NATURE AND ORIGIN OF RSL: SPECTROSCOPY AND DETECTABILITY OF LIQUID BRINES IN THE NEAR-INFRARED.
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Introduction: If water has likely flowed on Mars in its early history, the current presence of liquid water is debatable. However, some recently discovered features named "Recurrent Slope Lineae" (RSL) suggest that superficial liquid can occur on present day Mars in a transient state [1]. RSL are dark (up to 40% darker than the surrounding areas), narrow (0.5-5 m) (Fig. 1) and are mostly found in the southern mid-latitudes. Repeated MRO/HiRISE images reveal that they appear and grow during warm seasons and fade and disappear during cold seasons. They develop on steep slopes (25°-40°), favoring equator-facing slopes, times and places with peak temperatures of ~250-300K.

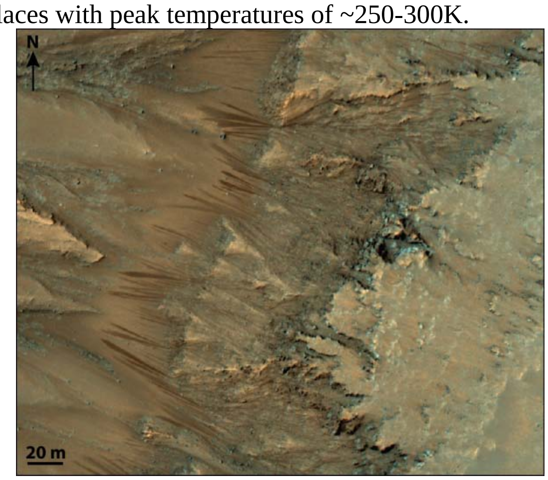

Fig. 1: RSL observed in Newton Crater (HiRISE image, ESP_022689_1380).

The most likely formation process of RSL involves the presence of liquid brines near the surface. Brines are more stable on Mars than pure water [e.g. 2, 3, 4] because salts can depress the freezing point of water by up to 70 K. However, this hypothesis suffers from the lack of clear identification of brines with the high resolution CRISM spectra. The mineralogical characterization of RSL is challenging because RSL are much smaller than the ~18 m pixel scale of CRISM data but spectral features diagnostic of water or brines [5] are not observable even on the largest RSL.

The goal of our study is to reproduce with laboratory experiments some hydration and dehydration cycles of different kind of brines mixed with basaltic soil. These experiments aim to understand the spectroscopic behavior of brines during these processes and to determine the diagnostic spectral features that we can expected to find for Martian RSL.

Methods: We have used the combination of the IPAG bidirectional reflectance spectrometer [6] with the simulation chamber SERAC [7]. The spectral measurements can be made under various incidence and emission angles and from 0.4 and 4.8 µm [6]. The SERAC chamber reproduces martian atmospheric conditions. It is optimized for measurements at low temperature and allows the exposure of a sample from low (~10^{-5} mbar) to high values (~0.8 mbar) of water vapor relative pressure [7].

For both dehydration and hydration experiments we have used a sample of basalt (from "La Reunion") grinded to obtain a fine-grained powder (<30 microns). We have realized these experiments for three different salts: a ferric sulfate ($(Fe^{3+})_2(SO_4)_3$), a magnesium chloride ($MgCl_2$) and a magnesium sulfate ($MgSO_4$) with respective eutectic temperatures of 205 K, 252 K and 270 K [3, 8].

For the dehydration experiments, we have wet a basalt sample with a brine solution. The sample is placed in ambient atmosphere and heated at 308 K. A spectrum is acquired every hour.

For the hydration experiments, we start with a dry mixture of basalt with 10% by mass of one of the 3 salts. The samples are placed in the SERAC chamber which is put under vacuum and we then progressively introduce increasing quantity of water vapor.

Results: *Dehydration experiments:* Some results of our dehydration experiments are represented on Fig. 2. The main spectral variations observed on all the experiments (example Fig. 2a for the MgSO4 dehydration) are: (1) an albedo increase by ~40-50%, (2) a decrease and a shift of the 1.5, 2.0 and 2.5 µm hydration absorption bands, (3) various changes on the shape and intensity of the 3 µm water absorption band. We noticed that the hydration bands centered at 1.5 and 2.0 µm quickly decrease while the albedo at 1 µm remains stable during few hours before it increases (Fig. 2b).

Our preliminary interpretation is that all these variations could be related to successive surface states and evolution processes linked to the progressive disappearance of water: (1) the initial presence of a thick and flat water film (very wet sample), (2) the formation of a residual rough water, (3) the residual persistence of of intergranular water only and (4) its disappearance, and (5) the possible formation of hydrated minerals. The 2 last dehydration steps can lead to a surface fading.

