Recurring Slope Lineae (RSL) and Chloride Hydrates within Mars Subsurface

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RSL is an important phenomenon revealed by HiRISE-MRO observations on Mars (McEwen et al., 2011). The RSL form and grow on some equator-facing slopes during warm seasons on Mars when $T_{afternoon}$ is in the range of ~250-300K (with even higher T_{peak}). Over a thousand RSL have been observed, they are narrow (0.5–5 m) and long (over 100 m). They occur repeatedly on steep slopes (>25°) with growth rates of ~ 0-20 m per day. RSL were reported at 7 confirmed sites and 32 likely sites, mostly in the southern hemisphere and rarely associated with martian gullies. RSL have been found in regions with moderate thermal inertia, without any direct association with surface mineralogy. RSL itself does not have any distinct spectral feature in the Vis-NIR range. The HiRISE team has noted that the distribution of RSL bears some similarity with putative chloride deposits in the southern hemisphere and they proposed that salty brines (chlorides or Fe sulfates) could be the source of RSL (McEwen et al., 2011).

We hypothesize that chloride hydrates may exist in some areas within the subsurface of southern hemisphere on Mars, and the deliquescence of these chloride hydrates at elevated temperature may have produced large quantity of brine that caused the RSL observed by HiRISE team.

This hypothesis is based on three lines of reasoning: (1) chlorine (Cl) is found to be broadly distributed on Mars (GRS-ODY) and has been detected in the chemistry of *every* surface samples during *all* Mars surface exploration missions (Vikings, Pathfinder, Spirit, Opportunity, and Phoenix). In addition, the existence of chlorides in martian southern hemisphere was suggested by a set of THEMIS-ODY data analyses (Osterloo et al., 2008, 2010). In terrestrial saline playas, large amounts of chlorides invariably appears in the precipitates from salty brines (Zheng et al., 2009, Wang et al., 2009), although the precipitation sequence of chlorides on Mars might be different from that on Earth (Tosca et al., 2008, McLennan et al., 2012). (2) A subsurface layer when enriched with ice, or hydrous sulfates or chloride hydrates (all have high thermal inertia) and covered by a dry layer of surface soils (very low thermal inertia) will be able to maintain a very lower T_{max} and a much smaller ΔT that are not affected by the large temperature variations at the surface during diurnal and seasonal cycles (Mellon, 2004). (3) Chloride hydrates (such as $MgCl_2 \cdot 12H_2O$, $FeCl_2 \cdot 6H_2O$, CaCL2.6H_2O, etc) would form from Cl-bearing brine at low T, would be stable in a large temperature range (beyond room T in lab), until deliquescence occurs abruptly at an elevated temperature (Baumgartner & Bakker 2009, and many others).

We have started a systematic laboratory investigation on the thermodynamics and kinetics properties of chloride hydrates. The goals are to determine (1) the stability fields of Mg-, Fe^{2+}-, Fe^{3+}-, Ca-, Al-, Na-chloride hydrates in RH-T space, especially the boundaries of hydrate-deliquescence; (2) the rate of their dehydration, and especially the rate of their deliquescence as function of T, P, and P_{H2O}; (3) the RH level that each chloride hydrate can maintain in an enclosure at Ts relevant to those within Mars subsurface.

We will report the results from (3), and will compare them with a similar set of data from hydrous sulfates (Mg, Fe, Ca, Al). The criticality of learning the property (3) is that the deliquescence of a hydrous salt at a T only occurs when RH is higher than a threshold. For example, deliquescence of ferricopiapite would happen when RH > 75% at 0 ℃. If the environmental RH is lower, the hydrous salt will go through dehydration (i.e., solid-solid phase transition) instead of deliquescence, such that water would be released to the atmosphere and brine would not form. It is possible that deliquescence of both hydrous sulfates and chloride contributed the RSL. Our working hypothesis favors chloride hydrates because dry chloride (after releasing water) in RSL would not be visible by Vis-NIR spectroscopy, which is consistent with the mission observations.