

# Geology of the southern part of the Yandal greenstone belt, Eastern Goldfields

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## Abstract

The southern part of the Archaean Yandal greenstone belt contains metamorphosed clastic and chemical sedimentary rocks, intrusive and extrusive mafic rocks, ultramafic rocks, and calc-alkaline volcanic rocks. There is no clear stratigraphy, and metamorphism is mainly low grade but ranges to medium grade. Although exposure is typically poor and there is a deep weathering profile, there are local areas of good outcrop, including the Spring Well calc-alkaline volcanic complex. The Yandal belt is bounded to the east and west by major faults, and granitoid and greenstone rocks are interleaved and deformed along both contacts. Two major regional deformation episodes are recognized. The first is characterized by upright folds around north-northwesterly trending axes, and the second by north-northeasterly to north-northwesterly trending shear zones. Granitoid rocks of mainly monzogranitic composition, some of which clearly pre-date the major shearing, occur in broad areas to the east and west of the greenstone belt. Post-deformational granitoid intrusions at the margins of and within the greenstone belt range in composition from quartz monzonite to granodiorite. The southern part of the Yandal greenstone belt hosts a number of significant gold deposits.

**KEYWORDS:** Archaean, Eastern Goldfields, Yandal, Spring Well, Darlot, Sir Samuel, greenstone, felsic volcanic, calc-alkaline, gold.

Geological mapping by the Geological Survey of Western Australia (GSWA) in 1994 on SIR SAMUEL\* and DUKETON (1:250 000 sheets) has resulted in a better understanding of the distribution of the major rock types, and provided some new insights into the geological evolution and structural history of the northern part of the Eastern Goldfields. This work is being carried out in cooperation with the Australian Geological Survey Organization (AGSO) as part

of the National Geoscience Mapping Accord (NGMA).

Field mapping in the southern part of the Yandal greenstone belt (Griffin, 1990) was undertaken between March and November 1994 using colour 1:25 000 aerial photographs taken in March 1994. Aeromagnetic data acquired by AGSO for the NGMA (400 m line spacing) assisted geological interpretations in areas of poor outcrop. Landsat Thematic Mapper images generated at the compilation scale were used in conjunction with aerial photographs to interpret the regolith.

DARLOT (1:100 000; Wyche and Westaway, in prep.) and the eastern part of SIR SAMUEL (1:100 000; Liu et al., in prep. a), which together make up the southwestern part of SIR SAMUEL (1:250 000; Bunting and Williams, 1979), were mapped by S. Wyche and J. M. Westaway in 1995. This area includes the southern part of the Yandal greenstone belt, a north-northwesterly trending Archaean greenstone sequence that extends for about 200 km from the northwestern part of WILUNA (1:250 000; Elias and Bunting, 1982) to the southern edge of DARLOT, where it has been extensively intruded by granitoid rocks. The belt contains a number of significant gold deposits including Jundee, Bronzewing, Mount McClure, and Darlot (Fig. 1).

Much of the southern part of the Yandal greenstone belt is very poorly exposed with the weathering profile commonly exceeding 60 m depth. Lake Darlot, which lies approximately east-west across the central part of DARLOT, is part of a large palaeodrainage system that extends from the northern edge of the Yilgarn Craton west of Wiluna to the southeastern part of the Craton via Lake Carey and Lake Minigwal. It discharges into the Eucla Basin. Away from the lake system much of the area is covered by sand and sheetwash. Remnants of a cover sequence of Permian mudstone and glacial conglomerate outcrop locally, such as around Ockerburry Hill. Proterozoic dykes are evident on aeromagnetic images but are rarely seen in outcrop.

## Archaean geology

The southern part of the Yandal greenstone belt comprises mainly

\* Capitalized names refer to standard map sheets.

