Low pH weathering of Mars analog lithologies: Thermodynamic modeling.

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Antarctic and martian soils are rich in sulfates that may imply involvement of sulfuric acid solutions in weathering processes [e.g., 1]. We calculated thermochemical equilibria among sulfuric acid solutions and basaltic rocks. Equilibrium compositions of solids and aqueous solution are being calculated as functions of solution to rock (W/R) mass ratio (0.1 to 10^5), initial solution pH (1-6), opening or closing the system to atmospheric CO_2 and O_2, and rock composition. Bulk compositions of the Antarctic Ferrar dolerite and a martian olivine basalt from Gusev crater [2] are used to characterize rocks. Calculations are performed at 0°C and 1 bar with the GEOCHEQ code [3].

Results for a dolerite composition in a system open to Earth's atmosphere show that with low pH (1-3) initial solutions and high W/R (~10^4-10^5), mainly amorphous silica forms. At W/Rs of ~10^3-10^5 (calculated pH ~3-7), kaolinite and silica can form, as well as illite and goethite. At higher calculated pHs and lower W/R, which may characterise advanced stages of weathering and neutralization, goethite and dolomite dominate. Gypsum forms at calculated pHs of ~1-7 and W/Rs of ~10-10^3, but only for initially very acidic solutions (pH≈1) which provide enough sulfur. For solutions with higher initial pH (4-6), high W/R (~10^3-10^5) results in mainly silica, kaolinite, and zeolites. At lower W/R, goethite and dolomite dominate. Weathering of Gusev basalt in a system open to Mars' atmosphere results in less Ca-zeolites, more goethite, and in magnesite in addition to dolomite, consistent with a greater Mg+Fe to Ca ratio in Gusev basalt.

Results agree with some characteristics of Antarctic and Mars materials. Ferrar-derived soil fines contain clays, zeolites and Ca-sulfates. Lack of abundant carbonates in martian, and some Antarctic, materials may indicate an early stage of acid weathering. Incomplete weathering also plays a role. Amorphous silica is formed during the first stages of weathering (high W/R), at all initial pHs. Formation of silica is consistent with terrestial observations, experiments, and may contribute to silica-rich martian surfaces [e.g., 4].

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