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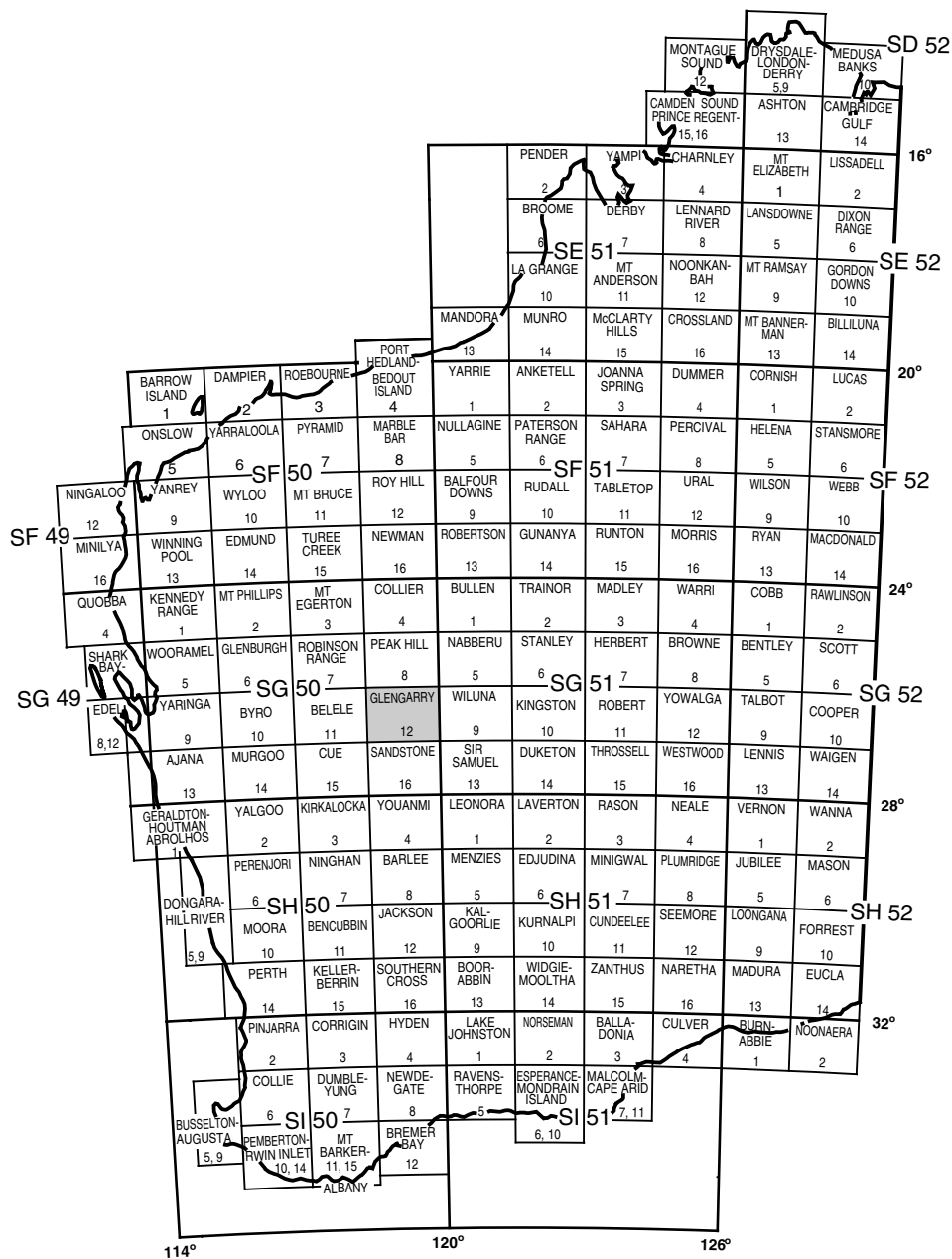
GEOLOGY OF THE MEREWETHER 1:100 000 SHEET

by D. D. Ferdinando

1:100 000 GEOLOGICAL SERIES



Geological Survey of Western Australia



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GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

GEOLOGY OF THE MEREWETHER 1:100 000 SHEET

**by
D. D. Ferdinando**

**with contributions from
N. S. Tetlaw**

Perth 2002

MINISTER FOR STATE DEVELOPMENT
Hon. Clive Brown MLA

DIRECTOR GENERAL, DEPARTMENT OF MINERAL AND PETROLEUM RESOURCES
Jim Limerick

DIRECTOR, GEOLOGICAL SURVEY OF WESTERN AUSTRALIA
Tim Griffin

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Information Centre
Department of Mineral and Petroleum Resources
100 Plain Street
EAST PERTH, WESTERN AUSTRALIA 6004
Telephone: (08) 9222 3459 Facsimile: (08) 9222 3444

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Cover photograph:

Low-angle cross-bedding in partially silicified shale of the Yelma Formation, northwest of Slate Hill bore (MGA 754250E 7066070N)

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Geology of the Merewether 1:100 000 sheet

by

D. D. Ferdinando

with contributions from

N. S. Tetlaw

Abstract

The MEREWETHER 1:100 000 map sheet covers the southern boundary of the Palaeoproterozoic Yerrida Basin, which unconformably overlies the Archaean Yilgarn Craton. Outliers of the Palaeoproterozoic Earaaheedy Basin are present on the northeastern part of the map sheet, and unconformably overlie the Yerrida Basin.

On MEREWETHER, the Yilgarn Craton consists of extensive granitoids and the Joyners Find greenstone belt, which is an overturned synclinal structure that comprises ultramafic, mafic, and clastic rocks, and prominent banded iron-formation.

The Yerrida Group was deposited in the c. 2175 Ma Yerrida Basin, and on MEREWETHER comprises the Juderina and Maraloou Formations. The Juderina Formation unconformably overlies Archaean granitoids, and contains a succession of quartz arenite and carbonate rocks, including local stromatolites and evaporitic features. The formation was probably deposited in a marginal marine to nearshore environment. The overlying Maraloou Formation forms small mesas of shale and siltstone in the northern part of the map sheet, and was possibly deposited in a lacustrine environment.

The Yelma Formation, the basal formation of the Earaaheedy Group, unconformably overlies the Yerrida Group, and comprises a succession of arenites and silicified stromatolitic carbonates that formed in a low-energy nearshore to shallow-marine environment.

The Archaean rocks of the Joyners Find greenstone belt have undergone low- to medium-grade metamorphism. This took place as two events: the first producing widespread low-grade metamorphism of the parent rock, and the second resulting in localized medium-grade metamorphism producing regrowth of actinolite.

Gold mineralization is present in the Joyners Find greenstone belt and lead mineralization is developed within the Yelma Formation at the Magellan deposit. The Yelma Formation also has potential for copper and zinc mineralization.

KEYWORDS: Archaean, Joyners Find greenstone belt, Proterozoic, Yerrida Group, Juderina Formation, Earaaheedy Group, Yelma Formation, Magellan prospect, lead, gold.

Introduction

The MEREWETHER* 1:100 000 sheet (SG 50-12, 2844) is located west of the town of Wiluna, bounded by latitudes 26°30'S and 27°00'S and longitudes 119°30'E and 120°00'E, and is the southeastern 1:100 000 map sheet of the GLENGARRY 1:250 000 map sheet (SG 50-12). The area lies in the northern part of the Archaean Yilgarn Craton, which is unconformably overlain by the Palaeoproterozoic Yerrida Basin.

Access to MEREWETHER is by the main Meekatharra–Wiluna road in the northeastern part of the sheet. The Meekatharra–Wiluna railway, now abandoned, provides vehicle access east to west through the central portion of the map area. The Wiluna–Sandstone road provides access to the southern part of MEREWETHER. Fence lines, mineral exploration tracks, and pastoral tracks mostly allow good access to the remaining areas. The boundary between the shires of Meekatharra and Wiluna crosses the western part of MEREWETHER, and is marked by a vermin-proof fence, which is still maintained and serviced by a track along its eastern side. Access through the fence is restricted to several gates across major pastoral tracks.

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

Geological mapping of MEREWETHER was undertaken during 1997 and 1998. Field observations were integrated with Landsat and aeromagnetic images, and 1:50 000 black-and-white airphotos flown by the Department of Land Administration (DOLA) in 1993.

Physiography and vegetation

The northern half of MEREWETHER is dominated by hills forming an easterly trending range, whereas the southern half is mostly flat to undulating. Relief across areas of Archaean rock is very low, with the exception of two prominent banded iron-formation (BIF) ridges along the eastern edge of MEREWETHER. Numerous granitoid breakaways, three quartz pods, and sand dunes rise above the alluvial plain. A large east-trending scarp in the northern part of the sheet area marks the unconformity between Archaean and Proterozoic rocks. The breakaways formed where the Neogene plateau surface, which was originally part of an extensive drainage basin (Mabbutt, 1963; Bettenay and Churchward, 1974; Hocking et al., 2002), was elevated and dissected by later erosion.

MEREWETHER lies within the Austin Botanical District (Beard, 1976; Beard and Sprenger, 1984), which is essentially a mulga region. Numerous species of flora have been identified, many of them characteristic of specific physiographic units. A detailed account of the plants from arid parts of Western Australia, including the MEREWETHER region, is provided by Mitchell and Wilcox (1994). The most abundant of the larger shrubs is Mulga (*Acacia aneura*), which is present in almost all habitats and commonly associated with broad-leaf acacia species. River red gum (*Eucalyptus camaldulensis*) is common along the major watercourses, and spinifex (*Triodia* sp.) and mallee (*Eucalyptus* sp.) dominate the sandy plains. Several species of everlasting daisies associated with larger annuals (purple mulla mulla and cotton bush) make colourful displays during spring.

Previous investigations

The Proterozoic Yerrida and Earahedy Basins outcrop on the northern part of MEREWETHER, and Archaean granite–greenstone rocks occupy the southern portion (Fig. 1).

A brief geological account of parts of MEREWETHER was given by Elias et al. (1982) as part of the GLENGARRY (1:250 000) regional mapping project. Bunting et al. (1977), Bunting (1986), and Gee (1990) included the area in their work on the Naberu Basin (now divided into the Yerrida, Bryah, and Earahedy Basins). Gee and Grey (1993) and Grey (1984, 1994a,b,c) studied stromatolites from the Yerrida and Earahedy Groups and identified several forms that are useful in correlation both locally and regionally. Recent work by the Geological Survey of Western Australia has resulted in the division of the Glengarry Basin of Bunting et al. (1977) into the Yerrida and Bryah Basins (Occhipinti et al., 1997). Pirajno and Adamides (2000) provided a regional synthesis of the Yerrida and Earahedy Groups.

The groundwater potential in the area between Wiluna and Meekatharra was discussed by Brookfield (1963), and the geomorphology of the same region was described by Mabbutt (1963).

Regional geological setting and stratigraphy

Archaean granite–greenstone rocks occupy the southern half of MEREWETHER, whereas the northern portion is covered by sedimentary rocks of the Yerrida Basin, which unconformably overlies the granite–greenstones. The Palaeoproterozoic Earahedy Group overlies the Yerrida Group in the northeastern and northwestern parts of the region. The geological history of MEREWETHER is summarized in Table 1.

The Archaean Joyners Find greenstone belt is a succession of ultramafic, mafic, and sedimentary rocks, emplaced around 2921–2903 Ma (Greenfield et al., 2001; Wyche et al., 2001). It forms an overturned syncline in the eastern part of MEREWETHER, and hosts minor gold mineralization. To the north, granite–greenstones are unconformably overlain by Proterozoic sedimentary rocks of the Yerrida and Earahedy Groups (Fig. 2). To the west are several outcrops of Archaean granitoids, including biotite monzogranite, which were emplaced around 2700–2680 Ma (Bagas, 1998). Aeromagnetic data (Fig. 3) indicate that the granitoids are intruded by easterly trending dolerite dykes, although few of the dykes outcrop.

It is uncertain whether the Joyners Find greenstone belt is part of the Eastern Goldfields Granite–Greenstone Terrane or the Southern Cross Granite–Greenstone Terrane. However, Myers (1997) assigned the greenstone belt to the Southern Cross Granite–Greenstone Terrane. This correlation is supported by the large volumes of BIF and clastic sedimentary rocks present in the Joyners Find greenstone belt, which are typical of greenstone belts within the Southern Cross Granite–Greenstone Terrane (Eisenlohr et al., 1993). No rocks suitable for dating were recovered during the present survey.

The Proterozoic stratigraphy is well established for both the Yerrida and Earahedy Groups (Table 1). An idealized stratigraphy for the Palaeoproterozoic units found on MEREWETHER is shown in Figure 4.

The Yerrida Group is subdivided into the Windplain and Mooloogool Subgroups (Pirajno and Adamides, 2000), and was deposited over the Yilgarn Craton granite–greenstones between 2100 and ?1950 Ma. The Windplain Subgroup contains the Juderina and Johnson Cairn Formations, of which only the Juderina Formation is exposed on MEREWETHER. The Juderina Formation comprises siliciclastic, evaporitic, and carbonate sedimentary rocks, and has undergone varying degrees of diagenetic silicification. The younger Mooloogool Subgroup is divided into the Thaduna, Doolgunna, Killara, and Maraloou Formations. On MEREWETHER the Maraloou Formation is exposed on the northwestern portion of the map as small mesas of shale and siltstone.

