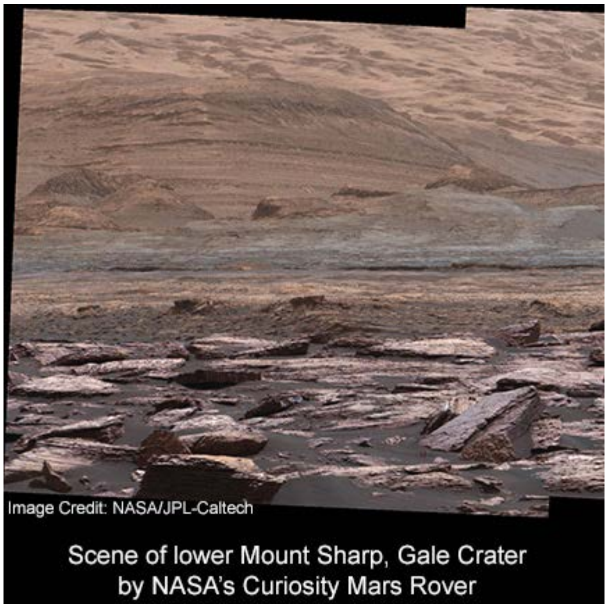
The Idea of Hematite Formation on Mars Through Photo-Oxidation



Scene of lower Mount Sharp, Gale Crater by NASA's Curiosity Mars Rover

A research team has reported details of laboratory experiments of an iron oxidation process that could explain ancient chemical sedimentary rocks on Earth – known as banded iron formations – and the hematite (Fe_2O_3) deposits in ancient Martian rock layers being invesigated today by NASA's Curiosity rover on Mount Sharp in Gale Crater.

Backstory
The story of hematite on Mars began in 2000 when a hematite-bearing rock layer was discovered along with evaporite deposits in Terra Meridiani with Thermal Emission Spectrometer (TES) data from NASA's Mars Global Surveyor. This discovery prompted researchers to consider the role of water in the formation of Martian hematite (for more, see **PSRD** article: ***Gray Iron Oxide in Meridiani, Mars***.)

A 2010 detection of hematite by NASA's Mars Reconnaissance Orbiter in Gale Crater was associated with a proposed paleolake environment. The current Curiosity rover mission is finding an increased abundance of hematite in rock layers as it moves uphill on Mount Sharp. Researchers are using the hematite signals to learn more about the interactions of rock and water and atmosphere, and the oxidation conditions of early Mars. How did the Fe^{2+}, the iron in Martian basalts, oxidize into Fe^{3+}, the iron in hematite?

Photo-oxidation Experiments
Nicole Nie, Nicolas Dauphas (both from the University of Chicago), and Richard Greenwood (The Open University, UK) conducted experiments of oxidation caused by the action of light, more formally known as photo-oxidation. They studied the iron isotope fractionation between precipitated Fe^{3+}-bearing mineral and dissolved Fe^{2+}. They designed the experiments to shed light on photo-oxidation processes on planetary surfaces where water exposed to sunlight stimulates the fractionation of iron isotopes by the bombardment of ultraviolet radiation. No biological process is evoked or necessary in this scenario.

The team's experimental results confirmed enrichment in the heavy isotopes of iron, values which equal the values measured in banded iron formations on Earth: Iron photo-oxidation is a viable formation path to banded iron formations. They used their results to estimate the "quantum yield of the photo-oxidation process," which translates into: How many Fe2+ atoms are oxidized per UV photon absorbed. Nie and coauthors estimate a value of ~0.07.

A Model for Hematite Formation on Mars Through Photo-Oxidation
Nie and colleagues developed a model for iron photo-oxidation on Mars using their new estimate of the quantum yield for photo-oxidation, which let them estimate the time required for a water body (at an initial pH of 7) containing Fe^{2+} to be oxidized. The pH of the water decreases as Fe^{2+} is oxidized and the acidity slows down the reaction. Nevertheless, in centimeter to meter-deep water ponds on early Mars, the team estimates that iron photo-oxidation would have taken months to years to complete, or longer for deeper water bodies with icy crusts, and could have formed the hematite deposits on Mars.

See Reference:

· Nie, N., Dauphas, N., and Greenwood, R. C. (2017) Iron and Oxygen Isotope Fractionation During Iron UV Photo-Oxidation: Implications for Early Earth and Mars, *Earth and Planetary Science Letters,* v. 458, p. 179-191, doi: 10.1016/j.epsl.2016.10.035. [***abstract***]

See also:

· Hurowitz, J. A., Fischer, W. W., Tosca, N. J., and Milliken, R. E. (2010) Origin of Acidic Surface Waters and the Evolution of Atmospheric Chemistry on Early Mars, *Nature Geoscience,* v. 3, p. 323-326, doi: 10.1038/ngeo831. [***abstract***]

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December 2016

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