

COORDINATED SPECTROSCOPY, GEOCHEMISTRY, AND MINERALOGY OF MARS BRINE POND ANALOGUE SEDIMENTS FROM ANTARCTICA. Z. F. M. Burton^{1,2}, J. L. Bishop², P. Englert³, P. Dera³, C. Koeberl⁴, and E. K. Gibson⁵, ¹Stanford University (Stanford, CA; zburton@stanford.edu), ²SETI Institute (Mountain View, CA), ³University of Hawai'i at Mānoa (Honolulu, HI), ⁴University of Vienna and Natural History Museum (Vienna, Austria), and ⁵Johnson Space Center (Houston, TX).

Chlorides, phyllosilicates, and sulfates at or near the surface of Mars indicate a complex history of aqueous activity [1-5]. Understanding this history is critical to understanding past and present martian habitability. Fortunately, excellent analogues for the cold and xeric martian climatic conditions, and for the martian regolith, are available in the McMurdo Dry Valleys (MDV) region of Antarctica [6] (Fig. 1). Here, liquid surface water is unstable most of the year [7], and yet, life flourishes [8]. Our study focuses on the mineralogical assemblages that have developed in MDV sediments due to the activity of a transient brine pond, referred to as the VXE-6 pond (Fig. 2). This pond provides an analogue for ancient salt ponds on Mars, and for the observed aqueous mineral assemblages on the surface.

Introduction: The climate and geology of the MDV is in many ways analogous to martian settings. Despite an extremely cold (mean annual temperature of -18°C) [6,7] and dry (<10 cm precipitation/year with sublimation >50 cm/year) [6,8] environment, liquid water occurs in the MDV. This water – in lakes, ponds, and streams – is highly saline, thus bearing a close similarity to runoff- and groundwater-fed saline water bodies inferred to have existed in the martian past, and importantly, inferred to have produced the observed suite of aqueous minerals on the martian surface [e.g. 5,9,10]. Furthermore, the Ferrar dolerite of the MDV contains abundant pyroxene, feldspars, and phyllosilicates [11,12], providing a close analogue for martian regolith in its weathered form.

Study Site: We performed coordinated spectral, geochemical, and mineralogical analyses of sediments collected in 1980 [13] at a dry, shallow-groundwater-fed transient salt pond in the South Fork of Wright Valley (Fig. 1 & 2). Our samples represent sediments collected from six depth intervals (0-1, 1-4, 4-7, 8-10, 12-15, 20-24 cm) in a pit excavated at the pond site, as well as sediments collected at ten one-cm depth intervals from a core taken at the site.

Methods: In a previous study [14], we compared various methods of sample preparation and found spectral signatures to be similar regardless of method. Therefore, we here report on spectral analysis of original coarse soil pit and core samples. These samples were analyzed via visible/near-infrared (VNIR) reflectance spectroscopy using an ASD spectrometer at the SETI Institute, as in [15]. Major and trace element

geochemical analysis was performed by X-ray Fluorescence (XRF) at the Bureau Veritas in Vancouver and by Instrumental Neutron Activation Analysis (INAA) at the University of Vienna. Mineralogical analysis was performed by X-ray Diffraction (XRD) using a Bruker D8 Advance with a LYNXEYE XE detector at the University of Hawai'i at Mānoa.



Figure 1. Area surrounding the VXE-6 pond site in the South Fork of Wright Valley.



Figure 2. The dry VXE-6 pond and site of core/soil pit.

Spectroscopy Results: For spectra at the surface (0-4 cm), broad bands at ~ 1.43 , 1.93 , and 2.20 μm suggest the presence of hydrated salts and/or poorly crystalline aluminosilicates (Fig. 3 & 4). At 4-6 cm depth, asymmetry at ~ 1.93 μm and a stronger band at ~ 2.20 μm in the spectra suggest allophane-like material (Fig. 3 & 4). At 6-8 cm, spectra suggest a mixture of the overlying poorly crystalline aluminosilicates and the underlying gypsum. At 8-10 cm, a triplet at ~ 1.44 , 1.49 , and 1.53 μm , a band at ~ 1.75 μm , a doublet at ~ 2.22 and 2.26 μm (plus at 4.4 - 4.8 μm [16]) in the spectra are all characteristic of gypsum (Fig. 3 & 4).

