A LOW T, HIGH RH, AND POTENTIALLY LIFE-FRIENDLY ENVIRONMENT WITHIN THE MARTIAN SALT-RICH SUBSURFACE IN EQUATORIAL REGIONS. Alian Wang[1], M. P. Zheng[2], F. J. Kong[2], Z. C. Ling[3], W. G. Kong[3], P. Sobron[1], B. L. Jolliff[1], [1]Dept. of Earth and Planetary Sciences and the McDonnell Center for the Space Sciences, Washington University in St. Louis, One Brookings Drive, St. Louis, MO, 63130, USA. [2]R&D Center of Saline Lakes and Epithermal Deposits, Chinese Academy of Geological Sciences, Beijing, 100037, China. [3]School of Space Sciences and Physics, Shandong University, Weihai, China.

Observations on Mars — temporal changes in the properties of subsurface hydrous sulfates. Salt-rich light-toned soils were excavated by the Spirit rover at 18 locations in Gusev crater. Beneath the basaltic surface soils at the Tyrone site, two layers of sulfate-rich soils were found: the upper layer was white in color and rich in Ca-sulfates, the lower layer was yellow in color and rich in Fe-sulfates. A set of seven systematic Pancam observations of Tyrone salty soil were made from sol 864 to sol 1062 after its first excavation on sol 784. The major change observed was a reduction of albedo of the yellowish salty soils at 673 nm and 753 nm [1]. Recent spectral analysis based on two well-defined ROIs (Region Of Interest) for Tyrone yellowish and whitish salty soils [2] further confirmed that a spectral slope reduction from 673 nm to 432 nm (Fig. 1) of Tyrone yellow Fe-sulfate-rich soil occurred after its exposure to current surface atmospheric conditions. The change of spectral shape is consistent with the dehydration of Fe-sulfates [2].

A temporal property change of the subsurface soils excavated from tens of cm depth indicates that those soils were originally NOT in equilibrium with the surface atmospheric conditions at Gusev, and that *a different environment exists within the subsurface salt-rich regolith* [1, 2].

Terrestrial observations -- sulfates with high degrees of hydration found in the subsurface of a hyperarid region on the Qinghai-Tibet (QT) Plateau. QT Plateau has the highest average elevation on Earth (~ 4500 m), with ~50-60% of atmospheric pressure (P) at sea-level, high levels of UV radiation, low average temperatures (T_{ave}), and large diurnal (and seasonal) temperature swings (ΔT >80°C). In addition, the Himalaya mountain chain (average height >6100 m) at south of the QT Plateau largely blocks humid air from the Indian Ocean, and produces a hyperarid region, the Qaidam Basin (N32-35°, E90-100°, Aridity Index, AI = 0.04 - 0.01) at the north edge of the QT Plateau [3]. Climatically, the low P, T, large ΔT, high aridity, and high UV radiation all make the Qaidam basin one of the most similar places on Earth to Mars.

We conducted a field investigation at Da Langtan (DLT) playa in the Qaidam basin [4], with combined remote sensing (ASTER: Terra satellite) [5], in-situ sensing with a portable NIR spectrometer (WIR-2: 1.25-2.5 µm) [6], and laboratory analyses of collected samples from the field (ASD: 0.4 -2.5 µm, WIR-3: 1.14 - 4.76 nm, Laser Raman spectroscopy, and XRD). One of the preliminary results is the finding of Mg sulfates with high degrees of hydration ($MgSO_4 \cdot 6H_2O$ & $MgSO_4 \cdot 5H_2O$) within the subsurface salt layers [Fig. 2, 3]. Notice that hexahydrite and pentahydrated Mg sulfates would dehydrate quickly at relative humidity (RH) ≤ 33% and 5°C ≤ T ≤ 25 °C [7]. Thus finding these phases in the subsurface of a hyperarid region (AI < 0.01) indicates, analogously to Tyrone, *the existence of a different environment within the subsurface salt-rich layer.*

Extrapolation from thermal modeling -- low T_{ave} & small ΔT within the salt-rich subsurface. Thermal modeling of a two-layer regolith (low-thermal-inertia material on top of high-thermal-inertia material) suggests a distinct temperature profile in the subsurface

