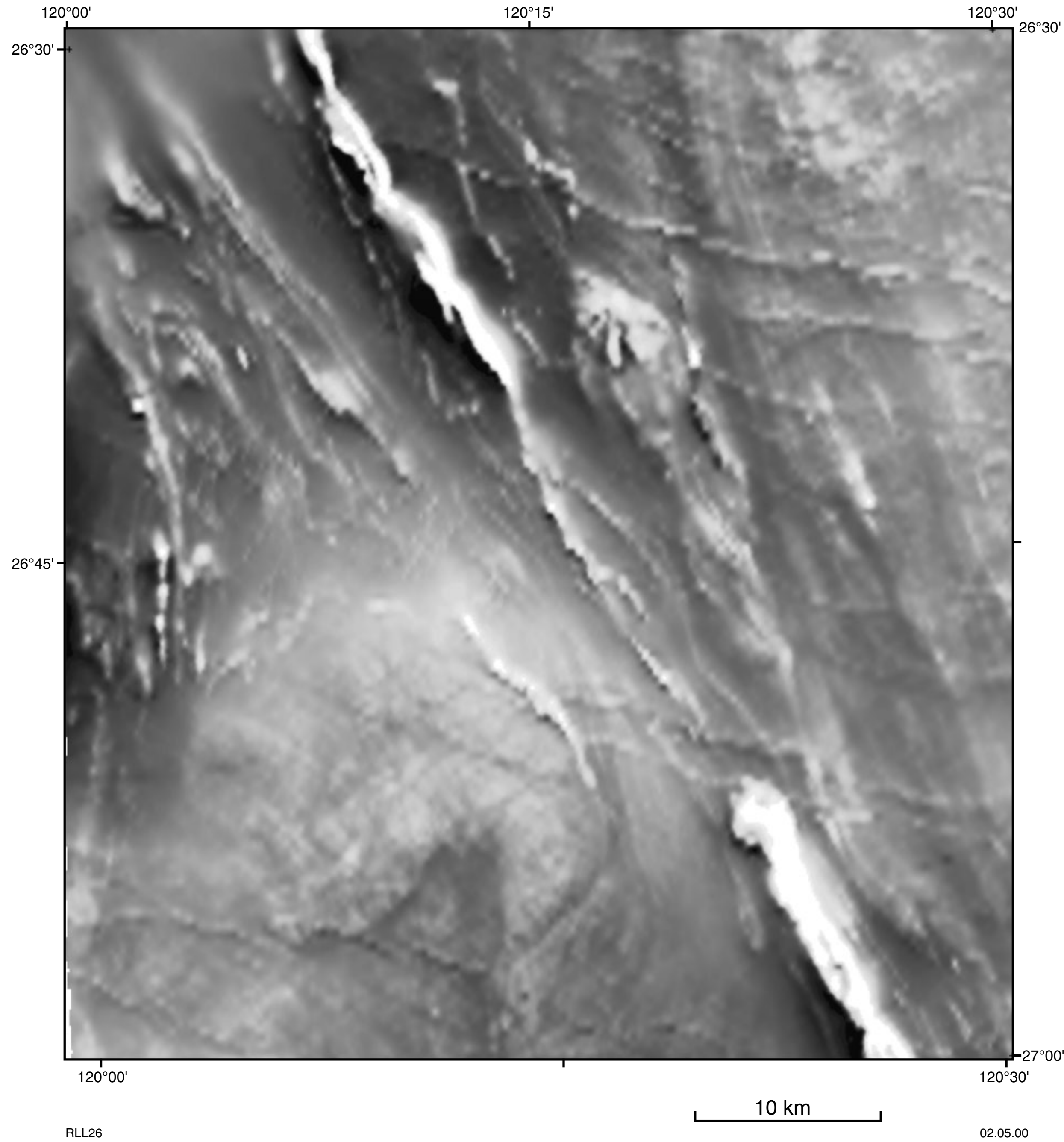

Figure 4. Grey-scale image of total magnetic intensity for WILUNA

Archaean rock types

WILUNA lies at the northern end of the Agnew–Wiluna greenstone belt (Fig. 1), which is an elongate, fault-bounded, dominantly north-northwesterly trending sequence of Archaean supracrustal rocks flanked by granitoid rocks that are commonly foliated and locally interleaved with greenstones. At its widest point on WILUNA the greenstone belt is about 35 km across, but narrows markedly to the south so that it is less than 10 km wide near the southern edge of the sheet area. The belt contains a deeply weathered, deformed, and metamorphosed sequence of ultramafic, mafic, and felsic volcanic rocks with associated volcaniclastic sedimentary rocks and thin units of banded iron-formation and chert. Most of the sequence is poorly exposed, although there are local good exposures (e.g. in the Mount Way area).

All Archaean rocks on WILUNA have been deformed and metamorphosed, and some have been hydrothermally altered. However, in many instances, primary textures are preserved and it is possible to identify the protolith. For this reason, igneous or sedimentary rock terminology has been used wherever possible. The nomenclature of the igneous rocks, including pyroclastic rocks, follows that of Le Maitre et al. (1989).

Stratigraphy

Although no formal stratigraphy has been established for WILUNA, detailed studies in mineralized areas have resulted in the generation of local stratigraphic sequences that may have broader regional implications.

Hagemann et al. (1992) described a west-younging sequence of mafic volcanic and intrusive rocks near the Wiluna gold deposits in the Wiluna domain. Here, younging directions are clearly established by the presence of pillow lava structures in basalts (Fig. 5; AMG 247537*).

Gole and Hill (1990) described a west-younging sequence in the southern part of WILUNA, east of the Erawalla Fault in the poorly exposed Honeymoon Well area, mainly based on drillhole data. The stratigraphy in this area comprises a lower unit of basalt and dolerite overlain by felsic volcanic and volcaniclastic sedimentary rocks with intercalated minor basalt and gabbro. The felsic rocks are overlain by two units of ultramafic rocks comprising a diverse range of rock types, including olivine spinifex-textured flows, olivine othocumulates, and coarse-grained olivine adcumulates. Textures in the ultramafic rocks indicate younging to the west. The two ultramafic units are separated by an interval of felsic volcanic and volcaniclastic sedimentary rocks, but are in local contact where the intervening rocks have been removed either structurally or by thermal erosion by the intervening komatiite flow. The ultramafic rocks are overlain to the west by metasedimentary rocks and basalt. Because the sequence is so poorly exposed, the nature of geological contacts in this area is unclear, and some contacts are clearly faulted. Thus, the anomalous width of the ultramafic sequence at Honeymoon Well may represent stratigraphic duplication due to faulting (Gole et al., 1996).

Liu et al. (1995) suggested a tentative correlation between the sequence at the Wiluna mining centre and that at Honeymoon Well. In their Wiluna domain sequence, the lowest preserved unit to the east is a mixed unit of basalt and gabbro overlain to the west by a unit dominated by basalt, including both high-Mg and tholeiitic basalt. The basalt unit is overlain by a unit of felsic volcanic and sedimentary rocks that is in turn overlain by the regional ultramafic unit. The uppermost unit preserved east of the Erawalla Fault consists of sedimentary and felsic volcanic rocks.

There is no readily identifiable stratigraphy in the Matilda domain because the mafic-dominated sequence here is poorly exposed, and possibly repeated by folding (see **Structure and metamorphism**). However, the major ultramafic unit and extensive felsic and sedimentary components of the Wiluna domain may not be present.

The ages of Archaean rocks on WILUNA are poorly constrained. The only published sensitive high-resolution ion microprobe (SHRIMP) U–Pb age is a date of 2749 ± 7 Ma for a microdiorite dyke within the Wiluna mine sequence (Kent and Hagemann, 1996). If this age represents the true magmatic age of this rock, then it suggests that the greenstone succession at Wiluna is substantially older than the typically c. 2700 Ma age of greenstones in the southern part of the Eastern Goldfields (Nelson, 1997a) and adjacent greenstones such as the Yandal belt (Nelson, 1997b, 1998).

The Jones Creek Conglomerate, which forms a substantial unit on the western side of the major komatiite-rich sequence to the south on YEELIRRIE (Champion and Stewart, 1997) and SIR SAMUEL (Liu et al., 1998), has not been unequivocally identified on WILUNA. However, it may be represented by some of the schistose felsic rocks near the Erawalla Fault, and possibly by conglomeratic rocks described by Elias and Bunting (1982) near Jeffries Bore.

Greenstones

Metamorphosed ultramafic rocks (*Au, Auf, Aus, Auc, Aut, Aur, Aup, Aud*)

Ultramafic rocks are widespread on WILUNA, typically as thin, laterally extensive units (Fig. 3). They are poorly exposed and, in most cases, seen only in mineral exploration drillholes or costeans. However, they host a major nickel sulfide deposit west of Honeymoon Well. Descriptions of the rock types, geochemistry, stratigraphy, and mineralization of the Honeymoon Well deposit, based on extensive studies of diamond and percussion drillholes, are in Gole and Hill (1990).

Ultramafic rocks have been mapped as undivided (*Au*) where they are deeply weathered and primary textures and mineralogy are unclear, and where strongly foliated or schistose (*Auf*). Recognizable metamorphosed or otherwise altered varieties include massive serpentinite (*Aus*), and talc–carbonate (*Auc*), talc–chlorite (*Aut*), and tremolite–chlorite schists (*Aur*). Less deformed and metamorphosed ultramafic rocks on WILUNA include serpentinized peridotite (*Aup*) and dunite (*Aud*). In some areas, weathering has resulted in the formation of a distinctive, resistant siliceous cap (*Czu*) over ultramafic rocks.

Metamorphosed and foliated ultramafic rocks (*Auf*) are interleaved with mafic schist 1 km northeast (AMG 461149) of the Enterprise gold mine. The foliation in the ultramafic rocks is spaced at about 1 to 1.5 mm. These rocks contain some larger crystal aggregates (3–5%) ranging from 1 to 3 mm across, probably the result of alteration of primary olivine or pyroxene to tremolite and chlorite.

Talc–carbonate rock (*Auc*) is composed mainly of talc and carbonate minerals, with chlorite as a minor constituent. This rock is recognizable in the field by the presence of brown iron-oxide spots or cavities resulting from the breakdown of the carbonates. Where these rocks contain abundant chlorite, they have been

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

Figure 5. Pillowed high-Mg basalt in the Wiluna mine (AMG 247537), dipping and younging to the west. The pillow in the centre of the view is about 1.5 m across

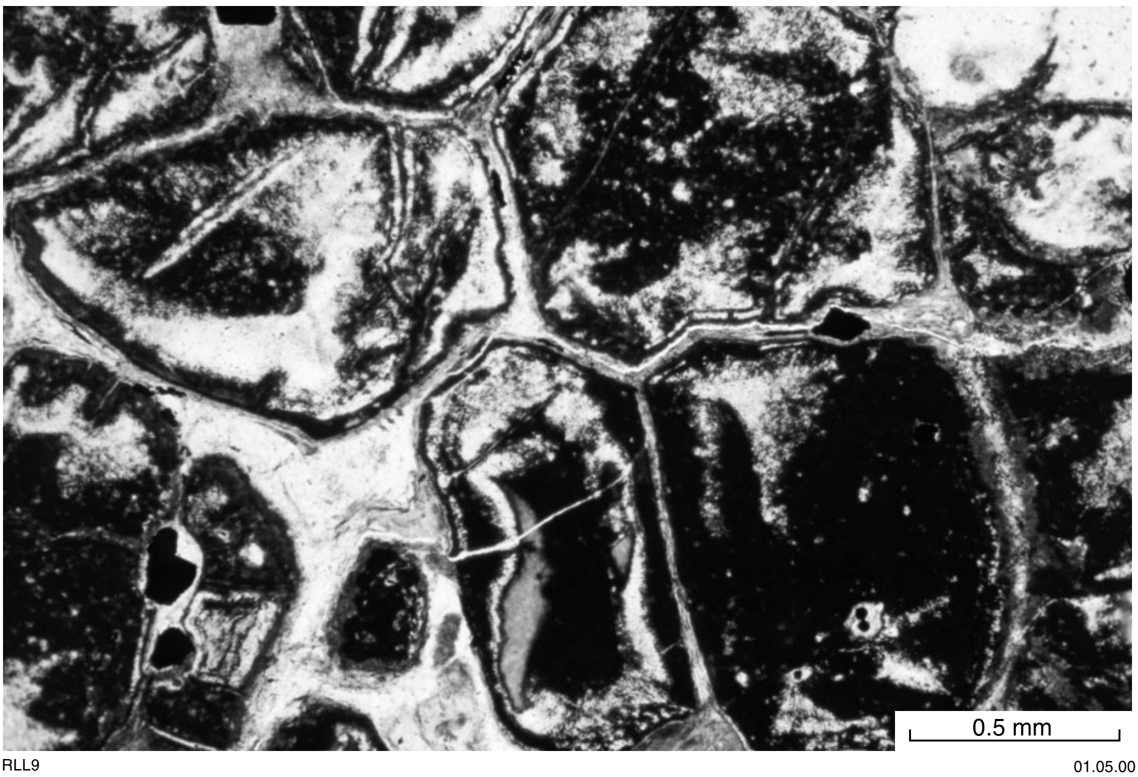

Figure 6. Adcumulate-textured metadunite (GSWA 121812; AMG 229496), from a drillhole about 2 km south of Wiluna airport (plane polarized light)

called talc–chlorite(–carbonate) schist (*Aut*). About 1 km north (AMG 259305) of Bridal Well, the talc–chlorite schist consists of a soft, fine-grained, well-foliated rock, containing varying proportions of talc and chlorite as well as minor amounts of carbonate and opaque minerals. Here, the foliation is defined by the alignment of carbonate-rich zones, differentiation into chlorite-rich and talc-rich bands, and the preferred orientation of chlorite and talc. Tremolite–chlorite schist (*Aur*), comprising tremolite–actinolite with minor amounts of chlorite and iron oxides, is mainly recognized in drillhole cuttings on WILUNA.