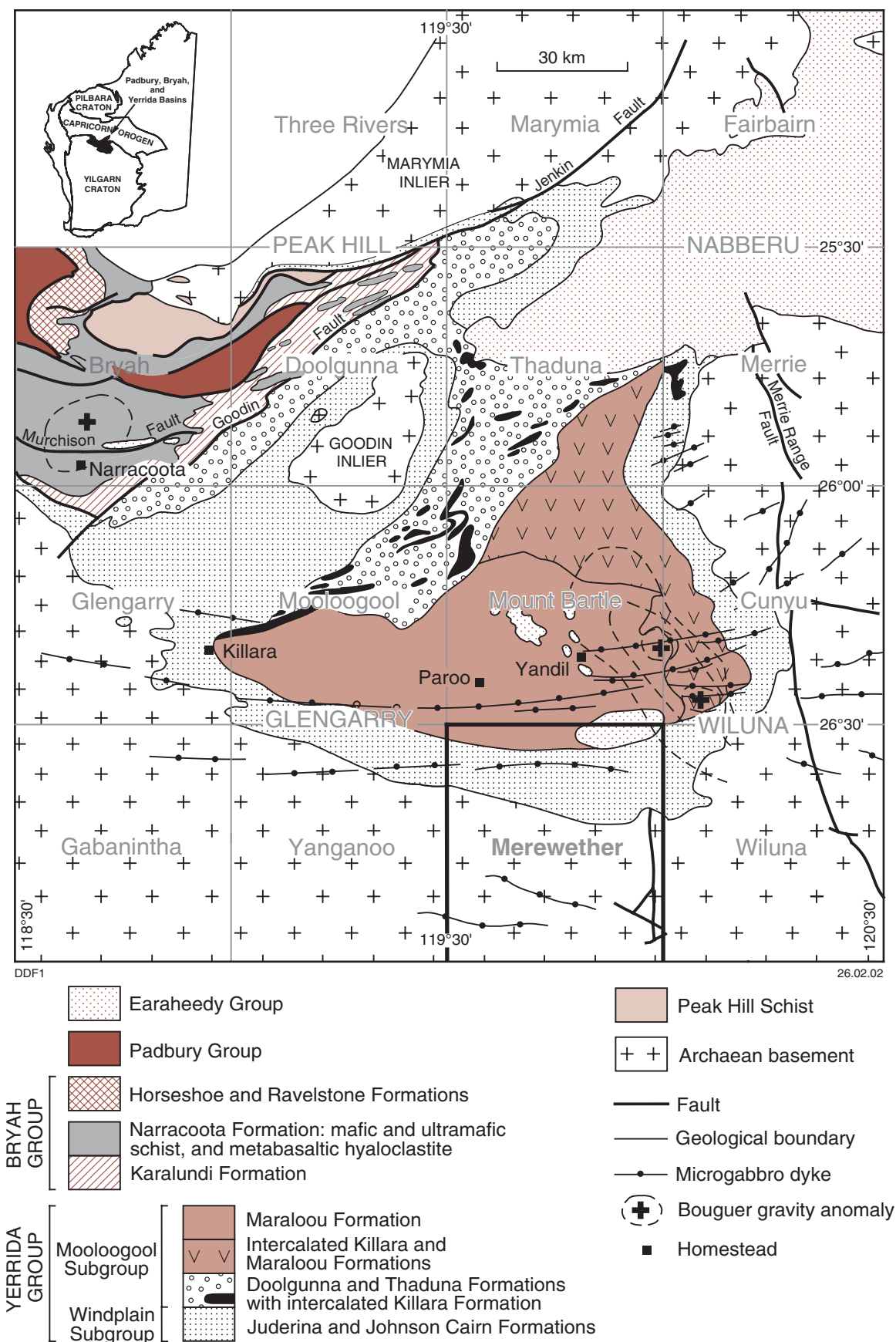


Figure 1. Location of MEREWETHER showing the main regional tectono-stratigraphic units

Table 1. Geological history of MEREWETHER

<i>Age (Ma)</i>	<i>Event</i>
2921–2730	Deposition of greenstones and interflow sedimentary rocks of the Joyners Find granite–greenstone belt
2700–2680	Intrusion of early granitoids
2660–2650	Major phase of gold mineralization in Joyners Find granite–greenstone belt related to D ₂ or late D ₃ to post D ₃
2640–2620	Intrusion of late granitoids
2620–2200	Late Archaean to early Palaeoproterozoic dyke emplacement across Yilgarn Craton
2200–?1950	Deposition of Yerrida Group on Yilgarn Craton Juderina Formation — marginal marine to nearshore deposition of sandstone and stromatolitic carbonate (supratidal and intertidal) Killara Formation — tholeiitic volcanism with related dyke emplacement Maralouou Formation — possible lacustrine deposition of siltstone and carbonate
?1900–1800	Deposition of Earaaheedy Group Yelma Formation — nearshore to shallow-marine deposition of sandstone and stromatolitic carbonate (supratidal and intertidal)
1830–1780	Capricorn Orogeny — deformation of Yerrida Group along Goodin Fault and contacts with the Marymia Inlier and Goodin Dome, waning to the southeast (e.g. MEREWETHER)
>1650	Mississippi Valley-type base metal mineralization in Earaaheedy and Yerrida Groups (e.g. Magellan deposit)
Late Mesozoic	Development of drainage system across interior of Western Australia, following episodes of ferruginous and siliceous duricrust development
Late Eocene – Miocene	Waning of interior drainage system, with last significant flow probably Late Miocene

The Earaaheedy Group unconformably overlies the Yerrida Group throughout the Yerrida Basin, and was deposited between ?1900 and 1800 Ma. On MEREWETHER only the basal unit of the group, the Yelma Formation, is exposed. It consists of interbedded quartzose sandstone and siltstone, and a silicified carbonate unit that is in part stromatolitic. The contact between the Yerrida and Earaaheedy Groups is not exposed on the map sheet.

Archaean rocks

The southern half of MEREWETHER comprises Archaean granitoids and the Joyners Find greenstone belt. The Archaean rocks are typically poorly exposed, obscured by a cover of eolian sand, alluvium, colluvium, sheetwash, laterite, and local silcrete. Archaean rocks outcrop over only about 10% of the map area.

Joyners Find greenstone belt

The Joyners Find greenstone belt lies at the northeastern margin of the Southern Cross Granite–Greenstone Terrane (Griffin, 1990) and is dominated by BIF and clastic sedimentary rocks. The belt is approximately 40 km long and has a maximum width of about 6 km. It forms a tight, north-trending, V-shaped overturned syncline and is exposed as three segments on MEREWETHER. In the northern segment, which is the largest, a prominent north-trending BIF ridge is present on each side of the syncline. Mafic and ultramafic rocks and a number of thinner BIF units lie between these large ridges. Clastic sedimentary rocks and ultramafic rocks lie to the west of these ridges, and quartz–chlorite schist is exposed on the eastern edge of

the belt. The central and southern segments of the greenstone belt on MEREWETHER also contain BIF, although in these segments the BIF is concentrated on the western side of the syncline. Outcrop in the central and southern segments comprises predominantly ultramafic units with some BIF, although in the southernmost segment some metamorphosed shale and siltstone is exposed on the western edge.

No formal stratigraphic sequence has been defined for the Joyners Find greenstone belt due to the lack of reliable younging data and the strong deformation (see **Structure**). Wyche et al. (2001) gave an age range of 3.0 – 2.73 Ga for greenstone emplacement in the central Southern Cross Granite–Greenstone Terrane.

Ultramafic rocks

Ultramafic rocks on MEREWETHER are mostly restricted to the Joyners Find greenstone belt, where they outcrop in the centre of the syncline. Other ultramafic rocks — feldspathic pyroxenite (*Aux*) and small outcrops of undivided ultramafic rock (*Au*) and talc–actinolite–chlorite(–tremolite) schist (*Aur*) — outcrop elsewhere. Outcrops are typically small and irregularly shaped areas (<25 m²) with very low relief. The rocks are covered by a veneer of black to reddish-black, shiny ironstone cobbles, on slopes or as alluvial material in streams. The ultramafic units comprise yellow, brown, orange, or greenish-grey schists and are highly oxidized. Small exposures of less-weathered ultramafic rock are present in deeply incised stream channels. Silicification and small quartz veins are common, and chert (*Czu*) locally caps ultramafic rocks. The rocks are metamorphosed and highly deformed (see **Structure** and **Metamorphism**), with a

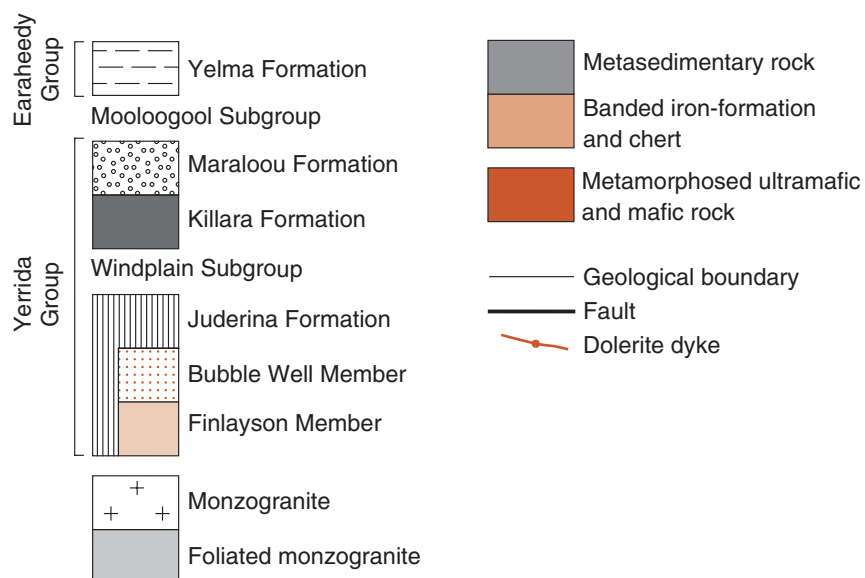
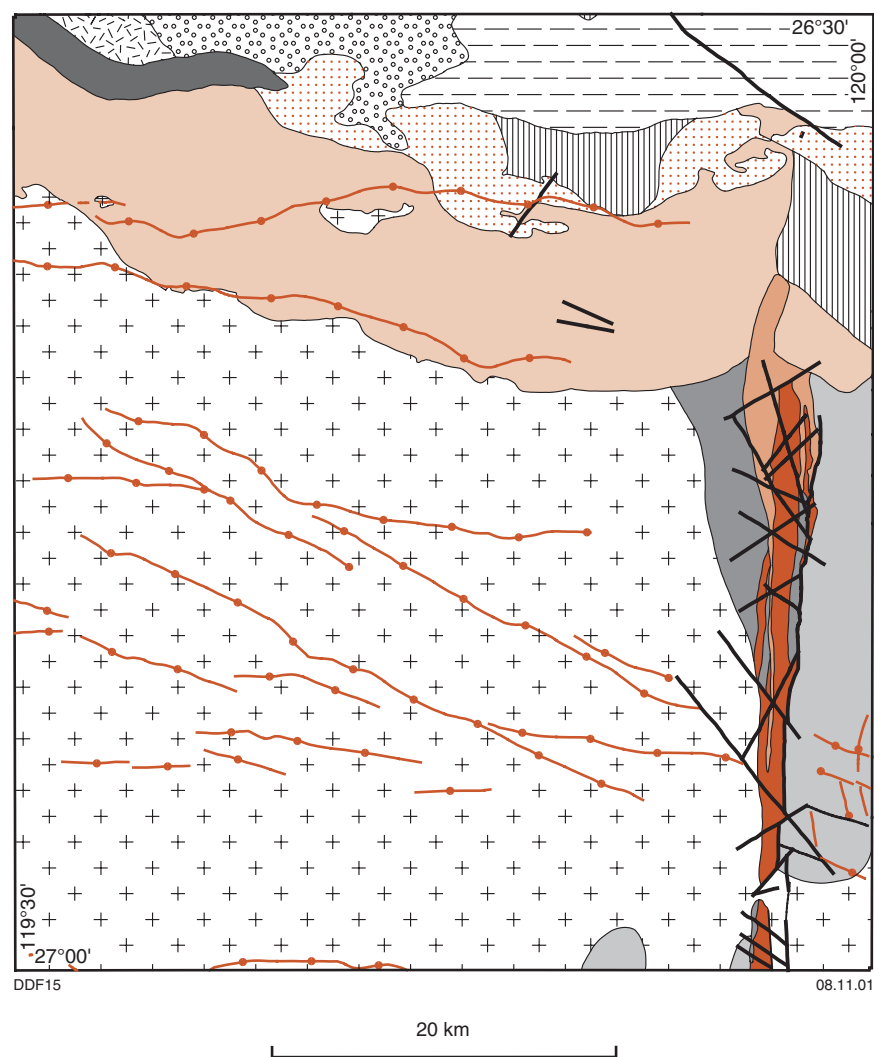
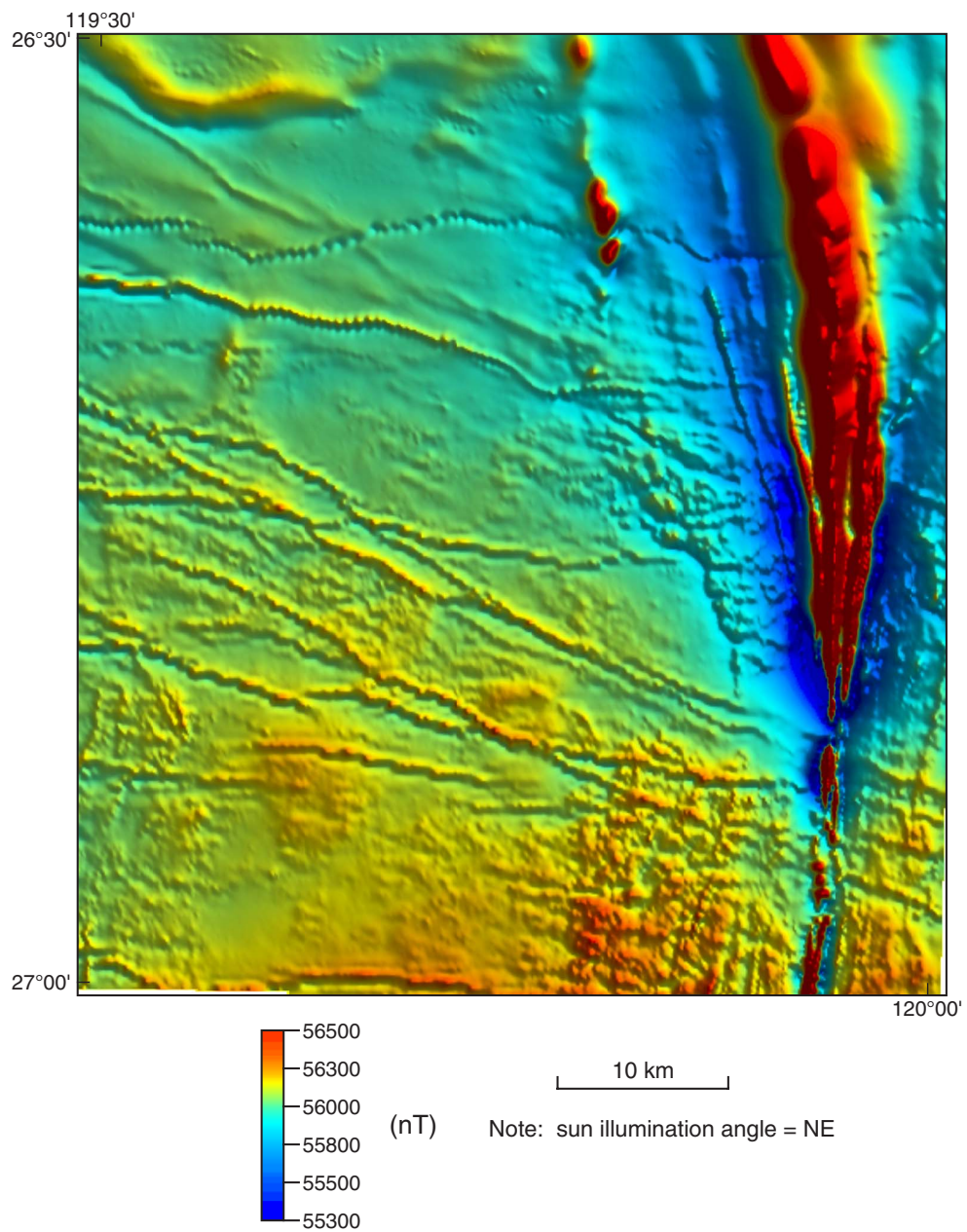