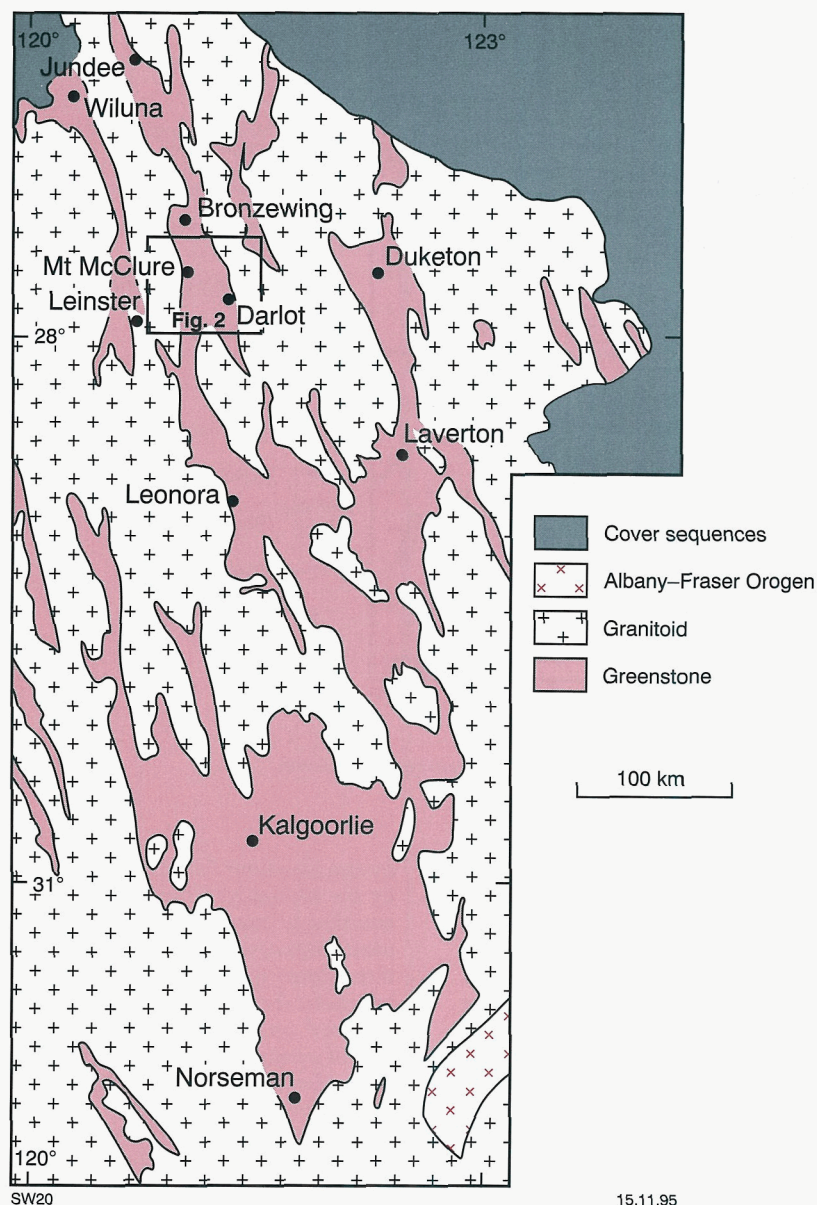


Figure 1. Regional geological setting of the Yandal greenstone belt

low-grade metamorphic rocks derived from felsic volcanic rocks, extrusive and intrusive mafic rocks, ultramafic rocks, and clastic and chemical sedimentary rocks. Contacts with broad areas of granitoid rocks to the east and west are either intrusive or faulted, and there is no indication of the nature of any pre-greenstone basement. The major features of the interpreted granite-greenstone geology are illustrated in Figure 2.

#### The greenstone sequence

Immediately east of the Mount McClure Fault, the Yandal green-

stone belt comprises an easterly younging sequence of mafic rocks with interbeds of siliceous meta-sedimentary rock (chert), shale, tuffaceous sedimentary rocks, and thin, commonly discontinuous, ultramafic units. Younging directions are given by sedimentary structures (e.g. graded bedding) and differentiation trends in gabbro. Exposure further to the east is poor, but scattered outcrops and chip samples from mineral exploration drillholes indicate a mixed succession of metamorphosed felsic, intermediate, and mafic volcanic rocks, some thin ultramafic units, sedimentary rocks, and gabbro.

A major structure, the Ockerburry Fault (Bunting and Williams, 1979), which trends north-northeast across the western part of DARLOT, is probably related to the shearing along granite-greenstone contacts described below. Although it passes through areas with little or no outcrop, the Ockerburry Fault stands out as a linear feature on aeromagnetic images and has been identified in mineral exploration drillholes as a zone of strongly sheared rock, possibly more than 1 km wide. Rocks within this zone outcrop in the vicinity of Ockerburry Hill, where they are strongly deformed and contain a shallow south-plunging mineral lineation.

The poorly exposed sequence immediately east of the Ockerburry Fault appears to be similar in character to that west of the fault. Younging directions have not been determined in this part of the sequence. Scattered outcrops of ultramafic rock, together with subsurface rock types identified from mineral exploration drillholes, indicate that at least some of the linear magnetic features in areas of poor exposure, both east and west of the fault, represent thin ultramafic units. However, it is possible that some of the magnetic features may be attributed to the gabbroic intrusions that occur throughout the greenstone belt. Many of the gabbros have an internal layering defined by compositional and grainsize variations.