Serpentinized ultramafic rocks (*Aus*) outcrop 1 to 2.5 km north of Bridal Well, and are found in mineral exploration drillholes into the Honeymoon Well nickel deposit west of Honeymoon Well and about 2 km west of Kingston Well. These rocks are massive serpentinites in which no primary igneous texture can be recognized. There are rare, fresh exposures of serpentinized peridotite (*Aup*), which, together with serpentinized dunite (*Aud*), is commonly seen in drillholes. Both are typically weakly foliated, fine- to medium-grained, granular rocks, with well-preserved cumulate textures. The serpentinized dunite shows relict adcumulate textures (Fig. 6), whereas the serpentinized peridotite is typically mesocumulate textured. Both rock types are commonly silicified. Small exposures of serpentinized, mesocumulate-textured peridotite are seen about 2 km west-southwest (AMG 169586) of No. 1 Well, where there is also a costean into bedrock. The rock is fresh to moderately weathered, with pale-green olivine relicts from 1 to 5 mm across and a greenish-black matrix. Rock chips of serpentinized dunite from drillholes through sedimentary rocks of the Finlayson Member on the Finlayson Range (AMG 150637) are fresh, olive-green to black, and composed of tightly packed relict olivine crystals about 1 mm across, now pseudomorphed by serpentine, with minor, opaque-oxide-rich interstitial material.

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

Metamorphosed mafic rocks constitute a major component of the greenstones on WILUNA, and are widely distributed throughout the area (Fig. 3). Mafic rock types include amphibolite, metabasalt, metagabbro, and metasedimentary rocks of mafic igneous provenance. Subdivision of the mafic rocks is primarily based on variations in mineralogy and textural characteristics, but includes mappable units based on structural style and association.

Very fine grained or highly weathered mafic rocks have been mapped as undivided mafic rocks (*Ab*). Metabasalt with abundant intrusions of metagabbro (*Abr*) has been distinguished near Mount Way. Mafic rocks interleaved with minor granitoid rocks (*Abg*) adjacent to a fault east of Mount Way have also been shown as a separate unit. Fresh metabasalt of mainly tholeiitic composition (*Abv*) is abundant around Mount Way and east of the Erawalla Fault to the northeast of Bridal Well. Metamorphosed plagioclase-phyric basalt (*Abp*) may have relict intersertal texture. Fine-grained amphibolite (*Aba*) forms extensive outcrops northeast of Bridal Well, and strongly foliated metabasalt (*Abf*) is found in and near major faults and shear zones.

Metamorphosed high-Mg basalt (*Abm*) is well exposed at a number of locations in the Wiluna mining area. This metabasalt is characterized by the presence of pyroxene-spinifex texture in which relict pyroxene needles are commonly set in a finer grained matrix that was originally composed mainly of pyroxene and plagioclase (Fig. 7). Randomly oriented, acicular amphibole tremolite–actinolite pseudomorphs after igneous pyroxene may be up to 9 mm in length, but are typically finer grained. High-Mg basalt can be seen in several openpits at Wiluna (e.g. AMG 247537), where well-developed pillow structures are commonly preserved (Fig. 5). The pillow structures dip steeply, and young, to the west.

Metamorphosed coarse-grained mafic rocks (*Ao, Aog, Aod, Aogf, Aoh*)

The coarser grained metamorphosed mafic rocks are shown as undivided (*Ao*) where mainly medium grained or deeply weathered. These rocks are typically poorly exposed in the northern half of WILUNA, where they have also been sampled in a number of drillholes.

Medium- to coarse-grained metagabbro (*Aog*) is well exposed in the southeastern corner of WILUNA, and shows considerable variation in mineralogy, primary texture, grain size, and degree of deformation. The metagabbro is principally composed of amphibole after pyroxene, with subordinate amounts of plagioclase as well as accessory magnetite. Metaleucogabbro, containing more than 65% leucocratic minerals, and metamorphosed quartz gabbro are minor variants. About 2.5 km southeast (AMG 503119) of Mount Way, the gabbro is medium grained and consists of about 60% ferromagnesian minerals, now amphibole, and about 40% plagioclase. In some exposures in this area, the gabbro has intruded the adjacent basalt. For example, there are fragments of metabasalt in a metagabbro unit north of a track about 1.2 km southwest of the Lake Way Homestead. Metadolerite or microgabbro (*Aod*) consists of about 30 to 40% plagioclase with a grain size of about 1 mm or less.

In weakly deformed metagabbro, the pseudomorphous replacement of igneous minerals during metamorphism has resulted in the preservation of much of the primary texture. These rocks typically show relict subophitic and intergranular textures, and may be markedly inequigranular. In contrast, strongly deformed metagabbro (*Aogf*) characteristically contains highly strained, relict individual grains or aggregates of pyroxene and plagioclase enclosed by a finer grained, foliated, and completely recrystallized matrix.

The dominant mafic rock type in higher grade parts of the greenstone sequence, commonly within the granitoids, is foliated medium- to coarse-grained amphibolite (*Aoh*) composed mainly of acicular hornblende and plagioclase. There are good exposures of

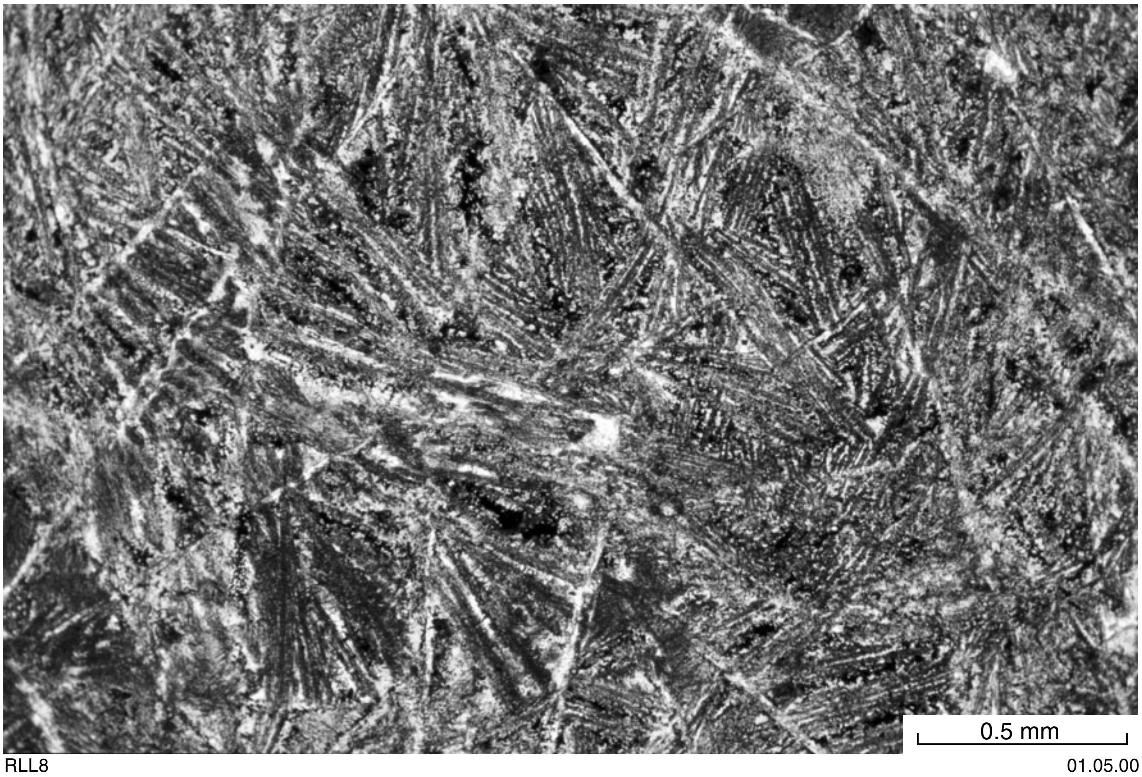

Figure 7. Metamorphosed high-Mg basalt (GSWA 121806; AMG 244541), showing the typical spinifex texture of acicular amphibole pseudomorphs after pyroxene (plane polarized light)

coarse amphibolite in the western part of WILUNA, between 5 and 10 km southwest of Little Diorite Well. The largest mapped metagabbro body in this area is about 1 km long and up to 400 m wide. Here, exposures of fresh, weakly foliated metagabbro (AMG 036322) are dark greenish-grey and speckled white, with a grain size of 2 to 4 mm. There is abundant quartz-vein development close to the unexposed contact with granitoid country rock to the east. The western margin of the body is fine grained and in contact with strongly foliated granitoid rocks with thin (centimetre-scale) quartz veins. The strongly deformed zone is 2 to 4 m wide, with granitoid rocks farther to the west becoming gradually less strongly deformed. Elias and Bunting (1982) noted thin doleritic offshoots within granitoid rocks in this area. These features, and the fine-grained margins of the metagabbro, indicate that the mafic body intruded the granitoid rocks. This suggests that these mafic bodies may be substantially younger than the main supracrustal sequence.

Metamorphosed felsic volcanic and volcaniclastic rocks (*Af, Afv, Aft, Afs, Aff, Afi, Afip*)

Although poorly exposed over most of the sheet area, metamorphosed felsic rocks form a substantial part of the greenstone succession on WILUNA. The most abundant exposures of felsic rocks are in the central part of the sheet area, mainly along and east of the Erawalla Fault. Felsic rocks are commonly associated with metasedimentary rocks.

Metamorphosed felsic volcanic and volcaniclastic rocks are shown as undivided (*Af*) where they are rich in relict quartz and plagioclase crystals, but relict textures are not sufficiently well preserved to allow determination of a more specific protolith. These rocks are typically weathered. Where primary textures can be recognized, they are shown as metamorphosed felsic volcanic rocks (*Afv*) and felsic tuff (*Aft*). Felsic rocks have been mapped as felsic schist (*Afs*) where they are strongly deformed and recrystallized, and consist of white mica, quartz, and plagioclase, with relict, partly recrystallized quartz grains enclosed by the foliation.

Thin beds of metamorphosed felsic rocks are a common feature in the metabasalt and metadolerite of the Mount Way area. The beds are up to a few metres thick and, in some instances, can be traced for more than 1 km along strike on aerial photographs. Foliated, metamorphosed felsic rocks (*Aff*) and felsic schist (*Afs*) have also been distinguished in this area.

