Ce anomalies in ~2.4 Ga iron and manganese formations as proxy for early oxygenation of oceanic environments

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Transition from sulfur mass-independent isotope fractionation (S-MIF) to mass-dependent isotope fractionation (S-MDF) signatures has been recently documented across a sequence boundary between the Lower and Upper units of in the ~ 2.32 – 2.43 Ga Duitschland Formation [1] of the Transvaal Supergroup in South Africa. This is thought to mark the change from an essentially anoxygenic to oxygenic atmosphere [1]. However, other redox-sensitive elements like Mo, Cr, Fe and N suggest that whilst the atmosphere remained anoxygenic, the ocean may have been oxygenated as far back as 2.6 Ga [2, 3]. Early oxygenation of the ocean is supported by marked negative Ce anomalies documented for deep drill core samples of iron formations in the Lower Duitschland Formation, stratigraphically well below the documented S-MIF – S-MDF transition, and laterally equivalent (or older) Koegas Subgroup [4]. Negative Ce anomalies in iron formations are coupled with positive Ce anomalies in manganese carbonate-rich units of the Rooinekke iron formation of the Koegas Subgroup. Such Ce anomalies are absent from all older iron formations of the Transvaal Supergroup. These observations indicate that oxygen concentrations in ocean water were – at least in some environments - sufficient to oxidize cerium during the deposition of Duitschland and Koegas iron formations. As such the Ce anomalies most probably signify an increase in the oxygenation state of the ocean immediately prior to the rise of atmospheric oxygen.

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Geochemistry and Nd isotopic systematics of ~ 3.3 Ga Banasandra spinifex-textured, ultramafic komatiites, Western Dharwar Craton, southern India: Constraints on mantle sources and melting

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Many well-preserved extrusive and intrusive ultramafic to mafic complexes have been mapped in the Middle to Late-Archaean (ca. 3.5-2.6 Ga) greenstone belts of the Western Dharwar Craton, southern India. However, their spatial and temporal correlation remain largely unclear due to paucity of age data at many localities. The Banasadra pillowed and spinfex-textured peridotitic komatiites are exposed on a km-scale outcrop in the Kibbanahalli arm of the Chitradurga greenstone belt [1]. In general, the rocks are highly serpentinised and show a near complete replacement of the primary mineralogy by a greenschist facies assemblage.

Fresh samples analysed from a drill core in this study show significant compositional variations (wt. % MgO: 22-40, Al_2O_3: 1.24-5.5, TiO_2: 0.07-0.37). The chondrite-normalised REE patterns are generally unfractionated or show a marginal LREE-depletion in a few samples. However, no clear correlation is evident either with the Al-depleted Barberton-type or the Al-undepleted Munro-type komatiites.

Seven whole-rock samples from a single flow unit yield an Sm-Nd isochron age of 3.25 ± 0.12 Ga with an εNd of –1.2 suggesting an undepleted mantle source or crustal contamination of a komatiite melt derived from a depleted mantle. This is in broad conformity with the wholerock Sm-Nd age of 3.35 ± 0.11 Ga based on the pooling of sixteen samples from five different Komatiite occurrences in the craton [2]. A petrogenetic model for the Banasandra Komatiite is discussed in the light of the geological setting and data on contemporaneous ultramafic-mafic extrusives elsewhere in the craton.

[1] Srikantia & Bose (1985) *J. Geol. Soc. India* **26**, 407–417 [2] Jayananda *et al.* (2008) *Precamb. Res.* **162**, 160–179.