Further east, the southern part of DARLOT is dominated by the locally well-exposed Spring Well calc-alkaline volcanic complex (Giles, 1982). Whole-rock geochemistry from the Spring Well complex indicates a bimodal compositional distribution, with one group in the rhyolite-dacite field and the other in the andesite-basaltic andesite field (Westaway and Wyche, in prep.). A wide range of rock types exposed in the vicinity of Spring Well, including flow-banded rhyolite lavas, porphyritic rhyolite and dacite, ash and lapilli tuffs, and coarse-grained fragmental rocks, which may include both pyroclastic and mass-flow deposits, indicate that this area may have been close to the ancient volcanic centre. Lapilli and ash tuff, and volcanoclastic sandstone and conglomerate, which outcrop in the northern part of DARLOT where they

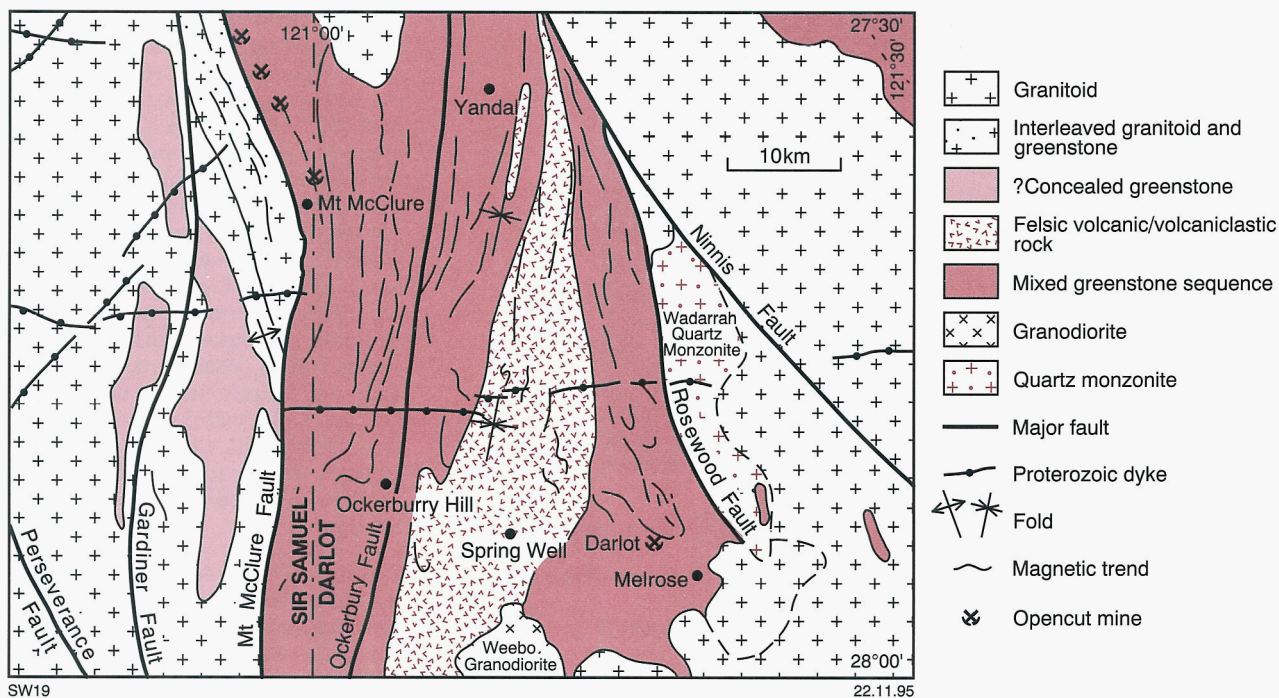


Figure 2. Simplified geological sketch map of DARLOT and the eastern part of SIR SAMUEL

are interbedded with extrusive and intrusive mafic rocks, represent a distal facies to the Spring Well volcanic centre. The rapid lateral lithological and compositional changes, high proportion of pyroclastic rocks, and large volume of volcanoclastic breccias around Spring Well suggest that the complex represents the Archaean equivalent of a continental stratavolcano (Cas and Wright, 1987).

East of Spring Well a poorly exposed mixed sequence of mafic and felsic volcanic rocks contains numerous gabbroic intrusions. The felsic rocks within this sequence may also be a distal component of the Spring Well complex. Pillow lavas and sedimentary structures in felsic volcanoclastic rocks in the Darlot openpit indicate younging towards the east, but the overall lack of outcrop through the region makes it unclear whether this younging direction is representative.

There is no clear stratigraphic succession across the Yandal greenstone belt. The greenstones are different in character to those of the Kalgoorlie Terrane (Swager et al., 1995), and to those in greenstone belts to the east and west (Langford

and Farrell, in prep.; Liu et al., in prep. b), in that they appear to contain a smaller ultramafic component. However, they are similar to parts of the sequence described by Hallberg (1985) in the Leonora–Laverton area and may correspond to the upper part of his Association 1 and the lower part of his Association 2.

