FORMATION OF RSL ON MARS BY REWETTING OF SALT DEPOSITS FORMED IN AN EARLIER WETTER CLIMATE.

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Introduction: Recurring slope lineae (RSL) are relatively dark and narrow flow-like features on Mars that extend downslope from bedrock outcrops and occur annually during spring and summer, especially on steep, equator-facing, southern slopes [1]. Several mechanisms have been proposed to explain their occurrence, ranging from dry granular flows [2] to effects caused by rapid heating of nocturnal frost [3] or boiling of metastable water [4]. The best current hypotheses for the formation of RSL involve either the seasonal discharge of a local aquifer, the melting of frozen brines, or via deliquescence of salts dispersed in the soil [5,6,7]. All of these proposed mechanisms would play an important role in the water cycle of Mars that also involves the Martian Polar Regions. RSL like features formed via deliquescence of $CaCl_2$ enriched soil were also observed on Earth in thalwegs close to the Don Juan Pond, Antarctica [8].

In our studies we investigated the deliquescence process and the resulting darkening of Mars analogue soil mixed with various chloride and perchlorate salts via electrical conductivity (EC) measurements and visible observations [9] in order to better understand the relationship between the salts and changes in the content/distribution of the water and the soil albido.

Experimental setup: As a Mars analogue soil we used JSC Mars-1a. In a recently published concept paper [9] that described more detailed the principle potential of the used techniques we mixed 10g of the soil with either 0.0123 mol $Mg(ClO_4)_2 \cdot 6H_2O$, $Ca(ClO_4)_2 \cdot 4H_2O$, $MgCl_2 \cdot 6H_2O$, or $CaCl_2 \cdot 6H_2O$. All salts were ground in a mortar before mixing them with the soil. The samples were initially dried for 2 days in a desiccator. To increase the relative humidity (RH) in the system the desiccant in the lower part of the desiccator was then replaced by water. Through intense stirring and slight temperature changes between 290 and 298 K the RH was kept between 70 and 85%.

The deliquescence process was monitored via visible observations and EC measurements. All EC measurements were made using two parallel 1mm diameter copper wire electrodes inserted 25mm apart into the soil samples and connected to a CR 10 data logger (Campbell Scientific). The data logger is capable of applying an AC excitation voltage that prevents polarization of the electrodes. The applied excitation voltage

(V_X) results in a current between the electrodes proportional to the EC of the sample. This current is converted to a measured voltage (V). The observed output value of the data logger, equivalent to the conductivity, is a normalized voltage N given by

$$N = \frac{V_X}{V} \cdot 1000.$$

RH and temperature were measured with a HOBO Pro v2 data logger throughout the entire experiment.

For experiments that were done more recently some experimental parameters (salt concentration, hydration state, particle size, temperature) were varied to investigate changes in the deliquescence behavior.

Results: Our experiments have shown that the typical darkening of RSL can be reproduced by the deliquescent wetting of a perchlorate- and/or chloride-containing martian simulant soil. This darkening process caused by deliquescence induced adsorption of intergranular water [10] starts quickly after the soils have been exposed to a relative humidity that is higher than the deliquescence relative humidity (DRH) of the salt intermixed with the soil. First, separated soil particles on the top of the samples begin to darken (Figure 1a). When deliquescence continues a wet soil layer is formed (Figure 1b), which results in a detectable EC, that increases in time with propagating soil wetting.

However, producing greater amounts of liquid water in the forms of bulk or droplets (Figure 1c), which probably would leach out salts present in martian soil, takes much longer than previously assumed, which lead us to the assumption that RSL formation does not necessarily require a salt recharge mechanism, as the darkening might be only the result of a temporally rewetting of older salt deposits that formed in an earlier wetter climate. The salt deposition in this period, resulting from water evaporation, would have been most effective on the warmer equator-facing slopes of the craters and dunes, where RSLs are found today. The steep slopes of these formations may have also impeded new dry soil from covering the salt deposits.

