American Mineralogist, Volume 103, pages 1877–1890, 2018

Diverse mineral assemblages of acidic alteration in the Rio Tinto area (southwest Spain): Implications for Mars

Christian Mavris[1], Javier Cuadros[1,*,†], José Miguel Nieto[2], Janice L. Bishop[3], and Joseph R. Michalski[4]

[1]Department of Earth Sciences, Natural History Museum, Cromwell Road, London SW7 5BD, U.K.
[2]Department of Earth Sciences, University of Huelva, 21071 Huelva, Spain
[3]SETI Institute, Mountain View, California 94043, U.S.A.
[4]Department of Earth Sciences and Laboratory for Space Research, University of Hong-Kong, Pokfulam Road, Hong-Kong, China

Abstract

Earth analogs are indispensable to investigate mineral assemblages on Mars because they enable detailed analysis of spectroscopic data from Mars and aid environmental interpretation. Samples from four sites in the Iberian Pyrite Belt (El Villar, Calañas, Quebrantahuesos, and Tharsis) were investigated using mineralogical, chemical, and spectroscopic techniques, with a focus on clay minerals and alteration environments. They represent Earth analogs of areas on Mars that underwent acidic alteration. X-ray diffraction and transmittance mid-infrared data indicate that the rocks were subjected to several degrees of acid alteration corresponding to assemblages characterized by the following mixtures: (1) illite, chlorite, interstratified chlorite-vermiculite, kaolinite-smectite, and kaolinite; (2) illite, kaolinite, and alunite; and (3) jarosite and goethite. According to mineral stability data, these three assemblages correspond to pH values 7–5, 5–3, and <3, respectively. The lack of goethite in the illite-kaolinite-alunite assemblage suggests an alteration in reducing conditions. Illite was progressively dissolved by acidic alteration but is sufficiently resilient not to be diagnostic of the intensity of the alteration. Illite and kaolinite were the two most abundant phyllosilicate minerals observed, and the main reaction involving phyllosilicates was the alteration of illite to kaolinite. Mixed-layer phases appeared mainly in the mildest degree of acid alteration, with few exceptions. This suggests a transition from a mechanism dominated by transformation to a mechanism dominated by dissolution-precipitation as the intensity of the acid alteration increases. Our results highlight the sparse kaolinite-alunite occurrences on Mars as worthy of specific investigation. Acid alteration on Mars is expected to be patchy and/or consisting of fine alteration rims. Alunite occurrences on Mars in the absence of goethite may indicate an acid alteration in reducing conditions. Kaolinite produced through acid alteration on Mars is expected to exist mainly as an end-member phase of low crystallinity, which would enhance IR absorption and increase its visibility.

Keywords: Acid alteration, alunite, jarosite, kaolinite, Mars; Earth Analogs for Martian Geological Materials and Processes