SALTY CLAY SITES IN THE MOJAVE DESERT AS ANALOGUES FOR MARS: VNIR SPECTROSCOPY INVESTIGATIONS OF FLUVIO-LACUSTRINE VOLCANICLASTIC DEPOSITS.

R. Bonaccorsi[1,2], J. L. Bishop[1,2], and Z. F. M. Burton[3], [1]SETI Institute (Mountain View, CA) [2]NASA Ames Research Center (Moffett Field, CA; rosalba.bonaccorsi-1@nasa.gov)), and [3]Stanford University (Stanford, CA).

Introduction: Investigating Mars analogue environments on Earth is essential for constraining early martian geochemical environments. Phyllosilicates and sulfates are the most common materials formed through aqueous processes on Mars; regions containing both phyllosilicates and sulfates provide information about the conditions governing the transitions from the ancient phyllosilicate-rich outcrops to the younger mixed materials or sulfate-rich outcrops. This point in Mars' history is critical to understand because it is likely the time when liquid water ceased to exist long-term on the surface of Mars.

In order to understand transitions on Mars from the phyllosilicate-rich outcrops to the sulfate-rich ones, we are investigating salty, clay-bearing materials in the Mojave Desert. This dry region is shaped by volcanic activity and resembles some aspects of aqueous alteration and fluvio-lacustrine processes on early Mars. Some of these sites include Holocene to 5-20 million-year-old sediments from the Koehn Lake (KL) [**1,2**] and Red Rock Canyon (RRC) [**3**] sites, which lie at the boundary of the Sierra Nevada range on the western side of the Mojave Desert.

Koehn Lake: KL is a seasonal lake in an endorheic basin located about 5 km east of Red Rock Canyon State Park. Lower elevations still collect water due to shallow groundwater (moist playa), but much of the area termed "saltdale" consists of efflorescent salts (**Fig. 1**) deposited through evaporation of brine (borate-halite-gypsum evaporite) rising to the surface via capillary action. Gypsum was mined here in the early 1900s [**1**] when 60-70% of the evaporite deposit was gypsum [**2**].

Samples of the salt crust and mud were collected from several sites (**Figs. 1-3**) and exhibit a fluffy surface texture described as snow-like [**1**]. Additional yellowish sandy-silt materials were acquired from the shoreline deposits north of KL (**Fig. 4**). Visible/near-infrared (VNIR) reflectance spectra were measured in the lab using an ASD spectrometer from 0.35-2.5 µm. Selected spectra are shown in Fig. 5. Spectra of the yellow silt sample (K6) include sharper water bands near 1.41 and 1.91 µm, characteristic of montmorillonite [**4**], while spectra of the efflorescent coatings and mud samples have broader bands shifted towards longer wavelengths, more consistent with gypsum or hydrated salts [**5**].

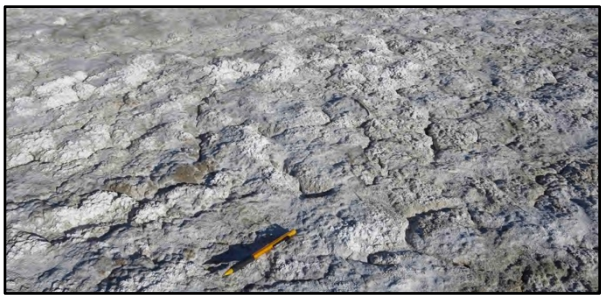

Fig. 1. *KL's efflorescent salt crusts showing variability in color and texture.*

Fig. 2*. Fluffy texture of white knobs on surface of crusts (~5 cm across). Sample K4 collected from area shown in Fig. 1 with white coating over orange-brown mud.*

Fig. 3*. Close-up view of thin white crust coating (K5) on orange-brown mud. (~2 cm across).*

Fig. 4*. KL shoreline deposits where the K6 yellow sandy silt sample was collected (~3 m across).*