Our most recent results show that the deliquescence rate in soil/salt mixtures is strongly dependent on the
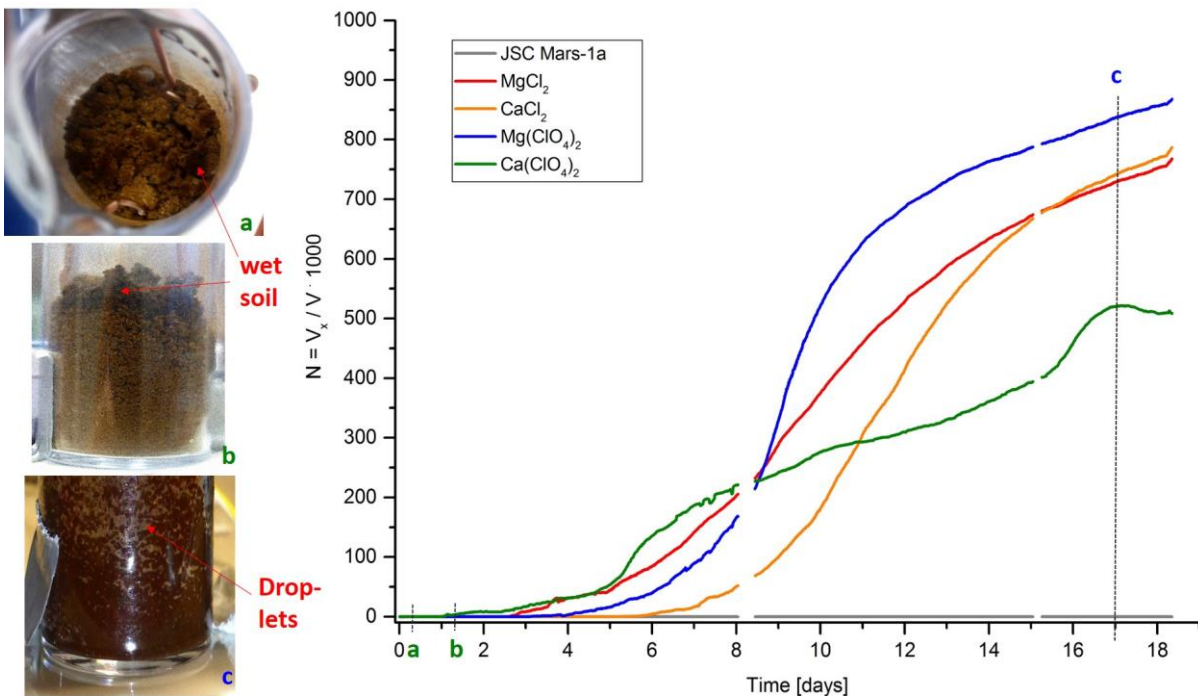
Figure 1. Changes in normalized voltage (N) as a function of time, and photos of soil samples. (a–c) The time when sample photos were taken. Wet separated grains on surface of the $Ca(ClO_4)_2$ sample with no measurable conductivity after 2.5 h (a). Thin wet layer of soil in the upper part of the sample causes first measurable conductivity values after 19 h (b). Wet layers and droplets of salty water in the sample of $Mg(ClO_4)_2$ with the highest measured conductivity after 17 days (c). RH was kept at 70 – 85% throughout the whole experiment [9].

type of salt used, the salt concentration, the particle size and the hydration state. It seems that even though perchlorate salts start to deliquesce earlier than chlorides, they do not always have higher deliquescence rates.

It also can be observed that the higher the salt concentration in the soil the higher the deliquescence rate, while the lowest salt concentration necessary for detectable deliquescence seems to be around 1 wt% after two weeks, which is a good approximation for the general salt content in martian soil at the Phoenix lander site [11]. For samples with high salt concentrations (>25–50 wt%, depending on the type of salt) a steep slope in the deliquescence rate curve can be observed after several days. This is due to the formation of liquid layers which increases conductivity spontaneously. This demonstrates that the EC measurement technique is capable of detecting the change from intergranular water (before the steep slope) to bulk solutions (after the steep slope) which would be necessary for a flowing behavior in RSL like features.

Furthermore, our investigantions show that the smaller the particle size of the salt the earlier deliquescence occurs. In comparison, samples with larger salt particles need longer to produce measurable EC values,

however, in these samples often a steep slope in the EC curve can be detected after several days, because the local concentration around a large salt particle (e.g. >2 mm) is high enough to produce a liquid layer between the electrodes while most of the residual sample stays dry.

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