

MODELING ALTERATION MINERALS ON MARS – INVESTIGATING THE HIGH TEMPERATURE COMPONENT. S. P. Schwenzer¹, and Mark H. Reed², ¹The Open University, Department of Physical Sciences, CEPSAR, Walton Hall, Milton Keynes MK6 3AQ, UK, s.p.schwenzer@open.ac.uk, ²Department of Geological Sciences, University of Oregon, Eugene, Oregon, USA, mhreed@uoregon.edu.

Introduction: Alteration minerals are important indicators of thermochemical environments at the time of their formation – and thus indicators for the potential habitability of a site [1,2]. Therefore, the detection of alteration minerals, especially nontronite [3], on Mars was an important step to understand Mars' hydrous history. This initial finding was followed by the detection of a wide variety of alteration minerals, including but not limited to diverse phyllosilicates, carbonates, sulfates and hydrous silica in a variety of geologic settings in – mostly – Noachian terrains [e.g., 3-8], see [9] for review.

The importance of thermochemical modeling lies in the fact that the observation of minerals on the ground delivers an end result, but information of alteration conditions, such as T, P, and composition of the fluid, are lost. For Mars, diverse geologic settings with their respective temperature and host rock requirements have been modeled, ranging from very low-T surface evaporation scenarios [10,11] and acid weathering [12,13] to hydrothermal silica deposition [14]. We have focused on impact-generated hydrothermal systems [14,15,16], i.e., systems at warm to hot water conditions. Those subsurface systems contain water, CO₂, and host rock components, but no species are added from magma degassing or acid weathering. We used CHILLER [17] and limited the upper temperature range to ~250 °C. CHILLER is now replaced by CHIM-XPT [18], which allows for a much higher temperature range up to 600 °C. CHIM-XPT has been applied to terrestrial basaltic settings at temperatures up to 500°C [19]. High temperatures are important in the central peak settings of large impact-craters, where initial temperatures readily exceed 250 °C [20] and form high-temperature alteration phases – as is documented for terrestrial craters [e.g., 21]. With new exploration techniques on Mars, such as the CheMin instrument on the Mars Science Laboratory (MSL) rover [22], those rare but important phases might be found in the near future. Their detection will allow for a more complete understanding of the Martian alteration history. Here we compare our previous CHILLER results obtained on the Martian meteorite composition LEW 88516 [15] to CHIM-XPT and carry out models at 500 °C.

CHILLER-CHIM-XPT results and discussion.

We modeled LEW88516 earlier [15], and details on input data can be found there. Host rock and starting fluid chemistry are identical for all runs.

