Late Archaean mineralised high-field-strength-element (HFSE) enriched igneous rocks in the Gindalbie Terrane, Eastern Yilgarn Craton, Western Australia

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Introduction

The Eastern Yilgarn Craton is an intensely mineralised Late Archaean mainly low-grade granite-greenstone terrane (Myers, 1997). Consisting of five tectonostratigraphic terranes (Gindalbie, Kalgoorlie, Kurnalpi, Laverton and Duketon-Burtville (Figure 1) defined by their distinct geological characteristics (Myers, 1990; Swager, 1997; Barley et al., 2002) the Eastern Yilgarn Craton is a site of enormous economic significance. While individual terranes are well defined within the Eastern Yilgarn, the history of terrane accretion, deformation, volcanism, sedimentation and metamorphism, and ultimately the thermal history, is not so well understood. Barley et al., (2004, this volume) gives more detail on the terranes of the Eastern Yilgarn Craton.

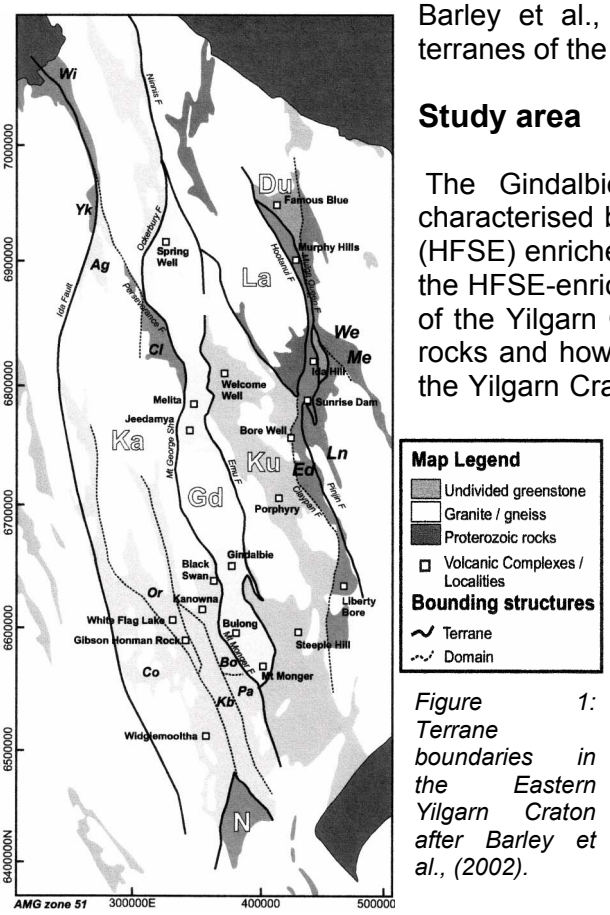

Figure 1: Terrane boundaries in the Eastern Yilgarn Craton after Barley et al., (2002).

Study area

The Gindalbie Terrane in the Eastern Yilgarn Craton is characterised by a suite of ~2.69Ga high-field-strength-element (HFSE) enriched plutonic and bi-modal volcanic rocks. Although the HFSE-enriched rocks have been included in general studies of the Yilgarn Craton, a petrogenetic history of these particular rocks and how they fit into the overall geodynamic evolution of the Yilgarn Craton has not been investigated thoroughly before. The Gindalbie Terrane locally hosts VHMS-mineralisation at Teutonic Bore and the recently discovered Jaguar deposit. A better understanding of the petrogenesis and tectonic setting of HFSE-enriched rocks in the Gindalbie Terrane is important to understanding relationships between terranes in the Eastern Yilgarn Craton and developing a better model for its overall geodynamic evolution; this will be important for understanding the regional mineralisation potential of the Eastern Yilgarn, and at a local scale evaluating which parts of the Eastern Yilgarn have the best VHMS potential.

Geochemistry

The Gindalbie Terrane consists of a series of volcanic successions consisting of mostly coarse quartz-bearing volcaniclastic breccias, rhyolitic lavas and sills, pillowed basalts and associated hyaloclastites, and fine-grained sediments which are geochemically similar to contemporaneous granitoid plutons, and are intruded by lamprophyre dikes, and thick dolerite and gabbro sills (Barley et al., 1998). A previous study at Melita shows that these rhyolites are typically high-silica rhyolites (SiO_2 >74%), which are highly enriched in all incompatible elements relative to other Eastern Goldfields felsic volcanic associations (Brown et al., 2002). MORB-normalised multi-element plots show enriched LILE, HFSE, and HREE, with slight to moderate negative Ta-Nb anomalies and strong negative Ti anomalies (Figure 2).

