**GLOBAL DISTRIBUTION OF AQUEOUS BRINES ON MARS: IMPLICATIONS FOR RSLs AND SPECIAL REGIONS.**

V. F. Chevrier[1], R. Melchiorri[2]. [1]Arkansas Center for Space and Planetary Sciences, University of Arkansas, Fayetteville, AR, 72701; [2]SOFIA, NASA Washington; vchevrie@uark.edu.

**Introduction:** Numerous active geomorphologic features have been on the martian surface which indicate present-day liquid activity [1,2]. In addition, abundant hydrated minerals have been found associated to these features, suggesting the presence of brines [3,4], which present the advantage of stabilizing liquid water at lower temperatures [5,6].

The objective of this paper is simply to study the stability and dynamics of liquid brines on the surface of Mars at a global scales, focusing on the various processes that affect brines: freezing, evaporation, boiling and deliquescence. The immediate outcome of such study will be not only to put constraints on the possible liquids at the origin of RSLs (by comparing distribution of RSLs with corresponding regions of "ideal" conditions for liquid formation) but also help defining regions of astrobiological interest or potential contamination risk, e.g. the "special regions" [7].

**Methods:** The stability maps presented in this study were detwermined by overlapping the evaporation rates, calculated using our previously well developed model of water diffusion modified by the buoyancy of $H_2O$ in heavier $CO_2$ [5,8]. This model is also adapted for highly concentrated solutions relevant to Mars, using the Pitzer model [5,6]. Moreover, the behavior of brines as a function of water activity allows comparing various salts on the same basis.

In addition these maps are overlaid with the limits for boiling, e.g. where the saturation pressure of water overcomes the atmospheric pressure, thus is mostly dependent on the altitude. Finally we also include freezing which can be permanent or occasional. Occasional freezing ir particularly important since it allows a cycle of liquid formation and thus the seasonality observed at the RSLs locations. Maps are presented on the surface uing maximum temperatures (Fig. 1) or in the subsurface using average temperatures (Fig. 2).

Finally we also determined the deliquescence of salts on Mars, based on water activity as well [9]. We determined the number of hours per year at which temperature and relative humidity were above the deliquescence relative humidity (DRH). We used the LMD Global Circulation Model database to obtain humidity and temperature at various times and locations.

**Results and discussion:**

*Brines stability.* The first very important result is that water is nowhere stable on the surface of Mars (Fig. 1). Not only it undergoes fast evaporation rates, but it is also most of the time boiling. Northern regions are permanently frozen, confirming previous observations by Phoenix. An interesting region, however, is around 30˚ North, since we have the possibility of liquid water occasionally boiling. This would be a potential region where RSLs could form due to the "relatively higher" stability of water.

Salts with lower water activity show a similar pattern except that their frozen region is much more reduced to higher latitudes. For the lowest eutectics, liquid can always be stable in high latitudes. Boiling will still occur at low latitudes.

These salty brines can nevertheless be stable in the subsurface because of their much lower eutectics (Fig. 2). This allows them to remain permanently liquid in the low latitudes, but only for the lowest eutectics ($CaCl_2$, $Ca(ClO_4)_2$, $Fe_2(SO_4)_3$). This happens because in the subsurface, there is no more temperature variation and the entire regolith is at the average temperature. So this is a tradeoff with the surface, brines are permanently stable at lower temperature but only for the lowest activities of wate.

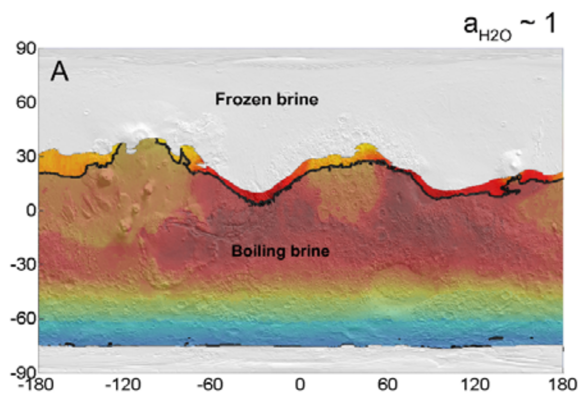


**Figure 1:** Stability map for pure water or poorly soluble salts (e.g. gypsum) on the surface. Liquids are mostly permanently frozen (grey zone) or boiling (shadow area southern of the thick black line).

*Deliquescence of salts.* Because of the anticorrelation between temperature and relative humidity (observed by Phoenix and MSL, e.g. [10]), it is very hard to find conditions when both are above the DRH. Therefore, only the salts with very low eutectics ($CaCl_2$, and perchlorates, Fig. 3) can deliquesce on the surface [XX]. Deliquescence only occurs for a maximum of ~500 hours per year, less than 5% of the year, and mostly in the northern regions (Fig. 4). $CaCl_2$ barely deliquesces, but very low eutectics like $Mg/Ca(ClO_4)_2$ can deliquesce over larger portions of the planet, down to mid-latitudes. Therefore, deliquescence could be a possible process for liquid formation linked to RSLs but only for salts with extremely low eutectics.

