Silica alteration zones and cherts as a record of hydrothermal processes on the Archaean seafloor

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Silicification of volcanic rocks, ranging from komatiitic to dacitic in composition, is a common phenomenon of the 3.5–3.2 Ga old volcano-sedimentary succession of the Barberton greenstone belt (South Africa) and > 3.2 Ga old successions elsewhere. Silica enrichment occurs in 20–50 m thick zones at the top of volcanic sequences that are capped by sedimentary cherts. Cross-cutting chert veins are common in the alteration zones and bedded cherts. SiO_2 contents in the alteration zones increase upsection, from the original igneous value to ~ 90 %. Silicification is associated with a depletion of most mobile elements, except for K, Rb and Ba, which are enriched in these zones. Ni, Co, Cu and Zn were mobile and are depleted. LREE were enriched relative to the HREE. $\delta^{18}O$ values (9.0 to 17.3 ‰) of volcanic rocks show a positive linear relationship with silica content. Bedded cherts consist of silicified sedimentary and tuffaceous material that are enriched in metals leached from the volcanic rocks. Chert veins have the same petrographic, geochemical and isotopic (C, O) characteristics compared to overlying cherts and represent sediment-filled hydraulic fractures.

The element depletion–enrichment patterns and oxygen isotope data indicate low-temperature (100–150 °C) hydrothermal processes for the origin of the alteration zones. Hydrothermal activity led to the silicification of overlying seafloor sediments, giving rise to the formation of impermeable chert cap rocks. Fluid overpressure resulted in the breaching of the cap rocks at times and the formation of sediment-filled hydraulic fractures. The loss of most elements coupled with the addition of SiO_2 during silicification and REE systematics indicate very high water–rock ratios and a fluid REE composition typical of Archaean seawater. Hydrothermal activity is attributed to a high heat flow in the early to mid-Archaean and not to mid-ocean ridge processes or shallow-level igneous intrusions. High heat flow resulted in the establishment of shallow subseafloor convection cells and a diffuse upflow of hydrothermal fluids over broad areas of the Archaean seafloor.