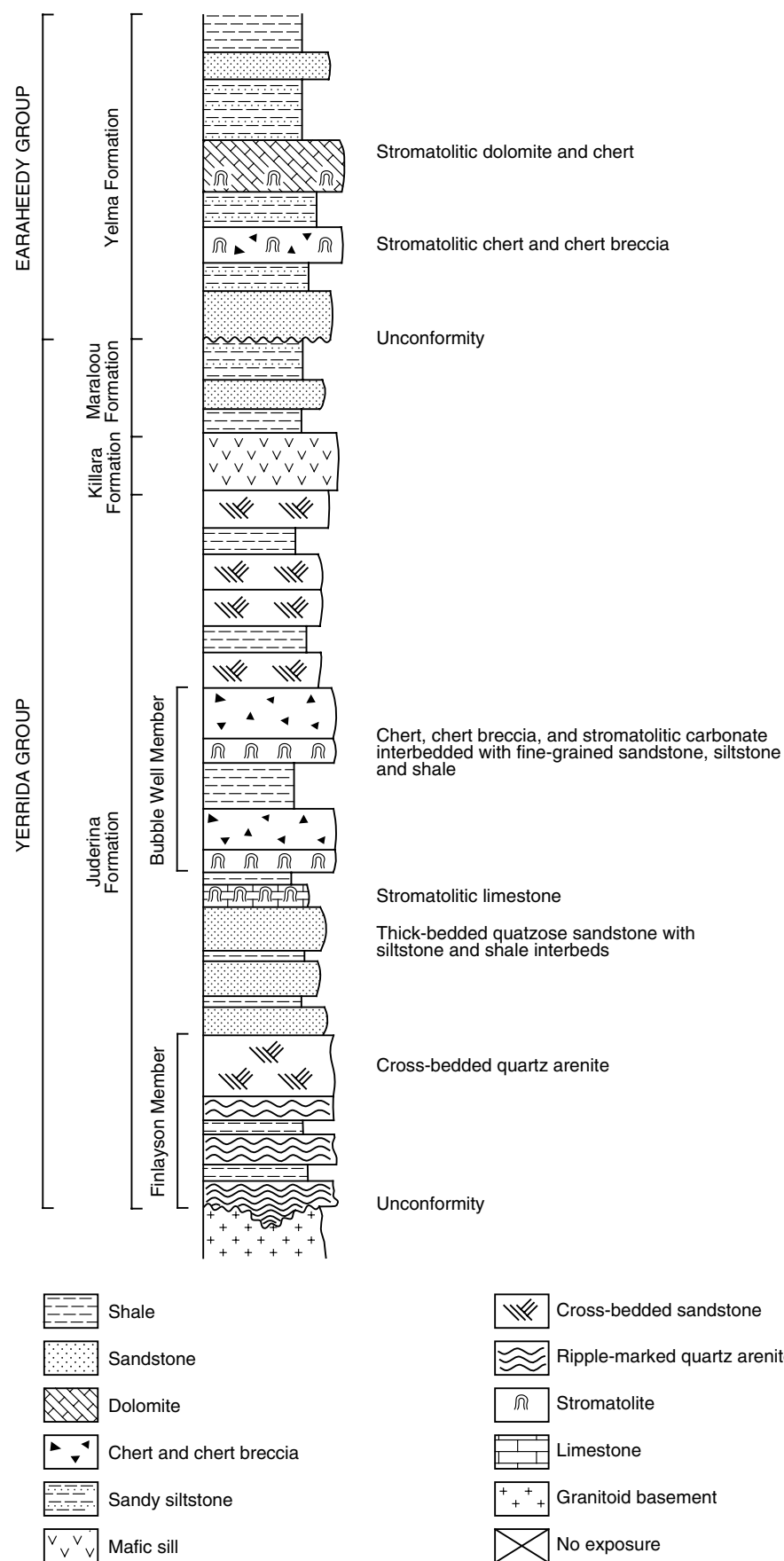
Figure 2. Interpreted bedrock geology of MEREWETHER



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Figure 3. Aeromagnetic image of MEREWETHER



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Figure 4. Idealized stratigraphic column for the Palaeoproterozoic units on MEREWETHER

strong west-dipping foliation, minor folding with west-dipping axial surfaces, and fracture patterns oriented at 210° and 320°. They are distinguished from high-Mg basalt (*Abms*) by a lack of plagioclase, a higher degree of weathering, and silicification.

Undivided ultramafic rock (*Au*)

Undivided ultramafic rock (*Au*) outcrops predominantly in the centre of the Joyners Find greenstone belt. It is poorly exposed and outcrops as weathered pale greenish-grey, yellow, or reddish-brown schist that is locally silicified. A faint fibrous texture is locally developed. Chlorite schist and tremolite–chlorite–epidote schist are interleaved, and these are grouped together as *Au*.

The chlorite schist is well foliated and varies from greenish-grey (in areas of fresh rock) to yellow. The freshest outcrop lies north of the greenstone belt, just west of the Eagle prospect (MGA 793800E 7036800N*). In thin section the rock comprises a groundmass of fine-grained chlorite with scattered coarser aggregates of chlorite and small amounts of smectite. Veinlets of quartz are locally developed, as well as small patches of limonite possibly after disseminated pyrite. Small amounts of leucoxene are also present.

The tremolite–chlorite–epidote schist varies from greenish-grey to reddish-brown where strongly weathered. The rock appears to display a spinifex-like texture, defined by tremolite crystals, and may represent a metamorphosed komatiitic flow.

Talc–actinolite–chlorite(–tremolite) schist (*Aut*)

Talc–actinolite–chlorite(–tremolite) schist (*Aut*) forms extensive, weathered, and commonly silicified outcrops of pale greenish-grey rock. In thin section, chlorite forms sparsely disseminated flakes up to 0.25 mm long within the talc groundmass. The groundmass defines a strong foliation that is weakly crenulated. Outcrop of the talc–actinolite–chlorite(–tremolite) schist is well preserved 2 km north of the Joyners Find mine (MGA 793300E 7035300N).

Feldspathic pyroxenite (*Aux*)

Feldspathic pyroxenite (*Aux*) outcrops with pebble conglomerate (*Asc*) on the western side of the Joyners Find greenstone belt. The best preserved outcrop is in a streambed 3.5 km southwest of the Joyners Find mine (MGA 791800E 7030000N), where fresh, bluish-green rock with a poorly developed cleavage is present. Elsewhere, it typically outcrops as an orange weathered rock. Roughly cube-shaped silica-filled voids are present, which become progressively smaller from west to east (medium grained to fine grained). These voids indicate that sulfide mineralization was present in the form of ?pyrite.

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

In thin section, the feldspathic pyroxenite has been metamorphosed to a tremolite–actinolite–chlorite–albite schist, with tremolite and actinolite pseudomorphing pyroxene crystals up to 4 mm long. There are also millimetre-scale quartz crystals, small quartz-filled veinlets, and rare clusters of epidote crystals up to 2 mm long. A foliation is defined in thin section by alignment of the matrix minerals.

High-Mg basalt (*Abms*)

The best preserved exposure of the north-trending high-Mg basalt (*Abms*) on MEREWETHER, is west of a streambed 1.5 km south-southwest of the Joyners Find mine (MGA 792700E 7031600N). The high-Mg basalt is greenish-blue, fine grained, massive, and weakly foliated, but not as weathered as the ultramafic rocks elsewhere in the greenstone belt.

In thin section, the high-Mg basalt comprises tremolite, actinolite, and laths of albite, with lesser amounts of epidote, disseminated titanite, quartz, and chlorite. As well as defining the foliation, tremolite and actinolite crystals partly preserve a quench texture. Epidote, quartz, and chlorite are present in veins that are parallel to the foliation.

Most of the samples taken from the high-Mg basalt were extrusive, but one sample (GSWA 164637) may have been a cumulate, with tremolite after coarse pyroxene in a tremolite–chlorite schist matrix and minor plagioclase.

Metamorphosed sedimentary rocks

On MEREWETHER, metamorphosed sedimentary rocks mostly outcrop on the western flank of the Joyners Find greenstone belt, although some outcrops of quartz–chlorite schist (*Alql*) are present on the eastern flank. The sedimentary rocks are exposed on the outer margin of the syncline and locally contain clasts of BIF, and mafic and ultramafic rocks. These sedimentary rocks are less deformed than the nearby mafic and ultramafic rocks.

Pebble conglomerate (*Asc*)

Pebble conglomerate (*Asc*) lies on the western side of the northern segment of the Joyners Find greenstone belt and is common in this area. The rock has a west-dipping foliation, and north-plunging folds with west-dipping axial surfaces are locally developed.

The pebble conglomerate contains black, brown, and white layers that dip to the west. The highly weathered and lateritized brown and black layers contain ferruginous, well-foliated quartz–mica schist, with many elongate clasts of banded chert or BIF (Fig. 5). These clasts are typically subangular to subrounded and between 1 and 5 cm across, but locally up to 20 cm. The white layers are coarse grained and comprise predominantly quartz with subrounded chert pebbles typically less than 2 cm across. The conglomerate is also locally interlayered with very fine-grained, pale greenish-grey, crenulated quartz–sericite schist, probably after siltstone and sandstone.



Figure 5. Deformed conglomerate beds within the Joyners Find greenstone belt (MGA 791200E 7033500N)

The well-rounded nature of the clasts indicates that they had undergone substantial transport before incorporation into the sediment under high water-energy conditions. This is further supported by the large grain size of the quartzose matrix in the white layers. The mica component of the matrix indicates that the protolith was an immature sediment.

Shale and siltstone (Ash)

Metamorphosed shale and siltstone (*Ash*) are present on the western flank of the Joyners Find greenstone belt. They are exposed as low areas of reddish-brown and pale greenish-grey rock in the north, or as greyish-yellow, very finely laminated, porphyroblastic metashale in the south. The unit contains a west-dipping foliation and is locally weakly folded.

