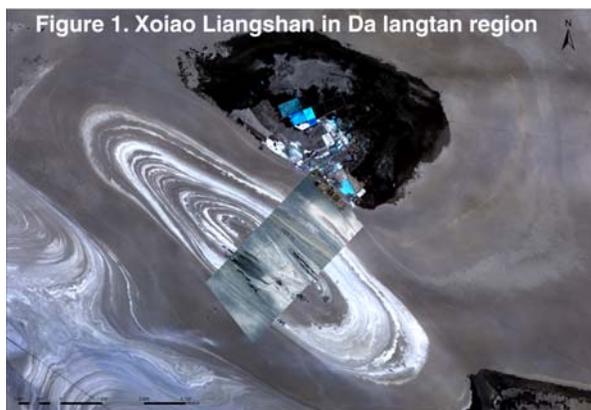


EVAPORATIVE SALTS FROM SALINE LAKES ON TIBET PLATEAU: AN ANALOG FOR SALTS ON MARS, Alian Wang¹, M. P. Zheng², ¹Dept Earth and Planetary Sciences and McDonnell Center for Space Sciences, Washington University, St. Louis, MO, 63130 USA (alianw@levee.wustl.edu), ²The Research and Development Center of Saline Lakes and Epithermal Deposits, Chinese Academy of Geological Sciences, Beijing, 100037, China (zmp@public.bta.net.cn).

Martian salts: Salts have been identified on Mars by spectrometers on orbiters and rovers. Among them, Mg-, Ca-, and Fe- sulfates were identified or implied in Meridiani outcrop [1] and in Gusev salty soils and rocks [2,3]; kieserite ($\text{MgSO}_4 \cdot \text{H}_2\text{O}$) and “polyhydrated sulfates” were found in Valley Marineris, Meridiani Planum, and gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) near North Pole [4,5,6,7]. Recently, chloride-bearing materials were suggested to present in low albedo region of Southern highlands on Mars [8], and carbonate bearing rocks at Nilli Fosse beneath an olivine-rich layer [9]. The majority of these salts and their geomorphic occurrences suggest a deposition origin from aqueous solutions [10] in the early part of Mars history and the subsequent dehydrations/degenerations. In each mission to Mars, there were certain limitations for salt detection and characterization. Laboratory simulation experiments [11,12,13,14,15] and terrestrial analog studies [16,17] can help to interpret the exact mineral species observed on Mars, to delineate their original hydration status, the co-existing minerals (even spectrally non-active), the environments of deposition, and the subsequent diagenetic histories. In this abstract we report initial results from a field campaign to a sulfate-dominated lacustrine system on the Tibetan Plateau.



Saline lakes and evaporative salts on the Tibetan Plateau: Tibetan Plateau (or QT-Plateau) has the highest average elevation on Earth (~ 4500 m), thus 50-60% of sea-level atmospheric pressure. Although located in the temperate climate zone at 24° to 35° latitude, the high elevation induces a tremendous diurnal (and seasonal) temperature swing caused by high level of solar irradiation during the day and low level of atmospheric insulation during the evening. In

addition, the Himalaya mountain chain (average height >6100m) in the south of the Tibetan Plateau largely blocks the pathway of humid air from the Indian Ocean, and produces a Hyperarid region (defined by Aridity Index, AI ~ 0.04) in the north part of the Tibet Plateau, the Qaidam Basin (N32-35°, E90-100°) in Qinghai province of China. Climatically, the low P, T, large ΔT and high aridity all make the Qaidam basin to be the most similar place on earth to Mars.

Thousands lakes occur on the Tibetan Plateau. The distribution of these lakes was controlled mainly by tectonics. The aqueous chemistry of the lakes and evaporative deposits was controlled by the following factors: the deep-seated hydrothermal fluid induced by tectonics, the weathering of regional rocks, the fluvial /groundwater systems, and the overall and regional climatic conditions. Based on the chemistry, the lakes on the Tibetan Plateau are classified into four types and distributed in four zones [18]. Qaidam basin has the most ancient playas (as old as the Eocene) and the lakes with the highest salinity. More importantly, Mg-sulfates (those found on Mars) appear in the evaporative salts from lakes and playas in Qaidam basin, which mark the nearly final stage of evaporation sequence of K, Na, Ca, Mg, Fe, C, B, S, and Cl bearing brines. The details in deposition sequence depend on the solubility of various salts affected by temperature and on the brine chemistry, while Mg-sulfates generally precipitate after carbonates, Ca-sulfates, borates, Na-sulfates and often co-exist with K, Mg-chlorides.

The climatic conditions and salt mineralogy within the lacustrine deposits of the Qaidam basin on Tibetan Plateau indicate that this area can be an excellent analog site for studying the precipitation sequence and subsequent dehydration/degeneration of Martian salts. A related abstract [19] in this volume describes more details on the saline lakes/playas and evaporative salts on the Tibetan Plateau.