#### The granite–greenstone contacts

The southern part of the Yandal greenstone belt is mainly fault bounded. Contacts are characterized by strong deformation, local areas of relatively high-grade metamorphism, and interleaving of greenstone and granitoid rocks. Greenstones at the contacts are locally metamorphosed to amphibolite facies assemblages whereas those in the central part of the belt are in the greenschist facies, and are much less deformed.

The western contact of the Yandal greenstone belt is marked by a north-northeasterly to north-northwesterly trending corridor, up to 13 km wide, of intercalated granitoid and greenstone rocks, which has been called the Cocks–Satisfaction zone (Liu et al., in prep. b). This zone, bounded to the west

by the Gardiner Fault and to the east by the Mount McClure Fault, is commonly concealed beneath sandplain cover and has been interpreted mainly from aeromagnetic data. However, it is well exposed west of the Mount McClure line of openpits where there is a strip, about 5 km wide, of complexly interleaved granitoid and greenstone rocks. Bands from less than 1 m up to about 30 m thick of metamorphosed basalt, komatiite, and felsic rock, which are weakly to very strongly deformed, are intercalated with moderately to strongly deformed granitoid rock of mainly monzogranitic composition. There are local thin high-strain zones. Despite the strong deformation, primary textures are preserved in places. Deformed rocks in this sequence have well-developed mineral lineations that typically have a shallow plunge to the south, but locally plunge shallowly to the north. This area has a distinctive striped pattern on aerial photographs and aeromagnetic images. Large magnetic features within non-outcropping areas to the south are interpreted as greenstone enclaves in deformed granitoid rocks.

The eastern contact of the Yandal greenstone belt is represented by a

major regional ductile shear zone, the Ninnis Fault, formerly called the Celia Lineament (Bunting and Williams, 1979). In the southern part of the greenstone belt, where it has a northwest trend, exposure is commonly poor adjacent to the fault, but there is some clear interleaving of granitoid and greenstone rocks. The Ninnis Fault can be traced on aeromagnetic images as a linear feature that extends from within areas of granitoid rock southeast of DARLOT to the northernmost part of the Yandal greenstone belt. The Rosewood Fault may be a splay of the Ninnis Fault that has been intruded by a variety of granitoid rocks including the Wadarrah Quartz Monzonite.

### Structure

The two most readily recognizable structural elements in the Yandal greenstone belt are upright folds about north-northwesterly trending axes, and the north-northeasterly to northwesterly trending shear zones. Although the folds are rarely well exposed, locally close-spaced changes in younging directions in pyroclastic and volcanoclastic rocks suggest that two synclines, which are outlined by gabbros in the central part of DARLOT, are representative of more widespread medium-scale, tight, upright folding. The style and intensity of the folding and shearing are similar to that associated with D<sub>2</sub> and D<sub>3</sub> in the Kalgoorlie Terrane (Swager et al., 1995). Small-scale, late, east-northeasterly trending faults may correspond to D<sub>4</sub> of Swager et al. (1995). An early (pre-D<sub>2</sub>) fabric, which has been recognized both in the Mount Keith greenstone belt to the west (Liu et al., in prep. b) and in the Duketon area to the east (Langford and Farrell, in prep.), has not been recognized in this part of the Yandal greenstone belt, although shallow-plunging lineations at the granite-greenstone contact have been interpreted as evidence of an early extensional episode (Hammond and Nisbet, 1992).

### Granitoid rocks

Broad areas of poorly exposed granitoid rock between greenstone outcrops in the Yandal belt contain monzogranite. There is a range of textural varieties from fine- to

coarse-grained and porphyritic. Some of these plutons have contact zones in which strongly deformed granitoid rocks are interleaved with greenstones and so must at least pre-date the regional north-northeasterly to northwesterly trending shear zones. Monzogranites between the Yandal greenstone belt and the Dingo Range greenstone belt to the east contain fluorite. Clearly post-deformational granitoid intrusions range in composition from quartz monzonite to granodiorite.

### Gold mineralization

Gold mineralization in the southern part of the Yandal greenstone belt probably post-dates all major deformation. Gold occurs in a variety of host rocks in north-

northwesterly to northwesterly trending structures, which may be related to the large-scale regional shear zones, and in the late cross-cutting structures. At Mount McClure, a series of openpits in a variety of deformed and metamorphosed rocks, which include mafic, ultramafic, and felsic volcanoclastic and epiclastic rock types, are aligned along a north-northwesterly trend that is parallel to the sheared granite-greenstone contact immediately to the west (Liu et al., in prep. b). In the Darlot gold mine, mineralization is hosted by an easterly dipping laminated quartz reef that occupies a northwesterly trending shear zone in a sequence of metamorphosed extrusive and intrusive mafic rocks overlain by metamorphosed felsic rocks, all of which have been extensively intruded by lamprophyre dykes (Westaway and Wyche, in prep.).

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