Small exposures of metamorphosed shale, and pale greenish-grey metamorphosed shale and siltstone that are compositionally the same as the schist interlayered with the conglomerate (*Asc*), form a north-trending unit that lies between two large bodies of pebble conglomerate. The metamorphosed shale is reddish-brown, very finely laminated with a slaty cleavage, and comprises quartz and biotite.

A sample of the finely laminated, greyish-yellow rock from southern MEREWETHER (5.5 km west of White Bore; MGA 790800E 7011800N) is a quartz–biotite–garnet schist (a medium-grade pelite). Relict garnet crystals (now replaced by limonite) form porphyroblasts up to 4 mm in

diameter. In thin section, these porphyroblasts display a sigmoidal internal schistosity (defined by inclusions of quartz) that indicates rotation of the porphyroblast. The rock also contains quartz-rich layers, with quartz crystals typically 2–3 mm across. The rock is of a higher metamorphic grade than other rocks in the greenstone belt (see **Metamorphism**).

The fine-grained nature of these shales and siltstones indicates that they may have been deposited in low-energy conditions.

Banded iron-formation and chert (Aci)

The Joyners Find greenstone belt on MEREWETHER contains BIF and chert (*Aci*). This unit forms several prominent (up to 15 m high) north-trending ridges as well as smaller outcrops (up to 5 m wide and 2–3 m high) between these ridges, all of which are clearly visible on airphotos.

The black, red, and grey banding within the BIF, and associated narrow white chert beds, vary from 1 mm to 5 cm in width and typically dip steeply westwards, although they tend to be subvertical in the centre of the greenstone belt. In the larger ridges, the bands of chert are slightly thicker (10 to 20 cm). The chert varies from grey, massive beds up to 20 cm thick, to reddish-brown, yellow, or white laminated chert that forms beds up to 2 m thick. The chert laminae are typically wavy.

The unit is locally deformed, with variable deformation ranging from minor fracturing to intense folding and

fracturing. The fractures are typically filled with quartz. Brecciation of chert layers and layer-parallel shearing is also related to this deformation. Large-scale faults dislocate the prominent ridges (see **Structure**), which are strongly sheared and contain many cube-shaped voids (locally filled with silica) that vary from 1 mm to 1 cm across. Banded iron-formation is commonly associated with gold mineralization in the greenstone belt (see **Economic geology**).

The strong magnetic response of the BIF is illustrated in Figure 3, with the large ridges well defined as aeromagnetic highs. Several similar anomalies lie to the west of the greenstone belt. The source of these anomalies does not outcrop, and they probably represent subsurface BIF bodies.

The unit does not weather uniformly in the Joyners Find greenstone belt. The large ridges on the flanks of the greenstone belt are relatively fresh, whereas in the centre of the belt the BIF is extremely weathered.

The BIF and chert beds are indicative of an oxygen-poor, low-energy, marine depositional setting with very low sedimentation rates. The post-compaction brittle nature of the BIF and chert caused fracturing of these beds.

Quartz–chlorite schist (Alql)

Quartz–chlorite schist (*Alql*) outcrops on the eastern side of the Joyners Find greenstone belt. The rock is purple to yellow, indurated, lightweight, and harder than the shale and siltstone unit (*Ash*). It is medium grained with a steeply west-dipping foliation, and contains small green clasts aligned with the foliation. The clasts are angular, 2–3 mm long, and are composed of amphibole, plagioclase (as microlites), and chlorite. The clasts are elongate, with the long axis aligned with the foliation of the rock, and are not foliated. The presence of microlites within the clasts indicates that they are of mafic volcanic origin. The precursor of this unit was a sedimentary rock with mafic volcanic breccia fragments.

Granitoid rocks

On MEREWETHER, granitoids outcrop either in areas adjacent to or within drainage channels, or as large cusped breakaways. Weathering of the granitoids is strong in the 10 m-high breakaways; feldspars have been altered to clay and the mafic minerals have been removed. Some alteration of feldspar to epidote (as rims around feldspar phenocrysts) is present in porphyritic rocks and around pegmatite bodies (*p*). A thick layer of silcrete, in some places up to 2 m thick, caps the breakaways.

Granitoid rocks, undivided (Ag)

Approximately half of the granitoid outcrops on MEREWETHER have been mapped as undivided granitoid rocks (*Ag*). This unit is very poorly exposed and the mineralogy is difficult to ascertain due to weathering. It is pale grey to white in the breakaways and pale red in the few areas where the outcrop is relatively fresh. The rock is even grained, with grain size less than 3 mm in diameter, and

where relatively fresh is composed of feldspar, quartz, and biotite. Some outcrops also contain small amounts of hornblende.

Biotite monzogranite (Agm)

Large areas of pale-pink granitoid that outcrop on MEREWETHER are compositionally defined as biotite monzogranite (*Agm*). This unit outcrops mainly in breakaways and river channels, and is typically better preserved than the undivided granitoid (*Ag*) unit, with much of the original mineralogy still present.

The biotite monzogranite is medium grained and comprises 60% feldspar, 30% quartz, and 10% biotite and muscovite. Phenocrysts and poikiloblasts of microcline up to 1 cm across are evenly distributed throughout. Feldspar crystals are locally altered to muscovite, with lesser amounts of altered biotite. A weak foliation is developed, defined by the alignment of biotite crystals. Narrow veins of quartz and pegmatite, up to 2 cm wide, locally intrude the biotite monzogranite.

Strongly foliated, porphyritic biotite monzogranite (Agmf)

Strongly foliated porphyritic biotite monzogranite (*Agmf*) outcrops on the southeastern part of MEREWETHER, east of the Joyners Find greenstone belt, and in smaller outcrops on the southern edge of the map area. It has a similar outcrop form to other granitoids on MEREWETHER, and is not as weathered as the undivided granitoid (*Ag*) unit.

The unit is pale grey to white and strongly foliated (defined by the alignment of biotite and elongation of quartz and feldspar crystals). The rock comprises 65% feldspar, 25% quartz, 10% biotite, and lesser muscovite. Phenocrysts of microcline up to 1 cm long are present and are locally altered to muscovite. Pressure shadows surrounding rotated microcline phenocrysts are locally developed, and are typically filled with quartz and mica.

The porphyritic biotite monzogranite is locally interleaved with metre-scale fragments of ultramafic schist (*Alql*) that are of similar composition to schists found within the Joyners Find greenstone belt.

Proterozoic rocks

Proterozoic sedimentary rocks of the Yerrida and Earahedy Groups outcrop on the northern half of MEREWETHER. The Yerrida Group unconformably overlies Archaean granite–greenstone rocks, and the Earahedy Group is inferred to unconformably overlie the Yerrida Group, based on regional observations. Details of the Proterozoic stratigraphy are shown in Figure 4.

Dolerite dykes (Ed)

Dolerite dykes (*Ed*) intrude granitoids on MEREWETHER and are composed of plagioclase, clinopyroxene, leucosene,

epidote, and chlorite. The dolerite is very fine to fine grained with no preferred mineral alignment or schistosity. Dolerite dykes outcrop in the centre and to the south of MEREWETHER, and are overlain in the north by the Proterozoic rocks of the Yerrida and Earahedy Groups. The dykes are poorly exposed, and typically covered by Cainozoic sediments. Aeromagnetic imagery clearly defines their extent and westerly to northwesterly trend (Fig. 3). The orientation of the dykes, their strong magnetic signature, and mineralogy are indicative of dykes of the Widgiemoooltha Dyke Suite (Griffin, 1990).

Quartz veins and pods (q)

Several large quartz pods and numerous quartz veins and veinlets (*q*) outcrop on MEREWETHER. The quartz veins average 2 m in width and typically trend northwesterly, and large quartz pods form outcrops up to 10 m high. All of the exposed quartz veins and pods contain quartz-comb textures.

In the eastern part of MEREWETHER, two quartz pods parallel the eastern edge of the Joyner's Find greenstone belt (MGA 793000E 7014000N). The southernmost pod contains minor mica and tourmaline and is surrounded by a group of circular pegmatite (*p*) bodies that are too small to be shown on the geological map. The northern quartz pod is composed entirely of quartz. Both pods coincide approximately with aeromagnetic lineaments (Fig. 3), which represent faults through which the quartz may have intruded.

In the southwestern part of MEREWETHER, two quartz pods rise approximately 10 m above the surrounding plain (MGA 758000E 7021500N). The rock contains many inclusions of epidote-quartz rock and consequently has a distinctive green colour. Rare muscovite is present and quartz-comb growth is common in veinlets developed within the pod. Inclusions of biotite monzogranite (*Agm*) are also locally present.

Pegmatite veins and pods (p)

Two large pegmatite pods (*p*) are present on MEREWETHER. In the central part of the map sheet, 4 km west of Granite Well (MGA 780900E 7035900N), a roughly circular pod has intruded the surrounding granitoid. The pod is approximately 25 m in diameter and is distinctly zoned (Fig. 6). The central zone is a massive quartz body approximately 5 m in diameter, which has a 5 m-thick ring of very coarse-grained quartz-muscovite (including a lithium-rich variety) rock surrounding it. Quartz comprises about 80% of the rock and the crystals vary from 1 to 5 cm across. Muscovite crystals (20%) are of a similar size. A tan, massive siliceous rock, with rare limonite-filled fractures forms the outer zone. This siliceous rock also contains inclusions of altered granitoid. Epidote alteration of the surrounding granitoid is pervasive and extends for about 20 m.

The pegmatite unit in the southeastern part of MEREWETHER, 4 km northwest of White Bore (MGA 793000E 7014600N), is composed of a cluster of these

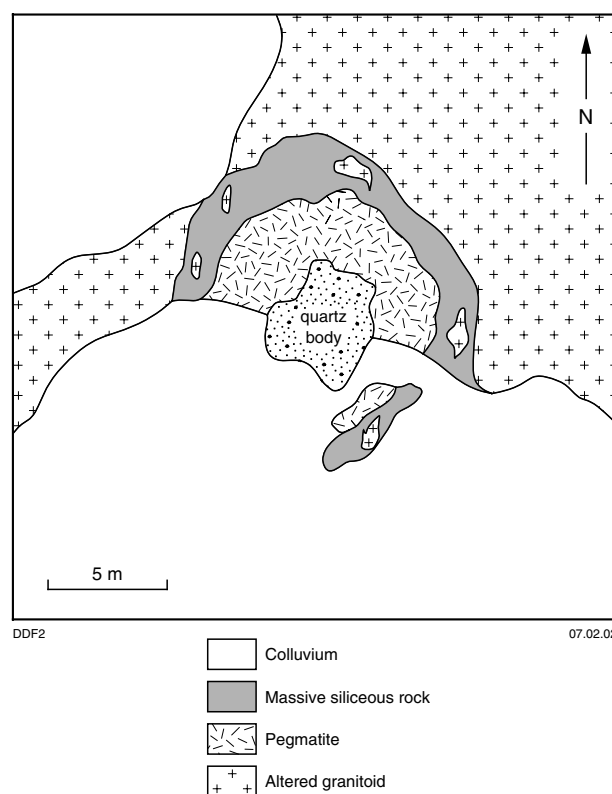


Figure 6. Simplified geological map of pegmatite body (at MGA 780800E 7035800N)

pods, which range from 10 to 20 m in diameter. This cluster surrounds a very large quartz vein (see **Quartz veins and pods**). As well as epidote alteration, the surrounding granitoid is extensively veined with pegmatites, which are composed of alkali feldspar and quartz.

Pegmatite veining (*p*) is common in granitoids on MEREWETHER. The pegmatites are composed of alkali feldspar and quartz and are typically up to 2 cm wide. Several wider veins lie near the contact between Proterozoic and Archaean rocks in the central and northwestern parts of the map sheet (MGA 776500E 7044800N). The veins are approximately 15 cm wide, with alkali-feldspar crystals up to 5 cm across.

Yerrida Group

The Yerrida Group outcrops in the eastern and south-eastern parts of the Yerrida Basin (Gee and Grey, 1993), and includes siliciclastic and carbonate sedimentary rocks, and mafic volcanic and hypabyssal rocks. The group unconformably overlies, or is in tectonic contact with, Archaean granite-greenstone rocks of the Yilgarn Craton and the Marymia and Goodin Inliers (Fig. 1). In the eastern Yerrida Basin around MEREWETHER, the Yerrida Group is unconformably overlain by the Palaeoproterozoic Earahedy Group.

The Yerrida Group is divided into the Windplain and Mooloogool Subgroups (Table 2), each related to different

Table 2. Stratigraphy of the Yerrida and basal Earraheedy Groups

<i>Group</i>	<i>Subgroup</i>	<i>Formation/member</i>	<i>Rock types</i>
Earaheedy	Tooloo	Yelma	Conglomerate, arenite, stromatolitic carbonate, and chert
~~~~~ Unconformity ~~~~~			
Yerrida	Mooloogool	Maralouu	Black shale, siltstone, and carbonate
		Killara	Mafic intrusive and extrusive rocks
		Thaduna	Lithic wacke, siltstone, and shale
		Doolgunna	Sandstone, siltstone, and shale
	Windplain	Johnson Cairn	Siltstone, shale, and carbonate
		Juderina	Arenite, shale, and carbonate
		<i>Bubble Well Member</i>	Silicified carbonate
		<i>Finlayson Member</i>	Arenite
~~~~~ Unconformity ~~~~~			

SOURCE: modified from Dawes and Pirajno (1998)

depositional settings (Pirajno and Adamides, 2000). The Windplain Subgroup contains the Juderina and Johnson Cairn Formations, and was deposited in a sag basin or pre-rift depression (Pirajno et al., 1995, 1996). The age of the Yerrida Group is constrained between c. 2.2 and c. 1.95 Ga. A Pb–Pb isochron age of 2173 ± 64 Ma was obtained from stromatolitic carbonate rocks of the Bubble Well Member on GLENGARRY (Woodhead and Hergt, 1997), giving a depositional age for these rocks. Pb–Pb isotopic dating of stromatolitic carbonate rocks from the overlying Yelma Formation (Earraheedy Group) at Sweetwaters Well on MERRIE, gave ages of 2008 ± 68 and 1946 ± 71 Ma (Russell et al., 1994), contrasting with regional studies of stromatolite taxa that suggest an age of between 1.9 and 1.8 Ga (Grey, 1994b).

