A potential mineral paleo-humidity measure for Martian hydrated evaporite minerals: First results

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The stable isotope fractionation that occurs between a solute and its precipitated solid should produce a Rayleigh fractionation pattern of isotope zonation within and between crystals precipitated from an evaporating brine. Evaporation of a magnesium sulfate brine offers the possibility of many linked Rayleigh fractionation processes. Evaporation of the water will produce a linearly correlated hydrogen and oxygen isotope trend, the slope of which depends on the humidity of the atmosphere [1]. The water of hydration in successive zones of the precipitated mineral will reflect the history of variation in isotopic composition of the brine (shifted by the fractionations between water and water of hydration). The fraction of water left can be calibrated by zoned variation in sulfur and oxygen isotopes of the sulfate, since the extent of precipitation is directly controlled by the amount of evaporation.

We tested the concept with a model system easily conducted in the laboratory: epsomite, MgSO₄·7H₂O. We evaporated a magnesium sulfate brine, growing a large single crystal of epsomite, taking samples of brine during the process and then took serial samples through the resulting crystal.

We used our recently-developed, continuous-flow method method for simultaneous isotope analysis of hydrogen and oxygen of water of hydration [2]. For oxygen isotope analysis we precipitated barium sulfate from the epsomite, which was reduced at 1450°C in the presence of graphite and glassy carbon in a Finnigan TC/EA to produce CO for analysis in a Finnigan 253 mass spectrometer. The corresponding sulfate sulfur isotope analyses have just been started.

Initial analyses show extensive within-crystal isotopic variation, greater than 20 permil for δ²H and 5 permil for δ¹⁸O in water of hydration; and greater than 3 permil in sulfate oxygen. Interpretation of the data acquired so far indicate an appropriate value of 20% relative humidity for the conditions of the experiment.