Komatiite-hosted Ni–Cu–PGE deposits of the Agnew–Wiluna greenstone belt — an overview

by

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Introduction

The Agnew–Wiluna belt is an intensely mineralized Archaean greenstone belt that hosts some of the world's largest komatiite-hosted Ni–Cu(–PGE) deposits. It is a strongly attenuated greenstone belt and forms the northern third of the Norseman–Wiluna belt in the Yilgarn Craton (Fig. 1). The Agnew–Wiluna belt has an hourglass shape and four distinct domains. The northern domain is defined by the broadening of the belt near Wiluna and Honeymoon Well. The belt thins to the south parallel to the Keith–Kilkenny lineament, before widening in the Agnew and Marshall Pool – Mount Clifford areas. There is considerable variation in metamorphic grade and strain within the belt. Metamorphic grade varies from prehnite–pumpellyite facies at Wiluna to mid-amphibolite facies at Perseverance (Binns et al., 1976; Hill et al., 1990).

The Ni–Cu(–PGE) ore deposits in the Agnew–Wiluna belt have been inferred to be hosted by channelized komatiitic dunite lava flows along a corridor from 11 Mile Well to Honeymoon Well (Hill et al., 1995). The belt hosts the type areas for giant komatiitic dunite-hosted Ni–Cu(–PGE) ore deposits at Mount Keith and Perseverance (Barnes et al., 1988; Dowling and Hill, 1990). Nickel sulfide mineralization in the belt occurs as two distinct types (Barnes et al., 1999), as defined by variations in the sulfide content (disseminated versus massive) and location of sulfides (intra-unit versus basal contact). Type 1 mineralization is typified by contact massive sulfides at the base of komatiitic units (Perseverance, Cliffs, Cosmos, Waterloo, Wedgetail). Type 2 mineralization is typified by the large low-grade disseminated sulfides at Mount Keith. In the western part of the belt, the komatiitic units are barren of nickel sulfides but locally host structurally controlled mesothermal gold deposits, such as Agnew (Broome et al., 1998).

Komatiites occur in three distinct facies associations in the belt:

- komatiite – felsic volcanic rock;
- komatiite – black shale;
- komatiite–basalt.

Some of these associations are mineralized but it is unclear whether there is a relationship between mineralization and the nature and sulfide content of the footwall.

Although the komatiites in the belt are intensely mineralized, there are domains that are known to be poorly mineralized and even barren. The corridor of komatiites that extends from 11 Mile Well to Honeymoon Well is variably mineralized, but the komatiites north of Honeymoon Well are barren of nickel sulfide mineralization.

Ore deposit diversity and stratigraphic relationships

The stratigraphy and mineralization in the Agnew–Wiluna belt is best characterized by the Mount Keith area. This area is located in the most attenuated portion of the Agnew–Wiluna greenstone belt, about 80 km south of Wiluna, where it has a maximum thickness of about 6 km (Fig. 2). The belt is bound to the west and east by voluminous Archaean granitoids. The greenstone sequence in the Mount Keith area includes three ultramafic horizons, locally designated the Eastern, Central, and Western Ultramafic units (Dowling and Hill, 1990). The ultramafic horizons can be traced 30 km north of Mount Keith to the Honeymoon Well nickel deposit, and 9 km south to the Cliffs–Charterhall nickel deposit. Beyond these limits, definition of the belts is uncertain due to structural complexities.

The Western and Central Ultramafics contain well developed spinifex-textured komatiites with Kambalda-style basal accumulations of massive sulfide (Type 1) occurring sporadically at the base of the Central Ultramafic, notably in the Cliffs–Charterhall area. The Eastern Ultramafic differs substantially from the other ultramafic horizons in three fundamental respects:

1. lack of spinifex-textured komatiites that are demonstrably contiguous with and not in structural contact with cumulate rocks anywhere along its strike extent (Rosengren et al., in press);
2. presence of thick (>500 m) coarse-grained olivine