Windplain Subgroup

Juderina Formation (Pyj, Pyjf, Pyjb)

The Juderina Formation (Pyj; Occhipinti et al., 1997) is present as a series of easterly trending ranges in the northern half of MEREWETHER, where it unconformably overlies granitoid of the Yilgarn Craton. Locally, the boundary between the Archaean rocks and the Juderina Formation is well exposed and is either fault bounded or forms an erosional unconformity. Two members of the Juderina Formation have been recognized on MEREWETHER: the Finlayson Member (Pyjf) and the Bubble Well Member (Pyjb). The Finlayson Member, at the base of the Juderina Formation, is a mature quartz arenite with subordinate quartz siltstone, and contains a variety of shallow-water sedimentary structures (ripple marks and herringbone cross-lamination). The Bubble Well Member is a distinctive unit of stromatolitic chert and chert breccia in the middle of the formation.

Higher in the sequence, the Juderina Formation becomes increasingly thicker bedded, and is dominated by grey quartz arenite, commonly with a purple hematitic surface colouration. The sandstone of the Juderina Formation is typically fine to medium grained and

moderately sorted. Quartz grains in the upper quartz arenite are typically angular. Cross-bedding and ripple marks are not as well developed as in the basal units, and tend to parallel bedding. The arenite is composed of rounded to subrounded quartz grains, 0.3 – 0.4 mm in diameter, with subordinate interstitial kaolinite, and traces of rutile, zircon, and tourmaline.

Ferruginous sandstone beds containing white mica are associated with platelets of hematite within a clay matrix. Siltstone laminae comprise angular quartz grains averaging 0.1 mm in diameter within a hematitic matrix. The argillaceous laminae contain fine disseminations of iron hydroxides.

Shale and quartz siltstone form up to 30% of the Juderina Formation, but commonly weather recessively. The siltstone varies from white to light grey and is typically finely laminated. It consists of quartz grains (around 0.05 mm in diameter) in a matrix of poorly crystalline illite- and kaolinite-group clays. The quartz has irregular crystal boundaries and is partly diffused into the clay matrix. Local white mica is altered along grain margins to clays. Fine-grained cherty beds are characterized by very finely crystalline interstitial clays that display a preferred orientation parallel to lamination, probably due to diagenetic compaction.

The Juderina Formation is thought to have been deposited in a marginal marine (supratidal and intertidal) to nearshore environment.

Finlayson Member (Pyjf)

The Finlayson Member (Pyjf; Occhipinti et al., 1997) is a white to brown, fine- to medium-grained, silica-cemented, well-bedded, well-sorted quartz arenite. It contains trough and herringbone cross-bedding, symmetrical and asymmetrical current ripples, parallel laminations, and local scour marks. Bedding thickness varies from about 2 to over 50 cm. Rare pyrite dissolution voids are scattered throughout the member, and cubic crystals of pyrite are locally present. In addition, there are

also pseudomorphs of evaporitic minerals and rain-spotted surfaces on the upper beds of the Finlayson Member. Conglomerate and gravelstone are common just above the contact with the underlying granite, and lens out along strike over a distance of between 50 and 200 m. The beds immediately overlying the granitoids of the Yilgarn Craton tend to be coarse grained at the contact, grading upward into medium-grained quartz arenite (Fig. 7)

The Finlayson Member was deposited in a predominantly shallow-marine environment, based on the rippled beds, well-sorted and rounded quartz grains, and planar and cross-bedded surfaces. Both symmetrical and asymmetrical ripples are present, with ripple crests that are predominantly straight, and wavelengths that vary from between a few centimetres to tens of centimetres. Raindrop impressions, mud cracks, and mud rip-up clasts on some bedding surfaces indicate that the member was intermittently subaerially exposed. The presence of lensoid conglomerate beds suggests a fluvial environment during the initial stages of deposition.

Quartz arenites of the Finlayson Member are characterized by very well sorted and well rounded quartz grains 0.2 – 0.5 mm in diameter. Heavy mineral concentrates from this unit contain subhedral zircon and tourmaline, associated with rounded brown biotite and rutile (Adamides, N., 1999, written comm.). Well-rounded zircon and tourmaline are subordinate, suggesting that the basal quartz arenite is derived directly from erosion of granitic source areas, with little second-generation reworking.

Moulds of ?gypsum and halite crystals indicate that the unit was periodically subjected to hypersaline conditions. This may indicate that the Yerrida Basin at that time was a barred basin, which is consistent with it being a rifted basin (Pirajno, 1996), with palaeocurrent directions to the north-northwest and east-northeast. Given the predominance of mature, well-rounded grains within the quartz arenite, it seems likely that the main sediment source was either a pre-existing sandstone, extremely distal to the depositional zone, or a felsic precursor that underwent extensive mechanical weathering in a high-energy depositional environment prior to sedimentation. The nature of the heavy minerals within the arenites of this member suggests that the latter was the case.

Bubble Well Member (EYjb)

The Bubble Well Member (EYjb; Occhipinti et al., 1997) is exposed in a number of locations across the northern part of MEREWETHER, where it is characterized by silicified sedimentary rock after carbonate, fine-grained clastic rocks, evaporite, and stromatolitic units. Parallel laminations, soft-sediment deformation, cross-bedding, and planar-bedding are preserved in the cherts within this unit.

The Bubble Well Member was defined by Occhipinti et al. (1997) as a unit of silicified carbonate and evaporitic sedimentary rocks, approximately 160 m thick, within the Juderina Formation. The type section is at the Eagle Roost locality of Gee and Grey (1993), on the extreme western boundary of WILUNA (MGA 798800E 7056700N). Gee and Grey (1993) carried out detailed studies of



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Figure 7. Contact (dashed) between Archaean granitoid (below) and Juderina Formation (MGA 770300E 7054700N)

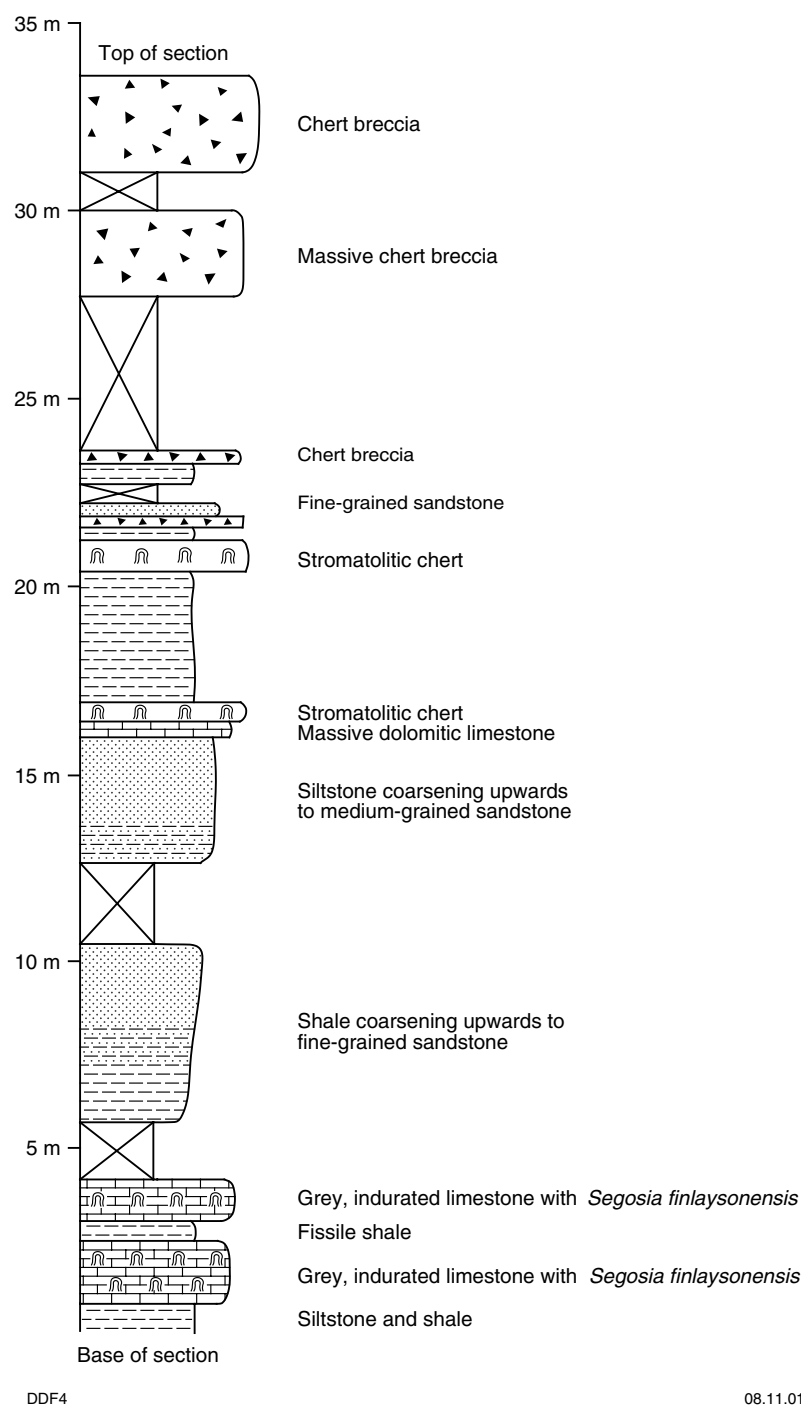


Figure 8. Stratigraphic column of Bubble Well Member, Eagle Roost locality on Wiluna. See Figure 4 for legend

evaporitic and stromatolitic features at this locality. A revised stratigraphic section of the Bubble Well Member based upon current work is presented in Figure 8. The member is a distinct facies of the Juderina Formation that does not occupy a unique stratigraphic position. Around Goosie Bore on CUNYU to the northeast, the member lies on granite basement, but elsewhere mostly overlies the Finlayson Member. Field and petrographic evidence suggest that the dominant precursor lithology was stromatolitic carbonate with evaporitic sedimentary

rock intercalations and early diagenetic replacement. Approximately 4 km south-southeast of Paroo Well (MGA 757500E 7049500N and MGA 756500E 7050400N) there are two outcrops of Bubble Well Member that are in faulted contact with the granite basement. These beds show some slight recrystallization at the contact margins, probably related to the faulting.

The Bubble Well Member typically consists of layers of chert breccia, chert with wavy laminations (probably



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Figure 9. *Wilunella glengarrica* Grey 1994, Bubble Well Member (MGA 798800E 7056400N)

derived from carbonate microbial laminites), and chert-replaced stromatolitic carbonate intercalated with evaporitic layers. It commonly outcrops as a red to cream chert and chert breccia, with diffuse grey banding. Rounded nodules, probably diagenetic, are widespread, and delicate wavy microbial laminations are present in some facies. Specimens of the stromatolite taxa *Wilunella glengarrica* Grey 1994 and *Segosia finlaysonensis* Grey 1994 have been identified in outcrops at Eagle Roost and also west-northwest of Russell Bore on MOUNT BARTLE (Gee and Grey, 1993; Grey 1994c). The former grows as domes up to 2 m in diameter (Fig. 9), and the latter is a columnar form.

Along strike from Eagle Roost, dolarenite units are interbedded with cross-laminated quartz arenite. The dolarenite units, which are too small to show on the geological map, are peloidal or locally oolitic. The peloids average 0.4 mm in diameter and are typically elliptical and set in a weakly iron-stained cherty matrix. Quartz grains are intermixed with the peloids and locally form the cores of ooids. Breccia beds are locally interbedded with subordinate, weakly ferruginous and well-sorted sandstone. Ripple-marked quartz arenite is overlain by a thick succession of chert and chert breccia, locally with elongate evaporitic pseudomorphs and stromatolitic laminations. Cherty beds up to 2 cm thick are present in some facies, alternating with finely laminated chert of probable microbial origin. These features suggest a shallow-water, probably intertidal environment with interfingering relationships between carbonate lagoons and bank deposits

(now represented by chert breccia). Quartz sandstone in washovers and channels, and evaporitic minerals and stromatolites in barred lagoons also developed locally (Gee and Grey, 1993).

Silicified evaporitic units, locally alternating with argillite beds (MGA 780100E 7057200N), contain cubic, bladed, needle, rosette, and swallowtail crystal pseudomorphs, some up to 3 cm long. These pseudomorphs are interpreted as having developed after evaporites (halite, gypsum, and anhydrite). In places, nodular forms are present, probably after anhydrite nodules (MGA 797000E 7056300N). El Tabakh et al. (1999) interpreted the Bubble Well Member evaporites as having formed by displacement within fine muds during intermittent flooding and dry periods of a saline environment. Precipitation of evaporite minerals from interstitial brines took place in the early stages of diagenesis.

