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Banded iron formations of the Daitari Greenstone Belt (India) as archives for ca. 3.4 billion-year-old marine environments: Insights from REE and Hf-Nd isotope signatures

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Banded Iron Formations (BIFs) are authigenic marine sedimentary rocks that serve as geochemical archives for reconstructing Precambrian marine environments. The ca. 3.4 Ga Algoma-type BIF of the Tomka Formation in the Daitari Greenstone Belt, India, is one of the oldest BIFs that experienced only greenschist-facies metamorphism [1].

We report new major- and trace element concentrations of oxide-facies BIF and shale samples, combined with Nd and Hf isotope compositions. Our data are used to reconstruct the marine paleo-environment during the Paleoarchean. Individual Fe- and Si-rich layers are monitored for suitability as seawater archives based on their chemical composition. Exceptionally low concentrations of immobile elements (Zr; Hf) indicate that the samples represent extremely pure seawater precipitates with negligible detrital contamination. Nineteen BIF samples have typical shale-normalized Archean seawater-like rare earth and yttrium ($REYs_N$) patterns with positive La_{SN}, $Eu_{SN,}$ Gd_{SN} anomalies, super-chondritic Y/Ho ratios, lack of negative Ce_{SN} anomalies, and an enrichment of heavy over light $REY_{SN,}$ implying an anoxic open marine-dominated depositional setting with contributions from submarine high-temperature, hydrothermal systems.

Seven sample layers plot along ^{176}Lu-^{176}Hf age reference lines of 3.3 to 3.5 Ga. Except for the Fe-rich BIF layers, the samples align along 3.5 to 3.3 Ga ^{147}Sm-^{143}Nd age reference lines, in agreement with geological constraints. Initial εNd values of the reference lines range from +1.7 at 3.5 Ga to +3.0 at 3.3 Ga, indicating mantle-like sources affecting ancient Daitari seawater. Very radiogenic εHf values between +33.9 at 3.5 Ga and +11.4 at 3.3 Ga may indicate isotopic Lu-Hf disturbance or incongruent weathering of temporarily emerged landmasses [2]. Based on these geochemical proxies, post-depositional fractionation of Sm-Nd (and Lu-Hf) is unlikely, implying that the Daitari BIF is a prime archive for reconstructing paleo-environmental conditions ca. 3.4 billion years ago.

[1] Hofmann et al., 2022, Earth Sci. Rev. 228.

[2] Viehmann et al., 2014, Geology 42.