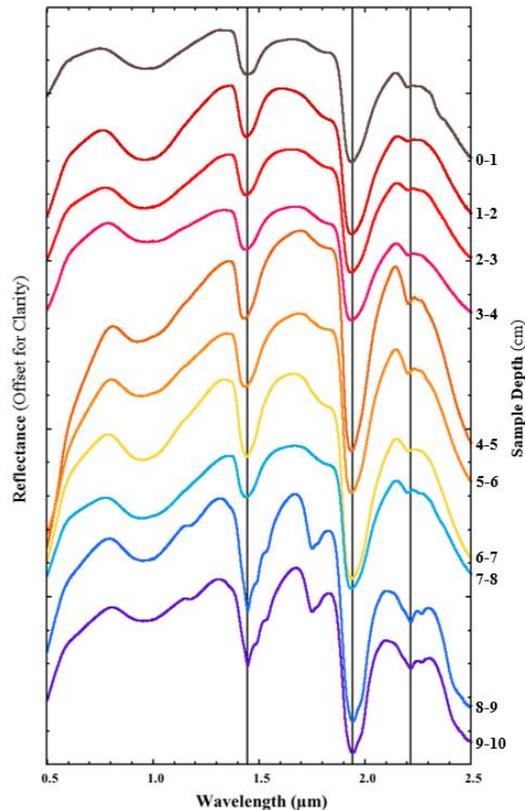


Figure 3. VNIR spectra of VXE-6 core samples.

Geochemistry Results: Major element geochemistry results from XRF show depleted SiO_2 and significantly elevated Al_2O_3 – consistent with an Al-rich clay – as well as high Fe_2O_3 , MgO , and K_2O at the 4-7 cm depth, while the 8-10 cm depth shows elevated CaO and SO_3 , consistent with gypsum (Fig. 4). Results from INAA similarly show elevated chemical abundances at the 4-7 cm depth, including elevated K, U, Cs, Fe, Th, Co, Zn, Rb, Zr, Ba, and Sr, as well as elevated rare earth element abundances (Fig. 4).

Mineralogy Results: XRD confirms the expected sediment composition of feldspar, quartz, pyroxene, and some authigenic Fe/Mg-clays, as well as the general trends with depth observed by reflectance spectroscopy and geochemistry. At the 8-10 cm depth, XRD revealed the presence of anhydrite and bassanite in addition to gypsum.

Conclusions and Implications for Mars: Spectroscopy, chemistry, and mineralogy of sediments from an intermittent brine pond site in the McMurdo Dry Valleys reveal a transition from surficial hydrated salts to a chemically active amorphous layer to sulfates (especially gypsum) at greater depth. We infer the chemically active proto-clay layer to have formed via precipitation of elemental components from liquid solution

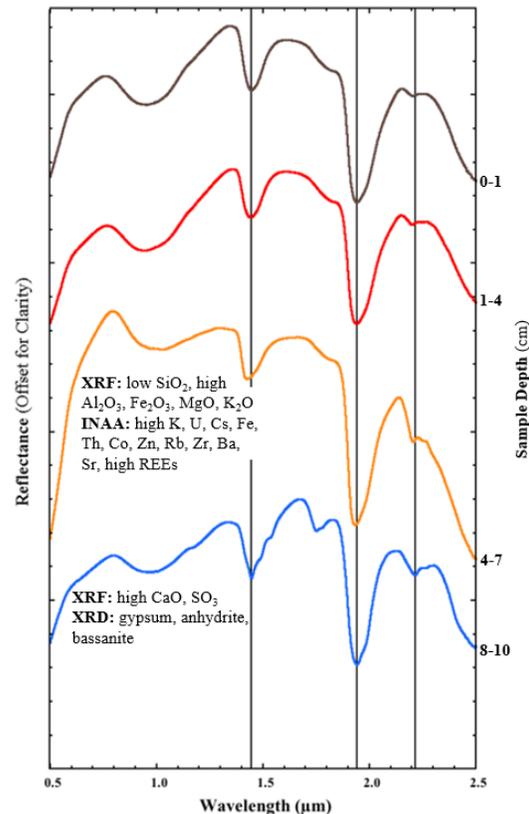


Figure 4. VNIR spectra of VXE-6 soil pit samples.

during activity of the pond, providing a direct analogue for formation of amorphous aluminosilicates at ancient salt ponds in cold environments on Mars, while chlorides and sulfates likely formed via intermittent evaporitic activity of the pond.

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