On MEREWETHER, the Bubble Well Member forms lenticular outcrops, commonly between basal arenite of the Finlayson Member and overlying thick-bedded arenites. At the eastern boundary of MEREWETHER, near Eagle Roost, chert and chert breccia of the Bubble Well Member form both well-bedded subrounded bioherms and chaotic breccia facies with intervening, thin, semi-continuous chert lenses (Fig. 10). Stromatolitic bioherms are widespread in the cherts, and diagenetic chert nodules are abundant. The cherts are in turn underlain by cream, ripple-marked quartz arenite close to the basal contact.



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Figure 10. Chert breccia in the Bubble Well Member (MGA 798700E 7056000N)

Mooloogool Subgroup

Killara Formation (*Pyk*)

The Killara Formation (*Pyk*; Occhipinti et al., 1997) contains mafic intrusive and extrusive rocks, and although not exposed on MEREWETHER, it is inferred to lie just beneath the surface in the northwestern part of the map area, based on exposures on adjacent MOUNT BARTLE. An aeromagnetic high in this area supports this inference and suggests that sills of the Killara Formation lie close to the surface (Fig. 3). Details of the geology, petrology, and geochemistry of the Killara Formation are documented in Dawes and Pirajno (1998) and Pirajno et al. (1998). In addition, Pirajno and Adamides (2000) gave a broad overview of the Killara Formation within the Yerrida Basin.

Maraloou Formation (*Pymk*)

The Maraloou Formation (*Pymk*; Elias et al., 1982) was named after Maraloou Well on MOUNT BARTLE. The formation is a succession of argillaceous sedimentary rocks, black shale, marl, dolostone, and minor chert and carbonate. It forms the uppermost unit of the Mooloogool Subgroup (Occhipinti et al., 1997). The type locality is at Mount Russell on MOUNT BARTLE, but there is no formally defined type section.

The Maraloou Formation on MEREWETHER outcrops in the northwestern extremity of the map area, just north of

Frustration Bore (MGA 761700E 7066000N), typically underlying the flat alluvial outwash plain. It consists of shale, finely laminated quartzose siltstone, argillaceous dolomitic limestone, and interbedded siltstone with thin beds of limestone and dolomite. The outcrops do not display the typical features of the type area, but are instead of a carbonate-rich variety. The dolomitic limestone is mostly pink to purplish brown, massive to flaggy, and commonly flecked with oxides of manganese and iron. It contains up to 80% dolomite; the balance being silt-sized quartz grains and clay minerals. The siltstone is parallel laminated and is the dominant lithology within the map area.

The fine grain size of the Maraloou Formation indicates that it was deposited under low energy conditions, probably in a lacustrine environment (Pirajno and Adamides, 2000).

Earaheedy Group

The Earraheedy Group unconformably overlies the Yerrida Group on MEREWETHER, forming isolated outcrops that, on the basis of stromatolite biostratigraphy, are correlated with the Yelma Formation, the basal unit of the Earraheedy Group (Gee and Grey, 1993; Grey 1994b). The Earraheedy Group is subdivided into the Tooloo and Miningarra Subgroups. Only the basal Yelma Formation of the Tooloo Subgroup outcrops on MEREWETHER (Table 2). The remaining formations of the subgroup, the Frere Formation

and the Windidda Formation, do not outcrop on the sheet area. Biostratigraphic correlation of stromatolitic species in the Yelma Formation provides a maximum age of deposition for the Earahedy Group of between 1.9 and 1.8 Ga (Grey, 1994b).

Tooloo Subgroup

Yelma Formation (BEy, BEya, BEyc)

The Yelma Formation (*BEy*; Gee and Grey, 1993) unconformably overlies the Yerrida Group on the northern margin of MEREWETHER. The formation is incompletely preserved and gently folded (Fig. 11). The basal unit is compositionally mature, and consists of stratified quartz-pebble conglomerate and cross-stratified sandstone (*BEya*). This is overlain by stromatolitic chert and chert breccia (*BEyc*), in which original carbonate rock is locally preserved. Above this, graded laminates of siltstone and shale are interbedded with thin sandstone beds and minor lenses of dolomite, which in places contain algal mats. Gee and Grey (1993) noted that the basal unit of the Yelma Formation is very similar to the Finlayson Member of the Juderina Formation, which it has been confused with previously. In outcrop, the basal arenite in the Yelma Formation is commonly distinguishable from the Finlayson Member by having a coarser grain size, thicker bedding, weaker cementation, and abundant cross-bedding (Dawes and Pirajno, 1998). The stromatolite-bearing chert and dolomite are readily distinguishable from the Juderina Formation by comparing the stromatolite assemblages.

Cross-stratified arenites form the basal unit of the Yelma Formation. On MEREWETHER, the contact between the Yelma Formation and the underlying Yerrida Group is not exposed. However, to the north on MOUNT BARTLE, the base of the formation is a clast-supported quartz-pebble conglomerate up to a few metres thick, which fines upwards into a quartz arenite (Dawes and Pirajno, 1998). The arenite is typically buff to red, medium grained, and trough cross-bedded. Near the Magellan prospect (MGA 793200E 7063400N), a bedding surface in the quartz arenite contains raindrop impressions, indicating emergence during the early depositional history of the Yelma Formation.

Stromatolitic chert and carbonate rocks, as well as chert breccia (*BEyc*), lie conformably above the arenites. The carbonate rocks are typically dolomitic, although some weathered limestone beds are present, particularly just south of the Magellan prospect (MGA 794000E 7062000N). Gee and Grey (1993) and Grey (1984, 1994b,c) documented the stromatolite fauna in the Yelma Formation and its outliers. The forms present on MEREWETHER include *Yandilla meekatharrensensis* Grey 1984, *Yelma digitata* (Grey) 1984, and *Pilbaria deverella* Grey 1984. Chert and chert breccia are intercalated with locally silicified stromatolitic dolostone units. These units are areally extensive and may record hydraulically fractured and brecciated units forming a palaeo-aquifer between impermeable stromatolitic units. Silicification of the unit resulted in a build-up of fluid pressure and resulted in hydraulic fracturing when the pressure of the aquifer exceeded the lithostatic load (Dawes and Pirajno, 1998).



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Figure 11. Gentle folding in the Yelma Formation, Earahedy Group (MGA 796200E 7062900N)

The Yelma Formation is thought to have been deposited in a nearshore to shallow-marine environment.

Cainozoic deposits

Cainozoic deposits dominate the surface geology of MEREWETHER. Ten units are recognized, four of which are Quaternary in age. The boundaries between some of the units are gradational, and most are based on Landsat image and airphoto interpretation.

An extensive sandplain system (*Qs*) covers most of the southern half of the map area and extends northwards. This sandplain commonly overlies granitoids and is eolian in origin. Areas proximal to granitoid outcrop dominantly comprise coarse- to medium-grained, white, quartzofeldspathic sands (*Czg*), formed by the mechanical weathering of these granitoids. Silcrete (*Czz*) formed as a siliceous duricrust over deeply weathered granitoid outcrops, and is composed of angular quartz grains in a fine-grained siliceous matrix.

Colluvium (*Qc* and *Czc*) forms scree slopes around elevated outcrop areas. This colluvium comprises rock fragments mixed with laterite and soil. The size of these fragments decreases with distance from the outcrop and increases in clay and silt content. As slope diminishes, this unit typically merges with sheetwash deposits in the distal regions from the outcrop.

Alluvial channels and associated sheetwash areas are distributed throughout the map area. Active alluvial channels (*Qa*) are prominent in the northern part where they form valley systems between hills of Proterozoic Juderina Formation. In the south, the alluvial channels are indistinct and abruptly grade into areas of sheetwash (*Qw*) in the flat-lying areas. In the Joyners Find greenstone belt the alluvial channels are incised into the surrounding higher topography. The alluvial channels are composed of unconsolidated red to brown cobbles, gravel, sand, and silt, and the sheetwash is dominantly sand and silt stabilized by low scrub vegetation.

Calcrete (*Czk*) is present in the northernmost part of MEREWETHER, where it forms sheet-like bodies of limestone and opaline silica. These are mainly derived from the breakdown and resedimentation of limestone horizons within the Bubble Well Member of the Juderina Formation. Some calcrete bodies may also be associated with chemical reprecipitation from carbonate-bearing groundwater.

Relics of ferruginous duricrust (*Czl*) are distributed on the eastern part of the map in association with the north-south elongated ultramafic (*Au*) and BIF unit (*Ac*). The duricrust is composed of ferruginized deeply weathered rock and associated detritus, as well as reworked ferruginous, and in places, pisolitic, soils. Chert cap rocks are closely associated with the duricrust overlying ultramafic rocks (*Czu*). These cream to green cherts preserve original textures of the precursor rock.

Structure

Archaean rocks of the Joyners Find greenstone belt on MEREWETHER have undergone multiple phases of deformation and metamorphism. The Joyners Find greenstone belt lies in the extreme northeastern part of the Southern Cross Granite–Greenstone Terrane (Griffin, 1990), and is separated from the Eastern Goldfields Granite–Greenstone Terrane to the east by the Ida Fault. According to Dalstra et al. (1999), the Southern Cross Granite–Greenstone Terrane underwent five phases of deformation. The first event (*D*₁, north–south shortening) produced low-angle thrust faults, isoclinal and sheath folds, and a gently dipping foliation with a locally developed downdip mineral lineation (Chen, 2001). East–west compression during *D*₂ produced large-scale upright to inclined folds (with wavelengths of several kilometres) with a penetrative north- to northwest-trending subvertical foliation. This shortening event is also related to pre- and syn-*D*₂ granite emplacement within the Southern Cross Granite–Greenstone Terrane (Chen et al., 2001). The *D*₃ event formed subvertically dipping shear zones (commonly associated with gold mineralization, see **Economic geology**) oriented northwest to northeast, after east–west compression. The foliation formed during *D*₃ is typically oblique to subparallel to the shear zones, distinct to that developed during *D*₂. Conjugate north-northeasterly trending dextral and east–west-trending sinistral faulting characterize the *D*₄ event. Brittle–ductile faults formed during this event typically have offsets of less than 100 m. The final deformation event, *D*₅, represents a north–south compression (after relaxation) causing brittle reactivation of the earlier structures. Events *D*₂–*D*₄ are thought to represent progressive deformation due to east–west compression, whereas the *D*₁ and *D*₅ events represent separate north–south compressive events (Dalstra et al., 1999).

No evidence of the *D*₁ event has been found on MEREWETHER. In the majority of units within the Joyners Find greenstone belt, a strong northerly to north-northwesterly trending, sub-vertical to steeply westerly dipping foliation is present. It is most pronounced in the ultramafic and mafic rocks in the centre of the greenstone belt, where deformation is uniform. The foliation is probably the result of the *D*₂ event, and has been subsequently faulted and folded into tight or isoclinal folds oriented north–south with west-dipping axial planes. This later deformation is most evident in the large BIF ridges flanking the greenstone belt. These BIF ridges are variably deformed and intensely folded, and brecciated lithologies typically lay only metres from undeformed lithologies. The elongated arcuate geometry of the Joyners Find greenstone belt is related to compression of the greenstones between rigid granitoid blocks to the east and west during the *D*₂ compression and shortening (Chen et al., 2001).

Thom (1994) recognized two major shear zones: the Joyners Find shear zone, which runs northwards through the centre of the Joyners Find greenstone belt; and the Brilliant shear zone, which is located on the eastern flank of the Joyners Find greenstone belt and oriented north-northwest. Both shear zones have dextral movement. Many small shear zones in the BIFs and mafic and ultramafic

rocks of the greenstone belt probably represent D₃ deformation. Shear zones formed during the D₃ event are locally mineralized, which is consistent with timing of mineralization elsewhere in the Southern Cross Granite–Greenstone Terrane (Dalstra et al., 1999; Chen et al., 2001; Greenfield et al., 2001; Wyche et al., 2001).

Large faults have broken the greenstone belt into three fragments, with each fragment also crossed by other major faults. This extensive brittle faulting took place subsequent to the D₃ event. The faults are predominantly oriented northwest and southwest, and although they have a slightly different orientation to the D₄ faults elsewhere in the Southern Cross Granite–Greenstone Terrane, it is likely that they represent D₄ deformation on MEREWETHER.

Palaeoproterozoic sedimentary rocks of the Yerrida and Earraheedy Groups have undergone minor deformation. The units typically dip less than 20° and tend to be unfolded, although there is some minor folding. These minor folds plunge gently at less than 30° to the east and north. Faults within the Yerrida Group trend eastwards, although some reactivated fault zones in the Joyners Find greenstone belt penetrating the Proterozoic strata trend northwards. Strike-slip displacement on these faults is less than a few hundred metres, with similar vertical displacement.

After the deposition of the Yerrida and Earraheedy Groups, the MEREWETHER region underwent deformation during the Palaeoproterozoic Capricorn Orogeny, which resulted from the collision between the Yilgarn and Pilbara Cratons (Tyler et al., 1998; Pirajno and Adamides, 2000). It is likely that the easterly trending faults and the reactivation of underlying faults within the Archaean granite–greenstones are a result of this orogenic episode. The Capricorn Orogeny is also the likely cause of the small-scale, gentle folding of the Yerrida and Earraheedy Groups.

