2815–2800 Ma mafic intrusions of the Murchison: a variety of mantle sources, magmatic processes, and mineralization

by

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Voluminous mafic–ultramafic layered intrusions in the central Murchison Domain of the Yilgarn Craton document the presence of coexisting hydrous and anhydrous mantle domains tapped during the late Mesoarchean. New geochemical and age data from the Windimurra, Youanmi, and Narndee Igneous Complexes in Western Australia highlight the diverse mantle melts and respective sources emplaced within a period of only 5–10 m.y. The Windimurra Igneous Complex shows very little evidence for contamination of any kind, and appears to be depleted mantle -like. In contrast, the Narndee Igneous Complex shows evidence for derivation from LREE (light rare earth elements)-enriched hydrous mantle material, and also lacks evidence for significant crustal interaction. Hence, differing mantle domains are envisaged for these two magmas: an initial anhydrous domain tapped at c. 2810 Ma was responsible for the Windimurra Igneous Complex and other Meeline Suite igneous complexes (e.g. Youanmi, Atley, and Barrambi Igneous Complexes); and a LREE and H_2O-enriched metasomatized domain at c. 2800 Ma was the source for the Narndee Igneous Complex.

Geological Setting

The Windimurra and Narndee Igneous Complexes are two distinctive layered mafic–ultramafic intrusions in the Murchison Domain of the Yilgarn Craton. Owing to their relatively good preservation, these complexes offer a potential window into the mantle during the late Mesoarchean. The complexes belong to the Meeline and Boodanoo Suites (respectively) of the c. 2815 to c. 2735 Ma Annean Supersuite. Their age and stratigraphic relationships have been poorly understood previously, but recently acquired U–Pb age data (Ivanic et al., 2010) indicate a significant mafic–ultramafic event at c. 2800 Ma that was responsible for the emplacement of voluminous intrusive complexes during this chaotic and relatively short-lived event.

The complexes of the Meeline and Boodanoo Suites (Fig. 1) formed as concentrically layered, inwardly dipping intrusions, now modified by strike-slip shear zones and brittle faulting. Recent seismic data reveal a broad, upward facing, conical form for the Windimurra Igneous Complex (Jones et al., in press). Strong reflectors within the lower parts of the complex indicate a well-layered and thick ultramafic zone down to approximately 7 km depth.

Geochemistry and mineralization

Primitive mantle -like trace element signatures emerge from the array of mafic–ultramafic rocks analysed in the Windimurra Igneous Complex, with LREE being only slightly depleted (Fig. 2a). In contrast, the rocks of the Narndee Igneous Complex indicate consistent, negatively sloped and LREE-enriched profiles (Fig. 2b). No primary hydrous mineral has been identified for the Windimurra magma (following Ahmat, 1986), whereas hornblende is abundant in the Narndee Igneous Complex (minor phlogopite has also been documented). The origin of water in the Narndee magma is suspected to be derived from the primordial mantle, owing to a lack of evidence of crustal–oceanic contamination (cf. Scowen, 1991). In addition, the curvature of boninitic REE signatures are not matched by the Narndee data (Fig. 2b), despite the presence of hydrous minerals; hence, evidence in support of an arc-affinity is presently lacking.

Iron–vanadium concentrations are extremely enriched in the upper zone of the Windimurra Igneous Complex; in comparison, the geochemical fractionation trend lacks significant iron enrichment at Narndee. In terms of PGE (platinum group element) content, it would be expected that Narndee harbors significant platinum; however, the ‘U’-shaped PGE concentration patterns indicate that this magma was fractionated at depth within its feeder system. Whole-rock PGE data from the Windimurra Igneous Complex indicates that the PGE content is low on average, but has the potential for reef-like concentrations adjacent to localized zones of cumulate sulfide crystals.

