Geology of the Lake Johnston greenstone belt, Youanmi Terrane, Yilgarn Craton

by

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Greenstones in the southern part of the Southern Cross Domain in the central Yilgarn Craton (Fig. 1) host a range of significant mineral deposits including gold (e.g. Marvel Loch), iron (Koolyanobbing), and nickel (Emily Ann, Maggie Hays, Forrestania greenstone belt). A new Geological Survey of Western Australia mapping program in the region is reassessessing the established stratigraphic setting of the greenstone belts and, through an ARC Linkage project being undertaken with scientists from The University of Western Australia, investigating the structural and metamorphic setting of the Southern Cross greenstones with a view to generating a tectono-metamorphic model of the region.

Regional setting

The Lake Johnston greenstone belt (Fig. 1) is the most southeasterly greenstone belt in the Southern Cross Domain of the Youanmi Terrane. The Southern Cross Domain is bounded to the west by the Murchison Domain and South West Terrane, and separated from the Eastern Goldfields Superterrane to the east by the crustal-scale Ida Fault. Recent work by Van Kranendonk and Ivanic (2009) established a regional stratigraphic scheme for the northern Murchison Domain, which is characterized by three volcanic cycles between c. 2820 and c. 2600 Ma. However, there is widespread evidence of older magmatic activity in the Murchison region dating back to c. 3000 Ma. The greenstones of the Kalgoorlie Terrane, the westernmost terrane of the Eastern Goldfields Superterrane, are dominantly 2710 to 2660 Ma volcano-sedimentary successions (Kositcin et al., 2008).

Lake Johnston greenstone belt

Gower and Bunting (1976) published a stratigraphic succession for the Lake Johnston greenstone belt consisting of the Maggie Hays Formation at the base, overlain by the Honman Formation, with the Glasse Formation at the top.

The lowest exposed level of the Maggie Hays Formation, a submarine volcanic succession, is a thick package of strongly deformed pillowed and massive basalts that are overlain by a mixed sequence of hyaloclastite, basaltic lava flows, and tuffite. Thin, quartz-rich sedimentary interlayers become more abundant towards the top. The mafic rocks are intruded by ultramafic rocks, dolerite sills, and aligned pods and sills of pyroxenite, gabbro, and leucogabbro. A genetic connection to the vanadium-bearing Lake Medcalf layered intrusion in the southern part of the greenstone belt is possible, but has not yet been investigated. It is also possible that the ultramafic rocks of the Maggie Hays Formation are related to those that intrude the Honman Formation (see below) but this is yet to be demonstrated.

Most previous work has focused on the Honman Formation, which hosts the nickel deposits at Maggie Hays and Emily Ann. Porphyritic intermediate rocks, interpreted as volcanic rocks in the Honman Formation, yielded SHRIMP U–Pb zircon ages of 2921 ± 4 Ma and 2903 ± 5 Ma (Wang et al., 1996). An additional small zircon population of c. 2856 Ma, with high Th/U ratios of 5, was initially interpreted by Wang et al. (1996) to be of metamorphic origin. More recent studies suggest that zircons with Th/U ratios above 0.2 are igneous (Hoskin and Black, 2000), so the older zircon populations might be xenocrystic, and the age of extrusion c. 2856 Ma or younger. Further evidence for a younger age for the Honman Formation is given by felsic volcaniclastic rocks within the formation that have a maximum depositional age of c. 2873 Ma (Thebaud et al., 2009).

Wang et al. (1996) interpreted the komatiite unit within the dated porphyritic intermediate rocks to be extrusive, and therefore considered that the ages of the intermediate rocks constrained the age of komatiites within the Honman Formation. Thus, the Emily Ann and Maggie Hays nickel deposits have been cited as examples of old (>2900 Ma) komatiite-hosted nickel deposits (Barnes, 2006). However, recent mapping supports drillcore studies by Heggie et al. (in press) which showed that, while there are ultramafic rocks present at all levels in the Honman Formation, extrusive (i.e. olivine spinifex-textured) komatiites are found only at the top of the formation. As the intermediate and felsic volcanic and volcaniclastic rocks underlie, or are intruded by, the komatiites, they must pre-date these ultramafic rocks.

The Honman Formation is overlain by the Glasse Formation, characterized by massive basalt with several amygdale-rich horizons, and minor ultramafic intrusive rocks. The context of the ultramafic rocks within the Glasse Formation is unclear. Although new mapping has not yet been completed on the formation, it is similar in character to the Maggie Hays Formation and aeromagnetic images show complexity that may indicate structural repetition.

