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Chemical Weathering Processes on Mars: Implications from Martian Meteorites and Rocks

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Among martian meteorites, the nakhlites contain the mineral iddingsite, which has formed during aqueous alteration of olivine on Mars. The instruments attached to the robotic arm of the Mars Exploration Rovers consisting of the Alpha Particle X-Ray Spectrometer (APXS), the Mössbauer Spectrometer (MB), the Microscopic Imager (MI), and the Rock Abrasion Tool (RAT) provide data of undisturbed surfaces, brushed rinds, and interiors of rocks for the study of the interaction with water in rocks and soils. Because of the missing possibility to determine directly water contents in samples on the martian surface, our key elements for the indication of weathering processes are S and P and the halogens Cl and Br. Substantial enhancements of Br over Cl in fracture filling secondary salts in Nakhla veins [1] and in sulfate-rich evaporates on Mars [2] indicate alteration processes in an aqueous environment.

All martian rocks are covered with Cl- and sulfate-rich soil. To remove the adhering soil the rock surfaces were brushed with the RAT and afterwards, the APXS measured the chemical composition of the fairly clean rock layer. In specific cases, the rock surface was abraded by the RAT down to several millimeters to expose fresh material. A comparison of the chemical composition of the outer layer and the interior revealed a weathering sequence of the rock as found in the primitive basalts of Gusev plains, the more evolved rocks of the Columbia Hills, and the outcrops at Meridiani Planum [2,3].

The influence of acidic brines was observed in phosphate-rich rocks at Columbia Hills in Gusev Crater. The chemical compositions of brushed and abraded surfaces of the three P-rich rocks, Champagne, Wishstone, and Watchtower, illustrate that they are

covered by an alteration rind. The P contents in the brushed samples are by a factor of about 2 lower than those of the abraded surfaces. When calculating molar concentrations of P and Ca as apatite and the remaining Ca and all Na and K as feldspar, a loss of apatite but no loss of feldspar was found for the brushed surfaces. This suggests that sulfate- and chloride-rich acidic water easily leached the phosphates from the rock surfaces and mixed them to the surrounding soils, without weathering the feldspar component.

Ref.: [1] Rao M. N. et al. (2005) *J. Geophys. Res. 110*, E12, E12S06, doi: 10.1029/2005JE002470. [2] Rieder, R. et al. (2004) *Science 306*, 1746-1749. [3] Gellert, R. et al. (2004) *Science 305*, 829-832.