MARS-ANALOG EVAPORITE EXPERIMENT: INITIAL RESULTS.

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Introduction: This research is part of a multi-year experimental investigation to understand the nature and evolution brines and evaporates on Mars [1][2]. The spectacular discoveries of the MER rovers, particularly those of Opportunity at Meridiani [3], both illustrate the relevance, as well as guide the future direction, of this work. Here we report the initial results from our just-completed and tested evaporites apparatus, using a synthetic brine analog to our brine experiment simulating a modern Mars environment [1] in which the brine was subjected to rapid evaporation under modern Martian conditions.

Evaporites Experiment Apparatus: Formation of the evaporites are carried out in thin, conical 50 cc teflon sample holders that sit inside and line cylindrical receivers. Precipitation occurs at the bottom of each sample holder on a gold-plated TEM sample grid with a holey-carbon thin film, which is removed at the conclusion of a run and placed directly into an XRD sample chamber. Each receiver contains a conical cavity for supporting the teflon sample holders, a helical path about the outside diameter, and two O-rings to contain coolant. The helical path provides efficient circulation of the coolant near each sample for temperature stability. The sample holders and receivers are mounted into a stainless steel cooling block that is itself fitted with coolant lines to further ensure an isothermal environment. The entire assembly (9 flasks within a block) resides within a vacuum desiccator chamber. The desiccator has been fitted with two gas valves; one for flushing its interior with a synthesized Mars gas, and the other for pumping the desiccator down to pressures as low as 1 mbar when required. The gas input and output valves are teflon solenoids which can be actuated both manually and by the computer-controller. A pressure sensor feeds information back to the computer to ensure appropriate pressure in the chamber. Cambridge Sensotec Rapidox 200 O_2 sensors (capable of detection of O_2 down to 10^{-17} ppm) have been fit into the vacuum lines. These are constantly monitored by the computer-controller in order to detect any oxygen contamination. An electrical feed-through allows signals from thermistors attached to the sample flasks to be passed to the computer controller. A laptop computer using Labview and a PCMCIIA data acquisition card serves as the controller, measuring temperature and pressure in the chamber, logging data and controlling the vacuum pressure in the chamber (Fig. 1).

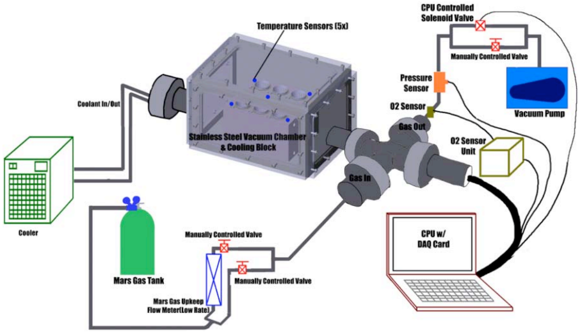

Figure 1. Mars-analog evaporites experimental apparatus schematic.

Experimental Procedure: The initial experiment was a study of evaporites formed by rapid evaporation, which involved artificial brine mixed to mimic the composition of brine produced by our brine experiment simulating a modern Mars environment [1]. We performed an analysis of our synthetic brine and compared its composition with the brine produced in our brine experiment. We found that the synthetically-produced brines were quite similar to those created in our year-long experiments, except that they were higher in sulfates by about an order of magnitude (Fig. 2).

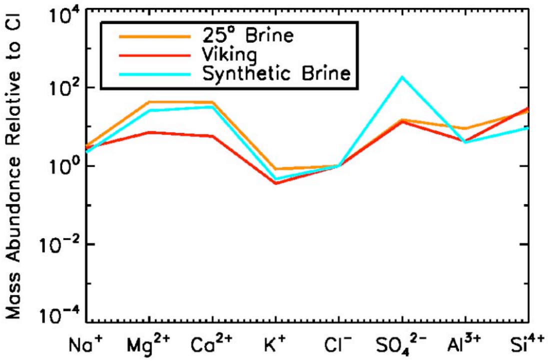

Figure 2. Composition of synthetic brine used to create evaporites (light blue line) compared with the composition of brine produced in the experiments reported in [1] (orange line) and the average composition of Viking soils (red line).

Brines were placed into 9 sample holders (in the amounts of 3 @ 20 ml, 3 @ 15 ML, 3 @ 10 ml), and desiccated under a simulated Mars atmosphere of modern composition at 20 mbar and 20°C to insure rapid evaporation. The desiccation of liquid samples was followed by visual (video monitoring) inspection. The 10 ml sample was desiccated in just over a day, and the 20 ml sample was desiccated in ~3.5 days. The thoroughly dry precipitate samples were removed in an oxygen and moisture free glove box, sealed, and sent to analysis.

Analysis:. The precipitate was analyzed using X-Ray diffraction (XRD) (Fig. 3). Our preliminary conclusions are that the predominant phase is gypsum, which occurs with a mixture of hydrous sulfates such as hexahydrite ($MgSO_4.6H_2O$), and possibly mirabilite ($Na_2SO_4.10H_2O$), and starkeyite ($MgSO_4.4H_2O$). Calcite is probably present in very small amounts and magnesian calcite is also possible. Sylvite and halite probably occurred in the Mars-analog evaporites in very small amounts.

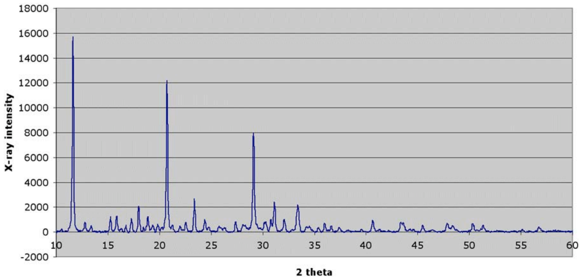

Figure 3. X-ray intensity as a function of angle from radiation diffracted by Mars analog evaporite salts.

Upcoming Experiments: *Evaporation: (Fast and Slow)* In these experiments we will identify the mineral suites precipitated by low temperature evaporation. Two synthesized mixtures of each of brines generated in our various brines experiments will be evaporated either rapidly (this is the experiment reported here for one of our brines) or slowly.

Freezing: (Rapid and Slow) The objective is to identify the mineral suites precipitated by freeze-drying the solution. Aliquots of each of the brines will be cooled to freezing, and the H_2O molecules will be trapped away. The evaporite materials will remain in the original vessel. The freezing process will be allowed to proceed either rapidly (minutes) or slowly (several days) by controlling the temperature of the freezer compartment. The brines will be held at 10°C below the lowest-freezing brine eutectic temperature to prevent thawing, and their headspaces opened to a moisture trap for drying. For slow freezing, we will slowly step the temperature of the freezer down to just below the calculated eutectic temperature for the brine composition. The progress of freezing will be tracked by including a Pt resistance thermometer attached to the outside of the sample flask liner, and monitoring the temperature as a function of time. The temperature will not fall below the eutectic temperature until the liquid has frozen. Latent heat release, and good insulation, will help slow the freezing process.

Conclusions: These experiments represent the first ever attempt to produce Mars-like evaporites in the laboratory. With the exciting discovery and initial characterization of actual evaporite beds at Meridiani Planum, it is imperative to understand the conditions (aqueous and atmospheric) that must have existed to form these deposits. Our future experiments will be responsive to both MER and future rover data, so that speculations about how layered deposits formed on Mars can be well-grounded in laboratory data.

References: [1] Bullock M.A. et al. (2004) *Icarus*, *170*, 404-423. [2] Bullock M.A. and Moore J.M. (2004) *GRL*, *31*, L14701. [3] Squyres, S.W. (2004) *Science*, 1344-1345.