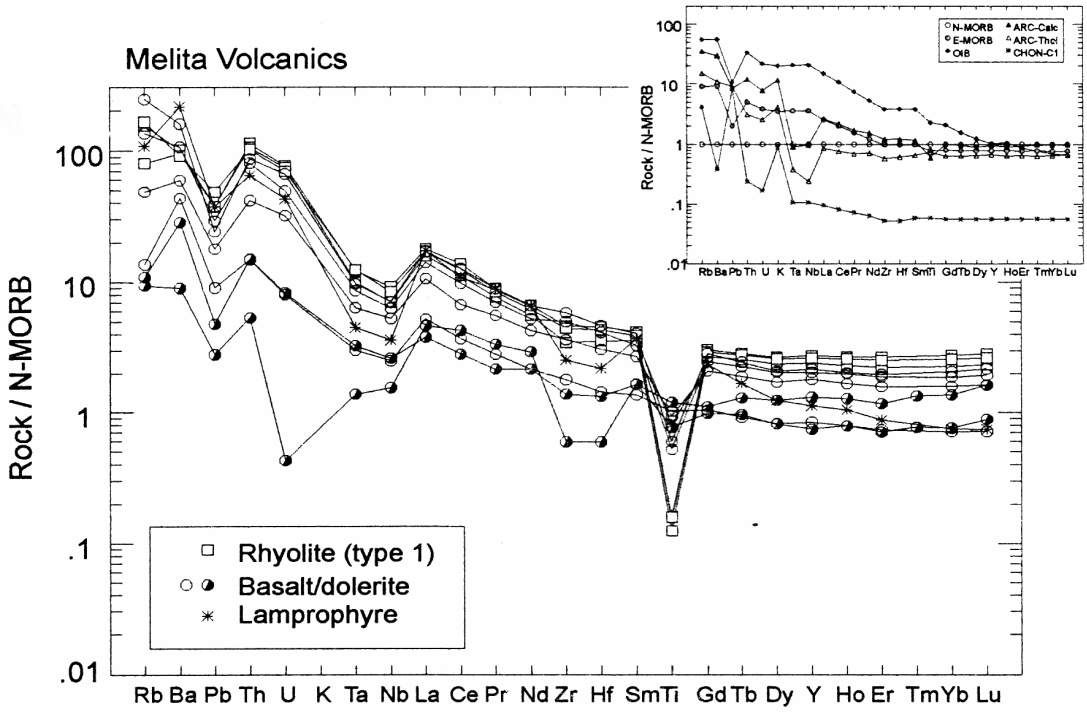

Figure 2: MORB-normalised spider plot for volcanic rocks from the Melita complex (after Barley et al., 1998).

Geodynamic significance

The Gindalbie Terrane occupies a key position between the Kalgoorlie (characterised by tonalite-trondjhemite-dacite TTD volcanism) and Kurnalpi (characterised by calc-alkaline volcanism) Terranes. While these terranes are interpreted as back arc and intra-arc volcanism respectively, the geodynamic setting of mineralised volcanic rocks in the Gindalbie Terrane is uncertain. Barley et al., (1998) suggested that the bimodal basalt-rhyolite volcanic association is most likely derived via decompression melting of subduction modified upper mantle with extensive crustal assimilation and fractional crystallisation processes producing dacites and rhyolites. In post-Archaean terranes bimodal tholeiitic to mildly per-alkaline, HFSE-enriched volcano-plutonic suites are typical of rifting of thickened magmatic arc crust. Geochemically similar volcanic complexes in the Abitibi belt studied by Barrie et al. (1993) have been interpreted to be the product of plume-arc interaction.

