NASA Astrobiology Early Career Collaboration Award

Progress Report for Origin and History of Jarosite in the Rock Record

A potentially strong analog for the jarosite- and alunite-bearing layered deposits on Mars is Mollies Nipple in southern Utah. At this site, jarosite and alunite occur as cements in Jurassic quartz-rich sandstones. The origin of the jarosite- and alunite-bearing cements at Mollies Nipple is not yet understood. Early results are being compared with the geologic setting of the layered jarosite- and alunite-bearing deposits on Mars to determine whether similar processes could be responsible for their deposition and persistence. Dr. Tom McCollom and Dr. Sally Potter-McIntyre spent a week at Mollies Nipple conducting field work. Samples were collected and some preliminary scanning electron microscopy and xray diffraction has been done to evaluate cements in the sandstones.

Preliminary Results

Mollies Nipple is a prominent butte located in southern Utah that rises ~200 m above the surrounding landscape. The base of the butte is composed of eolian Jurassic Navajo Sandstone, a fine-grained quartz arenite. The butte is resistant to erosion owing to the presence of a well-cemented, generally finer-grained caprock. The cements in the caprock are predominantly composed of either jarosite or alunite plus kaolinite, although all three minerals occur together in some deposits within narrow zones between the two main deposit types. The mineral zones crosscut lithology and stratigraphic layering as well as fractures, with no readily apparent lithological or structural features that control the segregation of jarosite and alunite/kaolinite cements. The sulfate cements compose up to several percent of the rocks and make up the bulk of the matrix, with the remainder of the rock composition dominated by framework grains of rounded, well-sorted quartz grains with small amounts of feldspar (<~2 %). The jarosite and alunite/kaolinite cements are present only in the caprock at the top of the butte.

In the jarosite-cemented rocks, the jarosite is present as fine-grained (5-50 μm), pseudocubic crystals infilling pore spaces between much larger quartz grains (Fig. 5a-c). Preliminary analysis by X-ray diffraction (XRD) and scanning electron microscopy coupled with (SEM/EDS) indicates that the matrix framework grains of these sandstones is composed predominantly of quartz while the cement is composed almost entirely of jarosite. However, in the external margins of some rocks the jarosite has weathered to hematite and other iron oxides/oxyhydroxides, giving them a brick-red coloration. The jarosite is near the K endmember, containing very little Na or Al. The alunite/kaolinite cemented rocks contain contain minor amounts of potassium feldspar (K-spar) in the matrix in addition to quartz. The K-spar is often corroded, suggesting that reaction of this component with acidic sulfate-bearing fluids may have provided a local source for the K, Al and Si that are now found in alunite and kaolinite. Jarosite is sparse in these rocks, although in some cases the alunite has been observed to contain jarosite cores. In other rocks, however, jarosite has been observed as overgrowth on alunite, so the paragenetic relationship of these minerals is unclear. The alunite is generally smaller grained (<1-20 μm) than the jarosite, and contains primarily K in the A site with very little Fe.

Products

Potter-McIntyre, S.L., and McCollom, Tom M., 2016, Jarosite in Ancient Terrestrial Sedimentary Rocks: Implications for Understanding Mars Diagenesis and Habitability; Geological Society of America Annual Meeting, No. 109-3.

Potter-McIntyre, S.L., 2017, Biosignatures and Habitability in the Rock Record, Graduate Colloquium, Northern Illinois University, Jan. 27.

This award also provided the background research for "Investigation of Jarosite- and Alunite-bearing Sandstones at Mollies Nipple, Utah as an Analog for Stratified Sulfate Deposits on Mars", a proposal submitted to NASA Solar System Workings, Solicitation: NNH16ZDA001N-SSW.