2008 expedition to Qaidam basin: Initial field investigations of three sites were conducted during the fall of 2008. They are Da Qaidam Lake, Xiao Qaidam Lake, and Da Langtan playa (Fig. 1). Local day/night temperature (T) and relative humidity (RH) were monitored to provide constraints on local environmental conditions. GPS information was collected in combination with geomorphologic observations. Salt samples were collected from vertical cross sections (up

to 5 meters, Fig. 2) and along a linear traverse (~ 2 km) across a light-toned anticlinal structure at Da Langtan playa (Xiao Liangshan, Fig. 1). NIR spectra (1.25 -2.5 μm) were collected at the selected locations in the field, using a portable IR spectrometer (WIR) developed by us in an ASTID project. The obtained spectra provided the ground truth for a remote sensing spectral analysis of Da Langtan salt distribution based on ASTER satellite data. Samples with potential biomass were analyzed. Three related abstracts [20,21,22] in this volume describe the details of these studies.

Evaporative salts at Da Langtan: Preliminary Raman spectral analysis was conducted on the salt samples collected from Da Langtan playa. From a vertical cross section in a depression shown with the lowest albedo in Fig.1, Mg-sulfates with different hydration degrees, including kieserite, starkeyite, and pentahydrate (Fig. 3), were found in the top layer of deposition sequence. The ellipsoidal high albedo rings in Fig. 1 is one of the Da Langtan anticlinal structures, controlled by regional tectonic activities happening during the same period of the evaporation of Qinghai paleolake, i.e. the old deposits occur on the top of anticline. Surface soil and subsurface materials (max depth ~ 0.7m) were collected from 16 locations across a linear traverse perpendicular to the long-axis of anticline. Among them, Ca- and Mg-carbonates were found in the surface soil, and also coexisting with subsurface sulfate deposits. Large gypsum crystals (>15 cm) formed at the surface of upper portion of anticline. Coexistence of Ca-sulfates with three hydration states, gypsum, bassinette, and anhydrite, was identified hitherto in a crust sample immediately beneath the surface soil. Large amount of thenardite (Na_2SO_4) formed a band of > 10 m width and >1 m thickness, in form of loose fine powder suggestive to be dehydrated mirabilite ($\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$). Thenardite (and glauberite, hydroglauberite) crystals of 1 to 50 mm size were also formed in subsurface. NaCl was seen as massive rock salt or mixed with soil forming thick and cohesive crust.

Field observation and preliminary Raman spectroscopy analysis suggest that the materials contributing the ellipsoidal high albedo rings in Fig. 1 are (from center to edge): carbonate-gypsum-bearing surface soils, salt-clay-bearing exhausted Pleistocene deposits, dehydrated Na-sulfates, and mixtures of Mg-sulfates, multi-cation-sulfates, carbonates, and chlorites. The dark bands among the light-toned rings are made of NaCl-bearing

salty crust with massive rock salt.

Future work: We are planning to continue the investigation of evaporative salts in Qaidam basin on Tibetan Plateau, to conduct systematic field explorations (climatic, mineralogical, and biological) with a set of comprehensive spectroscopic studies, by satellite, in field, and in laboratory. We will identify and map the salty minerals, to place them in a stratigraphic context and to infer the dynamics of formation, with implications for the formation of sulfate-bearing salts on Mars.

Acknowledgement: 2008 expedition was funded by McDonnell Center for Space Sciences at Washington University in St. Louis and by the Planetary Science Initiative Fund of the Ministry of Land and Resources of China. NASA funds from ASTID (NNG05GM95G) and MFRP (NNX07AQ34G) program helped the investigation in the field and in laboratory.

References: [1] Clark et al. (2005), *EPSL*, 240, 73-94. [2] Wang et al. (2006), *JGR*, 111, JE002513, JE002516. [3] Squyres et al. (2006), *JGR*, 111, JE002771. [4] Bibring et al. (2005), *Science*, V307, 1576-1580. [5]. Arvidson et al. (2005) *Science* 307, 1591-1593. [6] Gendrin et al. (2005), *Science* 307, 1587-1591. [7] Langevin et al. (2005), *Science*, 307, 1584-1586. [8] Osterloo et al. 92008), *Science*, 319, 1651-1654. [9] Ehlmann et al (2008), *Science*, 322, 1828-1832. [10] Mangold et al. (2007), 7th international conference for Mars, abstract #3141. [11] Wang et al. (2006), *GCA*, 70, 6118-6135. [12] Chipera et al. (2007), *GCA*, 71, 241-250. [13] Varniman et al. (2007), *Am. Minerals*, 91, 1628-1642. [14] Chou & Seal (2007), *JGR*, 112, JE002898. [15] Wang et al. (2008), *JGR*, 114, JE003266. [16] Fernandez-Remolar et al. (2004), *PSS*, 52, 239-248. [17] Fernandez-

Remolar et al. (2005) *EPSL*, 240, 149-167. [18] Zheng (1998), *An introduction to saline lakes on the Qinghai-Tibet Plateau*. [19] Zheng et al. (2009), *this volume*. [20] Mayer et al. (2009), *this volume*. [21] Sobron et al. (2009), *this volume*. [22] Kong et al. (2009), *this volume*.

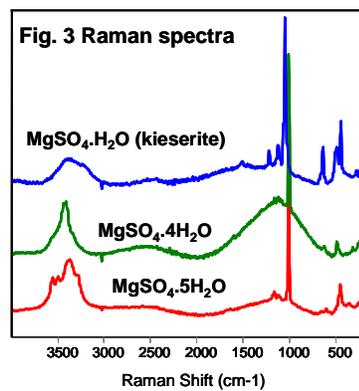


Figure 2. A sampling site

