Water Retention Mechanisms on the Near Surfaces of Mars: Gravimetric and Cryogenic Vibrational Spectroscopy Approaches

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The complex aqueous alteration on ancient Mars is associated with the presence of phyllosilicate clay minerals, iron hydroxides, sulfates, salts, and other types of hydrated minerals on the Martian surface today (Carter, Loizeau et al. 2015). Fe(III)-rich smectite clay, known as nontronite, and Cl-type salts have been detected all over the planet Mars by orbit analyses in varied weight percentages (wt.%). For instance, nontronite was detected at approximately 35 wt.% at Gale Crater (Gavin and Chevrier 2010, Bishop, Yeşilbaş et al. 2021). Nontronite is a swellable aluminosilicate-layered clay mineral. Its ability of swelling and the amount of absorbed water are controlled by factors such as the interlayer cations (*e.g.*, Na^+, Ca^{2+}), type of co-existing brines, humidity, and temperature. The interactions of nontronite with hygroscopic salts (*e.g.*, chlorides, perchlorides) on the near surfaces of Mars could lead to the formation and retention of liquid water through deliquescence and the formation of thin water-ice film on clay minerals following the Martian diurnal cycles. These salty solutions could potentially be retained within the interlayers of nontronite even well below 0 °C (Gavin and Chevrier 2010, Yeşilbaş and Boily 2016). Especially, it is believed that the formation of these brines in sulphate and Cl-salt mixtures on the near surfaces of Mars may play a significant role in Recurring Slope Lineae (RSL) geological structure formation during Martian early springs and summers (Bishop, Yeşilbaş et al. 2021).

This project reveals the roles of nontronite to form and retain liquid salty water from -100 to 20 °C, mimicking the conditions on the Martian subsurface. To achieve this, we investigated (i) the water sorption and deliquescence in our Martian analogues of nontronite-salt mixtures (*e.g.*, NaCl, $CaCl_2$, and $CaSO_4$) using the Dynamic Vapour Sorption (DVS) technique and (ii) the ability of nontronite to retain liquid salty water at various temperatures between -100 and 20 °C by probing the H_2O vibrational modes using Raman spectroscopy. Our preliminary findings suggest that the presence of hygroscopic salts enhances the water sorption of nontronite, even at low water vapour pressures. Our Raman results revealed that nontronite in $CaCl_2$ preserved water better than other nontronite-salt mixtures (*e.g.*, NaCl, $MgCl_2$). We shall further operate molecular dynamics (MD) simulations to investigate the interactions of liquid salty water mixtures in interlayers of nontronite at the molecular level and investigate their further expansion capabilities. This research provides fundamental information to understand the aqueous (geo)chemical history of Mars and could help to search for potential water resources on the near surfaces of Mars, where it could be of interest for the upcoming ExoMars rover mission.

References

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