

Hydrohalite formation in frozen clay brines.

Thursday, 12 November 2020 14:00 (20 minutes)

Hydrated forms of cryosalts in frozen brines play important roles in the polar landscape and troposphere of Earth [1], and their melting [2] is implicated in recurring slope lineae (RSL) in Antarctica's McMurdo Dry Valley [3] and equator-facing, mid-latitude (42°N-52°S) slopes of Mars [4]. Observation of the widespread occurrence of clay minerals and salts on the Martian surface [5] indicates that saline groundwater [6] may still be present on Mars. The surface of Mars ranges in temperature from 293 K on the equator at noon to 120 K at the poles and mobility of sub-surface water ice will depend on the local temperature and the mobility of confined water in the crustal clays.

We applied quasielastic neutron scattering using the backscattering spectrometer EMU (Australian Nuclear Science and Technology Organisation) at 1 μ eV resolution, to the system: sodium montmorillonite -5M NaCl (Na-Mt-NaCl) and calcium montmorillonite -5M CaCl₂ (Ca-Mt-CaCl₂); to establish boundary conditions influencing the dynamics of confined water. Results from elastic fixed window (EFW) data indicate a substantial increase in the mean square displacement of hydrogen (H) in the brine conditions at all temperatures above 100K, indicating enhanced mobility of water in the presence of brines. A phase transition was observed in Na-Mt-NaCl at 255K (on heating) indicating the presence of the cryosalt hydrohalite (NaCl · 2H₂O), but no phase transition was observed in Ca-Mt-CaCl₂. In addition, quasielastic neutron scattering (QENS) spectra highlighted that water in the Ca-Mt-CaCl₂ system was strongly confined at room temperature. Recently [6] hydrohalite was observed to form in frozen gels of Na-Mt brines, but not in Ca-Mt brines. They considered that textural differences in the two forms allowed the gel pores of the Na-Mt to retain liquid saline pore water to well below the freezing point of pure water. Based on our analysis, water is restricted to rotational mobility in the Na-Mt-NaCl below 255K, but presents more translational mobility above 255K. These findings largely support those of Yesilbas [7] in the importance of pore structure in controlling cryosalt formation, and further implicate their role in associated phenomena such as RSL.

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