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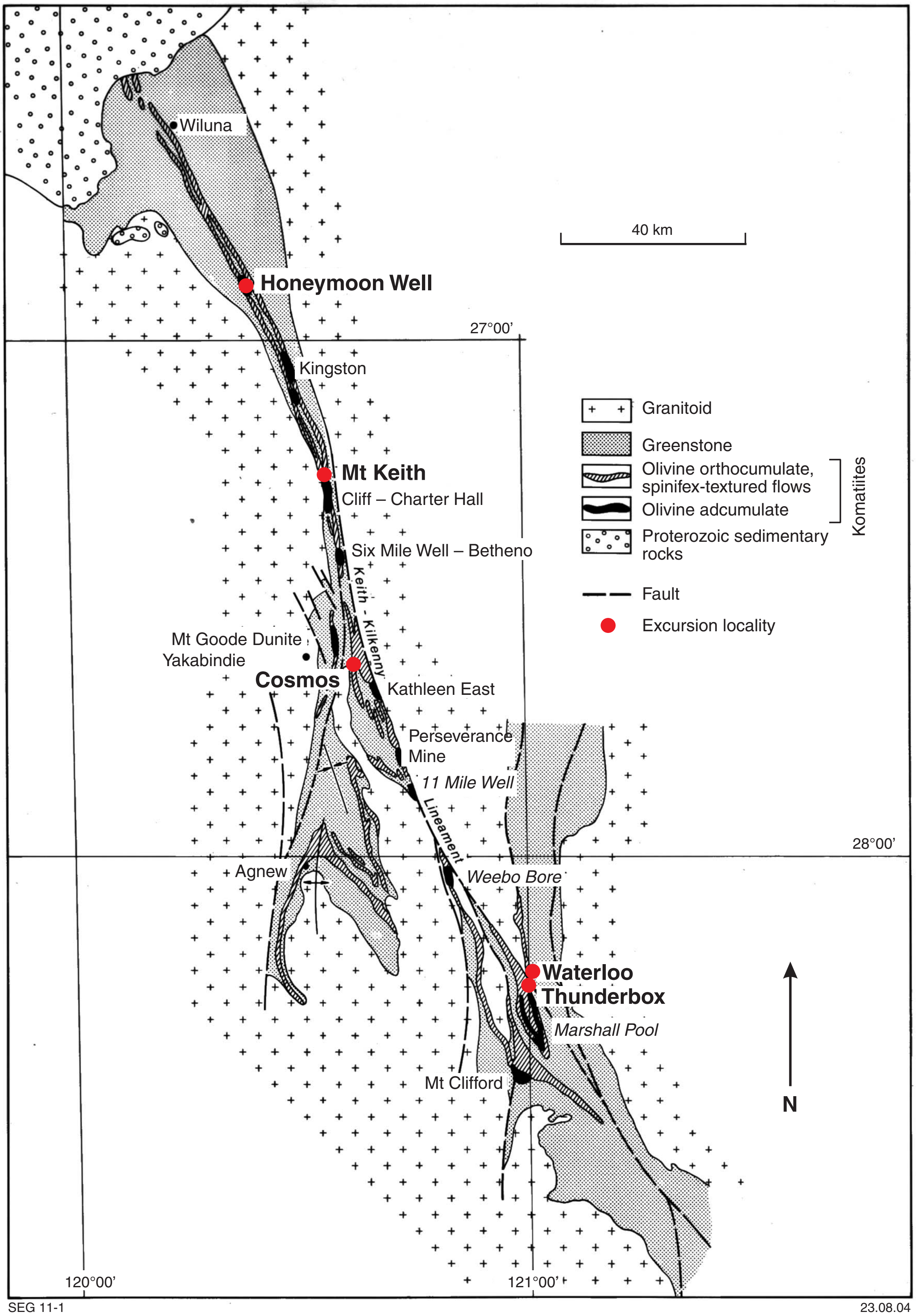

Figure 1. Geological map of the Agnew–Wiluna belt (adapted from Hill et al., 1990)

