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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. Reed³, J. Filiberto⁴, 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 micro-scale 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

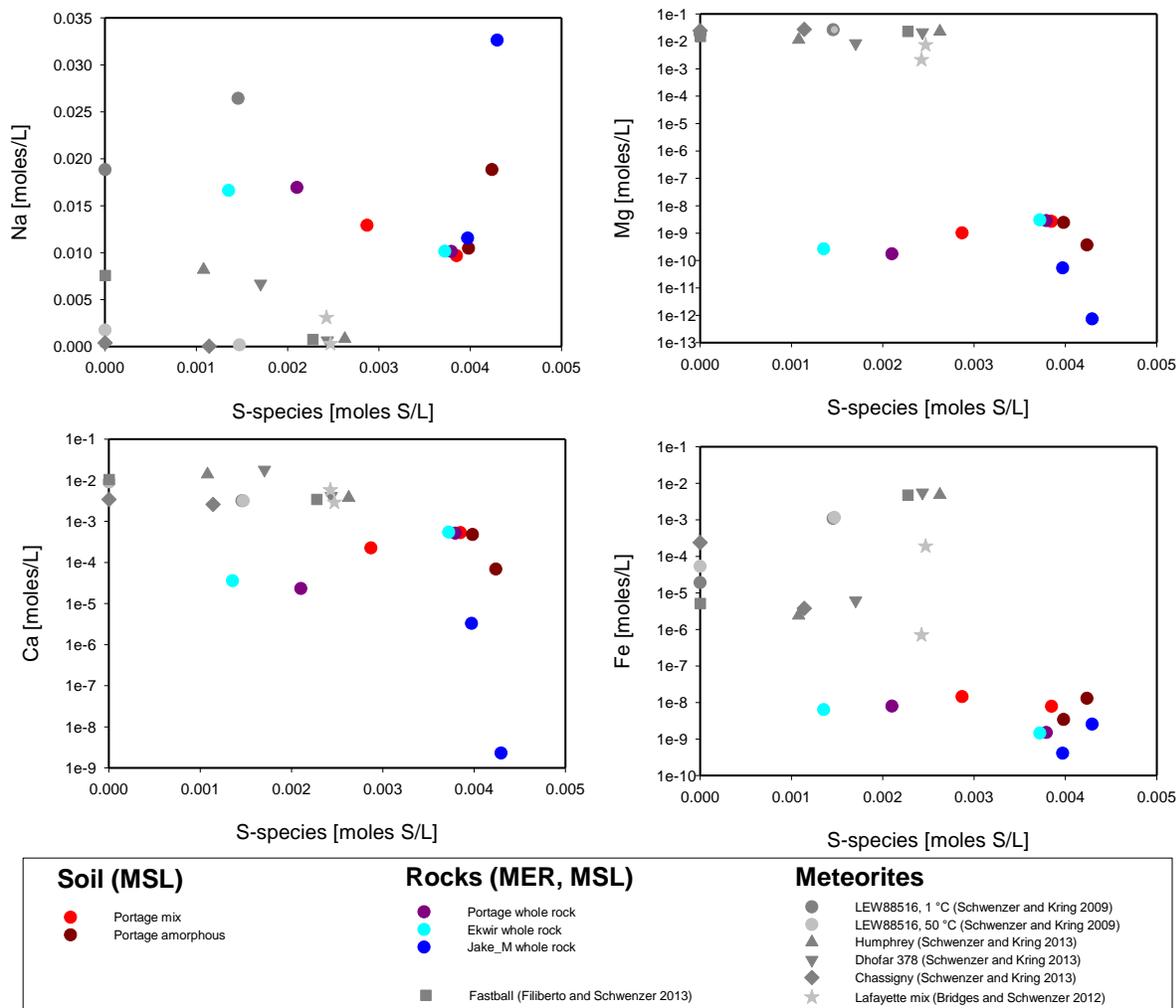


Fig. 1. Fluids modeled for the reaction of a ‘groundwater’ type fluid with Martian soil (MSL, [9,10]), rocks (MER – grey squares, MSL – blue and purple dots [11]) and meteorites [12-14].

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 diage-

netic 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 bio-availability of sulphur, as well as the overall redox of the system are important as they could support life via sulphur metabolism.

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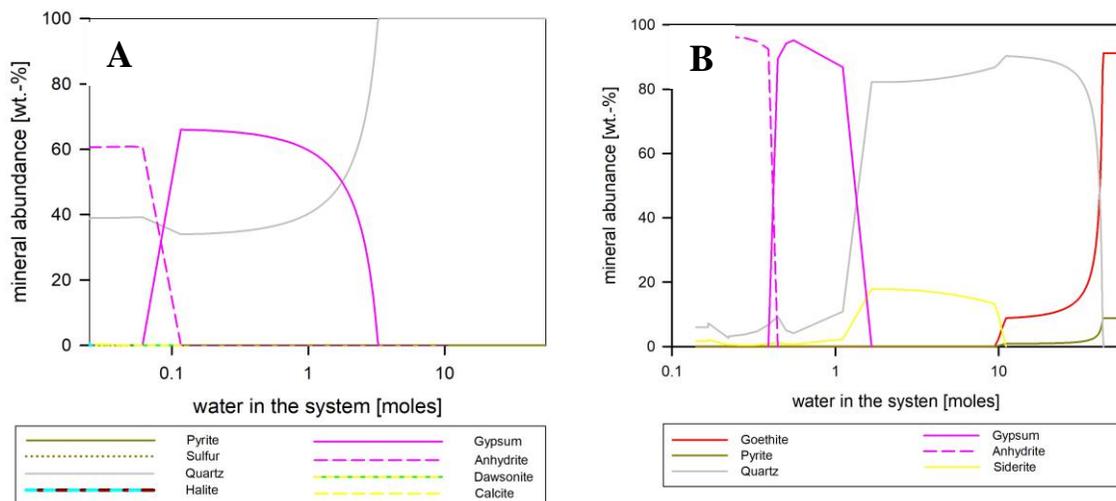


Fig. 2. A) Evaporation of the fluid resulting from a reaction of Portage soil with groundwater from [9], see also [10]; B) Evaporation of the fluid resulting from a reaction of the shergottite LEW88516 from [12].