Figure 1. Tyrone salty soils temporal change

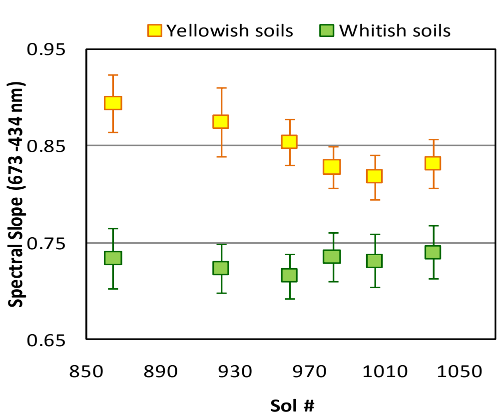



Figure 2. DLT subsurface salt layer

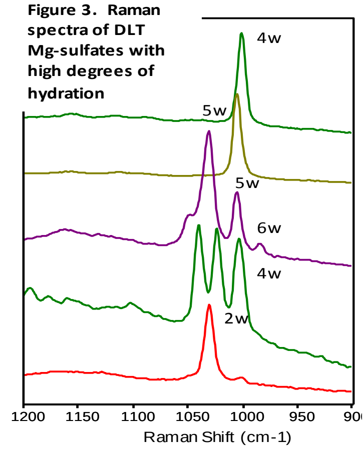


Figure 3. Raman spectra of DLT Mg-sulfates with high degrees of hydration

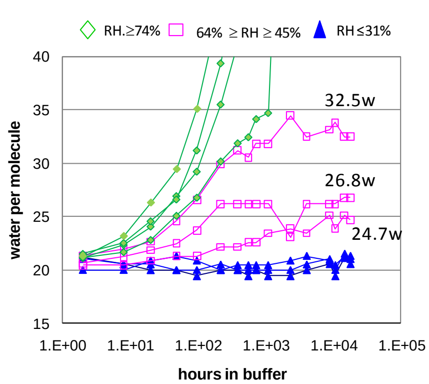
[8]. When this model is applied to the salt-rich regolith beneath the ordinary surface soil at Tyrone and to the subsurface salt layer at DLT on the QT plateau, it predicts the existence of *a low-T_{ave} zone in the subsurface with much smaller diurnal and seasonal temperature oscillation (ΔT).* This is due to the high thermal inertia of hydrous salts that suppresses the influence of surface atmospheric temperature variations.

Lab observation #1 -- large stability fields of highly hydrated sulfates at low T. Our systematic laboratory simulation experiments on Mg-sulfates and Fe^{3+}-sulfates [4, 9, 10] have yielded the following two related findings: (1) at low temperature (≤ -10°C), sulfates with high degrees of hydration, e.g., $MgSO_4·7H_2O$ & $Fe_{4.67}(SO_4)_6(OH)_2·20H_2O$, have *a large field of stability or metastability over a wide RH range (7-88%);* (2) *these hydrous sulfates are all good RH buffers*: for instance, a space filled with $MgSO_4·7H_2O$ at -10°C can maintain the RH in a 96-97% range, whereas $Fe_{4.67}(SO_4)_6(OH)_2·20H_2O$ at -10°C can maintain 75-79% RH in an enclosure.

Lab observation #2 -- thin film of liquid water on the surface of Fe-sulfate grains at low T. Figure 4 shows evidence of thin films of liquid water formed on the surface of Fe^{3+}-sulfate grains. At 45% ≤RH ≤64% and 5℃, the number of H_2O molecules that can be adsorbed at the surface of a ferricopiapite grain reaches 3.7 to 11.5 H_2O (varies w/RH) /per ($Fe_{4.67}(SO_4)_6$ $(OH)_2·$ $20H_2O$) molecule (pink data points in Fig. 4), with no deliquescence. A calculation based on these numbers suggests that *on a 2 μm diameter spherical ferricopiapite grain, 11.5W per molecule corresponds to 385 layers of H_2O molecules, and on a 10 μm diameter spherical grain, it corresponds to 1932 layers*.

Conclusion -- a high RH & potentially life-friendly environment within the salt-rich subsurface in Martian equatorial region. The RH at martian surface is determined by the surface temperature and the partial pressure of water vapor. On the other hand, two factors will determine the RH of subsurface enriched with hydrous salts: (1) *the buffer capacity of the hydrous salts buried at a given depth, and deeper;* (2) the low T_{ave} and small ΔT suggested by thermal modeling [8], i.e., without considering the RH buffering effects of hydrous salts, *the distinct T profile in salt-rich regolith itself would produce a relatively higher RH_{ave} and a smaller ΔRH (than at the surface),* which in turn helps the preservation of hydrous salt stability, as observed in DLT subsurface salt layer.

Figure 4. Fe4.67(SO4)6(OH)2.20H2O at 5°C



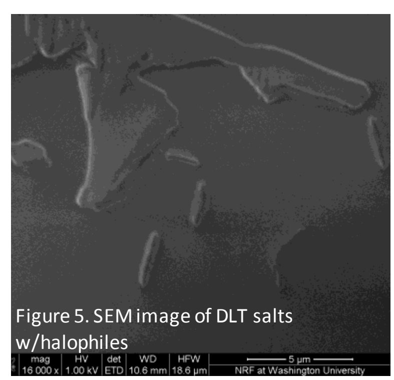


Figure 5. SEM image of DLT salts w/halophiles

In conclusion, the dehydration of Tyrone subsurface salty soils (after exposing to current Mars surface conditions) supports the existence of an RH gradient in salty-rich subsurface. This inference for Mars (equatorial region) is supported by the finding of Mg-sulfates with high degrees of hydration within the subsurface salt layer in a terrestrial hyperarid region (DLT on the QT Plateau). The temperature profile of a two-layer-regolith calculated by thermal model would support the maintenance of low T_{ave} and small ΔT within the salt-rich subsurface, which will produce a high RH_{ave} and a small ΔRH, and will facilitate the preservation of hydrous sulfates of high degree of hydration. Furthermore, thin films of liquid water were observed to form on the grain surfaces of ferricopiapite in laboratory experiments. In general, *an environment with locally high RH and the thin film of water forming on salt grains (at low T_{ave}) could be life-supporting for halophiles.* This hypothesis is proven on Earth by the finding of halophies under the salt crust of Atacama desert by Wierzchos et al [11], and by a similar discovery of different chains of halophiles within the salt crust at DLT saline playa on the QT Plateau by our team [12] (Fig. 5).

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