Arc rift or plume-arc interaction

Wyman (1999) conducted a study that established that the Kidd Creek giant massive sulphide deposit in the Abitibi, Canada, which is remarkably similar to the smaller Teutonic Bore massive sulphide deposit in the Gindalbie Terrane, occurs at a komatiite-to-arc-tholeiite transition (Wyman et al., 1999). This was further interpreted to reflect evolution from a proto-arc to an

evolved arc setting. The geodynamic history of the Southern Volcanic Zone in the Abitibi belt was then interpreted to be the result of plume ascent under and near an Abitibi arc, which generated a topographic and thermal high outboard. Subduction zone jamming and suture of plateau fragments caused stepback of subduction and formation of a proto arc, followed by rifting of juvenile arc along and near a significant break resulting in eruption of a tholeiitic group. In the study by Brown et al., (2002) of the Melita Volcanic Complex it was suggested that the compositional range, eruptive style, abundance of thick mass-flow deposits, and association with late mafic sill complexes demonstrated by the igneous rocks was typical of intra-arc-rift settings, such as the Sumisu Rift, Isu-Bonin arc, Japan, and the bimodal basalt-rhyolite volcanism was characteristic of active rifting in a marginal arc, like those demonstrated in the Taupo Volcanic Zone of New Zealand. The close proximity of the rocks at Teutonic Bore, and the similar style means that this geodynamic setting could also be a plausible model.

Due to the similar geochemistry of the Gindalbie Terrane HFSE-enriched igneous rocks to those at Kidd Creek in the Abitibi, this model could be used to explain the geodynamic evolution of the Gindalbie Terrane.

VHMS potential

Barrie et al. (1993) and Barrie (1995) reviewed the geochemistry of felsic volcanic rocks associated with Cu-Zn mineralisation in the Archaean Abitibi subprovince, which are geochemically similar to those in the Gindalbie Terrane. They showed that barren and mineralised successions can be separated on host-rock chemistry. Mineralised successions are characterised by bimodal basalt-andesite and high-silica rhyolite with elevated HFSE contents and flat to depleted LREE patterns with negative Eu anomalies. In contrast, barren successions consist of basaltic andesite to rhyodacite with low HFSE contents and relatively higher $(La/Yb)_{CN}$ ratios. Although VHMS deposits in the Gindalbie Terrane are much smaller than those in the Abitibi, the potential for VHMS discovery in the Gindalbie Terrane is high due to their elevated HFSE contents.

Barrie (1995) investigated zircon thermometry of high-temperature rhyolites in the Abitibi subprovince, and found that those rhyolites associated with VMS mineralisation had the highest zircon saturation temperatures (840-940°). Similar trends have been detected in preliminary work conducted by Brown and Barley (unpublished, Figure 3), and rocks from Teutonic Bore and Jaguar will be tested to see if they show similar high temperatures.

Understanding and unravelling the geological evolution of a particular mineralised rock association in an important terrane such as the Gindalbie Terrane will be imperative towards the discovery of VHMS deposits. VHMS mineralisation only occurs in one other terrane in the Yilgarn Craton at the Golden Grove-Scuddles deposit in the Murchison Terrane. Adding to our knowledge of terrane stratigraphy and the thermal history of the Yilgarn Craton will certainly aid in predictive mineral discovery.

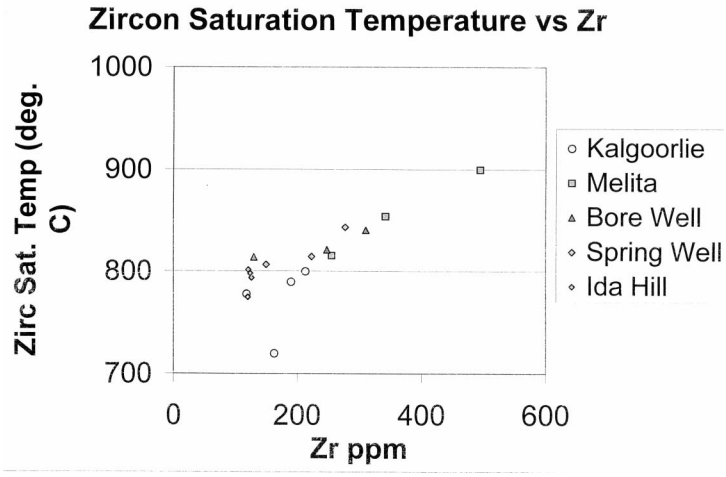

Figure 3: Zircon saturation temperatures for igneous rocks in the Eastern Yilgarn Craton. After Brown and Barley (unpublished).

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