Outcrops of felsic tuff (*Aft*) include eutaxitic metatuff about 5 km northwest (AMG 161636) of No. 1 Well. The rock contains small, euhedral relicts after feldspar pyroclasts up to 1 mm across and, given the absence of quartz crystals, is of probable intermediate composition. Nearby, exposures of intermediate ignimbritic tuffs contain relict euhedral to subhedral feldspar clasts, and pumice lapilli up to 5 mm long (e.g. AMG 167638; Fig. 8). Metamorphosed tuffaceous felsic volcanic and volcaniclastic rocks (*Aft*) east of Prospector Well are light-coloured clastic rocks, locally with planar or graded bedding. Metamorphosed felsic clastic rocks (*Aft*) with grain sizes in the sandstone and siltstone range, about 1.5 km southeast (AMG 262367) of Camel Soak, may be pyroclastic or tuffaceous in origin.

Metamorphosed intermediate volcanic rock (*Afi*), consisting of grey, porphyritic felsic rock with an aphanitic groundmass, is exposed west of two low hills about 7 km northeast of Bridal Well (e.g. AMG 314331). Mainly euhedral phenocrysts of altered plagioclase are 0.5 to 3 mm across and make up 5 to 10% of the rock. Similar rocks are found about 4 km west (AMG 149601) ofNo. 1 Well, where reddish-brown, highly weathered, volcanic rock, with an aphanitic groundmass and pseudomorphs after plagioclase up to 3 mm long, has been designated as porphyritic andesite (*Afip*).

Metasedimentary rocks (*As, Ash, Asq, Asf, Asd, Ac, Aci*)

Metasedimentary rocks are a minor component of the Wiluna greenstones, forming thin, discontinuous layers within mafic and felsic units. Protoliths ranged from claystone through to sandstone, and included minor dolomite. Most of the metasedimentary rocks are shown as undivided (*As*) on the map as they are deeply weathered and very fine grained.

Fine-grained metasedimentary rocks (*Ash*) include shale, siltstone, and fine-grained sandstone. Where these rocks have been more strongly deformed and metamorphosed, they may include slate, phyllite, and quartz–mica schist. Fine-grained metasedimentary rocks are typically not well exposed, but may be present as thin beds in mafic-dominated sequences, or as thicker sequences associated with metamorphosed chert and banded iron-formation (e.g. around Deep Bore in the west). Around Capellis Find gold mine, and beneath the Proterozoic unconformity west and northwest of No. 1 Well, the metasiltstone is typically very thinly bedded to laminated, and grey to light grey in colour. No younging indicators could be identified. Quartzite (*Asq*), exposed southwest (AMG 101573) of Capellis Find, is light grey to grey, with well-developed centimetre-scale bedding, and a grain size of around 0.1 to 0.2 mm. In places, associations, textures, and mineralogy suggest that sedimentary rocks may have a volcaniclastic origin (*Asf*).

Metamorphosed carbonate-rich sedimentary rocks, mainly metadolomite (*Asd*), which is locally strongly foliated, are found in an area about 5.5 km east-northeast of Bridal Well (e.g. AMG 310310). These rocks contain a shaly or silty clastic component.

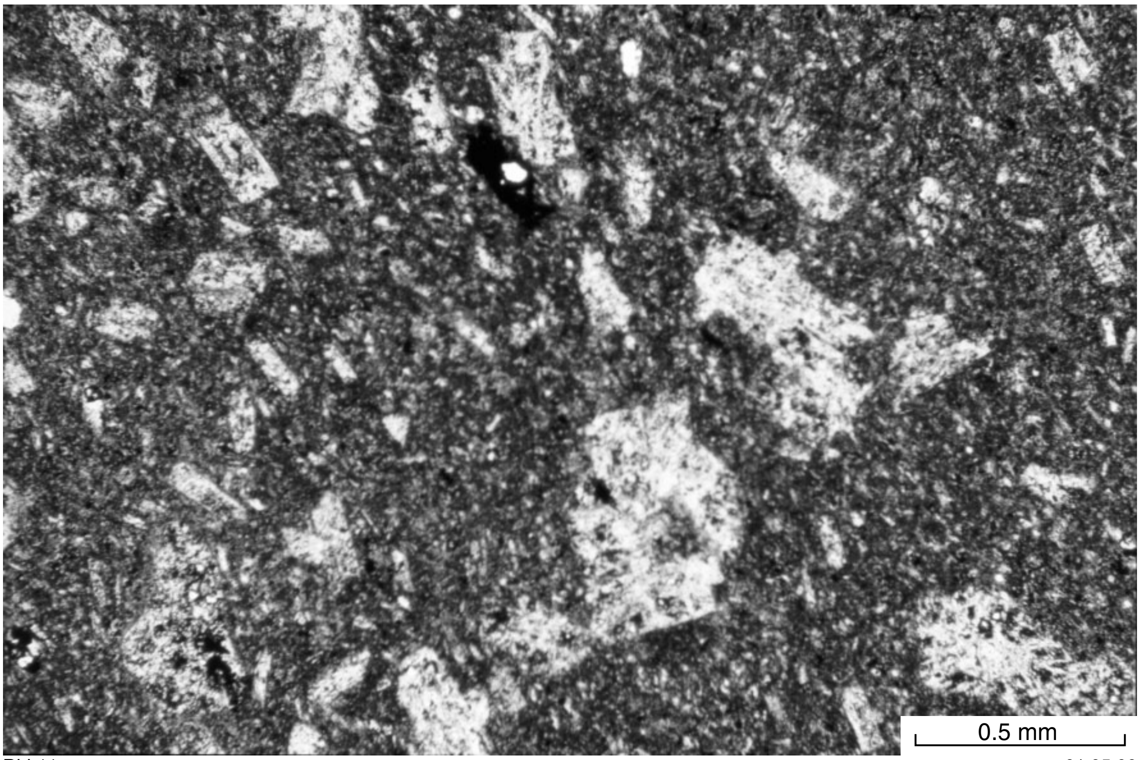

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Figure 8. Metamorphosed intermediate ignimbritic tuff (GSWA 121831; AMG 167638), showing shardic crystals and relict feldspar clasts in a recrystallized ash matrix (plane polarized light)

Metamorphosed banded chert (*Ac*) forms locally prominent, laterally extensive strike ridges, mainly in the Matilda domain and within the metasedimentary and felsic sequence adjacent to, and east of, the Erawalla Fault. The metachert is typically ferruginous with well-developed lamination and layering, 1 to 30 mm thick, defined mainly by variations in iron-oxide and silica content. About 3.5 km east (AMG 251314) of Mount Lawrence Wells, light-grey exposures of banded siliceous metasedimentary rocks (*Ac*) with centimetre-scale layering contain much less iron than the banded iron-formation unit to the west.

Metamorphosed banded iron-formation (*Aci*) is a distinctive, fine-grained, very siliceous rock with distinctive black and dark-red to red–brown laminations rich in iron oxides. The relationship of the banded iron-formation to the banded metachert units is uncertain, but it seems likely that they are facies equivalents. Banded iron-formation is well exposed in the low hills north and east of Bridal Well.

Low-grade metamorphic rocks (*All, Alqf, Alqm*)

Chlorite schist (*All*), a major rock type in the Coles mining centre, is commonly deeply weathered. This rock type (Fig. 9) may be a product of strong deformation of high-Mg basalt. Quartz–feldspar schist (*Alqf*) and quartz–muscovite schist (*Alqm*), possibly derived from felsic volcanic or sedimentary rocks, are abundant near the Erawalla Fault, east of Bridal Well.

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

The WILUNA greenstones are flanked to the northeast and southwest by large areas of Archaean granitoids. These rocks are extensively covered by sand sheets and, where exposed, typically deeply weathered. Magnetic images suggest that the granitoids northeast of the Wiluna domain are interleaved with greenstones in an unexposed zone about 10 km wide (Figs 3 and 4). Most granitoids range from monzogranite to granodiorite in composition. The broad areas of granitoid rocks that occupy the northeastern and southwestern parts of WILUNA were probably emplaced during or shortly after the D_2 regional folding event of Farrell (1997).

Undivided granitoid rocks (*Ag*) are typically deeply weathered. In the northeastern part of WILUNA, northeast of Scorpion Bore, moderately to highly weathered, foliated fine-grained granitoid rocks have been intruded by quartz veins and an easterly trending mafic dyke. The granitoid is locally coarsely porphyritic, with alkali feldspar phenocrysts up to 20 mm across, and contains rare late pegmatite and aplite veins.

Where granitoids are fresh, monzogranite (*Agm*), typically containing biotite, is the dominant granitoid rock type. The monzogranite is fine to medium grained, and composed of strained and partly recrystallized quartz, plagioclase, K-feldspar, and biotite, with accessory clinozoisite, sphene, apatite, and ilmenite. Fresh, fine- to medium-grained monzogranite is exposed in low hills

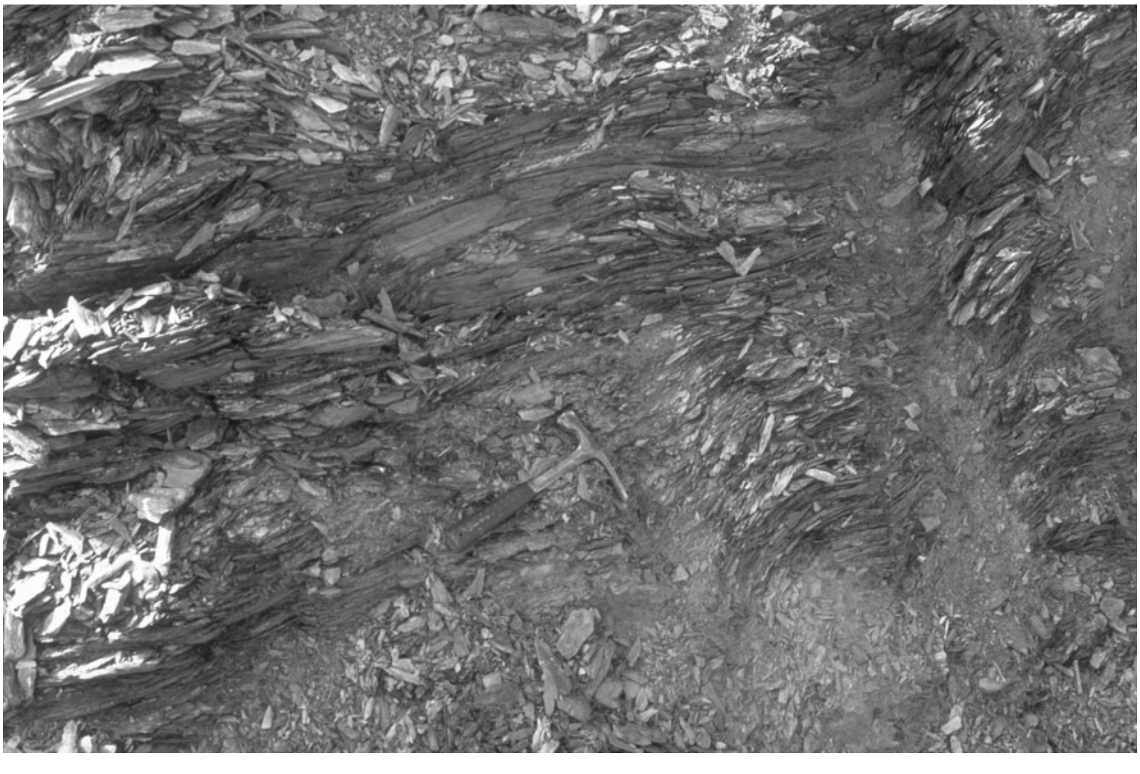

Figure 9. Exposures of chlorite schist in one of the Matilda openpits (AMG 226383)

