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Mineralogical and Geochemical Constraints on the Origin of the Banded Iron Formation: A Case Study of the Kuruman Formation in South Africa

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The Paleoproterozoic Era was a critical geological interval involving redox evolution of Earth's oceans and rapid production of banded iron formations (BIF). However, little is still known about the dynamic input and output of Fe in response to oceanic physicochemical evolution. One key variable is the BIF alternating layers that record the fluctuating oceanic physicochemical conditions. Here, we performed analyses of Fe isotopes and Fe-bearing species on samples from the Kuruman BIF ores in South Africa and presented an outline of compositional and textural evolution for BIF alternating layers. The resulting data suggest that these samples feature alternating layers due to varying ratios of goethite to hematite/magnetite. The goethite is interpreted as a secondary phase as a result of weathering of pre-existing Fe oxides. Most yellow goethite-rich layers are characterized by negative δ^{56}Fe values, but grey hematite/magnetite-rich layers by positive δ^{56}Fe values. Such isotopic fractionation is expected to involve the preferential precipitation of heavy Fe isotopes, which would make seawater to be enriched in light Fe isotopes for precipitation of Fe oxides with negative δ^{56}Fe values. The rhythmic compositional and textural variations within BIF ores might be attributed to pulsed input of Fe into the oceans, but more likely resulted from episodic loss of Fe compositions through oxidation from upper photic zones in closed ocean systems.