IMPACT-GENERATED HYDROTHERMAL ALTERATION ON EARLY MARS IN PRESENCE OF CO_2.

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Introduction: Impact-generated hydrothermal systems may have caused widespread alteration of the crust on early Mars. We previously explored the range of alteration products using several Martian meteorites as crustal proxies: LEW88516 [1-3], Dhofar 378, Chassigny [4], and Nakhla [5]. Overall, the dominating alteration phases are oxides, hydroxides, clay minerals, and other hydrous silicates. Our results match well with the hydrous silicates (nontronite, chlorite) observed by OMEGA and CRISM [e.g., 6,7]. The two most recent findings by CRISM are carbonates [8] and serpentine [9]. While the latter is formed in our calculations from all olivine-rich starting compositions (LEW88516, Chassigny), carbonates require CO_2 (or HCO_3^-, CO_3^{2-}) in the system. To evaluate the effect of CO_2, we conducted new calculations with ALHA84001 [10] and maskelynite [11] as starting compositions by exposing them to the same brine used before and, in a second set of calculations, with the addition of 0.5 mol H_2CO_3. We are using ALHA84001, because its secondary carbonates [10,11,12] provide a unique opportunity to compare model and mineralogical data. Moreover, it is the only sample of the ancient Martian crust [12] within the suite of Martian meteorites.

Results and conclusions: At a water to rock ratio (W/R) of 1 (P=110 bar, T=150 °C) the ALHA84001 alteration assemblage is dominated by serpentine and amphibole with chlorite, which is very similar to hydrous alteration of LEW88516. At intermediate W/R (~1000) the assemblage is hematite (51 %), nontronite, and quartz with pyrite; and at high W/R (~100,000) hematite dominates the precipitate. If 0.5 mole H_2CO_3 are introduced into the brine, the assemblage at W/R=1 is still dominated by serpentine and amphibole, but ~5 % of carbonate are present. At higher W/R, carbonate dominates the precipitate (71 and 99 % at W/R = 1000 and 100000, respectively). If maskelynite reacts with a Fe-, Mg-, and Ca-bearing brine at W/R=1, the alteration assemblage is dominated by albite (37 %), mica, and zeolite with 4.6 % of calcite. At W/R=1000 the assemblage is kaolinite (56 %), siderite, and quartz. At very high W/R, it contains 95 % siderite. While assemblages at low W/R remain similar to carbonate-poor precipitates, high W/R can produce a carbonate-dominated assemblage. Furthermore, the calculations show that a carbonate-dominated assemblage can be formed from a Fe- and carbonate-carrying brine reacting with maskelynite. The calculations suggest carbonate abundances and compositions on Mars have the potential to provide estimates of W/R in subsurface hydrothermal systems.

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