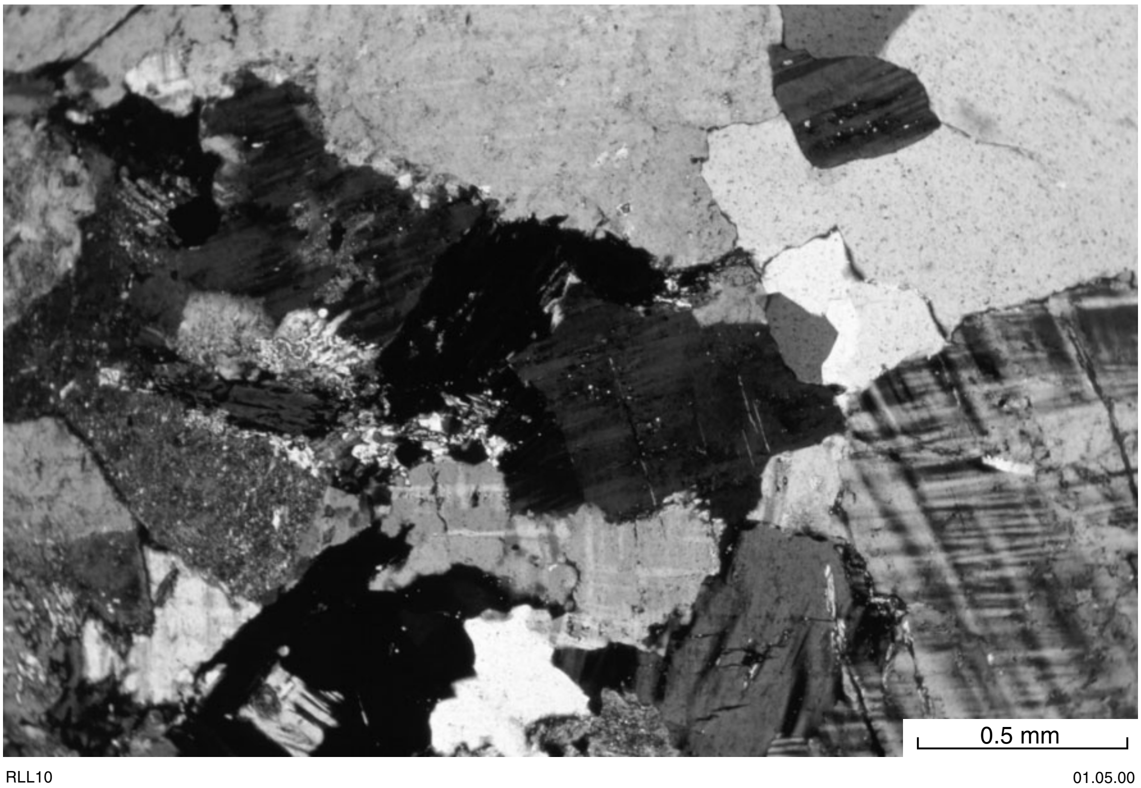

Figure 10. Textural characteristics of fine- to medium-grained biotite monzogranite, 5.5 km northeast of Scorpion Bore (GSWA 121850; AMG 455616; plane polarized light)

5.5 km northeast (AMG 455616) of Scorpion Bore. The rock is weakly foliated (Fig. 10).

Deformed granitoid rocks (*Agf*) are most abundant at or near granite–greenstone contacts. These rocks are mainly deformed varieties of the granitoids found throughout the region, and therefore are most commonly monzogranitic to granodioritic in composition. Granitoid rocks in the Mount Wilkinson – Mount Lawrence Wells area show varying degrees of deformation, in part related to proximity to the contact with the greenstones. However, intense deformation can be found at some distance from the contact. Granitoid rocks are strongly foliated on the northern flanks (AMG 179347) of Mount Wilkinson, adjacent to the massive quartz veins along the granite–greenstone contact. Exposures of deeply weathered granitoid rock southwest (AMG 214314) of Mount Lawrence Wells contain a pronounced, northerly plunging quartz-rodding lineation.

Where strongly foliated granitoid rocks are tectonically interleaved with metamorphosed mafic rocks (*Agb*), mostly amphibolite, both rock types are typically strongly deformed with a well-developed foliation. These rocks are mainly near granite–greenstone contacts.

Quartz veins (*q*)

Quartz veins are abundant in both the greenstones and granitoids. The most common variety, composed of massive milky quartz, is typically very fractured and trends subparallel to the regional foliation. This vein type is abundant in the Wiluna mining centre, and both north and east of the Wiluna township.

The second type of quartz vein is largely undeformed and comprises interlocking milky quartz crystals up to 12 cm in length. These veins commonly lie at a high angle to the regional foliation, and probably formed by open-space crystallization in late-stage extensional fractures. These are well exposed in easterly trending ridges in the sandplain east of Wiluna (e.g. AMG 437637; Fig. 11), where they cut the foliated granitoid country rock.

Mafic and ultramafic dykes (*Ꝑdy*)

East-southeasterly trending, highly magnetic linear features that cut across the regional trends on magnetic images (Fig. 4) are interpreted as Proterozoic mafic and ultramafic dykes (*Ꝑdy*). Hallberg (1987) described the common features of these bodies, which have been identified in outcrop at two localities on WILUNA.

A line of corestones and exposures of a mafic dyke lies about 4 km northeast of Scorpion Bore, in an area otherwise dominated by weakly foliated, fine-grained granitoid rocks. A thin section of the dyke (Fig. 12) shows it to be distinctly porphyritic with plagioclase phenocrysts

Figure 11. Easterly trending quartz-vein ridge in the sandplain east of Wiluna (AMG 437637)

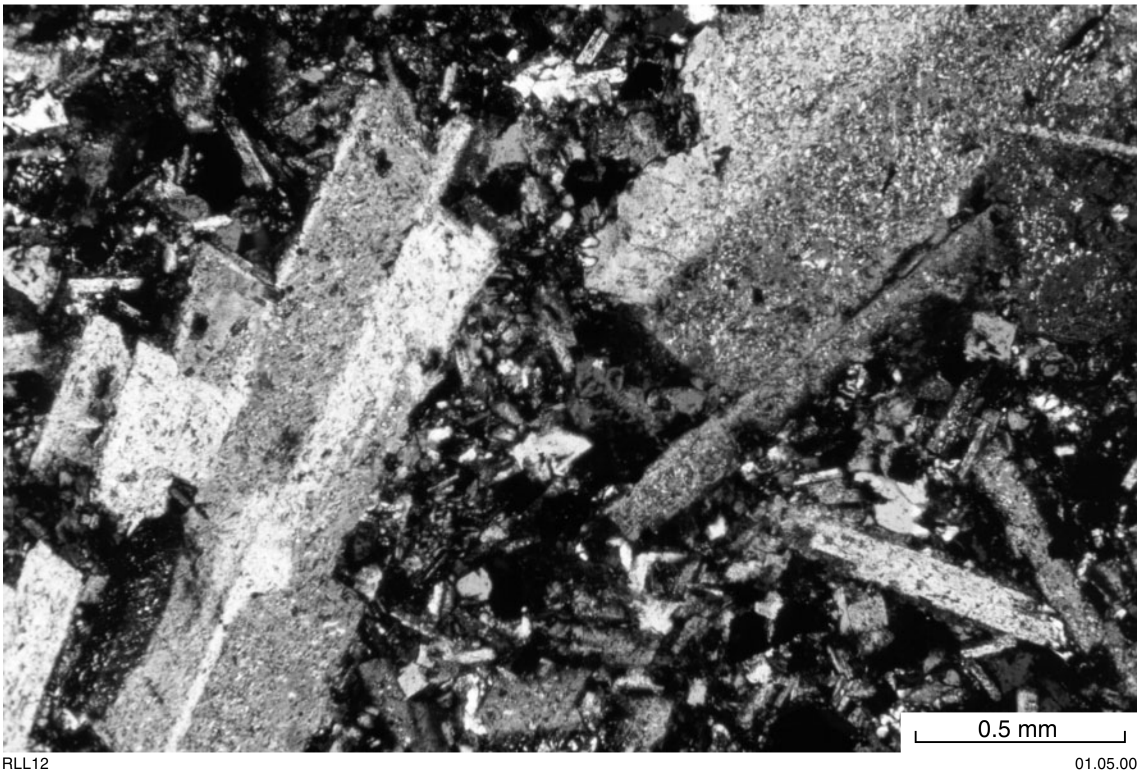

Figure 12. Textural characteristics of a Proterozoic porphyritic mafic dyke (GSWA 124196; AMG 451594), about 4 km northeast of Scorpion Bore (plane polarized light)

up to about 3 mm long. Two varieties of dykes have been described in this area by Elias and Bunting (1982) — a black, fine-grained dolerite, and a pink, medium-grained granophyre that is probably a differentiate of the dolerite.

At the northern end (AMG 249516) of the West Lode openpit, a fine-grained, pale greenish- to pinkish-grey mafic dyke is about 10 m wide and trends at about 110° (Fig. 13). It is steeply inclined to the north, and has an aphanitic margin in transgressive contact with the high-Mg metabasalt country rock.

Proterozoic sedimentary rocks

Sedimentary rocks that form hills and escarpments in the northwestern and western parts of WILUNA have been redefined in terms of the recently defined Proterozoic sequences elsewhere in the region (Occhipinti et al., 1997; Pirajno et al., 1998). These strata dominantly comprise flat-lying to gently dipping clastic (*Ꝑyjf*) and carbonate (*Ꝑyjb*) sedimentary rocks, although the carbonates are now completely replaced by silica. In addition, unassigned Proterozoic rocks (*Ꝑs*) have been identified in the Mount Lawrence Wells – Mount Wilkinson area south of the Wiluna township, and in the sandplain east of the Wiluna township.

Yerrida Group

Juderina Formation

The Palaeoproterozoic rocks in the region have been divided into the Yerrida, Bryah, Padbury, and Earaheedy Groups (Occhipinti et al., 1997; Pirajno et al., 1998), of which only the probable oldest, the Yerrida Group, has been recognized on WILUNA. The Yerrida Group has been further subdivided into the six formations of the Windplain and Mooloogool Subgroups. Only the Juderina Formation of the Windplain Subgroup, comprising the Finlayson and Bubble Well Members, outcrops on WILUNA. The Juderina Formation is equivalent to the 'Finlayson Sandstone' of Elias and Bunting (1982).

Finlayson Member (Ꝑyjf)

The Finlayson Member is the basal unit of the Juderina Formation (Occhipinti et al., 1997), and unconformably overlies the granite–greenstone terrain of the Archaean Yilgarn Craton. It is heterolithic, but predominantly comprises mature quartz arenite intercalated with shale and siltstone, minor sublitharenite, and conglomerate. The colour is dominantly brown to reddish brown in weathered exposures, whereas the fresh rock is typically pale grey to reddish brown. The Finlayson Member on WILUNA is characterized by trough cross-bedded and ripple-marked, fine- to medium-grained, well-bedded arenite, with thin conglomerate intervals. The abundant ripple marks include

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Figure 13. Mafic dyke at the northern end of the West Lode openpit (AMG 249516), about 10 m wide, trending 110°, steeply inclined to the north, with an aphanitic margin in contact with the high-Mg metabasalt country rock. The dyke is in the centre of the frame, behind and to the right of the vehicle

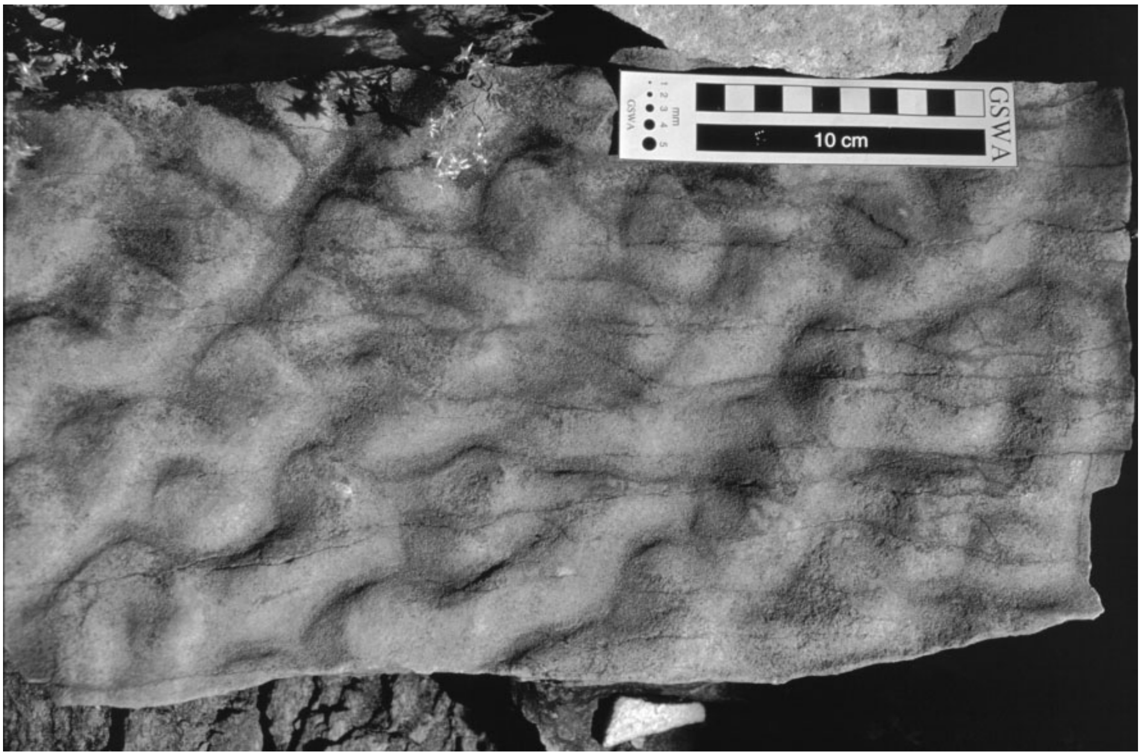

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Figure 14. Block of Finlayson Member sandstone (AMG 145600), with flat-topped interference ripples indicating deposition in an intertidal environment

