Manganese oxides on Mars: A potential biosignature?

N.L. LANZA[1], W.W. FISCHER[2], A.M. OLLILA[1], P.J. GASDA[1], AND R.C. WIENS[1]

[1]ISR-2, Los Alamos National Laboratory, Los Alamos, NM 87644 (correspondance: nlanza@lanl.gov)
[2]California Institute of Technology, Pasadena, CA

Manganese-rich rocks on Earth closely track the rise of atmospheric oxygen. Very high-potential oxidants are required to oxidize Mn to insoluble, high-valence oxides that concentrate Mn in rocks and sediments (much higher than those needed to oxidize Fe or S). Given the association between Mn-rich rocks and the redox state of surface environments, recent observations of anomalous Mn enrichments on Mars [1-3] and in martian meteorites [4] raise similar questions about redox history, solubility and aqueous transport, and availability as a metabolic substrate. On Mars, high Mn appears in multiple geologic contexts. At least some of the high Mn present occurs in the form of Mn-oxide filling veins that crosscut sandstones [2] and as thin coatings on rock surfaces [3]. Other observations of high Mn are found incorporated within the matrix of mud- and sandstones [5, 6].

Terrestrial aqueous environments that are favorable for Mn oxidation and deposition are almost always both habitable (potentially supportive of life) and inhabited by microbes [7]. Given its close association with life and habitable environments on Earth, manganese has long been considered a potential biosignature for Mars [e.g., 8]. However, we do not yet understand the unique Mn signatures that can distinguish Mn-rich deposits as biogenic in origin (i.e., produced by life) from altered, abiogenic Mn deposits. Initial results suggest that trace element abundances and mineralogy may provide clues about the origins of Mn-rich materials. In particular, the presence of trace elements such as Ba, Li, Rb, and Sr may help to infer the redox state of Mn, which in turn may identify samples that are more likely to have a biogenic origin. This information is of particular importance to the upcoming Mars 2020 mission, whose primary goal is to identify biosigatures.

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