Metamorphism

Most of the Archaean rocks on MEREWETHER have been metamorphosed, but to varying degrees. Metamorphic grades are highest in the Joyners Find greenstone belt, whereas the monzogranites that dominate the southern and eastern parts of MEREWETHER have only been slightly metamorphosed (alteration of feldspar to muscovite).

Ahmat (1986) noted that the Joyners Find greenstone belt comprises predominantly low-grade metamorphic rocks surrounded by a rim of higher grade metamorphic rocks. The ultramafic units in the centre of the greenstone belt have been metamorphosed to talc–chlorite schist, whereas the ultramafic–mafic rocks have been metamorphosed to chlorite, and the tremolite–chlorite–epidote schists and mafic units to tremolite–actinolite–albite schist. Ahmat (1986) attributed these mineral assemblages to low-grade metamorphic conditions. However, on the western flank of the greenstone belt, the presence of garnet in sedimentary rocks indicates that the area has been subjected to medium-grade metamorphism.

Mafic and ultramafic rocks in the Joyners Find greenstone belt have undergone two main metamorphic events. The first event involved metamorphism of the parent rock at low-grade metamorphic conditions, and the second metamorphic event resulted in local regrowth of actinolite. Elias et al. (1982) suggested that this may also indicate static metamorphism after deformation.

Economic geology

Gold and base metal mineralization are present on MEREWETHER. Exploration in the area has concentrated on the Joyners Find greenstone belt, where gold was discovered in 1925. Base metal exploration has recently been undertaken in the northern part of the map area on black shales of the Yelma and Maraloou Formations.

Gold

Small-scale gold mining took place in the Joyners Find greenstone belt following the discovery of gold at Channings in 1925 (producing 112 kg of gold between 1925 and 1941) and Joyners Find in 1935 (producing 1897 kg of gold between 1938 and 1941; Thom, 1994). Numerous workings are located within the northern segment of the greenstone belt; however, no mineralization has been discovered in the south.

At the Joyners Find mine, gold mineralization is hosted within the easternmost BIF unit, mafic and ultramafic rocks west of this BIF (Walsh, 1997), and some minor BIF units immediately to the northwest and southeast (Thom, 1994). Gold mineralization has not been found in the westernmost BIF. Walsh (1997) reported that the mineralization was at first thought to be associated with north-trending shear zones, but later work focused on north-northwest trending faults cutting the belt. According to Thom (1994), mineralization is contained within two major shear zones — the Joyners Find shear zone (parallel to the lithological strike) and the Brilliant shear zone (oriented about 5° to the lithological strike) — and within north-northwesterly trending faults (Fig. 12). The presence of similar faults in the smaller southern portions of the Joyners Find greenstone belt indicates that they are also prospective (Thom, 1994). Gold mineralization consists of pod-like shoots within shear zones, which are parallel to the foliation and strike of the greenstone belt in the Joyners Find shear zone, and near-parallel to the foliation and strike of the greenstone belt in the Brilliant shear zone (Fig. 12; Thom, 1994).

Lead

In 1993, Renison Goldfields Consolidated announced the discovery of the Magellan lead deposit (MGA 793000E 7063300N), hosted in the Yelma Formation of the Earraheedy Group (Pirajno et al., 1999), and extending into the Maraloou Formation of the Yerrida Group. The deposit contains a total resource of 210 Mt at 1.8% Pb, with defined zones at 2% cutoff containing an indicated resource of 5.5 Mt at 7.1% Pb and an inferred resource

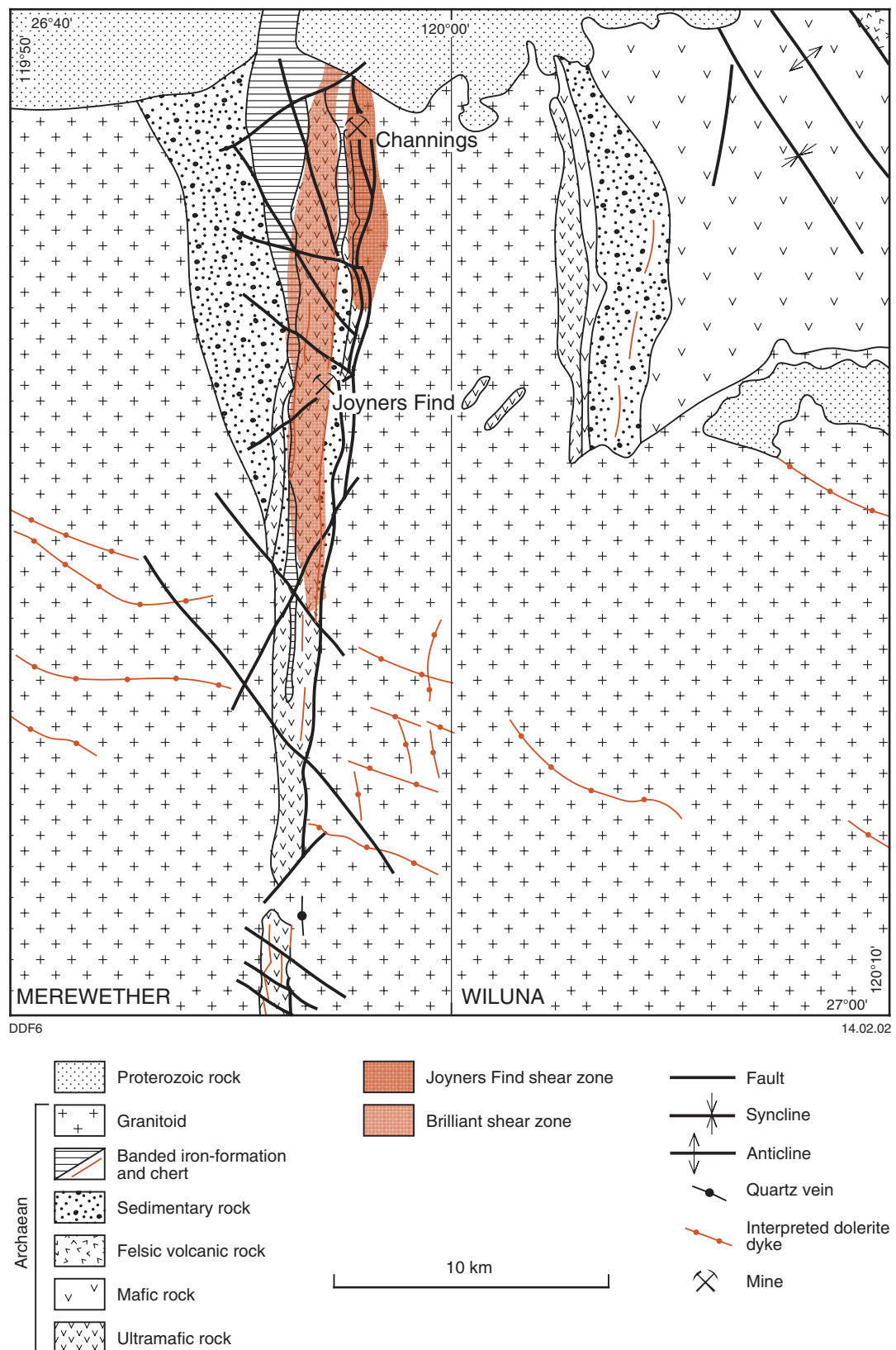


Figure 12. Mining localities in the Joyners Find greenstone belt

of 7.09 Mt at 4% Pb (Ferguson, 1999). The lead-bearing minerals — cerussite, platerite, and pyromorphite — may have formed after oxidation and mobilization (through expulsion of basal brines) of lead that was sourced from weathered basement rocks (Pirajno et al., 1999). The sulfidic shales and carbonates of the Yelma Formation are

prospective for Mississippi Valley-type and sedimentary exhalative lead–zinc–copper deposits. A Pb–Pb model age of 1.65 Ga was obtained from carbonate ore of the Magellan prospect and provides a minimum age for ore emplacement (Le Blanc Smith et al., 1995).

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Appendix

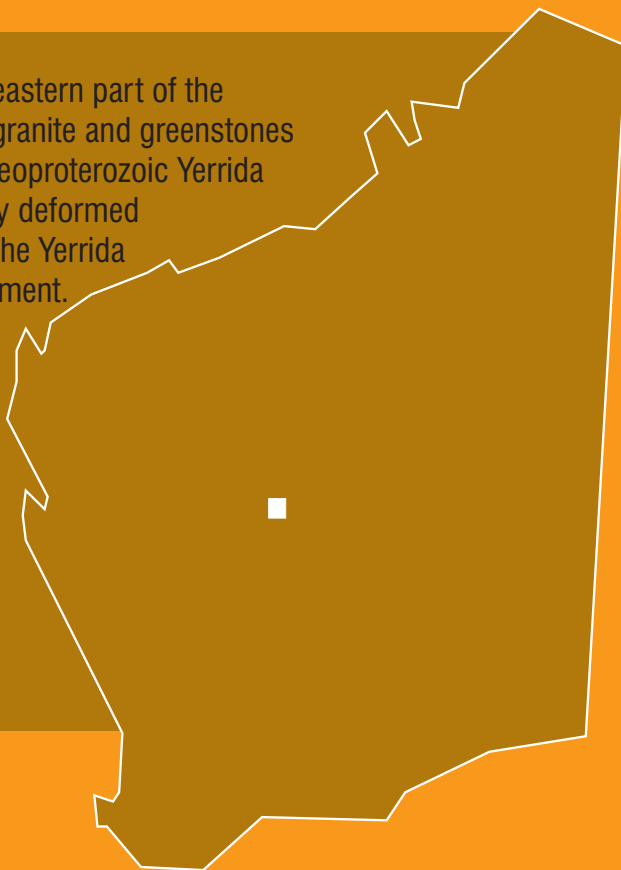
Gazetteer of localities on MEREWETHER

<i>Locality</i>	<i>GDA coordinates</i>	
	<i>Easting</i>	<i>Northing</i>
Channings mine	795700	7041600
Eagle prospect	793800	7036800
Eagle Roost ^(a)	756200	7099300
Frustration Bore	761100	7065500
Goosie Bore ^(b)	822490	7074500
Granite Well	758800	7020200
Joyners Find mine	793500	7033000
Magellan prospect	793200	7063300
Mount Russell ^(c)	783400	7066050
Paroo Well	755200	7053200
White Bore	796400	7012400

NOTES: (a) on WILUNA
 (b) on CUNYU
 (c) on MOUNT BARTLE

The MEREWETHER 1:100 000 sheet covers the southeastern part of the GLENGARRY 1:250 000 map sheet. Archaean monzogranite and greenstones of the Yilgarn Craton and rocks of the overlying Palaeoproterozoic Yerrida Basin dominate the area. The Yerrida Basin is slightly deformed and comprises mostly sandstone and carbonate of the Yerrida Group, deposited in a marginal to nearshore environment.

Outliers of the Palaeoproterozoic Earraheedy Basin along the sheet's northern boundary consist of sandstone and carbonate of the Earraheedy Group. The Yelma Formation of the Earraheedy Group hosts the Magellan lead deposit and is also prospective for copper and zinc. Archaean greenstones of the Joyners Find greenstone belt outcrop in the eastern part of MEREWETHER. They have undergone low- to medium-grade metamorphism, and host minor gold mineralization.