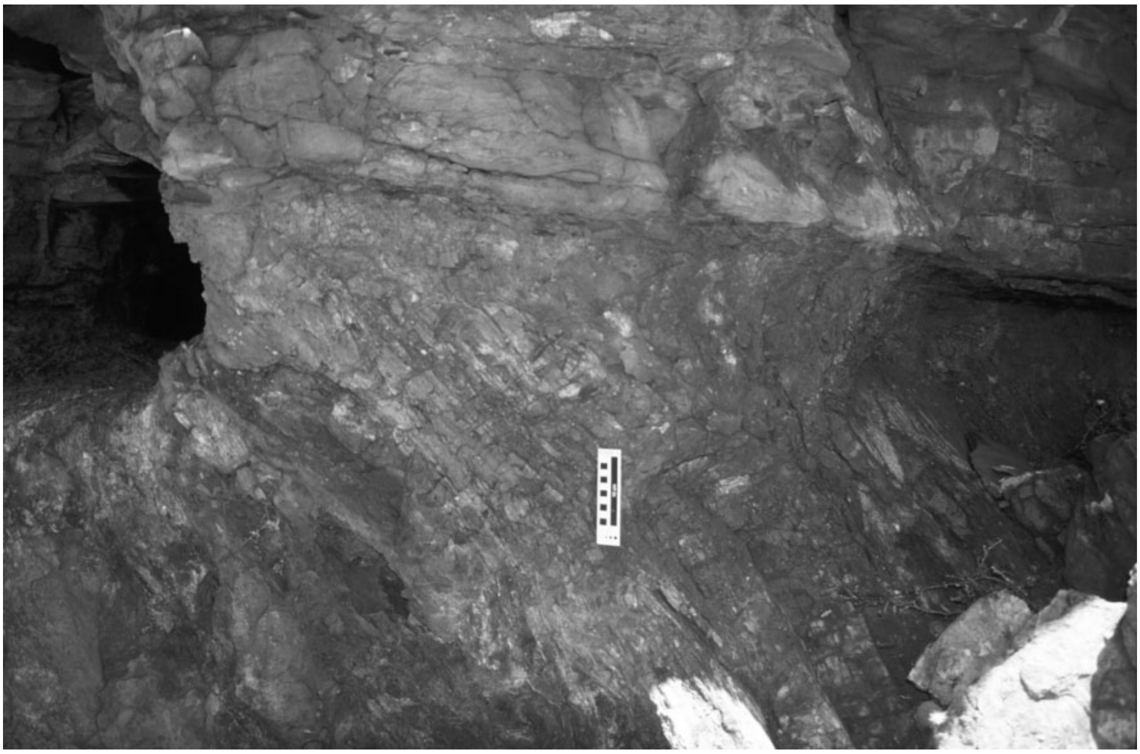

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Figure 15. Basal unconformity to the Finlayson Member exposed about 5 km west of No. 1 Well (AMG 145600). Well-bedded arenite overlies steeply dipping Archaean metasiltstone

areas of symmetrical ripples and interference ripples (Fig. 14), which suggest deposition in a shallow-marine to intertidal environment.

The Archaean–Proterozoic unconformity is well exposed about 5 km west (AMG 145600) of No. 1 Well, where well-bedded arenite overlies steeply dipping, finely laminated, folded Archaean metasiltstone. At this locality, the unconformity is planar, with no basal conglomerate or grain-size variation at the base of the Finlayson Member (Fig. 15).

Bubble Well Member (ⱣYjb)

Although the Bubble Well Member (*ⱣYjb*) is widespread and mainly present towards the top of the Juderina Formation, it is probably lensoidal and intercalated with the Finlayson Member down to the unconformity with the Archaean basement. The Bubble Well Member has a distinct lithology comprising chertified carbonate and evaporitic sediments, abundant microbial laminite, minor argillite, dolostone, and arenite, and chertified stromatolitic carbonate (Occhipinti et al., 1997; Pirajno et al., 1998).

Around Mount Pool, north of the Wiluna township (e.g. AMG 187651), exposures of massive, poorly bedded, locally brecciated chert locally contain acicular, radiating silica pseudomorphs after gypsum. In the same area (e.g. AMG 190649), exposures of a northerly dipping succession of arenite, mudstone, and probable silicified evaporites of the Bubble Well Member overlie well-bedded, reddish-brown weathered, fine-grained arenite of the Finlayson Member.

Other probable Proterozoic sedimentary rocks (Ᵽs)

Outliers of flat-lying rocks that extend from Mount Wilkinson to north of Mount Lawrence Wells, unconformably overlying the Archaean granite–greenstones, have been assigned a Proterozoic age. Elias and Bunting (1982) correlated these strata with their 'Finlayson Sandstone' (now Juderina Formation). However, there is no direct evidence for the age of these rocks and it is possible that they could correlate with similar rock types of Neoproterozoic or Permian age in the Officer Basin to the east.

The unassigned Proterozoic sedimentary rocks on Mount Lawrence Wells and Mount Wilkinson were described by Bunting (1986) as quartz arenite and shale (with a few lenses of silicified stromatolitic carbonate near the top) to cream, pale-green or grey chalcedonic chert breccia. The quartz arenite was described as mature and medium to coarse grained, with variable amounts of feldspar and magnetite.

Mount Wilkinson is interpreted as being dominantly composed of silicified carbonates, and has a silcrete (*Czz*) capping. The rock associations are characteristic of neither the Bubble Well Member nor the Finlayson Member of the Juderina Formation. In addition, the strata are flat lying, in contrast to the gentle dips seen in the Bubble Well Member in the Finlayson Range. At the western end (AMG 113318) of Mount Wilkinson, there are exposures of pitted, siliceous and cherty rocks, probably including silicified carbonate, together with well-bedded (5–10 cm), flat-lying to very shallowly dipping arenites. Along the hill to the east are exposures of pale-grey, well-bedded, siliceous arenite and conglomerate (Fig. 16; AMG 180341). There are also siliceous breccias and well-bedded, locally chertified siltstones. The unconformity with underlying Archaean foliated granitoid rocks is poorly exposed at the southeastern end of Mount Wilkinson (AMG 180318), where the basal sedimentary unit is a quartz-rich breccia with angular vein-quartz clasts up to 5 cm across.

Mount Lawrence Wells (AMG 218319) is composed of massive chert breccia, with abundant chalcedonic banding in the clasts (Fig. 17), resting unconformably on Archaean granitoid rocks of the Yilgarn Craton. Just north of the summit, exposures of greenish-grey, well-bedded cherty mudstone, in a gently westerly dipping unit about 1 m thick, are similar to the Bubble Well Member south of Bubble Well. A breccia at the base of the succession and a prominent sandstone horizon on the western side of the scarp may be equivalent to the Finlayson Member, but have not been differentiated (Fig. 18).

Isolated outcrops of silicified, quartz-rich arenite and conglomerate (Fig. 19), about 3 km east (AMG 454569) of Scorpion Bore in the northeastern part of WILUNA, were assigned by Elias and Bunting (1982) to the 'Finlayson Sandstone'. They are now informally called the Ngangganawili conglomerate to differentiate them from the established stratigraphy to the north and west. The outcrop is in easterly trending ridges that rest unconformably on foliated Archaean granitoid rocks. Bedding is not well displayed, but is probably sub-horizontal. The ridges trend parallel to several wide quartz veins in the underlying granitoid rocks. Silicification of these overlying sedimentary rocks has occurred along fractures related to quartz-vein emplacement. These sedimentary rocks may have formed in small extensional basins along the same trend as the fractures. The Kaluweerie Conglomerate of Allchurch and Bunting (1975) on DEPOT SPRINGS to the south (Wyche, 1998) contains similar rocks, has a similar trend, and is in a similar setting.

Structure and metamorphism

The structural evolution of the Archaean sequence on WILUNA is not well understood in detail due to the poor outcrop. However, structures have been documented in each of the major mining centres — in the Coles mining centre by Morgan and El-Raghy (1990) and Hagemann (1990a), and in the Wiluna mining centre by Hagemann (1990b) and Hagemann et al. (1992).

Farrell (1997) and Wyche et al. (1997) described four phases of Archaean deformation in reviews of the regional deformation history for the north Eastern Goldfields based on recent GSWA regional mapping. The first-

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Figure 16. Exposures of pale-grey, well-bedded, probable Proterozoic siliceous arenite and conglomerate, Mount Wilkinson (AMG 180341)

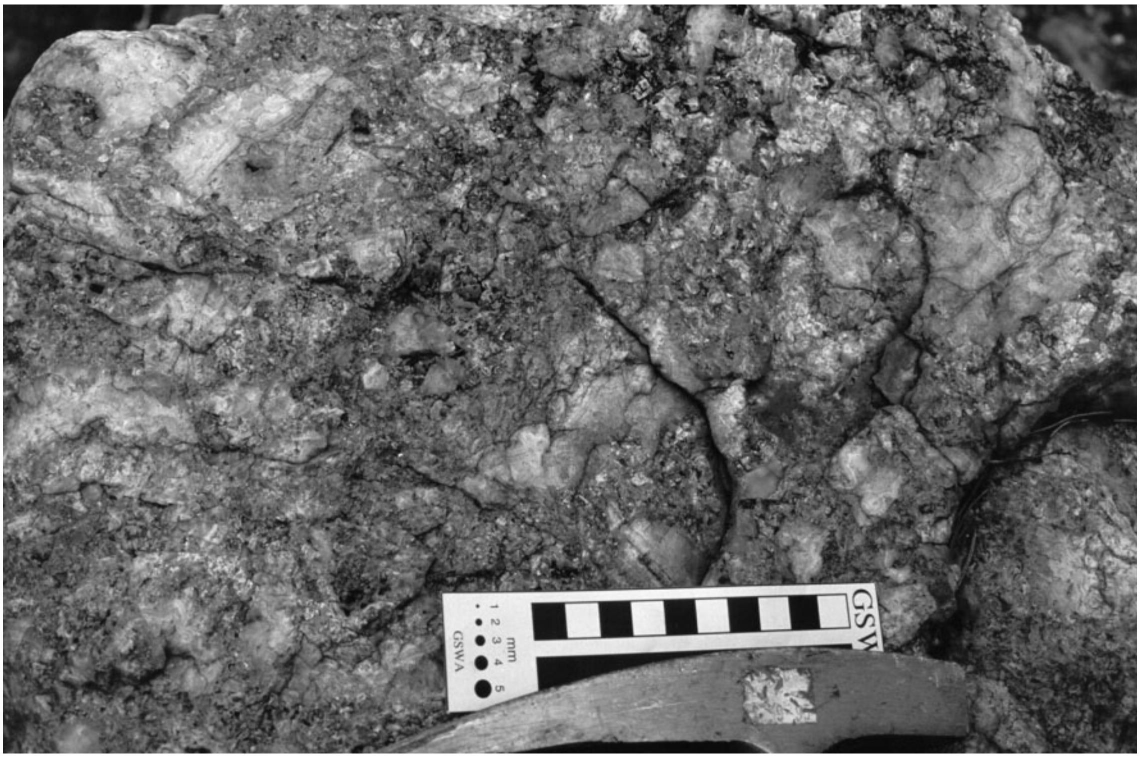

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Figure 17. Massive chert breccia, with abundant chalcedonic banding in the clasts, Mount Lawrence Wells (AMG 218315)

