Martian fluids and their evaporation products – an overview using thermochemical modelling

Conference or Workshop Item

How to cite:

For guidance on citations see FAQs.

© 2020 Simone Cogliati

https://creativecommons.org/licenses/by-nc-nd/4.0/

Version: Accepted Manuscript

Link(s) to article on publisher’s website:
https://www.hou.usra.edu/meetings/lpsc2020/

Copyright and Moral Rights for the articles on this site are retained by the individual authors and/or other copyright owners. For more information on Open Research Online's data policy on reuse of materials please consult the policies page.
MARTIAN FLUIDS AND THEIR EVAPORATION PRODUCTS – AN OVERVIEW USING THERMOCHEMICAL MODELING. S.P. Schwenzer1, J.C. Bridges2, S.M.R. Turner1, N.K. Ramkissoon1, S. Cogliati1, R.G.W. Seidel1, M.H. Reed1, J. Filiberto3, D. Vaniman5, and Karen Olsson-Francis1, 1AstrobiologyOU, EEES, The Open University, Walton Hall, Milton Keynes, Susanne.schwenzer@open.ac.uk, 2Space Research Centre, University of Leicester; 3University of Oregon, 4Lunar and Planetary Institute, USRA; 5PSS.

Introduction: Thermochemical modeling is a powerful tool to fill the gap between observable features of a water-rock reaction system and those features that are transient and not accessible through observation [e.g., 1,2]. On Mars, it depends on location, what is observable and what is not. For example, for the Martian meteorites, a very detailed record of alteration has been established for the nakhlites [3,4] and ALH84001 [5]. This record includes the observation of spatial and temporal relationships of mineral formation. The record from rover data is much less detailed as microscale spatial relationships cannot be discerned. It does, however, allow for localization within the wider Martian context, which is missing from the meteorite record. Results from three rovers are most relevant: the MERs Spirit and Opportunity [6,7], and MSL Curiosity [e.g., 8]. A third dataset is provided by OMEGA and CRISM, which allow mapping of larger-scale mineral occurrences; however minor minerals and those without strong spectral signatures can be masked. Here, we focus on rover and meteorite data as they provide the most detailed dataset as a basis for modeling. We reviewed model fluids and modeled the evaporation of a common fluid under varying conditions to show the differences that occur at the surface (with CO2), and also with an addition of a small amount of SO2 to the CO2 atmosphere), and in the subsurface (with less CO2, but at variable, and sometimes higher temperatures).

Methods: Data from previous models (Fig. 1) are used to illustrate the nature of the fluids resulting from

![Soil (MSL) vs Rocks (MER, MSL) vs Meteorites](image)

**Fig. 1.** Fluids modeled for the reaction of a ‘groundwater’ type fluid with Martian soil (MSL, [9,10]), rocks (MER – grey squares, MSL – blue and purple dots [11]) and meteorites [12-14].
water-rock reaction of Martian rock compositions. Compositions range from pure olivine (Chassigny) to mafic and ultramafic ‘basalts’, e.g. LEW88516, a shergottite (>60% olivine), to the basaltic compositions found at Gale and Gusev Craters. For the evaporation models, we extract fluids from the model at W/R of 1000 and evaporate them using CHIM-XPT [15]. Evaporation modelling was carried out at 10 °C, and mineral precipitates were allowed to re-dissolve (non-fractionating). pH is a free parameter.

**Results:** Fig. 1 shows an overview over the fluids modeled for soil, rocks measured by rovers and meteorites. There is a striking difference between Gale model fluids and meteorite model fluids, as the Gale fluids tend to be lower in Mg, Ca and Fe and higher in Na. When evaporated (Fig. 2A), Gale fluid precipitates quartz, then sulphates and finally chlorites, with very small amounts of carbonate (dawsonite). The example we show in Fig. 2B is evaporating LEW88516 fluids. This fluid precipitates two Fe-phases (goethite, siderite) alongside quartz before precipitating sulphates.

**Discussion and Outlook:** The difference in fluid composition is striking, and likely a result of the clay formation at Gale crater. Mg is taken up by the smectitic clays seen at Gale (e.g., [8]) and in our models [e.g., 9,10]. The fluids are neutral to alkaline in nature, and usually precipitate gypsum/anhydrite at some stage.

The current models are done with a small amount of CO₂, considering subsurface fluids with no connection to the Martian atmosphere. We also have also modeled higher-pressure, i.e., deeper subsurface, metamorphic conditions and found striking changes to the mineralogy at small to moderate changes in CO₂ [16]. Therefore, in the future, we will consider CO₂-bearing fluids at various concentrations in the context of diagenetic and hydrothermal fluids, and assess whether the presence of CO₂ suppresses sulphates entirely in those systems or if some sulphate forms alongside/after carbonate formation. We note, that redox state and the bioavailability of sulphur, as well as the overall redox of the system are important as they could support life via sulphur metabolism.

**Acknowledgements:** SPS, JCB and SMRT thank the MSL science team for their scientific, and UKSA for continuous financial support. SPS and SMRT thank Research England for additional financial support.


**Fig. 2.** A) Evaporation of the fluid resulting from a reaction of Portage soil with groundwater from [9], see also [10]; B) Evaporation of the fluid resulting from a reaction of the shergottite LEW88516 from [12].