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Between heaven and hell: early environments for life in the Palaeoarchaean

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The 3.33 Ga Josefsdal Chert in the Barberton Greenstone Belt, South Africa reflects deposition in shallow waters adjacent to a volcanically active, exposed landmass [1]. Detailed structural, sedimentological, petrological, geochemical and biosignature research documents changes to the environment controlled by the presence or absence of volcanism and the effect of hydrothermal activity on sedimentary deposits and on life. Sedimentological and petrological observations allow characterisation of the environmental conditions, while the geochemical signatures document the waxing and waning influence of marine versus hydrothermal and terrigenous inputs at different stages during the depositional history of the Josefsdal Chert (Fig. 1).

Shoreface-foreshore volcanic sediments were deposited upon an irregular, basaltic basement (Unit 1) in a relatively quiet environment, occasionally disrupted by storm events. They grade upwards into parallel laminated, alternating deposits of Fe-rich sediment (greenalite) and chemical silica gel precipitates (generated by seasonal terrigenous [cf. 2] and/or cyclic hydrothermal input, as documented by the geochemical signature, that were colonised by well-developed phototrophic microbial mats indicating mainly quiescent shallow water conditions (Unit 2), albeit frequently interrupted by storm currents. Subsequent episodes of eruptive volcanic activity produced widespread, laterally correlatable (up to 2 km of mm thick) layers of ashfall (Unit 3). While this tuffaceous sedimentation continued in generally quiet shoreface to foreshore conditions, occasional storm surges and seismic events produced intraformational disruption of early lithified sediment layers.

Hydrothermal activity from point sources and generalised hydrothermal outflow occurred throughout the history of deposition of the Josefsdal Chert but was most prevalent during major eruptions. The presence of deep-seated growth faults also acted as hydrothermal conduits. While phototrophic biofilms and mats developed on the volcanic and chemical (silica) sediment surfaces [3-5], identifiable chemotrophic microbial colonies occur at the hydrothermal point sources and in the strongly hydrothermally dominated chemical sediments [1, 6].

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