Abstract

On Mars, hydrous sulfates and phyllosilicates within basalts and overlying sedimentary successions suggest that liquid water once existed on the surface. While the phyllosilicates indicate existence of neutral to near neutral pH (acidic to alkaline) surface water, the hydrous sulfate mineral jarosite discovered on the Martian surface by the Opportunity rover indicates that in places, water also existed in highly acidic and oxidizing conditions. Spectroscopic and XRD results of this study establish jarosite occurrences in Kachchh, western India, that also overlie basalts. Deccan basalts at the base of the Cenozoic rift basins in Kachchh are altered to kaolinite; outside the basin, basalts are altered to smectite. Jarosite occurs in the Paleocene Matanumadh Formation above kaolinitized Deccan basalts, and in the stratigraphically overlying Eocene Naredi Formation. In the alternating carbonate-shale sequence at Naredi, jarosite associated with secondary gypsum is restricted to shale layers confined between carbonates. In the overlying middle Eocene Harudi Formation, jarosite also occurs within shale horizons sandwiched between carbonates and a lateritic cover. Jarosite layers and veins have also been detected in the Mesozoic shales of the Bhuj Formation that underlie the Deccan Traps. Geochemical modeling suggests that differential weathering of basalt to smectite and kaolinite can be attributed to rift-generated topography. REE compositions of the jarosite resemble those of the host shales, implying local scavenging of components to form jarosite, while stable isotopic compositions of the sulfate indicate an origin by pyrite oxidation. The occurrence of jarosite in different temporal units can be explained by simultaneous formation of the mineral in all exposed units during a single event that oxidized and acidified waters in exposed sulfide-bearing shale layers. This is most likely to have occurred during the final phase of marine regression and tectonic uplift in the Kachchh region in the Holocene, during which oxidized surface water percolated through fractures and mixed with in situ acidified groundwater near pyrites in the shales. Much of the acidity was thus very localized. Overall, the jarosite localities in Kachchh may represent excellent analogs to the disappearance of water from the surface of Mars.

Keywords: Basalt weathering; Tectonics of Kachchh; Spectroscopy; Jarosite; Mars.