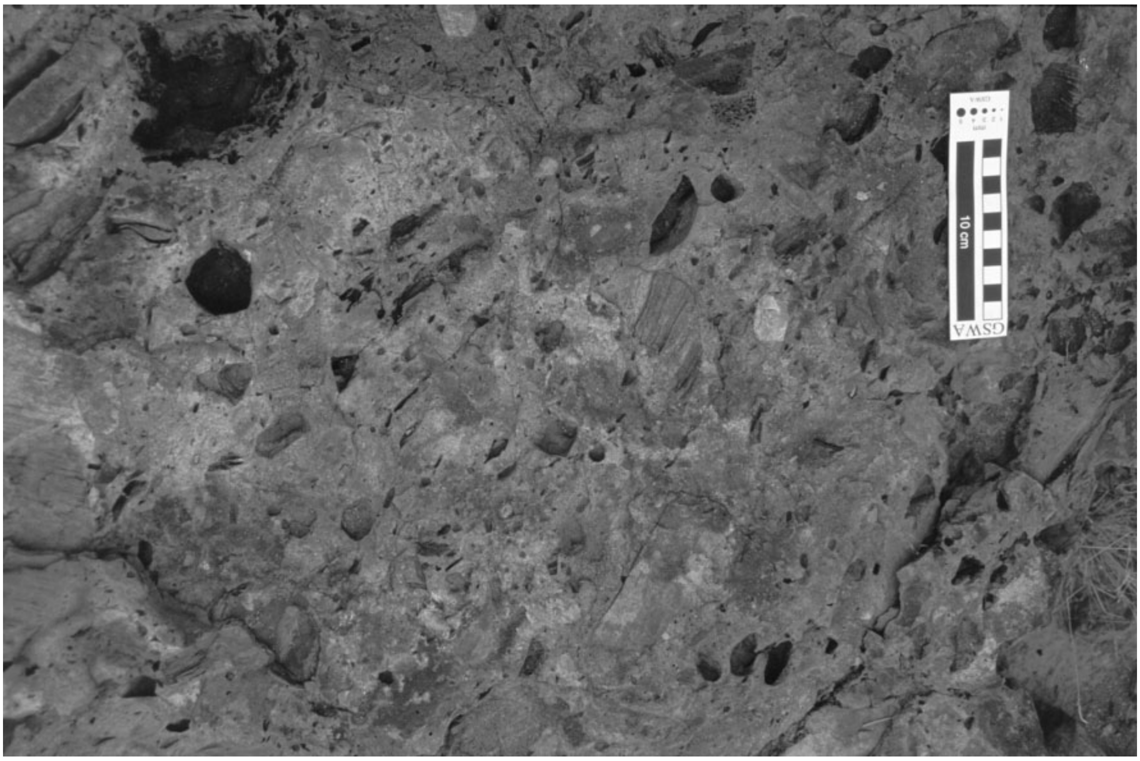

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Figure 18. Sedimentary breccia at the base of the Proterozoic succession, Mount Lawrence Wells (AMG 213318)

generation structures (D_1) have largely been overprinted by later deformation events, but are best preserved in gneisses adjacent to greenstones. The D_2 deformation event was associated with peak metamorphism and the major period of granitoid intrusion. Characteristic D_2 structures include a regionally extensive, steeply dipping, north-northwesterly trending foliation (S_2) with a moderate to steeply plunging mineral lineation (L_2). Chert units in high-grade areas typically have steeply plunging, tight to isoclinal intrafolial F_2 folds with a steeply plunging combined intersection–mineral lineation. The last major deformation event (D_3) was a progressive north-northeast shortening that produced shallowly plunging upright folds (F_3) and the major northerly to northwesterly trending shear zones such as the Perseverance Fault. It was this deformation that was largely responsible for the regional-scale structural architecture. The last recognized Archaean deformation (D_4) produced variously oriented, small-scale kinks and crenulations (Fig. 20). In addition, there are ?Proterozoic, regional-scale zones of brittle deformation that cut across all major rock units. Peak metamorphism probably coincided with widespread granitoid intrusion during or shortly after D_2.

According to Hagemann et al. (1992), the rocks that host the Wiluna gold deposits have undergone only very low grade metamorphism (prehnite–pumpellyite facies). They are among the lowest metamorphic grade rocks in the Yilgarn Craton (Binns et al., 1976). In contrast, rocks in the Matilda domain are of higher grade, typically to greenschist facies (Binns et al., 1976; Hagemann et al., 1990). The structures that host gold mineralization in each of the domains also have contrasting styles — those in the Matilda domain are dominated by ductile–brittle deformation (Kent and Hagemann, 1996), and those in the Wiluna domain are dominated by brittle deformation (Hagemann et al., 1992).

The sequence in the Wiluna domain strikes north-northwesterly and youngs towards the west. Although large-scale fold structures have not been identified in areas of poor outcrop, moderately plunging, small- to medium-scale folds (metre-scale to a few hundred metres across) west of Lake Way and east and southeast of Mount Way are probably equivalent to the D_2 structures of Farrell (1997).

The Erawalla Fault (Fig. 3) marks the boundary between the Matilda and Wiluna domains. Hagemann et al. (1995) proposed that the contrast in metamorphic grade and structural style across this feature suggests that the fault separates greenstone sequences from different crustal levels. Elias and Bunting (1982) and Hagemann et al. (1992) called the Erawalla Fault the Perseverance Fault. However, it is unlikely that the Erawalla Fault is the northern extension of the Perseverance Fault because the Perseverance Fault, where it has been mapped on Sir Samuel (Liu et al., 1998), marks the eastern boundary of the Agnew–Wiluna greenstones. The position of the Perseverance Fault on Wiluna is not well defined on magnetic images and the structure may break up into a set of fault splays in the southern part of the sheet area (Figs 3 and 4), or farther south on Mount Keith

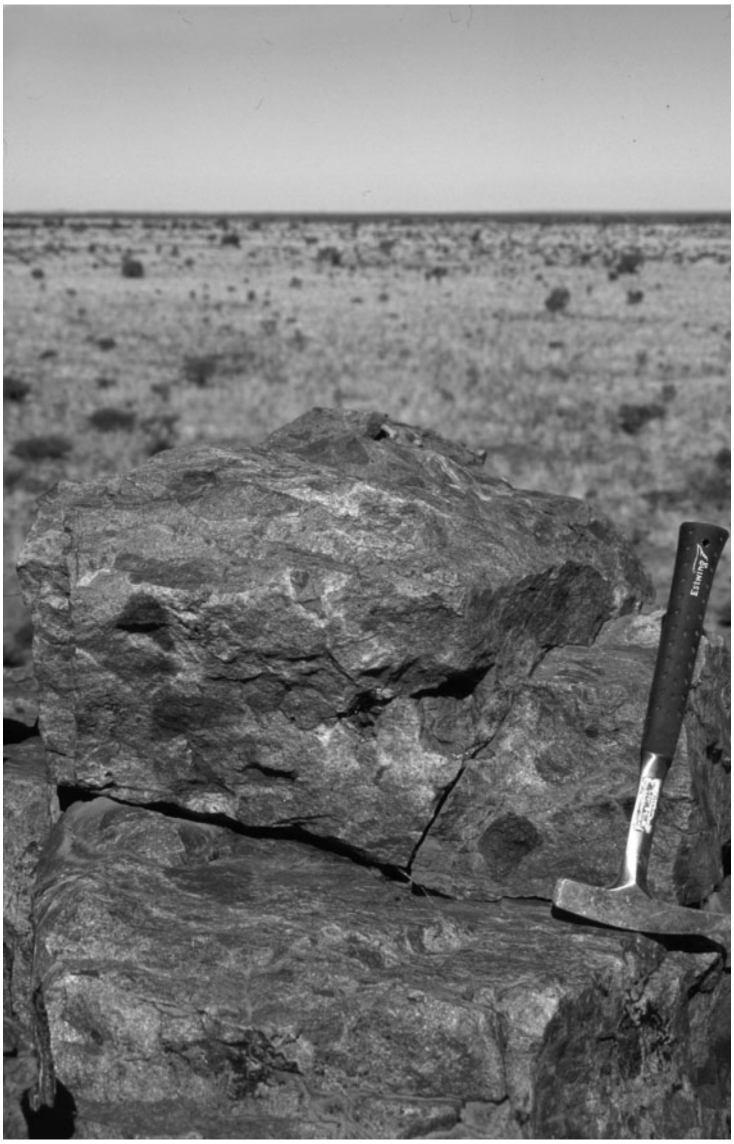
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Figure 19. Ngangganawili conglomerate; silicified, quartz-rich arenite and conglomerate, about 3 km east of Scorpion Bore (AMG 454569)

(Jagodzinski et al., 1997; Stewart and Liu, 1999). The Erawalla Fault is probably a D_3 structure of Farrell (1997). Hagemann et al. (1990) described a complex history of movement on the Erawalla (Perseverance) Fault involving normal (western-block-up) and sinistral movement, with some late dextral movement.

The Matilda domain is characterized by large-scale folds (Fig. 3) that are most evident on magnetic images (Fig. 4). A concealed anticline in the area around Freshwater Well is tight, about 5 km wide, and can be traced for a total length of nearly 30 km to the north and south. The fold axis plunges shallowly to the northwest. Rocks in the Matilda domain are not well exposed for the most part. However, strongly deformed rocks in the eastern part of the domain lie within a 600 m-wide corridor of north-northwesterly trending ductile(–brittle) shear zones — the Coles Find shear zone of Hagemann et al. (1990) and Kent and Hagemann (1996).

Late, ?Proterozoic fractures that trend in a commonly easterly direction across WILUNA coincide with quartz veins, mafic and ultramafic dykes, and, in the northeast, the Ngangganawili conglomerate.

Cainozoic regolith

Much of WILUNA is mantled by Cainozoic regolith deposits. They consist of residual, indurated deposits exposed by erosion, and a range of younger alluvial, eluvial, eolian, and lacustrine deposits. Individual regolith units have been mapped using field observations

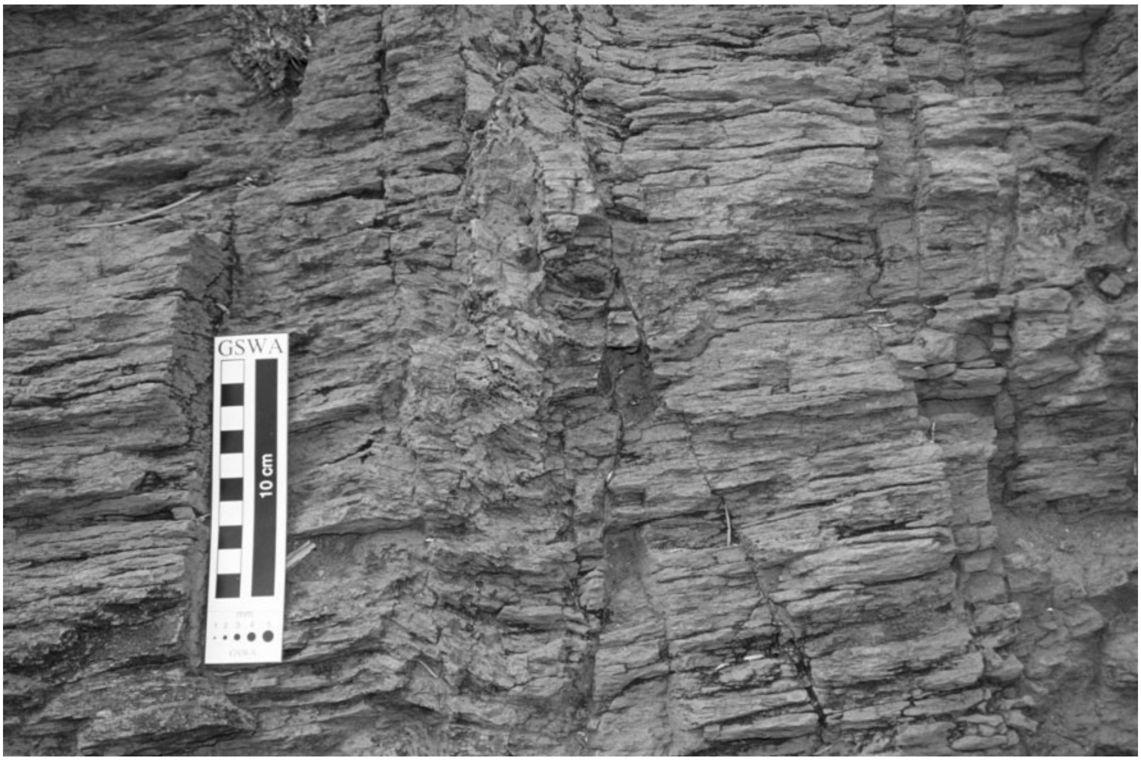

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Figure 20. Late-stage kinking and crenulation of earlier foliation in metamorphosed gabbro, about 4 km west of Gold Tooth Well (AMG 164431)

complemented by aerial photograph and Landsat TM image interpretation.