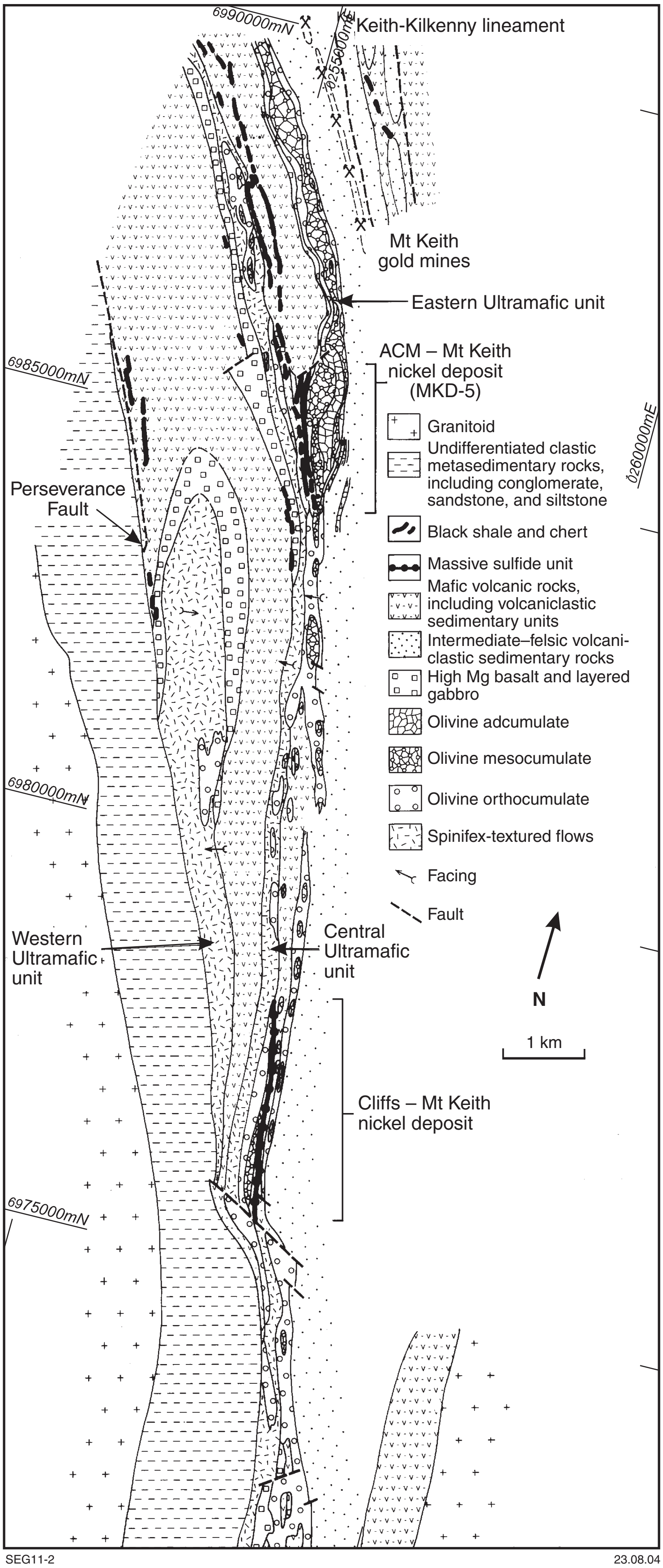

Figure 2. Geological map of Mount Keith area (adapted from Grgruric, 2002)

cumulate rocks (adcumulate and mesocumulate peridotite) with olivine crystals up to 2.5 cm in size (Dowling and Hill, 1990);

3. presence of extremely coarse grained, internally discordant olivine pegmatoids with crystals up to 4 cm in size (Dowling and Hill, 1990).

All three ultramafic units dip steeply (and locally subvertically) to the west. Igneous textures and geochemical trends indicate a west-facing orientation for the Eastern and Central Ultramafics (Naldrett and Turner, 1977; Dowling and Hill, 1990). Local easterly facings and shallow dips within the Western Ultramafic are attributed to shallowly plunging, tight to isoclinal synclinal folding (Bongers, 1994).

The giant MKD5 nickel deposit is a Type 2 nickel deposit and is hosted in a komatiitic dunite–peridotite pod that forms part of a zone of substantial thickening in the Eastern Ultramafic. The pod was completely serpentinized and talc–carbonate altered during a retrograde fluid infiltration event following metamorphism to mid-greenschist facies (Barrett et al., 1977; Rödsjö and Goodgame, 1999). Nickel sulfides are interstitial to former olivine grains with an abundance of 3–5%. The typical sulfide mineralogy comprises pentlandite, pyrrhotite, pyrite and minor millerite, hypogene violarite, godlevskite, and heazlewoodite (Grguric, 2002).

Within the Mount Keith area, the three ultramafic units are enclosed by a sequence of variably deformed and altered felsic and mafic rocks. The footwall to the Eastern Ultramafic comprises monotonous coherent to in situ fragmented, dacitic, phenocryst- and vesicle-rich lithological units (Rosengren et al., in press). The dacitic units are associated with breccia horizons comprising clasts of the coherent material. The jigsaw fit of the clasts and curviplanar nature of their edges indicates they are hyaloclastites caused by quench fragmentation of lavas upon contact with cold seawater. On this basis, the dacitic units are interpreted as submarine, autobrecciated to quench-fragmented lavas. Heptinstall (1991) and Palich (1994) identified lateral and vertical facies variations. The hangingwall rocks of the Eastern Ultramafic just north of the MKD5 deposit, and near Shed Well and Sarahs Find, consist of dacitic rocks that are geochemically and texturally identical to those of the footwall sequence. The hangingwall to the Eastern Ultramafic at the MKD5 deposit consists of a thin pyritic chert-like unit, overlain by fine-grained foliated mafic units and then the Central Ultramafic. The Central Ultramafic is in faulted contact with the Eastern Ultramafic in the southern part of the MKD5 pit, and at several locations along strike between the MKD5 and Cliffs–Charterhall deposit.

To the north of MKD5, the footwall and hangingwall rocks are compositionally and texturally identical, representing the same coherent to in situ fragmented dacitic to andesitic phenocryst-rich rocks present in the footwall at MKD5. This relationship has also been recognized south of the MKD5 deposit towards Shed Well and Golgotha (Hepinstall, 1991; Palich, 1994). Primary contact relationships indicate that this stratigraphy (dacitic lavas and associated fragmental facies) represents the primary sequence into which the Eastern Ultramafic was emplaced. Near the MKD5 pit, the hangingwall sequence to the Eastern Ultramafic is complicated by faulting that apparently juxtaposed the original felsic hangingwall sequence with the more mafic rocks. The mafic and felsic sequences in the hangingwall are separated by a layer of highly deformed pyritic chert, which appears to be the detachment locus for faulting.

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