Evaporation and freezing modeling to predict microbial habitability of potential Martian brines

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Mars mineralogy can provide critical insight to constrain the composition of possible aqueous Martian fluids, allowing us to evaluate important characteristics of potentially habitable Martian brines; including an activity of water (a_w) higher than 0.61, the activity of specific ions (a_i), ionic strength (I), and chaotropicity vs. kosmotropicity of salts. We present an evaluation of water chemistries in equilibrium with a range of possible Mars mineral assemblages to help determine the possible limits of life in a cold, hyperarid Martian environment. We modeled evaporation and freezing using the thermodynamic models GWB and FREZCHEM at various conditions relevant to the Martian surface. Calculated brine compositions were evaluated for the potential persistence of microbial life under extreme cold and evaporative conditions, with special attention to the activity of water (a_w) and eutectic temperatures. Waters developed into Mg-SO_4, Na-SO_4, Mg-Cl, K-Cl, and Na-Cl dominant hypersaline brines. In all cases, a_w remains above the lower limit for biochemical reactions. The pH of concentrated waters varies from 0.58-9.56 and I ranges from 3.9 - 18 mol/L. The negative effects of low a_w and high I may be counteracted by the presence of high concentrations of kosmotropic solutes such as NaCl, KCl, or Na-K sulfates. However, the presence of high concentrations of chaotropic solutes such as Ca-Mg chlorides, together with low a_w and low pH will have a negative synergistic effect on microbial activity. Results suggest that microbes could survive in very high salinity brines that may have been present during ancient Mars environmental conditions, and that potentially may exist in isolated micro-environments on present-day Mars.