HABITABILITY POTENTIALS OF EXTANT LIFE FORMS IN ICY-SALTY WORLDS.

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Low temperature, salty worlds in our Solar System: We would hypothesize a H_2O-rich cryosphere within the subsurface of Mars, made of ground ice layer at polar and high latitude regions, and of salt- or salt-enriched-regolith-layers at low latitude regions. This hypothesis is supported by mission observations, such as subsurface ground ice identified in Polar Region by Phoenix lander [1], by the color change of "white" impact ejecta at high latitude region through orbital imaging [2], by the color change of subsurface ferric sulfates at Tyrone site of Gusev Crater [3] (suggesting dehydration after exposure [4]), and by the tight correlation with temperature of the occurrence of Recurring Slope Lineae (RSL, from subsurface layers) [5, 6].

Furthermore, many missions to icy satellites of giant planets of our Solar System have revealed the existence of variety of salts in their crust and plums, e.g., Mg-sulfates, Na-sulfates, Na-chlorides [7, 8, 9].

These mission observations have demonstrated that low temperature, icy, and salty worlds are quite common in the extraterrestrial planetary bodies within our Solar System. Although some of these environments are out of the stability field of liquid H_2O, however, liquid H_2O film can be maintained by hydrous salty grains, and high water activity can exist in salty environments, *which would provide the habitability potentials for extant life forms*. To gain quantitative understanding of these phenomena, we need to study these potentials through simulating experiments of hydrous salts.

Stability of hydrous salts in these worlds: For these studies, the first order knowledge is *the stability of some salts with high degrees of hydration under relevant conditions*, such as hydrous sulfates, chloride hydrates, and perchlorate hydrates. In addition, in an environment where the dehydration of these hydrous salts might happen, such as martian subsurface, we need to learn *the rate of their dehydration at relevant conditions.*

Our experiments on hydrous Mg-, Fe^{2+}-, Fe^{3+}-, Ca-, Al-sulfates have shown two common phenomena: (1) sulfate with higher hydration degree have higher stability at lower temperature; (2) the dehydrations of these sulfates have slower rates at lower temperature.

Specifically, we compared the dehydration rates of Mg-, Fe^{2+}-, Fe^{3+}-, Ca-, Al-sulfates (those having the highest hydration degree for each of its type, e.g., epsomite for Mg-sulfates, melanterite for Fe^{2+}-sulfates, …), we have found that Mg-sulfates have the highest dehydration rate among the five types. Furthermore, we put the half-life of epsomite dehydration within the duration of most recent Mars snowball periods when obliquity >45° (5.4-5.8 million years ago), we have found within martian subsurface with $T_{average}$ ~ 170-180 K, the dehydration of epsomite would be so slow that 99-98 % of would have high potential to remain until today. An extrapolation of this conclusion is that under the same conditions, the Fe^{3+}-, Al^{3+}-, Ca-sulfates with high hydration degrees would have *even higher probability to stay*, because Mg-sulfates has the highest dehydration rate. This prediction was validated by the finding of ferricopiapite ($Fe_{4.67}(SO_4)_6.(OH)_2.20H_2O$, with the highest hydration degree of Fe^{3+}-sulfates) in subsurface yellowish Tyrone salty soil excavated by Spirit rover[3,4]. Experiments on chloride hydrates are continue, and will be reported at the conference.

Water activities in icy salty worlds: Sulfates, chlorides, chlorite hypochlorites, chlorates, and perchlorateds are all hygroscopic salts. Some of them can depress the frozen point of brine for several ten's °C. A manifestation of these properties is the formation of thin film of liquid H_2O at the surface of salty grains *when a suitable partial H_2O pressure presents*, at extremely low temperature.

Therefore in an icy salty world, *a habitability potential (HP), i.e., the availability of liquid water,* is directly determined by the local (even at microscopic scale) partial H_2O pressure, i.e., the relative humidity (RH), that can be maintained by salts (e.g., salt layers in martian subsurface).

To quantify this HP, we measured the RH values maintained by hydrous salts in enclosed spaces, which revealed that epsomite $MgSO_4.7H_2O$ can maintain 96-97% RH at -10±1 °C, and ferricopiapite $Fe_{4.67}(SO_4)_6.(OH)_2.20H_2O$ can maintain 75-79 % RH at -10±1 °C. More measurements are continuing and will be reported at conference. These values demonstrated the capability of hydrous salts in maintaining extremely high water activity, which may exist in salt-rich martian subsurface and in solid icy-salty crust of satellites of giant planets of our Solar System.

Where to search for extant life forms: Martian subsurface salty layers and salty crust/subsurface ocean of satellites of giant planets of our Solar System.

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