Residual duricrust and related chemical deposits are preserved mainly on low hills and breakaways. These are divided into lateritic duricrust (*Czl*), massive ironstone (*Czli*), calcrete (*Czk*), silcrete (*Czz*), and silica caprock over ultramafic and high-Mg mafic rocks (*Czu*). The massive ironstone units (*Czli*) are typically thin, ridge-forming units that may be deeply weathered relicts of original sedimentary rocks.

Undivided proximal slope or colluvial deposits are shown as colluvium (*Czc*). They are mapped separately where they are dominated by ferruginous saprolite and ironstone debris (*Czf*) or quartz-vein rubble and debris (*Czcq*). Proximal sand deposits over or close to exposures of deeply weathered granitoid rocks are also distinguished (*Czg*).

More-distal parts of the regolith are dominated by sheetwash (*Cza*) and sandplain deposits (*Czs*). Sheetwash deposits (*Cza*) are the most extensive regolith unit in areas of WILUNA underlain by greenstone. They consist of a thin layer of sand, silt, and clay over saprolite, and are gradational into sandplain deposits. Areas underlain by granitoid rocks are covered by extensive sandplains consisting of unconsolidated quartz sand and silt (*Czs*). Ridges of wind-blown sand are present locally.

The Lake Way drainage basin and associated major channels, part of the Carey Palaeoriver (Hocking and Cockbain, 1990), are dominated by playa deposits of unknown thickness that are still being deposited (*Czp*). The larger, gypsiferous dunes have been separately mapped (*Czd*).

Alluvium (*Qa*) of probable Quaternary age lies along fluvial channels and on floodplains that are currently active and cut into older regolith. These deposits grade laterally into older deposits, and may grade downstream into lacustrine sediments. The active fluvial system may also include small, mostly nonsaline claypans (*Qac*).

Economic geology

Gold

WILUNA lies within the Wiluna District of the East Murchison Mineral Field. Most gold production in the region, including from both openpit and underground operations, has come from the area south-southeast of the Wiluna township. Gibson (1908), Montgomery (1909), Talbot (1913), and Larcombe (1926) presented early descriptions of the geology and gold-mining activity. Ferguson (1998) provided a spatial index to historical mineral exploration activity on WILUNA, based on DME's open-file WAMEX database. Most historical gold production in the area (Table 1) has come from the Wiluna and Coles mining centres.

The Wiluna deposits (Hagemann, 1990b; Hagemann et al., 1992; Kent and Hagemann, 1996) are hosted by a

Table 1. Historical gold production on WILUNA up to 1999

Mining centre	*Mine group*	*Years mined*	*Ore (t)*	*Gold mined (kg)*	*Alluvial and dollied gold (kg)*	*Total gold production (kg)*
Coles	Black Adder	1920–1954	4 430.00	85.86	–	85.86
Coles	Matilda	?1989–1993	2 507 355.00	5 179.70	–	5 179.70
Coles	Other		5 500.00	46.85	0.65	47.50
Total			**2 517 285.00**	**5 312.41**	**0.65**	**5 313.06**
Wiluna	Black Swan	1898–1940	217 144.41	2 376.40	–	2 376.40
Wiluna	Brothers	1898–1911	3 603.75	91.95	–	91.95
Wiluna	Bulletin	1904–1925	13 480.80	134.30	–	134.30
Wiluna	Caledonia	1910–1935	2 857.91	69.65	–	69.65
Wiluna	Coolgardy Brilliant	1897–1905	21 734.78	230.47	–	230.47
Wiluna	Derwent	1898–1910	796.39	27.77	–	27.77
Wiluna	Essex	1897–1950	4 466.84	63.53	–	63.53
Wiluna	Florence No. 3	1898–1935	9 642.35	114.89	–	114.89
Wiluna	Golden Age Con. Ltd	1901–1904	43 201.34	614.32	–	614.32
Wiluna	Golden Age Lakeway	1897–1913	25 496.01	409.45	1.24	410.69
Wiluna	Golden Bracelet	1902–1916	1 717.55	62.16	–	62.16
Wiluna	Happy Jack	1909–1916	4 018.79	41.97	–	41.97
Wiluna	Just in Time	1897–1922	1 845.31	41.26	14.92	56.28
Wiluna	Lakeway G. F. Ltd	1900–1906	8 374.89	247.60	–	247.60
Wiluna	Monarch of the East	1898–1935	15 497.81	334.19	1.11	335.30
Wiluna	Moonlight	1908–1985	907 589.07	6 936.26	–	6 936.26
Wiluna	Try Again	1901–1912	2 911.09	72.65	0.07	72.72
Wiluna	Western Alluvials	1984–1988	976 279.00	5 949.63	–	5 949.63
Wiluna	Wiluna G. M. Ltd – Great Central Mines	(a)1910–1999	10 190 190.70	60 216.41	–	60 216.41
Wiluna	Wiluna – Wiluna G. M.	1989–1993	5 051 515.00	14 213.05	–	14 213.05
Wiluna	Wiluna Dumps	1989–1993	–	127.85	–	127.85
Wiluna	Brilliant	1923–1950	10 008.37	121.88	–	121.88
Wiluna	Jubilee	1935–1950	24 618.19	246.22	–	246.22
Wiluna	Squib	1906–1927	347 478.92	4 153.09	–	4 153.09
Wiluna	Other		6 985.05	1 489.98	1.54	1 491.52
Total			**15 611 454.32**	**83 836.54**	**18.88**	**83 855.42**

NOTE: (a) Wiluna production to September 1999

SOURCE: Department of Minerals and Energy's mines and mineral deposits information (MINEDEX) database

mafic-dominated sequence of very low metamorphic grade. The gold is associated with northerly and northeasterly trending brittle faults that formed late in the deformation history, and was probably deposited late in the structural history of the fault system. Arsenic and antimony have been produced from the Wiluna deposits as byproducts of gold extraction (Elias and Bunting, 1982).

The Matilda (or Wiluna South) deposits in the Coles mining centre (Morgan and El-Raghy, 1990; Hagemann, 1990a; Kent and Hagemann, 1996) are hosted by a series of north-northwesterly trending ductile(–brittle) shear zones. Gold mineralization probably occurred after peak regional metamorphism, but at the same time as the development of the ductile(–brittle) shear zones.

Nickel

There are major nickel sulfide deposits at Honeymoon Well, and indications of nickel mineralization associated with ultramafic rocks elsewhere on WILUNA.

The Honeymoon Well deposits lie within ultramafic rocks that are only rarely, very locally, exposed and are known mainly through extensive drilling programs and geophysical studies. They have been described by Donaldson and Bromley (1981) and Gole et al. (1996). Gole and Hill (1990) described the regional setting and detailed petrology and geochemistry of the komatiites, and Bourne (1996) described geophysical studies undertaken as part of the nickel exploration program. Nickel sulfides are found in two deposit types: as disseminated sulfides in olivine-rich cumulates, and as sulfide-rich rocks hosted by spinifex-textured flows (Gole et al., 1996). The indicated resource at Honeymoon Well in December 1995 was estimated at 158 Mt at 0.71% Ni in four deposits (using a 0.4% Ni cutoff grade and resources above 300 m depth), including a massive sulfide resource of 2.5 Mt at 3.36% Ni (Gole et al., 1996). The deposits have not yet been brought into production.

Minor nickel mineralization has been identified elsewhere in the Wiluna domain (Ferguson, 1998), probably associated with the northern extension of the ultramafic unit that hosts the deposits at Honeymoon Well.

Uranium

Butt et al. (1977) described the calcrete-hosted Lake Way uranium (carnotite) prospects. These deposits have been extensively investigated (Ferguson, 1998). Estimated resources (all resource types) at these deposits total about 9 Mt at average grades of 0.6 – 0.9 kg/t (data from DME's mines and mineral deposits information database, MINEDEX).

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Appendix

Gazetteer of localities

Locality	*AMG coordinates*	
	Easting	*Northing*
Black Swan gold mine	224414	7056106
Bridal Well (abd)	225600	7029300
Brothers gold mine	226280	7052734
Bubble Well (PD)	205400	7058600
Bulletin openpit	225700	7053500
Camel Soak	224800	7037500
Capellis Find gold mine	210700	7058300
Coles mining centre	222000	7038000
Deep Bore (abd)	209200	7035900
Enterprise gold mine	245100	7014600
Essex openpit	225300	7052300
Freshwater Well (abd)	212900	7046700
Gold Tooth Well (abd)	220600	7043700
Golden Age openpit	225800	7052500
Happy Jack openpit	225000	7052600
Honeymoon Well (abd)	243100	7022200
Jeffries Bore	211200	7056100
Kingston Well	242900	7016700
Lake Way Homestead	248300	7016800
Lake Way uranium prospect	237300	7043900
Little Diorite Well (abd)	208100	7039800
Matilda gold deposits (Wiluna South)	223000	7038000
Monarch of the East gold mine	223100	7057200
Moonlight openpit	224900	7053600
Mount Pool	220400	7061800
Mount Lawrence Wells	221800	7031900
Mount Way	248500	7013300
Mount Wilkinson	218100	7032000
No. 1 Well (abd)	219100	7059300
Prospector Well	225500	7034100
Scorpion Bore (abd)	242000	7057100
Squib openpit	225200	7053200
Try Again gold mine	224800	7055400
Warren Bore (abd)	236800	7045700
West Lode openpit	224900	7051500
Wiluna township	223500	7055500

NOTES: abd: abandoned
PD: position doubtful or uncertain

The WILUNA 1:100 000 sheet lies in the southwestern portion of the WILUNA 1:250 000 sheet. It covers granite–greenstones of the Eastern Goldfields in the Archaean Yilgarn Craton, and the southeastern margin of the Proterozoic Yerrida Basin. These Explanatory Notes complement the published 1:100 000 map and describe the various rock units, structure, metamorphism, and characteristics of the regolith. Also included is a discussion of the stratigraphy, geological history, and economic geology of the Archaean granite–greenstone terrain and the overlying Proterozoic sedimentary rocks.

