Goldschmidt 2021 Abstract
https://doi.org/10.7185/gold2021.6158

Salt partitioning on freezing closed-basin lakes in Mongolia: Implications for subsurface brine reservoirs on icy bodies in the Solar system

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Ceres and Europa would have possessed near-surface brine reservoirs, which may be a source of localized salts on the surfaces. Several processes of salt transport from the subsurface have been hypothesized. However, the salt partitioning between subsurface brines and mineralization upon freezing of the brines are insufficiently investigated through experiments or field observations.

Here, we report results of winter field surveys to ice-covered, closed-basin saline lakes of Orog and Olgoy Lakes in Mongolia. The surface ice exhibited complex morphology with pressurized ridges formed by compressive forces and wet cracks formed by extensional forces. Wet cracks allowed transportation of salinity to the icy surface. We measured the vertical salinity profiles in lake ice without the cracks. Using a coupled model of mass balance and low-temperature aqueous chemistry (the FREZCHEM code), we show that the observed vertical profiles of salinity in the ice layer can be explained by capturing of lake water within pores of ice grains. To explain high Mg^{2+} and Ca^{2+} concentrations of in the bottom water, we suggest that metastable phase of carbonates, monohydrocalcite and amorphous Mg-carbonate, controlled Ca^{2+}, Mg^{2+}, and ΣCO_2 concentrations of the freezing bottom lake water. This implies that if metastable carbonates control Ca^{2+}, Mg^{2+}, and ΣCO_2 concentrations in subsurface brine reservoirs on icy bodies (e.g., Ceres), these concentrations would become one order of magnitude higher than those with a consideration of stable carbonates.