MAPPING MINERALS AT A POTENTIAL MARS ANALOG SITE ON THE TIBETAN PLATEAU,

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Introduction: A variety of salts have been identified on Mars by by spectrometers on board orbiters and robotic landers, including sulfates, carbonates and chlorides [1, 2, 3]. All sulfates identified on Mars to date appear hydrated or hydroxylated. This indicates that sulfates on Mars originate from aqueous solution. Terrestrial analog studies can play an important role in helping to constrain exact mineral species observed on Mars and serve as a basis for hypotheses about the depositional environment of salts on Mars and their diagenetic histories. In this abstract, we report results from a combined field-based and remote sensing study of a sulfate-bearing lacustrine system on the Tibetan Plateau.

Study Area: This work focused on an area within the northeastern portion of the Qaidam Basin (32°-35°N/90°-100°E) on the Tibetan Plateau. This cold, arid basin contains numerous, extant and desiccated evaporative lakes, many of which contain sulfates [4]. The field site was located within the Da Langtan playa region of the Qaidam Basin. The playa represents the former location of a saline lake which desiccated in the late Pleistocene [5]. A partially eroded anticlinal structure within the playa, called Xiao Liangshan, exposes a sequence of deposits from the former lake, thus allowing mineral facies from multiple stages of the lake's evolution to be analyzed at the surface. In map view, the sequence of deposits on Xiao Liangshan appears as alternating light and dark-toned rings surrounding the structure (Fig. 1).

Analysis: Samples of minerals were collected along a ~2 km traverse across Xiao Liangshan and analyzed in the laboratory using an Analytical Spectral Devices LabSpec®-series reflectance spectrometer (2151 channels from 0.35 µm-2.5 µm). Collected samples were identified by comparing their spectra against those of minerals in a published spectral library [6]. Certain minerals, such as halite and large (up to 15 cm long) crystals of gypsum, were easily identified in hand sample at the field site.

Remote Sensing of Study Area. Xiao Liangshan was imaged by the Advanced Spaceborne Thermal Emission and Reflectance Radiometer (ASTER) onboard NASA's *Terra* satellite. ASTER is a multispectral imaging spectrometer containing 3 subsystems designed to image at visible near-infrared, shortwave infrared (SWIR) and thermal infrared wavelengths. The SWIR subsystem contains 6 bands centered at wavelengths useful for identifying geologically interesting materials (1.656, 2.167, 2.209, 2.62, 2.336 and 2.40 µm) at a resolution of 30 m/pixel. Seven spectral endmembers were determined for the ASTER scene in Fig. 1 using minimum noise fractionation and pixel purity indexing.

Spectral endmembers derived from the ASTER scene were compared with the laboratory spectra of handsamples to serve as the basis for classifying pixels in the orbital image of the study area (Fig. 4). Pixels in the scene were classified using spectral angle mapping. This method projects pixels from the ASTER scene as vectors in multispectral space along with spectral vectors of the endmembers. Pixels from the scene whose vectors diverge less than 0.02 radians from an endmember vector are classified as belonging to that particular endmember class.

Results: Laboratory spectra are plotted in Fig. 2. Laboratory spectra of minerals collected in the field are found to match well with library spectra of gypsum, a mixture of carbonate and hydrated sulfate minerals, mixtures of clay minerals and thenardite with adsorbed water. Resampling of the lab spectra to ASTER wavelengths aids the interpretation of the ASTER-derived endmembers (Fig. 3). For example, the handsample identified as thenardite shows an apparent absorption at 2.1µm when resampled to ASTER wavelengths due to its broad water absorption feature centered near 1.9µm. Thus, 2.1 µm absorptions in endmember Class #'s 1, 3, and 4 may indicate the presence of hydrated sulfates or sulfates with adsorbed water that have water absorption features undersampled by ASTER.

Areas on the classification map identified as belonging to Class# 3 match well with areas observed on the ground to be covered with gypsum crystals and interstitial clastic material. Absorptions in endmember spectra at 2.2 µm and 2.3 µm (i.e. Class #'s 2, 5, 6 and 7) are consistent with absorptions due to combination metal-OH bending and an OH stretch, characteristic of many phyllosilicate minerals.

The classification map of Xiao Liangshan shows a repeating sequence of mineral facies from the base to the top of the anticline. In particular, the northwestern portion of the anticline appears to display an alternating pattern of Class # 1 and Class # 3 material. A pattern of alternating bands of Class # 1 and Class # 5 material begins closer to the center (e.g. the topographically highest part) of the structure.

Conclusions and Future Work: Laboratory spectra of select hand samples from Xiao Liangshan have been identified as phyllosilicate mixtures and hydrated sulfates. Resampling of these spectra to ASTER wavelengths indicatess that endmember spectra derived from an ASTER image of the field site may represent assemblages of phyllosilicates and hydrated sulfates. A mineral facies classification map based on these endmembers shows a repeating sequence of mineral facies on Xiao Liangshan, hinting at cyclical episodes of mineral deposition at the site. Establishing the stratigraphic context of Xiao Liangshan will be a key focus of future work at the site. Additionally, we will seek to obtain orbital hyperspectral imagery of this site in order to improve the mineral facies identifications. The combined remote sensing, field and laboratory investigations will improve our understanding the geology of the site with implications for theories about sulfate formation on Mars.