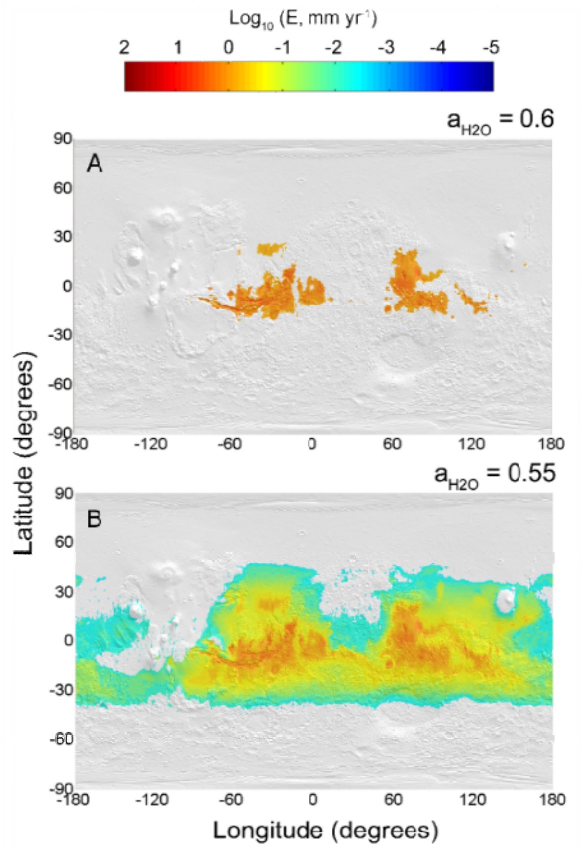


**Figure 2:** Map of the evaporation rate of salts of varying water activity (in Log scale) projected on a shaded MOLA topographic map. The grey zones correspond to permanently frozen regions (any salt with aH2O > 0.6 is permanently frozen). The colored regions indicate evaporation rates, which are lower than on the surface due to diffusion through the regolith.

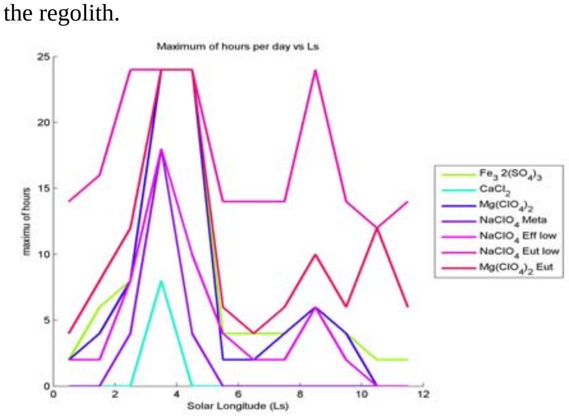


**Figure 3:** Number of hours of deliquescence as a function of solar longitude for various salts relevant to Mars. Only salts with an activity (or relative humidity at the eutectic) below 0.6 can deliquesce. Some metastable salts (for example NaClO4 monohydrate can be permanently in the deliqescent / liquid state, especially since there is a hysteresis with the efflorescence of the salts which occurs at much lower relative humidity (compare $NaClO_4$ Eut low and $NaClO_4$ Eff low, same temperature but a shift of 30% in relative humidity).

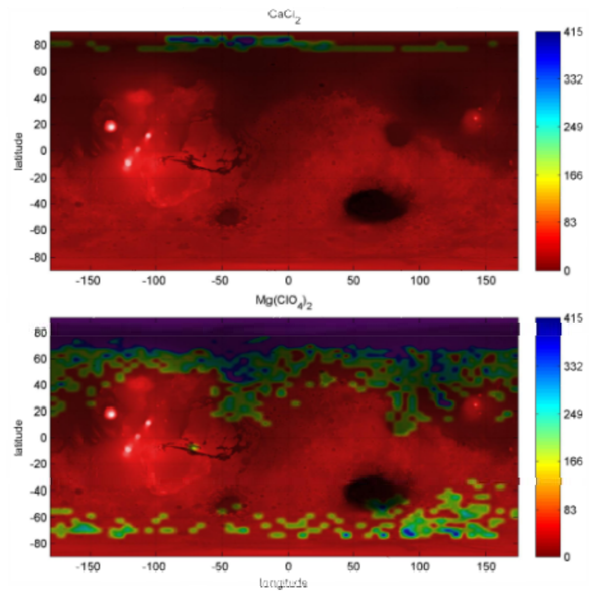


**Figure 4:** Geological features testifying of recent fluid flow activity on Mars: gullies (red circles), viscous flows (blue squares). The dark line represents the 201K isotherm or freezing point of the saturated ferric sulfate solution. The green stars represent gullies we identified in other areas where the 201K isotherm is present.

It is interesting to note that the northern mid-latitude zone (30 to 45°) is the limit between almost all the processes. For example southern of this latitude, liquids are permanently stable in the subsurface, but evaporate too quickly at the surface (or boil away). Northern of this latitude zone, permanent freezing occurs for the low eutectic salts in the subsurface and high eutectics at the surface. Therefore, this indicates that this laltitude is probably the most interesting in terms of seasonal and cyclic processes. This was already suggested this in the past for gullies but it is probably even more valid for RSLs.

**References:** [1] McEwen A. S. et al. (2014) *Nature Geosci* 7 (1), 53-58. [2] McEwen A. S. et al. (2011) *Science* 333, 740-743. [3] Ojha L. et al. (2015) *Nature Geosci* 8 (11), 829-832. [4] Chevrier V. F., E. G. Rivera-Valentin (2012) *Geophys. Res. Lett.* 39 (L21202). [5] Chevrier V., T. S. Altheide (2008) *Geophys. Res. Lett.* 35 (L22101). [6] Chevrier V. et al. (2009) *Geophys. Res. Lett.* 36 (L10202). [7] Rummel J. D. et al. (2014) *Astrobiology* 14 (11), 887-968. [8] Ingersoll A. P. (1970) *Science* 168 (3934), 972-973. [9] Gough R. V. et al. (2014) *Earth Planet. Sci. Lett.* 393 (0), 73-82. [10] Chevrier V. F., E. G. Rivera-Valentin, in *8th Mars Conference*. (Caltech, Pasadena, CA, 2014).