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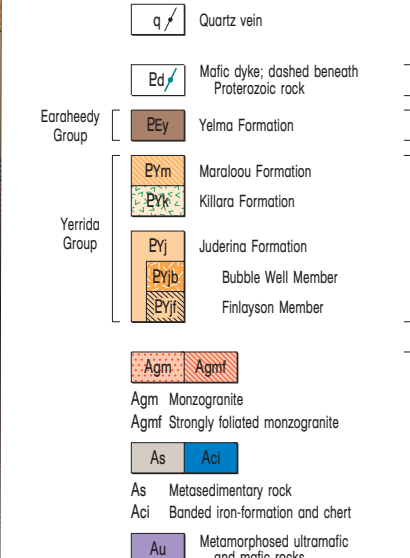
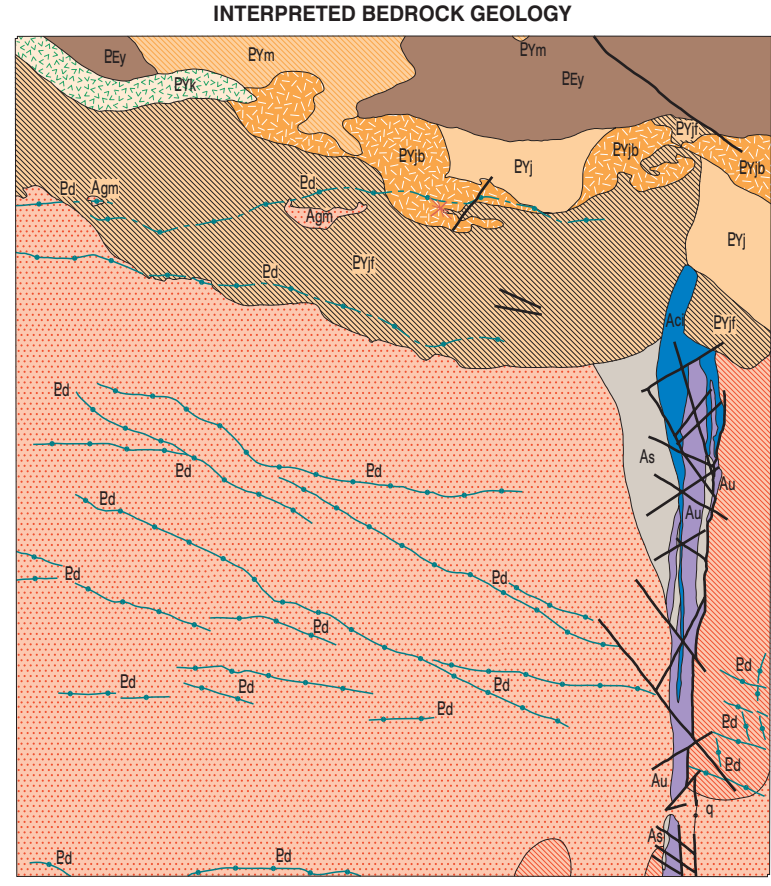
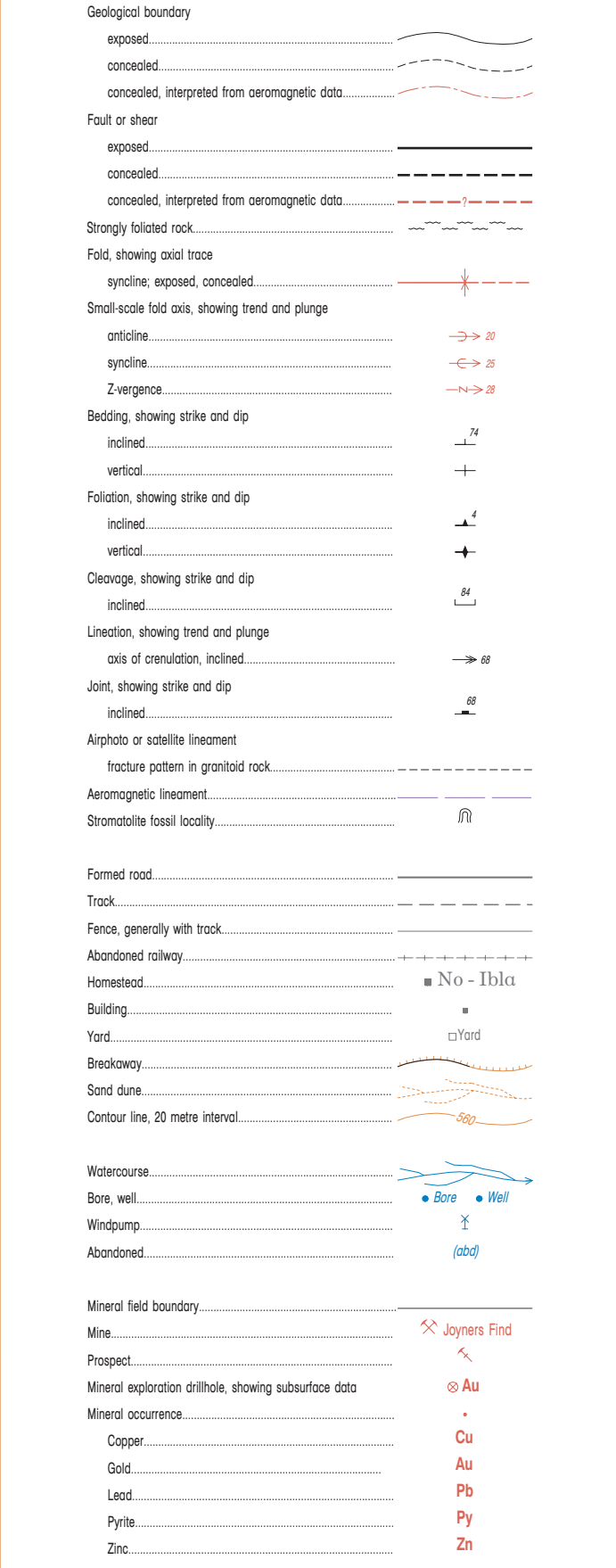
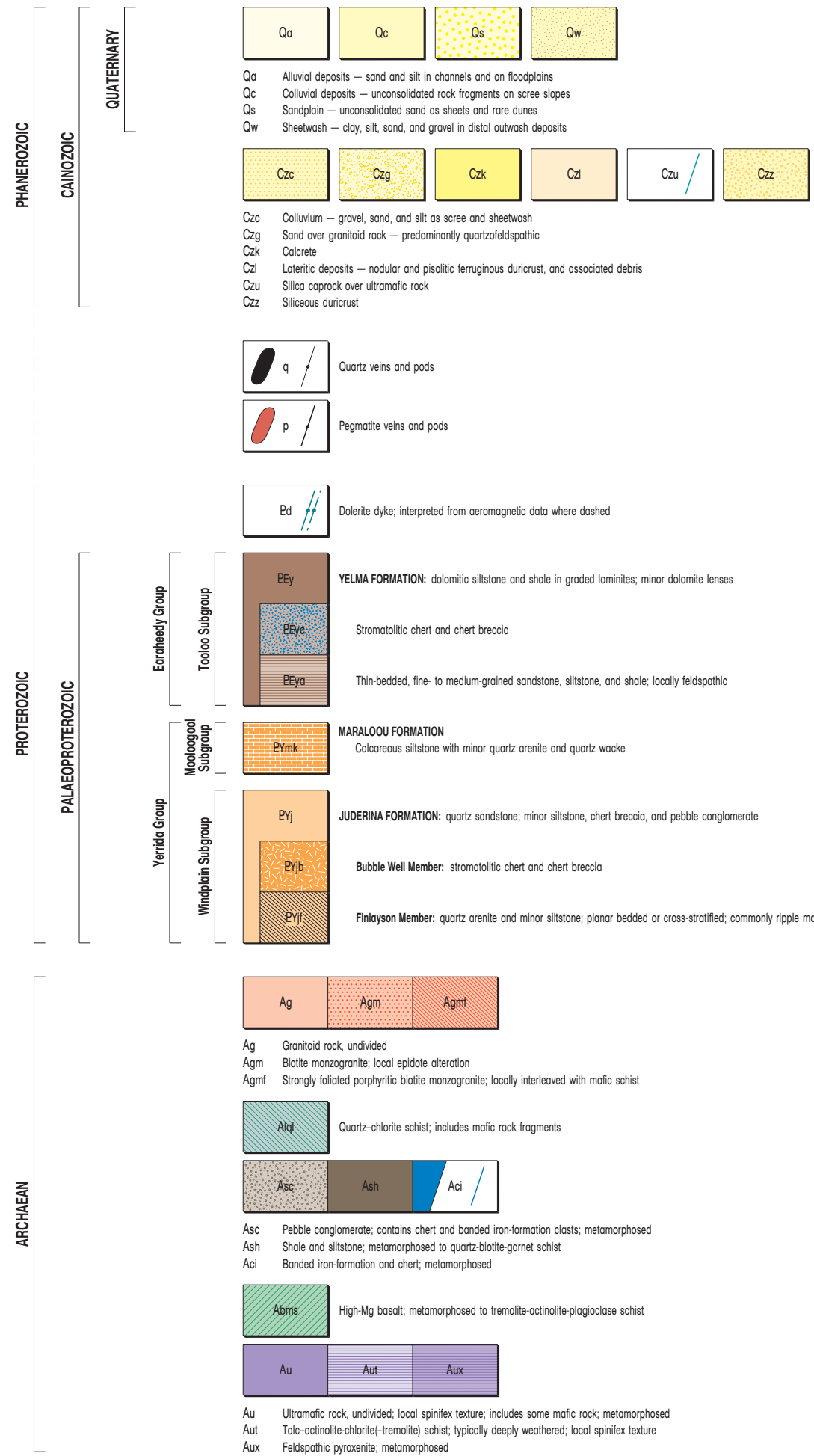
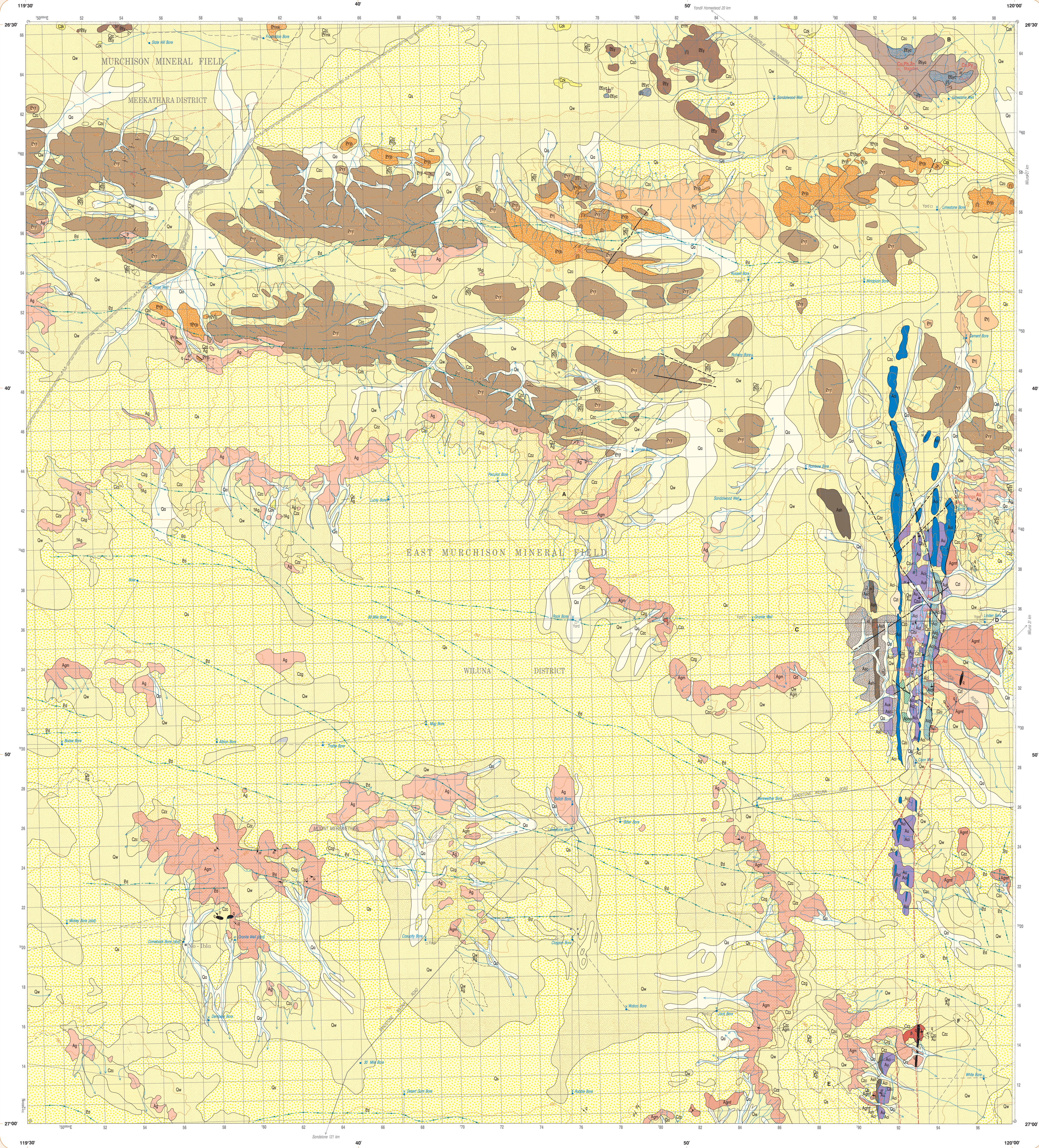
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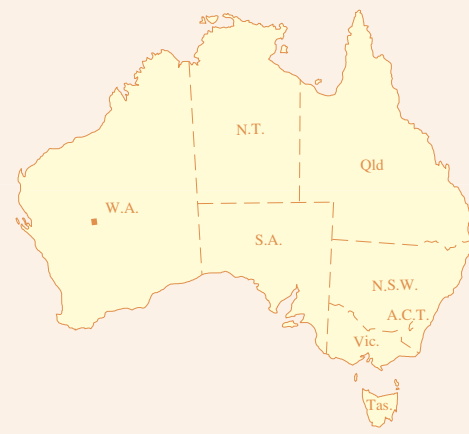
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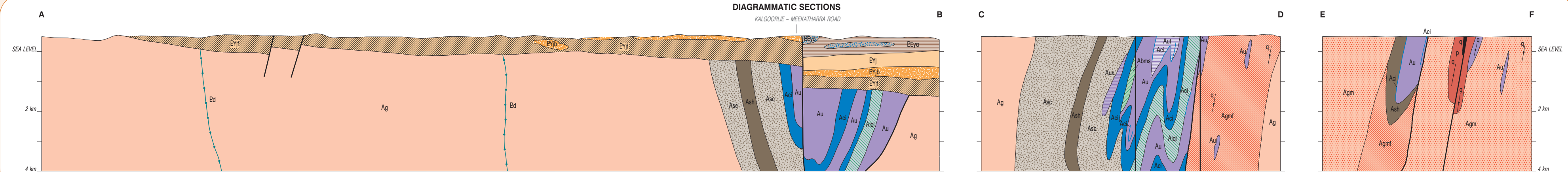
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DIAGRAMMATIC SECTIONS



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