Sulfate Brine Stability Under a Simulated Martian Atmosphere

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Introduction: Liquid water is thought to be unstable on the surface of Mars. However given that the surface conditions are close to the triple point of water under the appropriate conditions, liquid water could form and remain at least metastable for brief periods of time [1]. Various observations of recently formed gullies support this hypothesis [2].

The predictions of the Ingersoll [3] equation agree with previous experimental studies addressing the evaporation rates of pure water [4] as well as NaCl and $CaCl_2$-bearing brines [5]:

$$E = 0.612 \Delta\eta \rho_{atm} D \left[\frac{\frac{\Delta\rho}{\rho} g}{\nu^2} \right]^{\frac{1}{3}}$$

where E is the evaporation rate in mm/h, $\Delta\eta$ is the concentration difference at the surface of the sample and at distance, ρ_{atm} is the atmospheric density, D is the diffusion coefficient for water in CO_2, g is acceleration due to gravity, and ν is the kinematic viscosity of CO_2.

Previous studies have shown that brines could stabilize liquid water on Mars by lowering the eutectic point of the solutions [6], as well as their evaporation rate [5]. Recently obtained visible-near infared spectral data has added additional support suggesting the presence of sulfates on Martian surface [7]. The specific goal of this series of experiments is to investigate the stability of $MgSO_4$ brines under simulated Martian conditions. In the case of sulfate brines ions are more highly charged than for NaCl solutions [5] therefore ionic interactions will be stronger, which should influence the activity of water. Evaporative experiments were performed under silmulated Martian conditions; 5-7 mbar, pure CO_2 atmosphere and 0°C.

Conclusions: Numerous experiments were conducted to investigate the stability of $MgSO_4$ brines of varying concentrations under simulated Martian conditions. Crystallization was observed at high brine concentrations leading to a dramatic effect on the stability of water under these conditions. Therefore, in addition to the chemical effect of highly concentrated brines, the crystallization of salts strongly sztabilizes the brine. The hydration state of these crystals is currently being investigated utilizing X-Ray diffraction. This study provides initial evidence that sulfate minerals could conceivably serve as a reservoir of surface and subsurface water on the Mars.

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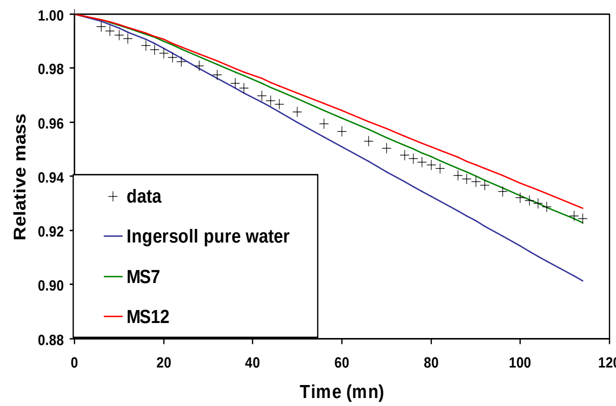

Figure 1. *20 wt% brine solution and fit with the predicted Ingersol derived rate for the evaporation of $MgSO_4.7H_2O$ (MS7) and $MgSO_4.12H_2O$ (MS12),*

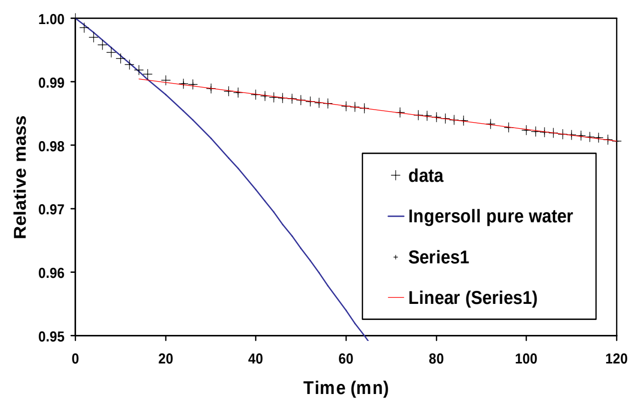

Figure 2. *20 wt% brine solution corresponding with the Ingersol equation initially, before diverging with a dramatically decreased rate of evaporation. Crystallization of the sulfates was observed in the sample.*