ISOTOPIC GEOCHEMISTRY OF THE NORTHERN GOLDFIELDS, YILGARN CRATON, WESTERN AUSTRALIA: SETTING THE SCENE FOR KOMATIITE EMPLACEMENT

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Introduction

The genesis of individual komatiite-hosted nickel-sulphide (KANS) deposits in Archean granite-greenstone terranes has been widely debated and is reasonably constrained (Barnes, 2006). However, the reasons why KANS deposits cluster and why mineralised komatiites are preferentially emplaced within specific lithospheric environments are not well understood. In this study, we investigate the early craton-scale lithospheric architecture that favoured the emplacement of large komatiite systems and the development of nickel-sulphide deposits and camps in the Yilgarn Craton of Western Australia. Our focus is on the 2.8-2.7 Ga greenstone belts of the northern portion of the Eastern Goldfields Superterrane (the Northern Goldfields), from the areas of Leonora and Laverton in the south to the northern edge of the craton (Fig. 1a).The ultramafic rocks in the study area comprise komatiites and komatiitic basalts, the latter of which have not been found anywhere else in the Yilgarn Craton. The purpose of this study is to examine the processes (both shallow and deep-seated) operating during the Archean and relate these processes to the emplacement of komatiites, komatiitic basalts and what role, if any it may have played in mineralisation of nickel-sulphide deposits.

Over the course of this study, Lu-Hf and Sm-Nd isotope systematics in conjunction with U-Pb sensitive high-resolution ion microprobe (SHRIMP) geochronology will be used to discern the characteristics of the deeper lithosphere through much of the Archean (>3.0–<2.6 Ga). The Sm-Nd map of Champion & Cassidy (2007) is one of the first forays into large scale lithospheric mapping, the result being a portrait of the ages of the various parts of the Yilgarn Craton (Fig. 1b). However, Sm-Nd analyses, which are performed by dissolution of whole rock powder, can only provide information about the time of formation of the rock. This is useful when performed on komatiites (providing their age can be estimated by other means, as komatiites are normally zircon poor) and on felsic rocks as well. However, the fact that plutons older than 2.72 Ga have yet to be discovered in the Eastern Goldfields restricts information that can be derived from Sm-Nd isotopes to the mid-to-late Archean. Zircons do take up Sm and Nd into their structure, but few Sm-Nd studies have been conducted on zircons, and the results have been somewhat erratic (Kinny & Maas, 2003). The Lu-Hf isotopic system behaves very similarly to the Sm-Nd isotopic system, Lu and Hf are also taken into the structure of zircon in measurable concentrations, and the database of successful Lu-Hf analyses is much larger (Kinny & Maas, 2003). Because of this, the Lu-Hf system is more suitable for estimating crustal setting further back in time using inherited zircons from granite plutons and felsic volcanics from the Yilgarn. Analyses of Lu-Hf and U-Pb on a given spot (core/rim) of a zircon will give information on the type (evolved/thicker/cooler versus younger/thinner/hotter) of lithosphere sampled by the pluton the zircon was in at a given time in geologic history. Examining zircon populations of various felsic rocks across the north Eastern Goldfields will help show the type of lithosphere sampled at different places and points in time in the history of accretion of the Yilgarn. Whole rock Sm-Nd provides an estimate of crustal residence time for a given melt and will allow us to compare the behaviour of Lu-Hf.

In addition, mass-independent sulphur isotopes on sulphides from VMS deposits, felsic volcanics and nickel-sulphide deposits will be used as a proxy for surface processes. More information on the tectonic setting of komatiites can be found by looking at sulphur isotopes. Work done by Farquhar & Wing (2003) revealed that $\delta^{33}S$ isotopes are most pronounced in the Archean, the result of interactions of sulphur compounds with ultraviolet radiation. The mass-independent fractionation of ^{33}S has revealed that isotopic fluctuation of sulphur was controlled by atmospheric conditions prior to 2.45 Ga, after which biological processes and oxidation overtook S sequestering (Farquhar & Wing, 2003). The interaction with UV causes fractionation into a light $\delta^{33}S$ that is taken up by as oceanic sulphate and a heavier $\delta^{33}S$ that is absorbed into subaerial sediments (Farquhar & Wing, 2003).This affords a unique signature to rocks greater than 2.45 Ga. One debate regarding komatiite hosted sulphide nickel deposits is how to achieve sulphur saturation once the komatiite erupts. Typically it has been assumed that sulphur was picked up from sediments that the komatiites came into contact with that was responsible for sulphur saturation (Lesher et al., 2001). However, Bekker et al.

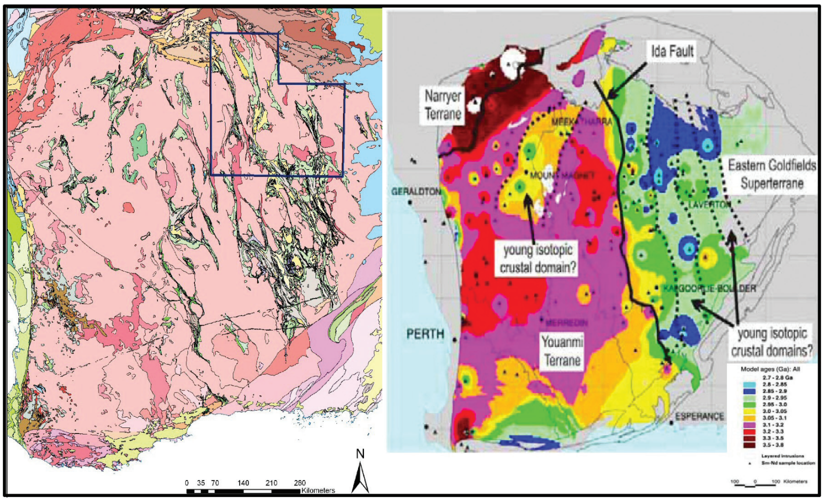

Figure 1: a) (left image): Geological map of the Yilgarn Craton, Western Australia. Study area is outlined in blue. b) (right image): Sm-Nd map of the Yilgarn from Champion & Cassidy (2007).

(2009) have suggested that alternate sources of sulphur such as volcanogenic massive sulphide could be an alternate source for additional sulphur for contamination and boosting S contents of komatiites to saturation. Mass-independent sulphur isotopes may be capable of resolving this ambiguity, as sediments derived from small continents will likely have a heavier (i.e. positive) $\delta^{33}S$ signature than those derived from marine settings (Farquhar & Wing, 2003). Additional sulphur isotopic studies from felsic volcanics and other deposits may help better estimate water depth and thus tectonic setting of their locations.

To date, work on this project has focused on samples of granites that were previously analysed for U-Pb SHRIMP ages (Nelson, 1997; Nelson, 1998). Preliminary analyses give εHf values ranging between -7 and +8, with the majority being between 0 and +5. These results exhibit a range of signatures between juvenile and reworked older source material, with the majority having a juvenile signature close to CHUR. These preliminary Lu-Hf data agree with the interpretation by Champion & Cassidy (2007) That prior to 2.68 Ga magmatism was primarily syn-volcanic, with crustal recycling starting after 2.68 Ga. The results of this in-depth study will expand considerably on the work done by Champion and Cassidy, provide a new powerful tool for exploration and much needed detail on a previously poorly studied portion of the Yilgarn.

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