Hydrothermal vent fluid-seawater mixing and the origins of late Archean iron formation

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Long-standing views concerning the origins of late Archean banded iron formation (IF) have begun to shift in recent years. A wave of new work has shown that precursor sediments to late Archean IF were dominantly composed of the Fe(II)-silicate greenalite [1], and diagenetic siderite (commonly altered to magnetite; [2]). Merging petrographic data with geochemical kinetics further indicates that $O_2(aq)$ was essentially absent from the photic zone of the late Archean ocean, suggesting that Fe(II) oxidation played a minimal role in sedimentation before the GOE [3].

Yet, how IF precursor sediments were generated, especially in deep marine settings, remain unclear. Sedimentology and stratigraphy show that laterally extensive IF accumulated from hydrothermal muds reworked by density currents [4], and that sediment fluxes were linked to sea level change (perhaps driven by isostatic responses to hydrothermal pulses) [4]. This suggests that interaction between vent fluids and Archean seawater played a key role in IF genesis [1].

Here we evaluate hydrothermal vent fluid-seawater mixing as a sediment source for late Archean IF. Our calculations show that as hot vent fluids with Fe^{2+}:H_2S >>1 [5] are mixed with cold SiO_2-rich anoxic seawater, greenalite and siderite dominate precipitate mineralogy across broad, but distinct temperature ranges. These results are consistent with the $\delta^{13}C$ of IF siderite, the least altered of which are close to the mantle value for dissolved CO_2 [6].

Because hydrothermal-seawater mixing would have attenuated Fe^{2+} and trace metal concentrations as greenalite precipitated, this process undoubtedly played a key role in geochemical cycling during the prelude to the GOE.

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