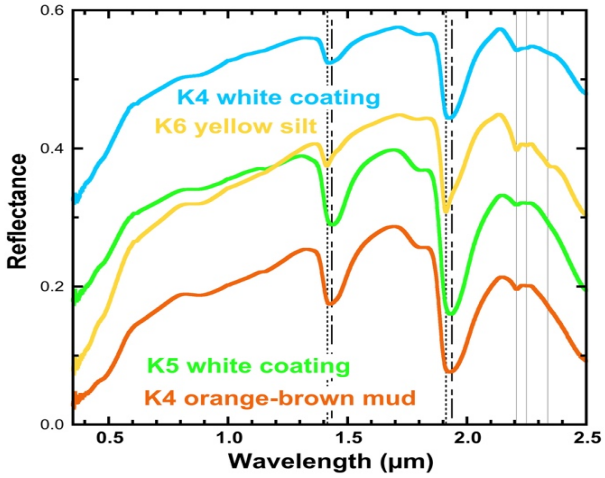

***Fig. 5**. VNIR reflectance spectra of selected samples from the Koehn Lake region.*

Red Rock Canyon: Red Rock Canyon (RCC) is situated between the El Paso and Garlock fault systems that uplifted these sediments and exposed them to erosion forming the current topography [**3**]. The Ricardo Group consists of ca. 2300 meters of volcanic material, sandstone, and sediments altered by volcanic vents and fissures, lacustrine processes, and pedogenesis that produced the brightly colored cliffs (**Fig. 6**) [**3**].

***Fig. 6**. Colorful cliffs of the Ricardo Group at Red Rock Canyon State Park (www.parks.ca.gov).*

Thick deposits of volcanic ash and bentonite are also present. Sulfate at the RRC site is primarily present in gypsiferous sandy soil, and NaCl salt is also present in varying abundance throughout the region [**2-3**]. We investigate here a range of wallrock, tuff, and basaltic materials. The reddish wallrock sample contains a mixture of iron oxides, clays and sandstone (**Fig. 7**), while the light brown wallrock material has a silty/clay salty matrix (**Fig. 8**).

VNIR reflectance spectra were measured for several samples and selected spectra are shown in Fig. 9. Variable bands near 0.5-0.9 µm (dashed lines) are due to iron oxides/hydroxides in the samples. The strong bands near 1.41 and 1.91 µm (dotted lines) in some samples are consistent with water in montmorillonite and related phyllosilicates [**5**]. Variations in the bands near 2.20-2.34 µm (solid lines) are due to montmorillonite, hydrated silica, Mg-clays, and gypsum [**4-5**].

***Fig. 7**. Close-up view of reddish wall rock material illustrating mixture of mineral grains (~2 cm across).*

***Fig. 8**. Close-up view of light brown wall rock material illustrating silty/clay salty matrix (~4 cm across).*

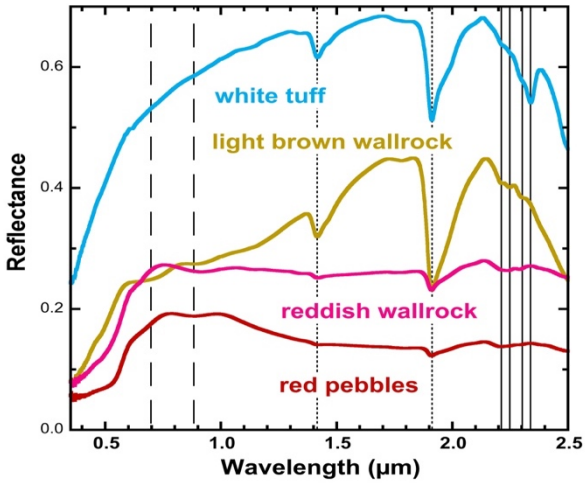

***Fig. 9**. VNIR reflectance spectra of selected samples from Red Rock Canyon.*

References: [**1**] Dibblee (1952) Geology of the Saltdale Quadrangle, Calif., Dept. Nat. Resources, 7-44. [**2**] Dibblee and Gay (1952) Mineral Deposits of the Saltdale Quadrangle, Dept. Nat. Resources, 45-88. [**3**] Harris (2010) Red Rock Canyon State Park, GeoGem Note 38, Geological Gems of California State Park [**4**] Bishop et al. (2008) *Clay Miner., 43*, 35-54. [**5**] Bishop et al. (2014) *Am. Miner., 99*, 2105-2115. [**6**] www.mindat.org/loc-272014.html.