Further details of geological publications and maps produced by the Geological Survey of Western Australia can be obtained by contacting:

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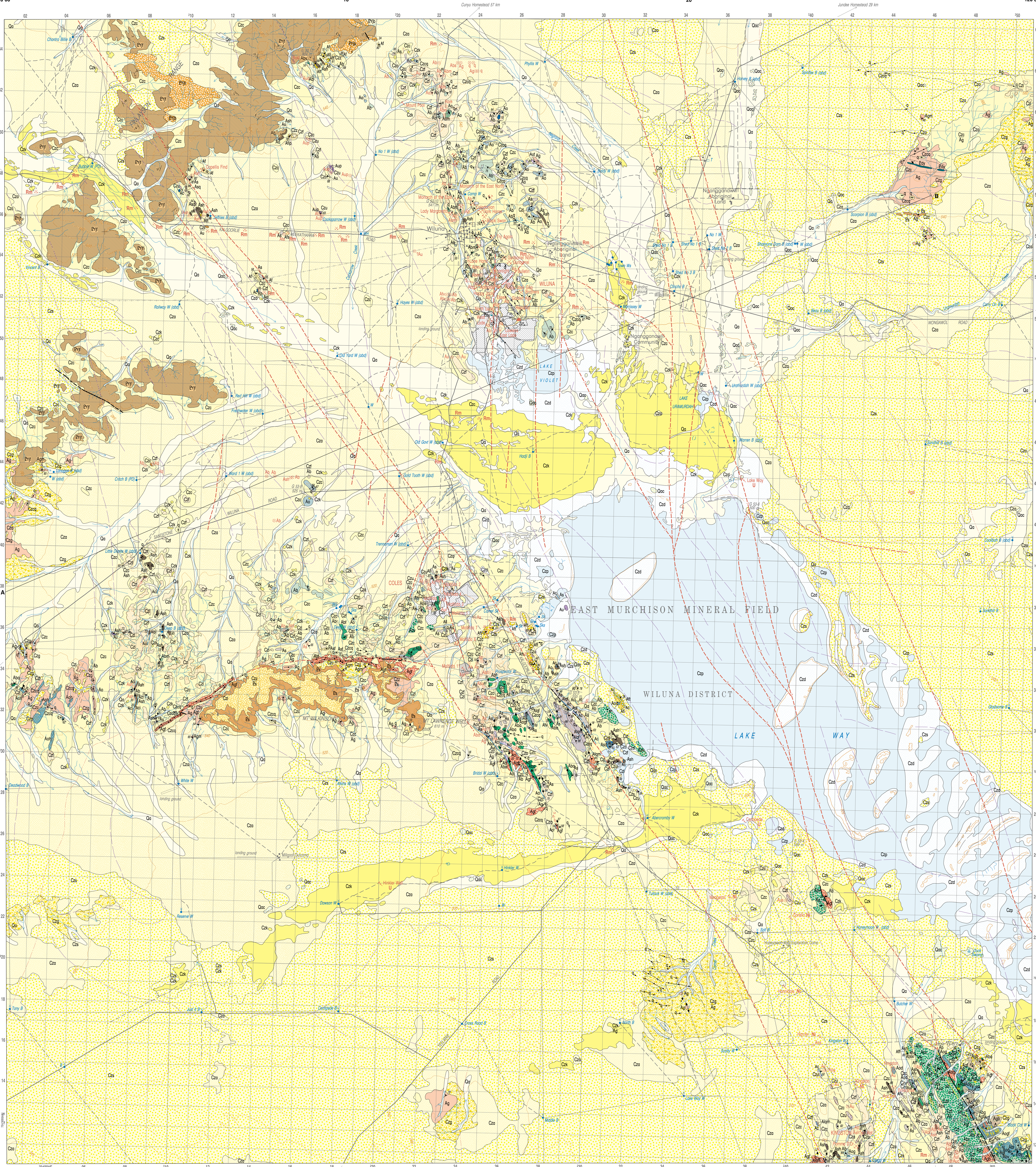
AUSTRALIA 1:100 000 GEOLOGICAL SERIES

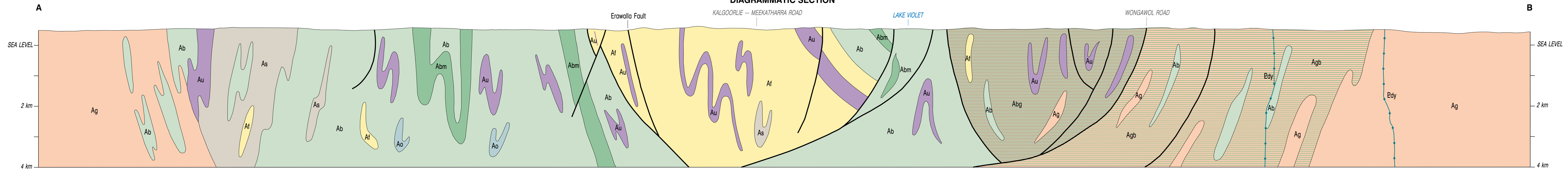
WILUNA

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

SHEET 2944



DIAGRAMMATIC SECTION



Reference

QUATERNARY

Qa — Alluvium—clay, silt, sand, and gravel in channels and floodplains
Qac — Clay and silt in claypans

PHANEROZOIC — CAINOZOIC

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

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

PROTEROZOIC

Ps — Conglomerate, quartz-rich sandstone, arkosic sandstone, and microbial laminates; commonly silicified and brecciated

Yerrida Group — Windplain Subgroup — YERRIDA BASIN

JUDERINA FORMATION
PYjf — **Finlayson Member:** mature, commonly ripple-marked quartz arenite
PYjb — **Bubble Well Member:** chert breccia and conglomerate; minor quartz arenite

Pdy — Mafic dyke

ARCHAEAN — YILGARN CRATON

q — Quartz vein

Ag — Granitoid rock, undivided
Agb — Foliated granitoid rock with minor lenses of mafic rock; gneissic banding locally developed
Agf — Foliated granitoid rock
Agm — Biotite monzogranite

All — Chlorite schist
Alqf — Quartz-feldspar schist
Alqm — Quartz-muscovite schist

As — Metasedimentary rock, undivided; includes felsic volcanic and volcaniclastic rock
Asd — Dolomite; metamorphosed
Asf — Felsic volcaniclastic rock; metamorphosed
Ash — Shale, minor siltstone and sandstone, metamorphosed; slate, phyllite, and minor quartz-mica schist
Asq — Quartzite
Ac — Siliceous sedimentary rock and chert; mainly grey and white banded; locally ferruginous and pyritic; metamorphosed
Aci — Banded iron-formation, metamorphosed

Af — Metamorphosed felsic volcanic, and volcaniclastic rock, undivided
Aff — Foliated felsic rock; metamorphosed
Afi — Intermediate volcanic rock; metamorphosed
Afip — Porphyritic intermediate volcanic rock; metamorphosed
Afs — Felsic schist
Aft — Felsic clastic rock, probably felsic tuff; metamorphosed
Afv — Felsic volcanic and volcaniclastic rocks; metamorphosed

Ao — Metamorphosed fine-to medium-grained mafic rock, undivided
Aoh — Amphibolite, medium and coarse-grained
Aod — Microgabbro; metamorphosed
Aog — Gabbro; metamorphosed
Aogf — Strongly foliated gabbro, metamorphosed

Ab — Metamorphosed very fine-grained mafic rock, undivided
Aba — Amphibolite
Abf — Foliated, metamorphosed mafic rock; mafic schist
Abg — Mafic rock intercalated with minor foliated granitoid rock; metamorphosed
Abm — High-Mg basalt; metamorphosed
Abp — Porphyritic basalt; plagioclase phenocrysts up to 20 mm; metamorphosed (subsurface only)
Abr — Basalt intruded by gabbros; metamorphosed
Abv — Basalt, mainly tholeiitic; metamorphosed

Au — Metamorphosed ultramafic rock, undivided
Auc — Talc-carbonate(-serpentine) rock; commonly schistose (subsurface only)
Aud — Dunite; metamorphosed (subsurface only)
Auf — Interleaved ultramafic and mafic schist
Aup — Peridotite; metamorphosed
Aur — Tremolite-chlorite schist (subsurface only)
Aus — Serpentinized ultramafic rock
Aut — Talc-chlorite(-carbonate) schist

Symbols

Geological boundary
- exposed
- concealed
- concealed, interpreted from aeromagnetic data

Structural symbols are numbered according to the sequence of deformation events, where known
Local deformation events
- D_1
- D_2
- D_3

Fault or shear
- exposed
- concealed
- concealed, interpreted from aeromagnetic data
- strongly foliated rock

Fold, showing trend and plunge direction
- anticline (Simplified Geology only)
- syncline (Simplified Geology only)

Minor fold, showing trend and plunge
- minor anticline
- minor fold, showing plunge and nature of vergence
  - Z, M, or S profile

Bedding, showing strike and dip
- inclined
- vertical
- horizontal

Way-up indicator
- pillow structure
- sedimentary structure

Igneous layering, showing strike and dip
- inclined

Metamorphic foliation, showing strike and dip
- inclined,
- vertical,

Cleavage, showing strike and dip
- inclined

Crenulation cleavage, showing strike and dip
- inclined

Mineral lineation, showing plunge
- plunging
- horizontal

Joint, showing strike and dip
- inclined

Vein, showing dip
- inclined

Airphoto lineament
- prominent trend, unspecified
- foliation or bedding trend

Aeromagnetic lineament

Formed road
Track
Fence, generally with track
Railway, abandoned
Powerline
Townsite, population less than 1000 — Wiluna
Homestead — Lake Way
Locality — Millbillillie
Building
Yard — Yd
Reserve boundary
Microwave repeater station
Horizontal control, minor
Breakaway
Sand dune
Contour line, 20 metre interval — 580

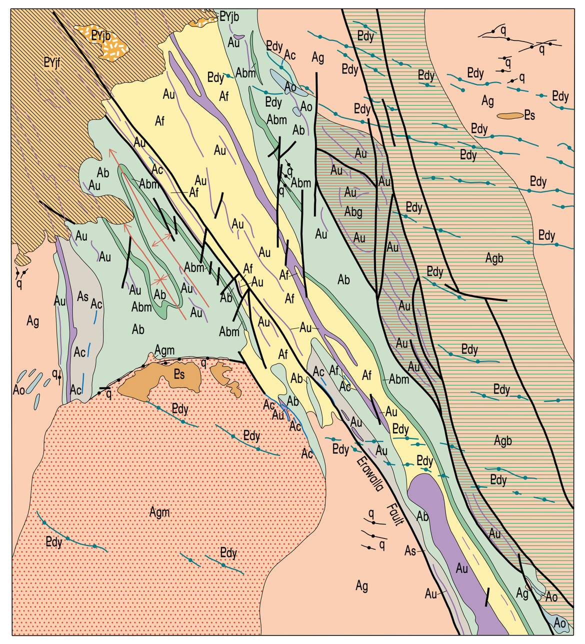
Watercourse, ephemeral
Waterhole — WH
Soak — Sk
Pipeline — P
Bore — B
Well — W
Windpump
Tank — T
Abandoned — (abd)
Position doubtful — (PD)

Mining centre — WILUNA
Mine (gold, unless otherwise indicated) — Capellis Find
Major opencut — West Lode
Opencut — Essex
Quarry
Prospect
Treatment plant
Mining area
- opencut
- made ground
- tailings, mullock

Mineral exploration drillhole, shallow trench, costean, or pit showing subsurface data — Ab

Mineral occurrence
- Nickel — Ni
- Road material — Rm
- Uranium — U

SIMPLIFIED GEOLOGY



Ps — Proterozoic sedimentary rock, unassigned

Yerrida Group — YERRIDA BASIN
PYjf, PYjb — Juderina Formation
- Finlayson Member
- Bubble Well Member

Pdy — Proterozoic mafic dyke

YILGARN CRATON

q — Quartz vein

Ag — Granitoid rock, undivided
Agb — Granitoid rock interleaved with mafic rock
Agm — Monzogranite

As — Metasedimentary rocks dominant
Ac — Metamorphosed chert and banded iron-formation

Af — Metamorphosed felsic volcanic and volcaniclastic sedimentary rocks dominant

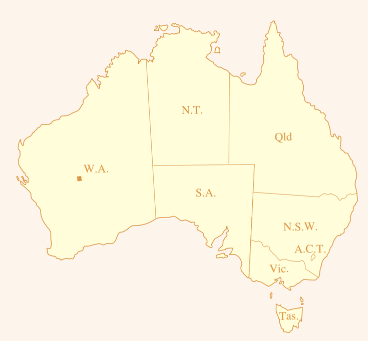
Ao — Metagabbro dominant

Ab — Metabasalt dominant
Abg — Foliated mafic greenstone interleaved with granitoid rock; metamorphosed
Abm — Metamorphosed high-Mg basalt dominant

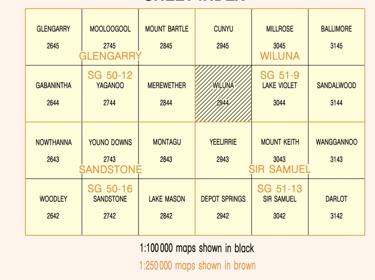
Au — Metamorphosed ultramafic rock dominant

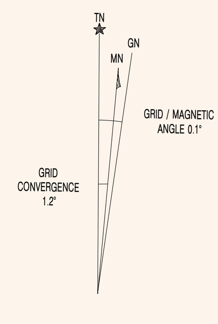
Aeromagnetic lineaments in Archaean rocks, overlain by Proterozoic rocks

SCALE 1:500 000
0 5 10 15 20 Kilometres



SHEET INDEX





DEPARTMENT OF MINERALS AND ENERGY

GOVERNMENT OF WESTERN AUSTRALIA

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

SCALE 1:100 000

Metres — Kilometres

TRANSVERSE MERCATOR PROJECTION

Grid lines indicate 1000 metre interval of the Australian Map Grid Zone 51

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WILUNA

SHEET 2944 **FIRST EDITION 1997 AMENDED 1998**