The role of salt precipitation for brine flow mechanism on Mars.

*Shoko Imamura[1], Yasuhito Sekine[1], Takenori Sasaki[2]

1. The University of Tokyo, 2. The University Museum, The University of Tokyo

On present-day Mars, pure liquid water is thermodynamically unstable, whereas high-salinity brine can exist on the surface, at least temporally, due to freezing point depression. In fact, the Curiosity rover on the Gale crater finds that transient liquid brine forms in night time, which then evaporates after sunrise [1]. The presence of chlorides across the equatorial, southern highlands [2] suggest that such transient liquid brine can form widespread on present-day Mars [1]. Recurring slope lineae (RSL) are narrow and dark markings appearing on steep slopes in summer but disappearing in winter [3]. Although no direct evidence for liquid water in association with RSL has been found, the detection of hydrated chlorides together with RSL implies that high-salinity brine might have played a key role for its formation [4]. These observations strongly suggest that repeated cycles of formation and evaporation of liquid brine occur upon diurnal or seasonal variations on present-day Mars. Such repeated cycles should result in salt precipitation within pores of soils, which in turn would affect permeation of subsequent liquid brine and thus would change brine flow mechanism. However, little is known how repeated cycles of evaporation and formation of brine would affect the flow mechanism and morphology.

In the present study, we investigate liquid flow mechanism and morphology upon repeated infiltration and evaporation of brine based on laboratory experiments. A solution of $MgCl_2$ with 5 M was infiltrated into basaltic sand layer (layer thickness = 3 mm; grain size of sand = 45-250 μm) on a 30° slope set in a controlled glovebox, where temperature was ~293K and relative humidity was maintained ~30% using an air drier connected with the globe box. The flow rate was controlled using a peristaltic pump. After the infiltration of the $MgCl_2$ solution for 10-15 minutes, the sand layer was completely dried for more than 8 hours using the air drier. The infiltration and evaporation of the solution were repeated several times. The controlled experiments using ultrapure water were also performed. During the infiltration, we observed time evolution of liquid flow morphology using a digital video camera. After the experiments, we collected the sand samples and analyzed their porosity and salt precipitation using X-ray Computed Tomography.

We find that the flow of ultrapure water develops as almost concentric from its source throughout the repeated infiltration and evaporation of water in the experiments. On the other hand, the flow morphology of the $MgCl_2$ solution changes throughout the experiments. In the beginning of the experiments, the flow develops as almost concentric, but its morphology becomes narrow and elongated over the repeated infiltration and evaporation. This would happen because significant amounts of $MgCl_2$ salt precipitate within the sand layer after evaporation, forming bridges between the grains and decreasing the porosity. In addition, the $MgCl_2$ salt may cover the grain surfaces, which could affect surface tension between the brine and grain. Since capillary pressure decreases against water saturation within porous media [5], a decrease in capillary pressure over the experiments would sift the flow mechanism from infiltration flow dominated by capillary pressure to near-surface flow dominated by gravity, resulting in narrow and elongated flow morphology. The observed flow morphology for repeated brine infiltration may be consistent with those of RSL. Our results imply that near-surface brine flow could have occurred in chloride-rich areas on present-day Mars.

[1] Martin-Torres et al. (2015) Nature Geoscience 8, 357; [2] Ehlmann & Edwards (2014) Annual Review of Earth and Planetary Science, 42, doi:10.1146/annurev-earth-06313-055024; [3] McEwen et al. (2011)

Science 333: 740; [4] Ojha et al. (2015) Nature Geoscience 8: 829; [5] Hiroyuki Tosaka, Mathematics of Water Cycle in Geosphere (2006)

Keywords: Mars, Morphology, recurring slope lineae, brine, capillary pressure