Geochemical and Nd-Sr isotopic study of jarosite and associated rocks at Kutch, India

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Jarosite is a hydrous sulfate mineral that forms under low pH, high Eh and a limited range in water/rock ratios [1] and its discovery on Mars is an evidence for past-aqueous activity on the martian surface [2]. Jarosites occurring within the Cenozoic sediments at Kutch, India are considered to be a martian analog because of their spatial proximity to the Deccan basalts [3]. In this study, samples of hydrous sulfates including jarosite and the associated shales and clay-rich sediments from multiple locations at Kutch were analysed for major and trace element concentrations using an ICPMS and for Sr and Nd isotope ratios using a TIMS, both at the Centre for Earth Sciences, IISc.

The jarosites and other hydrous sulfates show high concentrations of Fe, high chondrite-normalized La/Lu and low concentrations of Ni, Cr, Co. Heavy-REE are mobile compared to the light-REE while Ni, Cr and Co prefer to be in solution in an acidic fluid. Hence, the geochemical characteristics of the jarosites indicate that they formed by preferential leaching of elements from the host sediments by an acidic fluid. The $^{87}Sr/^{86}Sr$ ratio of the jarosites overlap with the composition of 10-20 Ma old seawater which constrains the age of formation of these hydrous sulfates to be less than 20 Ma and the parent fluid as seawater. Due to the similar behavior of Fe and REEs in aqueous fluids, the source of Fe in jarosites was investigated using Nd isotopic measurements. The $\varepsilon_{Nd(0)}$ of the jarosites range between -9.3 to -10.8, barring one sample with a value of -4, indicating a common provenance of Fe in these samples. However, the basalt sample from Kutch has $\varepsilon_{Nd(0)}$ of -0.1 which is different from that of the jarosites, thereby ruling out basalts as the source of Fe in the jarosites. We propose that the intruding seawater was rendered acidic by leaching of pyrite, present within the lignite deposits at Kutch and was enriched in Fe and SO_4^{2-}. This modified fluid leached the host sediments and subsequently precipitated the jarosites and other hydrous sulfates.

[1] Elwood Madden, Bodnar & Rimstidt (2004), Nature 431, 821-823; [2] Klingelhöfer et al., (2004) Science 306, 1740-1745; [3] Bhattacharya et al., (2016) J. Geophys. Res. Planets 121(3), 402-431.