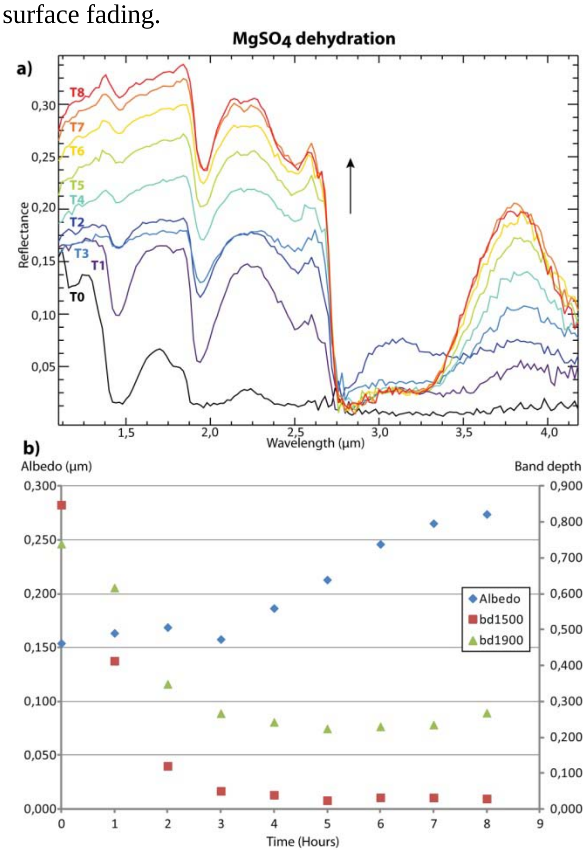

Fig. 2: Dehydration of a MgSO4 solution mixed with basalt powder. a) Time series of spectra. b) Evolution of water band depths and albedo with time.

Hydration experiments: Some results of our hydration experiments are represented on Fig. 3. With an atmosphere saturated in water vapor we obtain a liquid film at the surface of the sample in less than 2 hours (Fig. 3b). The main spectral variations observed for all our hydration experiments are: (1) an albedo decrease by ~40-50%, (2) an increase of the 1.5, 2.0 and 2.5 µm hydration absorption bands and (3) various changes of the 3 µm absorption band. During this hydration process, the albedo decreases very quickly even for a small quantity of water (Fig. 3b). The spectral variations can be linked to similar processes than for the dehydration processes.

Application to the RSL: Different photometric and spectral behaviors observed during these experiments can be consistent with the presence of brines as the origin of the formation of RSL. First, the surface albedo decrease during the hydration experiments is consistent with the albedo decrease observed on the RSL (up to ~40-50%). Moreover, the hydration experiments demonstrate that it is possible to form easily a liquid film on the surface of basaltic grains which can possibly lead to a flowing process. Fig.2b and 3b also reveals that during the first steps of dehydration the hydration absorption bands decrease quickly while the albedo stays very low during a long time. This could be consistent with the presence of low albedo features on Mars without detectable diagnostic absorption bands. We also observe different fading processes depending on the selected salt.

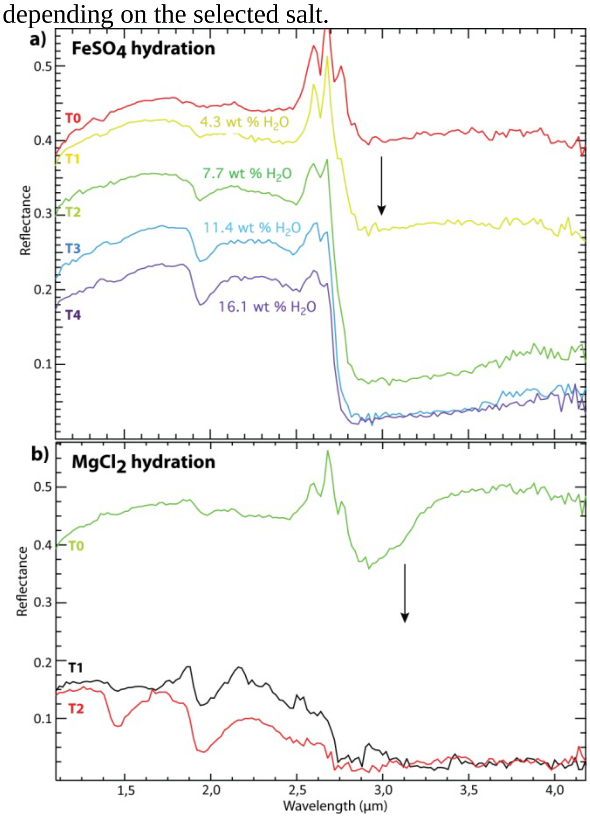

Fig. 3: a) Hydration of a dry $FeSO_4$/basalt powder mixture by injection of various amounts of water vapor. b) Hydration of a dry $MgCl_2$/basalt powder mixture in a water vapor saturated atmosphere.

Conclusions and future works: These experiments demonstrate that some RSL observations can be consistent with the presence of brines. In the future, we have to investigate in more details the RSL CRISM data in order to determine if we can observe similar spectral features on Mars. It would be also very fruitful to realize similar experiments with perchlorates, observed by the Phoenix lander in the northern plains.

References: [1] McEwen et al. (2011) *Science, 333*, 740-743. [2] Gough et al. (2011) *EPSL, 312*, 371-377. [3] Chevrier al al. (2009) *JGR, 114*, E06001. [4] Chevrier and Altheide (2008) GRL, 35, L22101. [5] Hanley et al. (2010) *41st LPSC*, abstract #1953. [6] Brissaud O. et al. (2004) *App. Optics, 43*, 1926-1937. [7] Pommerol et al. (2009) *Icarus, 204*, 114-136. [8] Altheide et al., (2009) *EPSL, 282*, 69-78.