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The Hf-Nd dichotomy: constraints from felsic, mafic and ultramafic rocks in the western Dharwar Craton, India

Arathy Ravindran, Klaus Mezger, and Srinivasan Balakrishnan

University of Bern, Institute of Geological Sciences, Geochemistry, Switzerland (arathy.ravindran@geo.unibe.ch)

The Hf-Nd dichotomy: constraints from felsic, mafic and ultramafic rocks in the western Dharwar Craton, India

Arathy Ravindran^{1*}, Klaus Mezger¹, S. Balakrishnan²

¹Institut für Geologie, Universität Bern, Bern, Switzerland

²Department of Earth Sciences, Pondicherry University, Puducherry, India

(* correspondence: arathy.ravindran@geo.unibe.ch)

The small extend of exposed Hadean-Paleoarchean (>3.2 Ga) rocks in the global record poses a major challenge in interpreting Earth's early crust-mantle evolution. This results in major uncertainty in the degree and extent of heterogeneity of the Archaean mantle (e.g. Nebel et al., 2014). Isotope systems like ¹⁷⁶Lu-¹⁷⁶Hf and ¹⁴⁷Sm-¹⁴³Nd are powerful tools in tracing the degree of mantle depletion and the influence of concomitant continental crust formation. However, these isotope systems are apparently decoupled in Archaean ultramafic rocks (e.g. Hoffmann and Wilson, 2017). Hence, the Hf-Nd isotope dichotomy in ultramafic rocks requires a detailed study of cratonic areas hosting granitoids spatially associated with greenstone belts and ultramafic rocks, as it is the case in the western Dharwar Craton (~3.4 Ga) of India.

The 3.25 Ga old rhyolitic to basaltic rocks of the craton that have flat, mantle-like REE patterns also have ¹⁴⁷Sm-¹⁴³Nd and ¹⁷⁶Lu-¹⁷⁶Hf signatures 'coupled' along a trend $\epsilon^{176}\text{Hf} = 1.55 * \epsilon^{143}\text{Nd} + 1.21$ (Vervoort et al., 2011). The minor depletion recorded in these rocks is a result of mixing at different levels between a 3.6 Ga old mafic crust (Ravindran et al., 2020) and the contemporary depleted mantle. The tonalite-trochjemite-granodiorite (TTG) gneisses have similar isotope ratios and their petrogenesis involved the mafic crust until 3.3 Ga, after which reworked crust was the major component. Komatiitic rocks (MgO=15-30%; Na₂O+K₂O <1%; (Gd/Yb)_N=0.6-1.8) with an age of 3.35 Ga have high and variable initial ϵ^{Hf} (+3 to +20) compared to their initial ϵ^{Nd} (+1.0 to +3.5). These ultramafic rocks have decoupled Hf-Nd signatures which is uncommon for the mafic and felsic rocks in the craton. This further shows that the mantle composition was more heterogeneous in the early Archaean than today. It is also possible that the presence of garnet in the mantle source was an important parameter which influenced the composition of the early Archaean crust.

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