POTENTIAL DELIQUESCENCE AT THE EXOMARS ROSALIND FRANKLIN ROVER LANDING SITE

B. D. Pál[1,2] [1]ELKH CSFK, Research Centre for Astronomy and Earth Sciences, 1121 Budapest Konkoly-Thege Miklós út 15-17, Hungary [2]Eötvös Loránd University, 1117 Budapest, Pázmány Péter sétány 1/A, Hungary (pal.bernadett@csfk.org)

Introduction: The ExoMars Rosalind Franklin rover of the European Space Agency (ESA) and Roscosmos will be launched in 2022, arriving at Mars in 2023. The mission of the rover is primarily to find biosignatures of present or past Martian life [1]. The HabitAbility: Brine Irradiation and Temperature (HABIT) instrument is part of the ExoMars Surface Platform Kazachok, that will investigate the habitability aspects of the landing site in Oxia Planum [2]. One of the modules is the Brine Observation Transition To Liquid Experiment (BOTTLE), that will investigate if liquid water can exist on Mars today in the form of brines. It will monitor the electric conductivity of four deliquescent salts previously found on Mars.

Perchlorates are hygroscopic minerals, which means an affinity to attract and hold on to water via adsorption or absorption from the atmosphere. Because of this affinity, they can form an aqueous solution if the temperature and relative humidity is appropriate (deliquescence). In this work I investigate the possibilities of calcium perchlorate ($Ca(ClO_4)_2$) deliquescence, a hygroscopic salt identified by the Wet Chemistry Laboratory instrument onboard the Phoenix mission [3].

Methods: The minimum temperature (eutectic temperature, ET) for possible calcium perchlorate deliquescence is around 198 K, while the relative humidity is 0.51 [4]. In this work I have used a modified code to calculate the probability of deliquescence while taking the temperature dependence of the deliquescence relative humidity (DRH) into consideration. For the calculations I have used surface temperature, atmospheric pressure and water vapor volume mixing ratio data from Laboratoire de Météorologie Dynamique Mars General Circulation Model (LMDZ GCM) version 5. The model is detailed in [5], the second generation of the model described in [6,7]. The location of the landing site in Oxia Planum used in this work is 18.75°N, -22.5°E [8].

Saturation water vapor volume mixing ratio (Q_{sat}) with respect to liquid and with respect to ice is calculated based on the Goff-Gratch equation [9,10], detailed in the methods section of [11]. Using Q_{sat} the relative humidity with respect to liquid and with respect to ice is calculated with Eq. 1., where Q_0 is the water vapor volume mixing ratio, and RH is relative humidity.

$$RH_{i,l} = \frac{Q_0}{Q_{sat\,i,l}} \quad (1)$$

Using the surface temperature and calculated relative humidity data, the possibly ideal times are selected with a C++ code. In this work I have taken the temperature dependent DRH into consideration [12] by modifying the code used in my previous works [13]. I consider the relative humidity with respect to ice, because recent works show that if this greatly exceeds 145%, nucleation is favored over brine formation [14].

Results: I have considered local times 9 PM, 11 PM, 1 AM, 3 AM and 5 AM. Out of these the overall highest chance of calcium perchlorate deliquescence is at 1 AM (Fig. 1.).

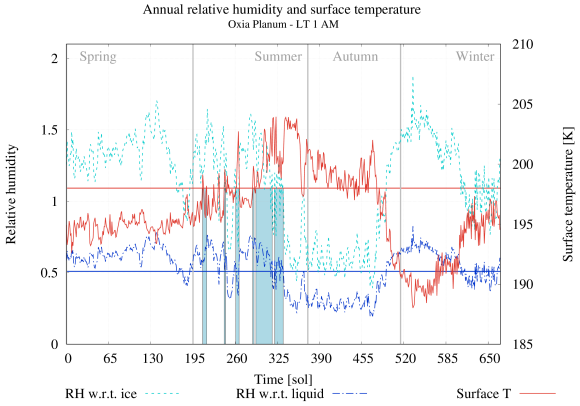

Figure 1: Ideal times for calcium perchlorate deliquescence at 1 AM local time at the landing site of ExoMars Rosalind Franklin rover in Oxia Planum. Solstices and equinoxes are denoted by vertical gray lines. The red horizontal line shows the ET of calcium perchlorate at 198 K, while the blue horizontal line shows the relative humidity at 0.51. The ideal times are illustrated by light blue rectangles.

In Fig. 1. we can see, that the ideal times are during the northern summer season, falling between the summer solstice and the autumn equinox. Local summer proved to be the most likely season at the other local times as well (3 AM and 5 AM).

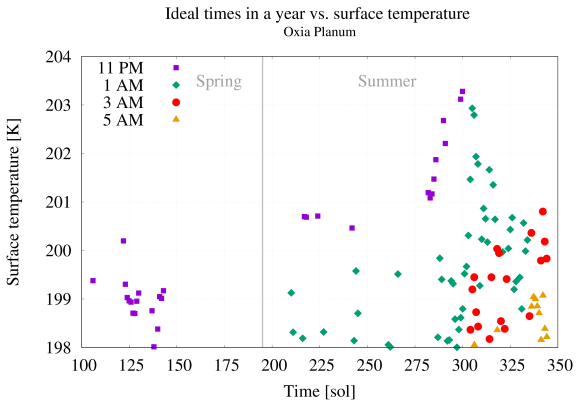

Figure 2: Ideal times for calcium perchlorate deliquescence at the landing site of ExoMars Rosalind Franklin rover in Oxia Planum at different local times.

In Fig. 2. all the different ideal times are shown with respect to season and surface temperature. With the exception of 11 PM, all the local times show potentially ideal periods during the summer. This is because 11 PM is the only one local time, where the surface temperature stays above the calcium perchlorate ET from spring throughout the end of autumn. Although the relative humidity is higher at later local times the temperature is too low for deliquescence to occur during the spring.

Summary and future work: In this study I have examined the deliquescence probability of calcium perchlorate at the landing site of ExoMars Rosalind Franklin rover in Oxia Planum. I have used data from the LMDZ GCM model to calculate relative humidity and the chance for deliquescence. The local summer, between the northern summer solstice and autumn equinox shows the highest chance for deliquescence between 11 PM and 5 AM local time. At 11 PM, the local spring also seems promising.

In this work I have taken the temperature dependence of the DRH in consideration. Although in theory solutions should recrystallize once the relative humidity with respect to liquid falls below DRH, experiments have shown that, owing to a hysteresis effect, efflorescence only occurs at lower relative humidity [15,16]. This would mean that metastable liquids could exist for much longer periods once in solution. In my next phase of work I will take efflorescence into account. The detailed analysis will also support the better evaluation of the astrobiology potential at this landing site [17]. By considering the efflorescence relative humidity the possibly ideal periods in Oxia Planum could stretch from spring to summer and into the early autumn season, resulting in an even better chance for brine formation.

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