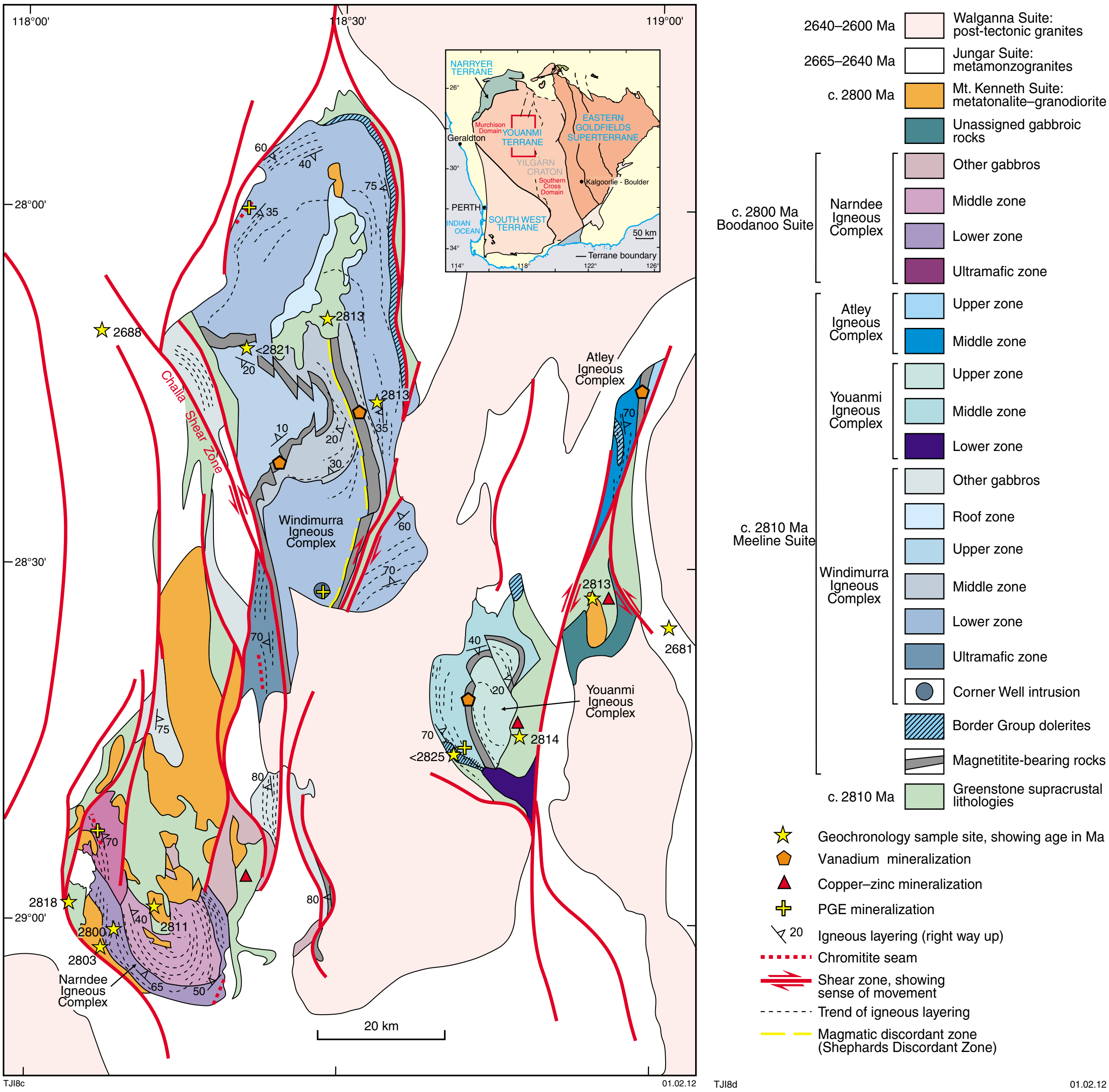

Figure 1. Interpreted geological bedrock sketch map of the eastern Murchison Domain, showing the Windimurra, Narndee, Youanmi, and Atley Igneous Complexes. Note the location of structures, and age and mineralization data. Zone nomenclature after Ivanic et al. (2010).

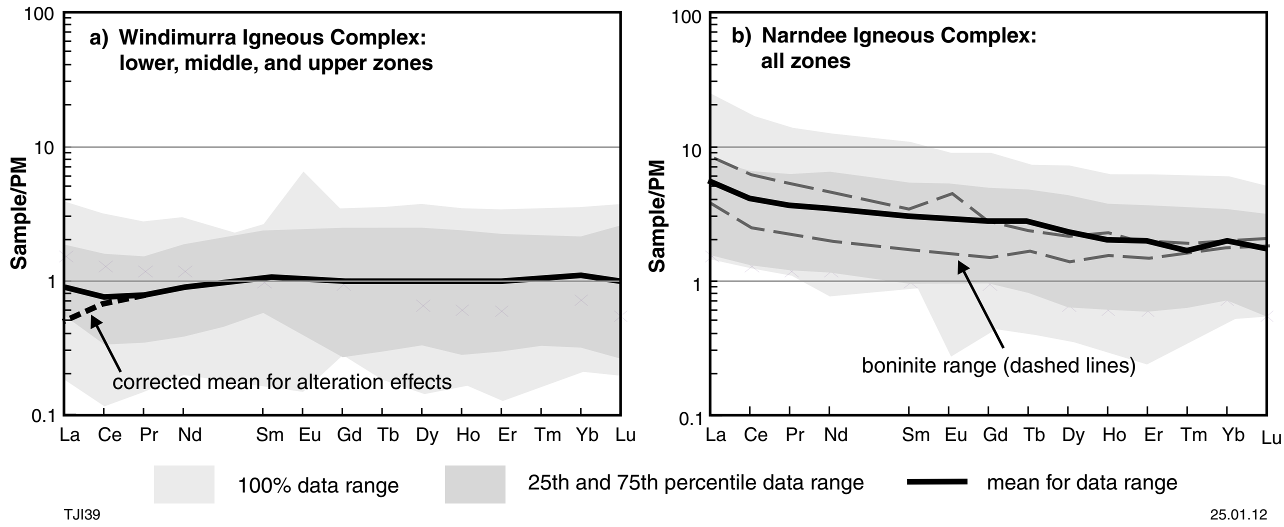

Figure 2. ***REE concentrations normalized to primitive mantle (PM) values (from Sun and McDonough, 1989) for the: (a) Windimurra Igneous Complex; (b) Narndee Igneous Complex.***

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