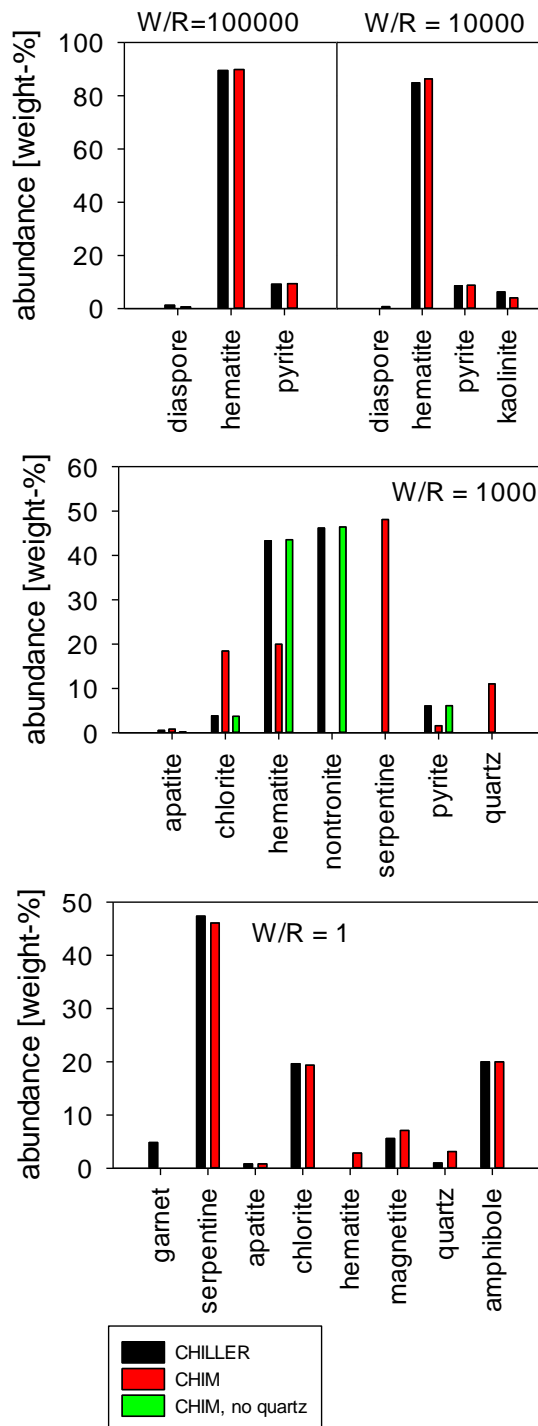


Fig. 1. Comparison of CHILLER and CHIM-XPT model runs of Martian lherzolite LEW 88516 at 150°C, 110 bar. See text for details.

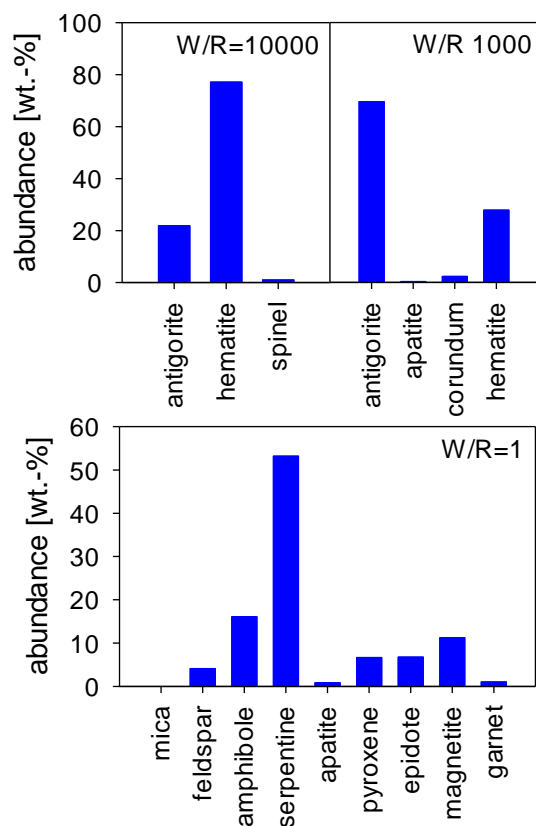


Fig. 2. CHIM-XPT model run at 500 °C and 990 bar. H_2O gas is excluded, which causes no gas phase to form. Host rock is Martian lherzolite LEW 88516.

Model 150°C run with CHILLER. Figure 1 shows that at high W/R the only mineral precipitates are hematite, diaspore, kaolinite and pyrite. All species not included in those precipitates stay in solution. At intermediate W/R a greater diversity of minerals precipitate, including Fe-smectite and chlorite. At low W/R the precipitate is dominated by serpentine, chlorite and amphibole. For details see [15]

Remodel 150°C run with CHIM. CHIM-XPT with its updated soltherm database results in the same precipitates with one exception: in the intermediate W/R range, quartz saturates in the CHIM-XPT run but is absent in the CHILLER run. As a consequence, serpentine forms instead of nontronite. Since, to date, no quartz or silica phase has been observed in assemblage with serpentine on Mars or in Martian meteorites [3,4,9,23], suppression of quartz seems justified – and results in nearly identical CHIM and CHILLER outputs.

Model 500°C with CHIM. At 500 °C few minerals precipitate at high and intermediate W/R and the assemblages are dominated by serpentine and hematite (Fig. 2). At low W/R serpentine (antigorite) still dom-

inates the assemblage, but is accompanied by higher temperature silicates. These are amphibole Fe-anthophyllite), epidote, pyroxene, and feldspar. Magnetite is present at >10 wt.-%. This is in accordance with terrestrial observations, e.g., at Chixculub crater, where the high-T alteration phase contains many of the same minerals [21].

Conclusions – and outlook for rover exploration: High-T phases are rare and mostly over-printed by later, longer lasting hydrothermal stages at lower temperature, so they are hard to find even with terrestrial methods. Therefore, orbiter instrumentation based detection of such phases might be impossible. With the next generation of rovers operating on the Martian surface, namely CheMin on MSL [22] – and future, similar instruments – it will become possible to detect these phases, even if present at a few percent only. This will provide important information on the early history of a system – including the chemistry of fluids potentially venting, cooling and evaporating at the surface above high-T subsurface alteration sites.

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