References:

[1] Bibring et al. (2005) *Science, 307,* 1576–1580. [2] Arvidson et al. (2005) *Science, 307,* 1591–1593. [3] Clark et al (2005) *EPSL, 240,* 73–94. [4] Zheng, (1997) *An Intro. To Saline Lakes on the Qinghai-Tibet Plateau*. [5] Huang et al. (1993) *Chin. J. Oceanol. Limnol., 11,* 34–45. [6] Clark et al. (2007) *USGS., Digital Data Series 231*.

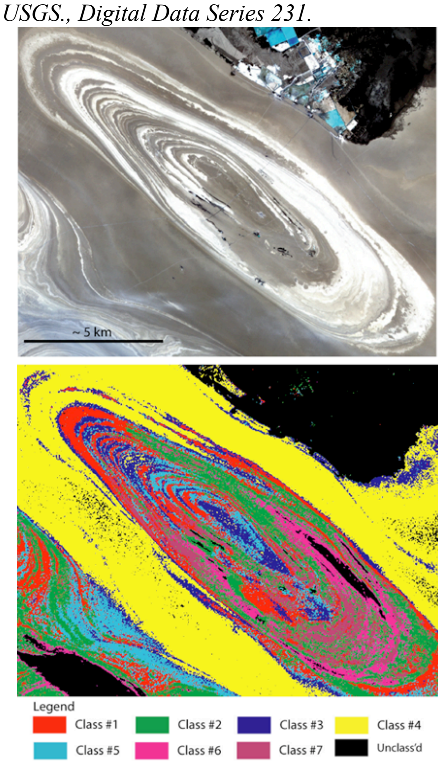

Figure 1: Top panel is ASTER true color image of Xiao Liangshan field site. Lower panel is spectral class map of the area based on spectral endmembers in Fig. 4

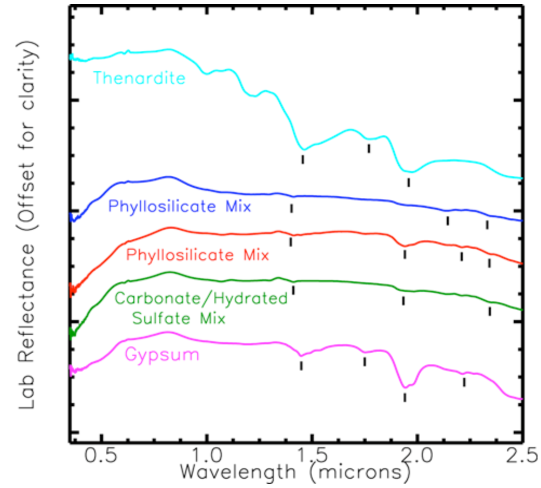

Fig. 2: Lab spectra of handsamples. Vertical bars mark diagnostic absorption features.

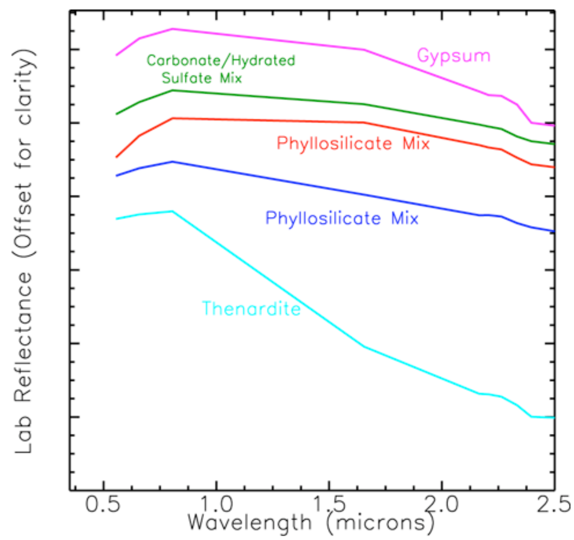

Fig. 3: Lab spectra resampled to ASTER wavelengths.

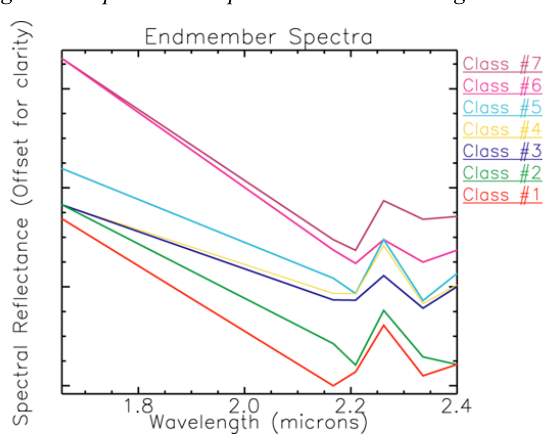

Fig. 4: Spectra of endmembers derived from ASTER image of field site. Spectra are interpreted to represent assemblages of phyllosilicates and hydrated sulfates (see text).