Understanding the evolution of Martian carbonates from a combined modelling and synthesis study

Conference or Workshop Item

Understanding the Evolution of Martian Carbonates from a Combined Modelling and Synthesis Study

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Introduction – There were several discoveries in 2008 regarding carbonates on Mars that are important in understanding the evolution of these salts. These include the identified $CaCO_3$ by Phoenix's TEGA and MECA instruments [1,2]. The Phoenix lander has also discovered the surrounding soils were pH alkaline (8.3 ± 0.5) [2] and enriched with subliming water ice, both conditions favourable to carbonate formation. Furthermore carbonates (in the form of $MgCO_3$) were detected by reflectance spectra from the orbital IR and VNIR spectrometer CRISM [3]. Despite these discoveries, without material being brought back directly from Mars by a sample return mission, martian meteorites provide the best source for analysis of the fine-scale mineralogy of the martian surface.

ALH84001 - The origins of ALH84001 carbonates are of great importance for understanding the ancient martian environment. Thought to have formed ~3.9 Ga [4], they are assumed to have precipitated from fluids with neutral to alkaline pH in contact with CO_2. Approximately 0.6 Ga separates primary crystallization of ALH84001 from formation of secondary mineral assemblages. The period in which the carbonates formed has been called the Phyllosian era, owing to the outcrops of phyllosilicates discovered by the OMEGA and CRISM spectrometers [5, 6]. Their ancient age, abundance and mineralogical variations make ALH84001 carbonates ideal candidates to provide insights into early martian environmental conditions.

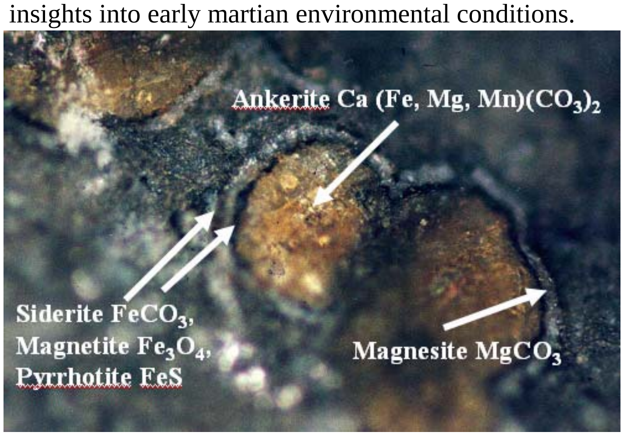

Figure 1 – Microscope image of rosettes within ALH8001, split 126.

We are investigating the formation conditions of carbonates in ALH84001 through two avenues:

(1) Modelling: We are attempting to constrain the carbonate precipitation environment by modelling how changes in fluid and atmospheric composition, oxygen fugacity, temperature, etc change the final precipitation products. We are using the Geochemist Workbench™ (GWB) program to assist with modelling the Mg-Fe-Ca system. A variety of initial concentrations will be combined with CO_2 fugacities and temperatures to assess the effect of each variable on the system. It should be possible to model the evolution of the carbonate assemblage as water evaporates, at set P/T conditions (or with 'sliding' variables) with some constraints on either Eh/O_2 fugacity and partial pressure/fugacity of CO_2.

(2) Synthesis: In order to determine the boundary conditions for precipitation, without straying into kinetically, or thermodynamically, unviable environments, we are also producing synthetic carbonates from fluids of known composition at known temperatures, following on from the precipitation experiments by Golden et al. [7, 8]. The resulting samples will then be characterized by XRD and SEM for compositional analysis, imaging and mapping. We will compare the synthesized carbonates with carbonate rosettes from ALH84001 to ensure that our derived environments are realistic for the martian surface. Solution compositions from our synthetic carbonate production experiments, as well as simulated or approximated compositions taken from literature [7, 9] will define the initial starting conditions for the modelling.

Future work – Once characterization of ALH84001 has been completed we will use GWB and our synthesis chambers to investigate the carbonate formations discovered by Phoenix. The ionic values obtained from MECA combined with surrounding mineral characterisation from CRISM will be used to produce candidate aqueous solutions.

Implications - The results from modelling and carbonate synthesis will help reveal the conditions of the period on Mars that is of greatest interest for future missions when the planet may have had a 'warm and wet' environment. The results from planned future work will provide insights into more recent cold and dry environment and how aqueous solutions have evolved over the history of Mars.

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