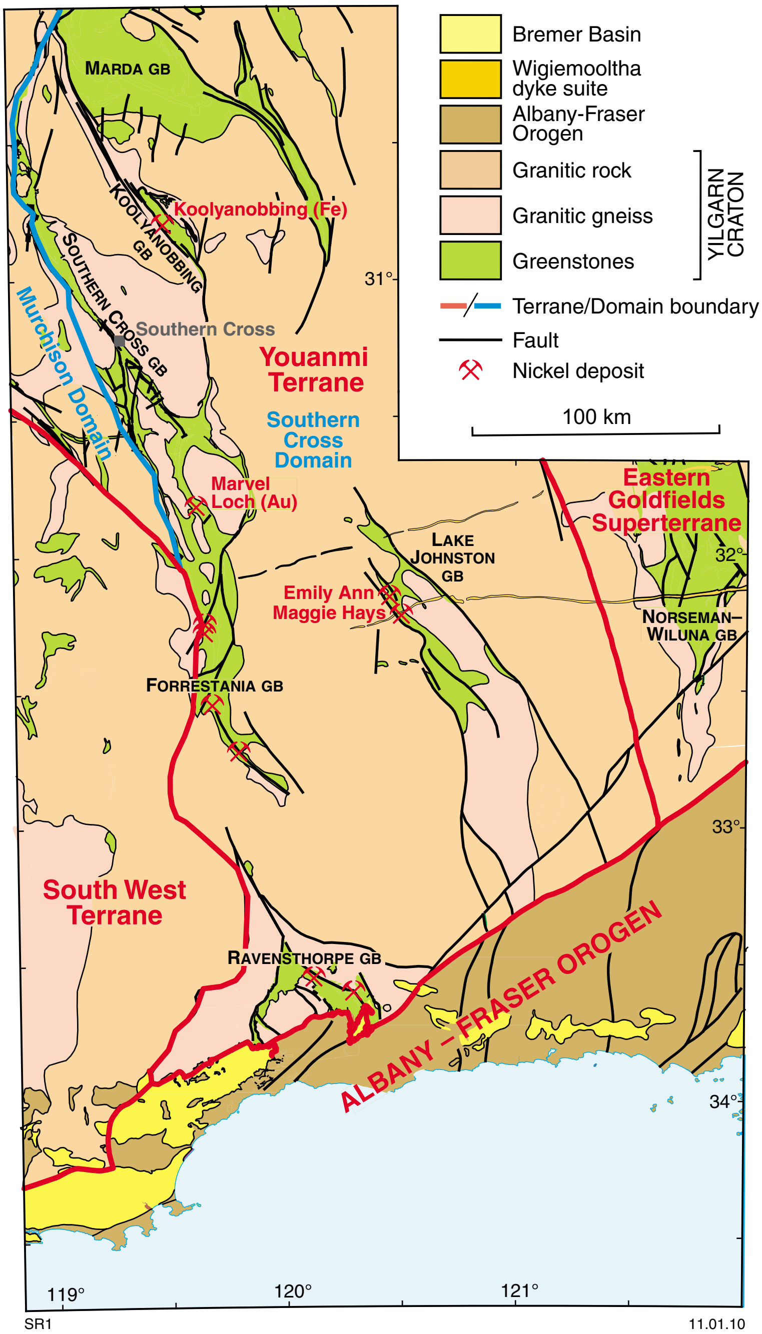

Figure 1. Geological map of the south Yilgarn (modified from the State 1:500 000-scale geology). The greenstone belts referred to in the text have been labelled (GB). The tectonic subdivision of the Yilgarn Craton is based on Cassidy et al. (2006).

Southern Cross greenstone belt

In the Southern Cross greenstone belt, porphyritic microgranites that intrude the mafic–ultramafic succession yielded ages of 2912 ± 5 Ma and 2934 ± 7 Ma (Mueller and McNaughton, 2000). However, a recent age of 2702 ± 17 Ma for quartzofeldspathic sedimentary rocks (Thebaud and Miller, 2009), interpreted as a maximum age of deposition, showed that the belt also contains a much younger component, which has not been previously recognized. The provenance, geological context, and maximum age of deposition for these sedimentary rocks are still poorly constrained. They appear to be slightly younger than the sedimentary rocks of the Diemals Formation (2729 ± 9 Ma; Nelson, 2001a) and felsic volcanic rocks of the Marda Complex (2732 ± 3 Ma; Nelson, 2001b) to the north and may be derived, at least in part, from rocks similar in age to the major magmatic event associated with komatiite volcanism in the Kalgoorlie Terrane to the east (Kositcin et al., 2008). Whatever the case, the data suggest a substantial depositional hiatus in the Southern Cross greenstone belt.

Regional significance

Already the reappraisal of the stratigraphy of the Lake Johnston greenstone belt suggests that early interpretations of the age and setting of the Maggie Hays and Emily Ann nickel deposits may need to be revised. One consequence of this is that the assumed age of the nickel deposits in the Forrestania greenstone belt to the west may also need reconsideration. The relatively young age (c. 2702 Ma) for sedimentary rocks in the Southern Cross greenstone belt suggests the possibility that greenstone belts in the Southern Cross Domain contain previously unrecognized younger successions, including successions that are the same age as nickel-bearing komatiites in the Eastern Goldfields.

The limited amount of geochronological control in the Lake Johnston and Forrestania greenstone belts provides little evidence of direct correspondence between magmatic events in the southern part of the Southern Cross Domain and the volcanic cycles in the Murchison Domain.

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