American Mineralogist, Volume 106, pages 1237–1254, 2021

Targeting mixtures of jarosite and clay minerals for Mars exploration

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Abstract

Terrestrial thermal environments can serve as analogs for subsurface environments in the search for life because they regularly host microbial communities, which may leave behind biosignatures. This study focused on an acid-sulfate hydrothermal site as an analog for a potentially habitable environment on Mars. A weathered boulder in the thermal area was dissected, revealing an interior marked with disconnected horizons of differently colored materials, very low pH, and increasing temperature. The mineralogy comprised weathering products from andesite (kaolinite, quartz, clinoptilolite) along with sulfate salts (alunite, jarosite, tschermigite, and copiapite) formed by oxidation of sulfide and ferrous iron. Characterization of organic matter in this boulder and several soil samples yielded interesting but surprising results. Both mass spectrometry and Raman spectroscopy identified organic compounds in portions of the soils and the boulder. Jarosite-associated samples showed more numerous and diverse organic signatures than did Al-bearing silicate samples, despite the lower total organic carbon content of the jarosite-associated soils (0.69 ± 0.07 wt% C_{org}) compared to the Al-bearing samples (1.28 ± 0.13 wt% C_{org}). Results from our geochemical, mineralogical, and spectroscopic study of hydrothermal alteration products and salts inform the heterogeneous distribution of inorganic and organic materials that could delineate habitats and demonstrate the limits on organic matter detectability using different analytical techniques. Furthermore, we relate our measurements and results directly to current and upcoming martian missions, and we provide recommendations for detection and characterization of minerals and organics as biosignatures on Mars using instruments on future missions.

Keywords: Mars, surface, astrobiology, exobiology, spectroscopy; Earth Analogs for Martian Geological Materials and Processes