Surficial processes on Mars: a planet on acid

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Surficial processes on Mars are thought to have been strongly influenced by low pH conditions. The martian surface is cold, dry and oxidizing and the meager atmosphere is dominated by CO_2, but that may not always have been the case. There is evidence that early Mars was warmer and wetter. The crust is dominated by basalts with distinct composition, rather than more evolved granitic rocks characteristic of terrestrial upper crust. Accordingly, few terrestrial analogs, experiments or theoretical modeling shed much light on possible martian conditions. An alternative approach uses experiments where synthesized martian basalt is altered under conditions thought to be relevant for Mars. Results are compared to *in situ* measurements, visible to infrared and gamma-ray orbital spectroscopy and theoretical modeling. Low pH experiments on olivine-normative and olivine-absent basalt compositions and key minerals (olivine, Fe-Ti-oxides) highlight the importance of olivine and/or low silica basaltic glass dissolution. Evaporation experiments and modeling that incorporates Fe(II) and Fe(III) in Pitzer equations suggest that martian groundwater and surface water produced distinctive evaporite suites with minerals such as jarosite, gypsum, and various Mg- and Fe-sulfates. Such assemblages are very reactive in response to modest changes in diagenetic fluid chemistry or redox state.

Observations from the Mars Exploration Rovers, *Spirit* and *Opportunity*, are consistent with fluid-rock interactions taking place at low pH (<3-5). Under acidic conditions, many chemical relationships, characteristic of terrestrial weathering. do not apply: Al and Fe are far more soluble, Si mobility is limited by fluid/rock ratio and iron oxidation is sluggish. Chemical constituents of Noachian-Hesperian sedimentary rocks at Meridiani Planum formed by evaporative processes and were diagenetically altered in high ionic strength groundwater. These processes led to a distinctive suite of chemically precipitated minerals including: jarosite, Mg- and Ca-sulfates, hematite, amorphous silica and possibly ferrous sulfates and Mg-, Ca-, Na- and/or Fe-chlorides, but no carbonates. Amazonian basalt surfaces exposed in Gusev crater were altered by small amounts of acidic water in near-surface environments and show evidence of mm-scale rinds of selective mineral dissolution that mimics trends revealed by martian basalt alteration experiments. Thus, aqueous alteration at low pH appears to be one hallmark of surfical processes throughout most of the geological history of Mars.