

Using the chemical composition of carbonate rocks on Mars as a record of secondary interaction with liquid water

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ABSTRACT

In the search for habitable environments on Mars, sites that have been altered by liquid water represent an important target. Quickly dissolving and precipitating carbonates, found in multiple locations on Mars, represent a key potential mineral indicator of locations with a history of aqueous alteration, and therefore possible habitability. Recent liquid surface water on Mars may differ significantly from the fluids, either sedimentary, hydrothermal, or pedogenic, that formed carbonate minerals on Mars. Interactions of carbonate rocks with such recent surface water may therefore cause changes in chemistry and mineralogy with depth that form weathering profiles recording the conditions of alteration. To test the prediction that martian carbonates may record a signature of aqueous alteration on Mars, we performed reactive transport modeling of putative carbonate outcrops on Mars using the reactive transport code CrunchFlow. Model inputs included two parent rocks chosen based on the carbonate-rich rock at Gusev Crater, Comanche, one consisting of 60% magnesite, 20% siderite, and 20% porosity, and one consisting of 50% magnesite, 20% siderite, 9% calcite, 1.6% rhodochrosite, and ~20% porosity. Reacting solutions consisted of four scenarios: acidic, sulfate-containing solutions, perhaps resulting from an acid vapor scenario; dilute solutions resulting from martian analog basalt dissolution; concentrated solutions resulting from modeled evaporation of the dilute solutions; and solutions based on the results of the Phoenix Lander. Modeling was performed under low oxidation and high oxidation conditions. Based on the modeling results, a carbonate rock would become enriched in siderite upon interaction with acidic water under low oxidation conditions; the same rock would become enriched in calcite after interaction with Ca-enriched solutions. A carbonate rock reacting under more oxidizing conditions would preferentially dissolve siderite, leaving a surface enriched in magnesite and ferric oxide. Therefore, the Mg-rich carbonates on Mars are consistent with possible interaction with liquid water under oxidizing conditions, similar to those measured at the Phoenix landing site. Future detailed chemical and mineralogical profiles through weathered rock into the unaltered interior of carbonate rocks may therefore allow the quantitative interpretation of the aqueous history and possible habitability of locations on Mars.

Keywords: Mars, weathering, carbonates, siderite, calcite, reactive transport modeling, dissolution, precipitation